THE INFLUENCE OF LOGISTICS MANAGEMENT ON FOOD SECURITY IN GHANA

A thesis

Submitted in fulfilment of the requirements of the degree of Doctor of Philosophy in Management Sciences, Specialising in Business Administration

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ABSTRACT

Research problem warehouse

Food insecurity has been reported to be increasing in Ghana despite recent government logistics infrastructure (warehouses) efforts. It is important to understand the extent to which logistics affect the agricultural sector in Ghana as food production is a vital part of the agricultural sector and efficient logistics management is essential to its success, as such a well-run logistics operation can make the difference between a successful harvest and a poor one. Notably, Ghana's food insecurity is snowballing in number and intensity and Ghana is among the countries with the highest post-harvest losses (PHL) in Sub-Saharan Africa. Several attempts have been made by successive administrations to curb the food insecurity issue with the adoption of contemporary policies involving the establishment of the infrastructure for poverty eradication programme (IPEP) initiative, nonetheless, these interventions influences are unknown as food security remains an earnest challenge for many households in Ghana. This study aims to develop a framework of logistics management that can be recommended to enhance food security. To design the framework, this study will measure the influence of logistics management on achieving food security in Ghana in objectives listed below:

- Assess road transport type(s) for achieving food security in Ghana.
- Measure warehouse packaging logistics contribution to attaining food security
- Examine the relationship between logistics management and food security in Ghana
- Analyse the influence of warehousing on Ghana's food security.
- Examine the challenges of logistics management that affect agricultural food security
- Recommend a Framework the government can adopt for sustainable improvement in logistics management in the food industry.

Research methods and procedures

This study adopted a mixed research methodology, where data was drawn from smaller holder farmers in two regions in Ghana. Questionnaire and interview schedules were deployed for data collection and analysed with regression, and correlation models as well as Sorensen's coefficient framework.

Findings and conclusion

At least 90 percent of foods produced in Ghana is found escaping post-harvest losses now with tricycle and head/human porterage being the primary means of transport, howbeit tricycle at ($t(38) = 0.66$, $p=.51 > level.05$, $n^2 > 0.01$) achieves food security with more assurance, not despising the

usefulness of Head/human porterage (t (38) =-1.57, p=.12, n^2>1 percent) proving 99 percent safe to farmer PHL.

This study finds that packaging logistics has a lesser impact on food security at R^2 equaling one percent, p=0.029 in testing with the regression model. Overall, logistics management has an insignificant positive association with food security at p=0.073 and Pearson's R=0.149, positing a feeble (R^2=1 percent) impact.

The IPEP warehouse invariably has a weak insignificant influence on the recorded food security as evidenced by Pearson's correlation 'R=0.130'or r=0.067, with a p=0.188, R^2 equaling one percent.

Smallholder farmers fairly agree to the ranking of logistical challenges impeding food security in the agricultural sector indicating the most severe issue to be “high transportation costs”. Kendall's coefficient (W) of 0.388 or 39 percent is obtained, indicating that food security status depends on the ranking of enumerated challenges.

Implication

A meagre impact does logistics management have on Ghana’s food security denoting 99 percent of the country’s food security inexplicable by the predictor variable. The IPEP warehouse is doing little to stimulate contemporary food security of the nation meaning other latent variable(s) spearhead the rise of the criterion thus, craving for a further search

Recommendation

A need for a conscious national plan to furnish the warehouses with relevant technologies is proposed in this write-up, to improve the warehouse operations/functionality, a few relating to individual logistics are discussed as follows;
Transport logistics; the government to setup efficient transport by supplying tricycles (be self-owned or under a private partnership), integrating ICT to ease farmer access economically
IPEP WRS; The IPEP model is to be an effective WRS kind of warehouse, therefore, the study advocates for the provision of unit load formation equipment (e.g., pallets and skids), transport equipment (e.g., sack-trucks and pallet/lift-trucks), storage equipment (e.g., shelves and racks), dryers, cleaners, timely fumigation, and consistent/stable electricity befitting a WRS.

Packaging logistics; The Government regulates or subsidises the cost of the hermetic bags, takes charge of its supply, and provides packaging and repacking machines to fast-track packaging at the warehouse.

Contribution to the Field of Study

Efficient logistics management is essential to the success of food production which is a vital part of the agricultural industry/sector as such a well-run logistics operation can guarantee a successful harvest. To warrant efficiency in the management of logistics in the agricultural industry/sector modern technologies involving digitisation should be adopted/embraced to streamline logistics operations, improve customer/farmer experiences, reduce cost and gain a competitive edge in the market. This includes the use of cloud-based platforms, and mobile apps to manage logistics operations more efficiently to reduce food post-harvest losses to an acceptable minimum. Adopting and utilising new technologies efficaciously can be achieved sustainably in Ghana's agricultural industry/sector by partnering with technology vendors, hiring skilled Information Technologists, and training farmers as well as logisticians like warehouse management on the need to embrace modern technologies for a successful food post-harvest handling, therefore the study augments the interconnected disciples of logistics and supply chain management with their interdependence/interconnected operations serving as an enabler for developing economies governments (like Ghana) to harness advancements following transformations thereby ensuring competitiveness and facilitating growth via paving the way for innovation, growth and sustainability to enhance food (like grains) production catering with sufficiency for population growth's high demand. Thus, stimulating developments in technologies by embracing the challenge of digitisation and bettering technologies for the efficacious handling of food (grains) within and across nations via a conscious national plan.

Keywords: Logistics Management, Food Security, Agricultural Sector, Infrastructure for Poverty Eradication Program (IPEP), Ghana

DECLARATION

I hereby declare that this thesis is an original work of my effort for the award of Doctorate of Philosophy in Management Sciences. This thesis contains neither material previously published by another person nor materials accepted for the award of any degree in any university/institution, except where due acknowledgement has been made in the research.

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DEDICATION

This research work is dedicated to my Heavenly Father for seeing me through this phase of HIS plan. Then, to my accommodating, outstanding and results-oriented nuclear and extended families for their steadfast affection and broad shoulder offered, for me to stand on resolutely during this programme. Also, to the fond memory of my remarkable Father for inspiring me for eternity.

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I am in awe of the goodness of my God; words fail me in comprehensively expressing HIS loving-kindness bestowed upon me through and through this research work. I am grateful to my supervisor, Professor Noluthando S. Matsiliza, co-supervisor, Dr John K Buor, and my Chaperon, Rev. Opoku, for their diverse, immense, notable contributions toward this achievement.

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ORIENTATION AND OVERVIEW OF THE STUDY

1.0 Introduction

Early assessments of the United Nations' Sustainable Development Goals 2030 (SDG2 goals 2.1 and 2.2) indicate that the COVID-19 pandemic could result in 83–132 million more undernourished people worldwide (Times of India 2020: 1). The government of Ghana has requested financial support from the International Monetary Fund (IMF) for its post-COVID economic recovery programme (IMF 2023) in response to the ongoing COVID-19 pandemic and its consequences, which are impeding progress towards achieving SDG 2 by 2030. This is because different countries experienced different patterns of economic recovery in 2021 (FAO, IFAD, UNICEF, WFP, and WHO 2022:1). Ghana is one of those countries. Many countries could enable recovery via massive investment in agricultural food systems, to improve food security and nutrition of their inhabitants (FAO, IFAD, UNICEF, WFP and WHO, 2022:1) as well as enhance the citizenry's living standards specifically in Ghana where 39.4 percent of the population live in moderately or severely food insecure situations (FAO 2023). It is worth noting that the government of Ghana should prioritise mobilisation and implementation actions to increase investment into the agricultural sector (AU 2023) in response to the call made by N'Zi-Hassane in 2023 for African leaders to take personal responsibility in light of chronic underinvestment, which accounts for an average of 3.8 percent of agricultural budgets (Oxfam International 2023) with Ghana being no exception. This is because the main obstacle to Ghana's agriculture sector is a lack of financing, as stated by Kijani and Dato'Onn (2018) of the Alliance for Financial Inclusion.

Food production is a vital part of the agricultural industry and efficient logistics management is essential to its success, as such a well-run logistics operation can make the difference between a successful harvest and a poor one (Driver 2023). Notably, Ghana's food insecurity is snowballing in number and intensity, which can be ascribed to post-harvest losses as is recognised in less developed countries as the accompanying aspect of the major cause of food loss and an earnest threat to food security (WFP 2023; Ishangulyyev, Kim and Lee 2019). In Sub-Saharan Africa, Ghana featuring amid the countries with the highest post-harvest losses is the validation of inadequate investment and inefficient logistics management in the agricultural

sector, in the light of the unknown intervention influences and food security remaining a grave challenge for many households in Ghana (Kolog, Asem and Mensah-Bonsu 2023; Acheampong *et al.* 2022; Abdoulaye *et al.* 2016: 1).

With 278 million malnourished people in Africa today, roughly one-fifth of the continent's population and the fact that WFP, WHO, FAO, IFAD, and UNICEF have all stated that the continent must transform its agricultural food systems to meet the targets of SDG2 by 2030 (Oxfam International 2023, FAO, IFAD, UNICEF, WFP, and WHO, 2022:1), is worth pursuing/undertaking especially because of the over 20 million individuals in Africa having been pushed into acute hunger (N'Zi-Hassane 2023). The focus of the 2021 United Nations Food Systems Summit (UNFSS) was on transforming food systems based on a holistic approach, with evidence and insights provided by the Africa Agricultural Status Report (AASR) on the prospects of accelerating the transformation of Africa's food systems towards resilience and sustainability (AGRA 2022). The common stance of Africa, AGRA (2022) lays out a clear continental vision for the transformation of food systems, thereby reinforcing the appeal for African governments, Pan-African organisations, and other stakeholders to map out a more resilient route. Drawing inspiration from a wise and well-known African proverb that goes, "if you want to go far, go together," Mnangagwa (2022: 6) stated in the Alliance for a Green Revolution in Africa's report on the continent's agricultural position.

It follows that the continent's agenda and transformation process should be inclusive. It is more important than ever for African leaders to bring food systems reform to the attention of the continent's and the world's development agendas (AGRA 2022) now. The African Continental Free Trade Area (AfCFTA) agreement was launched by African governments in response to the need to generate and demonstrate greater political commitment aimed at mitigating Africa's distress horn for the unrestricted benefit of its citizens (Africa Renewal 2023). This agreement is anchored in boosting commerce and industry as well as reducing poverty and making Africa more competitive in the global economy in line with the global shift towards a more interconnected economy. The largest free trade area in terms of member states is the African Continental Free Trade Area (AU 2023) following the World Trade Organisation (Africa Renewal 2023), of which 44 member states are state parties and 54 member states have signed the agreement. With 1.3 billion people living on the continent, the second largest in the world after Asia, trade would be necessary to ensure that food availability and accessibility are

distributed more fairly, disruptions in domestic production, in whatever form, will not raise serious food security concerns as diets will be more diverse (FAO 2020, 2023; WTO 2023).

According to this claim, given that Africa's infrastructure is developing more slowly than other continents, the continent still needs greater logistical infrastructure and unrestricted intra-African trade (Solistica 2022). One hundred years after the introduction of the Western-styled logistics system to the continent, the results have been different from other enclaves, indicating the need for a logistics system specifically adapted to Africa's socioeconomic conditions and the distinctive features of its population (Adeleke 2022:1). This is due to the fact that certain clients have unique requirements that must be satisfied, making the creation of a competitive logistics industry (Solistica 2022) necessary to support the AfCFTA and significantly reduce the number of undernourished and hungry people on the African continent.

A few of the ways that food insecurity can be reduced are food processing, proper storage logistics, efficient distribution networks (Sri *et al.* 2022: 1874; Elik *et al.* 2019: 3) and value addition (Kumar and Rameshchandra 2023; Adeyeye 2017:1). Most agricultural products in Ghana do not thrive in the value chain because of rancidity and a lack of processing businesses (Asiedu 2018: 1). In light of Ghana's current population growth, and logistics infrastructure needing improvement (Hellmuth-Sander 2023), it is imperative to support logistics outside of the processing and value chain to meet the demand for agricultural produce in nearby and distant urban areas. This will help reduce waste and product loss, as food security continues to be a major concern for many Ghanaian households (Acheampong *et al*. 2022).
Considering the global shipping crisis experience of the world in 2021, resulting from the covid pandemic that massively disrupted supply of goods across the globe, from every festive shopping to home/restaurant menus, the usefulness of logistics has been clearer to all and sundry as was never to us all (Harappa 2021).

In the context of food production, logistics management includes everything from seed selection and procurement to field planning and resource allocation, to harvest scheduling and product distribution (Driver 2023). However, generally logistics management is the process of organising, coordinating, and managing the efficient and effective movement and storage of products, services, and related data from the point of origin to the point of consumption to meet client demands (Puri 2022; Calixto 2016).

Logistics, which has distribution, warehousing, purchasing, and transportation as its four main components, is an all-inclusive term that encompasses the integration of a variety of activities, including transportation, inventory management, warehousing, material handling, packaging, and security (Puri 2022). Essentially, the purpose of logistics management is to organise, oversee, and preserve all of the resources involved in the logistics process, preserving their values and generating profits for a business instead of diminishing them (Anwar *et al.* 2023:692).

Another important factor that logistics management takes into account is the transportation of goods in both forward and reverse order. This includes the application of ICT, although these areas are not as prioritised in the agriculture sector. Thus, transportation of goods the other way or in reverse (Thompson 2023). Historical data unequivocally demonstrates that the aboriginal inhabitants of pre-colonial Africa created an Indigenous Logistics System (ILS) by utilising local environmental knowledge and effective resource management. The goal of the ILS's establishment and administration was to promote trade and business inside Africa (Adeleke 2022: 15). Applying decolonisation and indigenisation to social work, practices, and methods (Mugumbate *et al.* 2023: 6; Mupedziswa *et al.* 2019), the system's cornerstones were culture, values, trust, and brotherhood, similar to a system application of Ubuntu, which is the bedrock anchoring much African social policy (Mupedziswa *et al.* 2019; Rankopo and Osei-Hwedie 2011). This approach aligns with the promotion of the developmental social work approach, which many have argued is the best approach for Africa. According to Luwangula *et al.* (2019), Ubuntu offers a well-recognized philosophical framework that serves as a good framework for interpreting societal issues and formulating potential solutions. (Mugumbate *et al.* 2023: 5).

To concentrate on the seven main areas of the AfCFTA policy framework, the African nations' alliance launched the African Continental Free Trade Area (AfCFTA), calling on member state governments, including Ghana, which is hosting the AfCFTA secretariat in its capital named Accra to do so (Codjoe, 2023). Given the critical importance of the AfCFTA's movement facilitation component, African leaders must foster a supportive atmosphere that stems from political goodwill and commit to upgrading and optimising infrastructure, particularly in terms of logistics. Logistics facilitates the movement and distribution of goods and services between businesses, consumers, and nations. Therefore, it is crucial to continue developing and optimising logistics to promote trade, economic growth, and sustainable development globally (Chandel 2023), and to enhance economic activities and trade sustenance through the

application of best practices in logistics management that guarantee the resolution of related issues (Rouse 2018).

Agriculture will play a significant role in the AfCFTA as well, since food systems currently provide 62 percent of jobs in Africa. As a result, creating resilient food systems holds great promise for both ensuring food and nutrition security and being able to employ an estimated 1.6 billion people in low-and-middle-income countries in the coming years (IISD 2023), including Ghana's 7.14 percent of unemployed youth (GSS 2022). This will improve their living standards, then promote sustainable development (AU 2023), as in 2023, 41.8 percent of Ghana's populace lived below the poverty line of US$3.65 equivalent to GH¢40.88 on average according to Sasu of STATISTA (2024) which is far below the average percentage for African lower-middle-income countries (GSS 2023; ISS-AFRICA 2023; ROAPE 2016).

To meet the demands of the populace, the economy and the environment, the agricultural sector must change in several nations, including Ghana, which has the potential to become one of the continent's agricultural powerhouses (World Bank 2022). Therefore, the agricultural sector must undergo a radical transformation in terms of logistics, as the ability of a nation to trade internationally is largely dependent on its traders' access to effective networks of logistics that enable the efficient movement of agricultural goods across borders as well as continents (Ekici, Kabak, and Ulengin 2019). The value of global trade goods exports climbed to 19.48 trillion dollars in 2018 from 16.0 trillion dollars in 2010, the World Trade Organisation reported underscoring the need to improve logistics in the context of growing international commerce (Kumar 2023).

To prepare and carry out this crucial transformation, the Ghanaian government should make every effort and collaborate with partners in all facets of the food systems landscape. This is because sustainable technologies, creative solutions, novel approaches to problem-solving, and best practices for managing food quality and minimising food loss and waste are all necessary to maximise the appropriate use of the food that we produce on a global and local level (Russel 2022; 32; FAO 2015). That said, addressing the post-harvest losses issue will inherently result in food availability, accessibility and affordability which is key for sustainable food security and the AfCFTA success. In this recognition, N'Zi-Hassane of Oxfam International in 2023 called on governments to revamp infrastructure and spur cross-border trade in agricultural commodities.

This brings the ILS issue back to life, based on the idea of African values and spirit pitched to indigenous social work, which perfectly suits Ghana's agricultural role serving as both the continent's primary engine for intra-African trade and a solution to logistical challenges. Given the associated disadvantages—such as erratic delays, inadequate communication, hazardous tracking techniques, and a lack of insurance permitting inefficiencies in the ILS, improving and scaling up logistics through the integration and application of technology while preserving its distinctly African cultural features will be worthwhile (Adeleke 2022: 15).

1.1 Significance of the Study

Ghana and literature have expressed worry about the function that logistics of food play in post-harvest management highlighting a gap, hence researching in this area to fill this gap, has expectantly generated relevance presented below:

• **Importance of Food Security:** Food security is a pressing issue, particularly in developing countries like Ghana. Focusing on logistics management provides valuable insights into one of the key components affecting food security—post-harvest management. This is crucial as efficient logistics management is essential to the success of food production which is a vital part of the agricultural industry/sector as such a well-run logistics operation can make the difference between a successful harvest and a poor one. Thus, significantly reducing postharvest losses, improving food availability, accessibility and affordability, which are vital to food security enhancement.

• **Grain Focus:** Given that grains (rice, millet, and maize) are staple foods with substantial bulk production and consumption in Ghana, addressing their post-harvest logistics is highly relevant. These crops are central to food security in Ghana, and improvements in their logistics management can have a substantial impact.

• **Gap Filling:** By concentrating on the logistics of grain post-harvest production, the research fills a significant gap in the literature, particularly in the context of Ghana. It adds to the understanding of how specific logistics activities/practices influence food security.

• **Practical Implications:** The research has practical implications for policymakers, agricultural practitioners, and logistics managers. Insights gained can guide interventions to optimise logistics activities/infrastructure and enhance food security.

• **Local Context:** The focus on Ghanaian grain logistics makes the research highly relevant to local stakeholders. The findings could inform policies and practices that directly impact the efficiency of grain logistics management and food security.

1.2 The Preliminary Literature Review

According to Wudil *et al.* (2022), one of Africa's long-standing developmental challenges has been food security. Its intricate connections to the political, social, economic, and technical systems, all of which are exacerbating factors, have made it even more complex. Food experts predict that many approaches will be required to address the issue of food security in the future as a result of highly variable and unpredictable climate (McCarthy *et al*. 2018:1). Thus, a comprehensive systems-based strategy will be required to ensure long-term worldwide food security. This strategy needs to be based on technical and policy change, utilising best practices, innovative systems and technologies, and methodologies (McCarthy *et al.* 2018:1).

Since the 1970s, concerns related to agricultural food security have received a lot of attention. The Ghanaian agriculture business contributed 21 percent to GDP in the second quarter of 2023, third-placed behind the largest sector, which is the service with a 32 percent contribution to the GDP (GSS 2023), Low productivity and low competitiveness, however, are its defining characteristics. This is the result of smallholder production units using low-level and primitive technologies, which dominate the industry for subsistence (Adeleke 2022: 15; Duffour, 2010). In Ghana, the majority of people rely on agriculture for their subsistence. In addition to providing the majority of the country's food security, agriculture is a major source of foreign exchange and a supply of raw materials for industry. Providing the majority of jobs in rural areas, agriculture employs about 45.38 percent of Ghana's workforce, making it the country's top employer (GSS 2019). Ghana is one of the countries in Sub-Saharan Africa with the largest post-harvest losses, despite agriculture’s remarkable contribution toward food security, food security continues to be a serious concern for many households in Ghana (Acheampong *et al.* 2022; Abdoulaye *et al*. 2016: 1). As such food insecurity is an issue, particularly among growers, though several attempts have been made to curb this situation the effects of these interventions are unknown (Kolog, Asem and Mensah-Bonsu 2023: 1) including the IPEP logistics infrastructure. In Ghana's rural areas, undernourishment and malnutrition are pervasive, and a large number of peasant farmers live in extreme poverty. This is likely because several factors contribute to the annual loss of bulk harvest produce, which forces farmers to

sell their labour-intensive produce at low prices due to poor or a lack of logistics infrastructure like storage facilities and a lack of market information/ infrastructure as well as seasonal gluts (Atchulo 2024; Sri *et al*. 2022: 1874; Yeshiwas and Tadele 2021). That said, post-harvest losses directly result in food and income loss for farmers and consumers globally hence its reduction is crucial (Yeshiwas and Tadele 2021).

In 2020, food insecurity affected 5.5 percent of urban households and 19 percent of rural households, according to the Comprehensive Food Security and Vulnerability Analysis (CFSVA) study. This reveals that Ghana's overall agricultural productivity and production performance need to be improved, and more work has to be done to ensure food security. For these reasons, a large number of academics, public figures, and other professionals are currently concerned about the issue of food insecurity.

1.2.1 An overview of Ghana's Agricultural value chain.

According to Aidoo and Abdoulaye (2020) and Porter (1985), a tool for analysing the relationships between all of the actors involved in the value-addition process between the food production and ultimate markets at the micro, meso and macro level is the value chain. Its utility arises from the fact that agricultural commodity management investments become more efficient at different stages of the chain once the value chain becomes more transparent as a consequence of research and planning. According to Atchulo (2024), fragmented agricultural value chain leads to inefficiencies, reducing the profitability of farming activities and limiting opportunities for famers to improve their livelihoods. When inefficiencies in the chain are eliminated, trust among participants leads to larger profits. Producing companies, marketers/traders, processors, and consumers are considered value chain players, according to Aidoo and Abdoulaye (2020). On the other hand, non-actors include banks, other significant supply chain service providers, and governmental and non-governmental organisations. This study examines a few facets of the post-harvest handlings (inbound logistics) of smallholder farmers, which is the grain value chain. The processes involved in placing an order, receiving, storing, transporting, and managing incoming materials are known as inbound logistics according to Jenkins (2023).

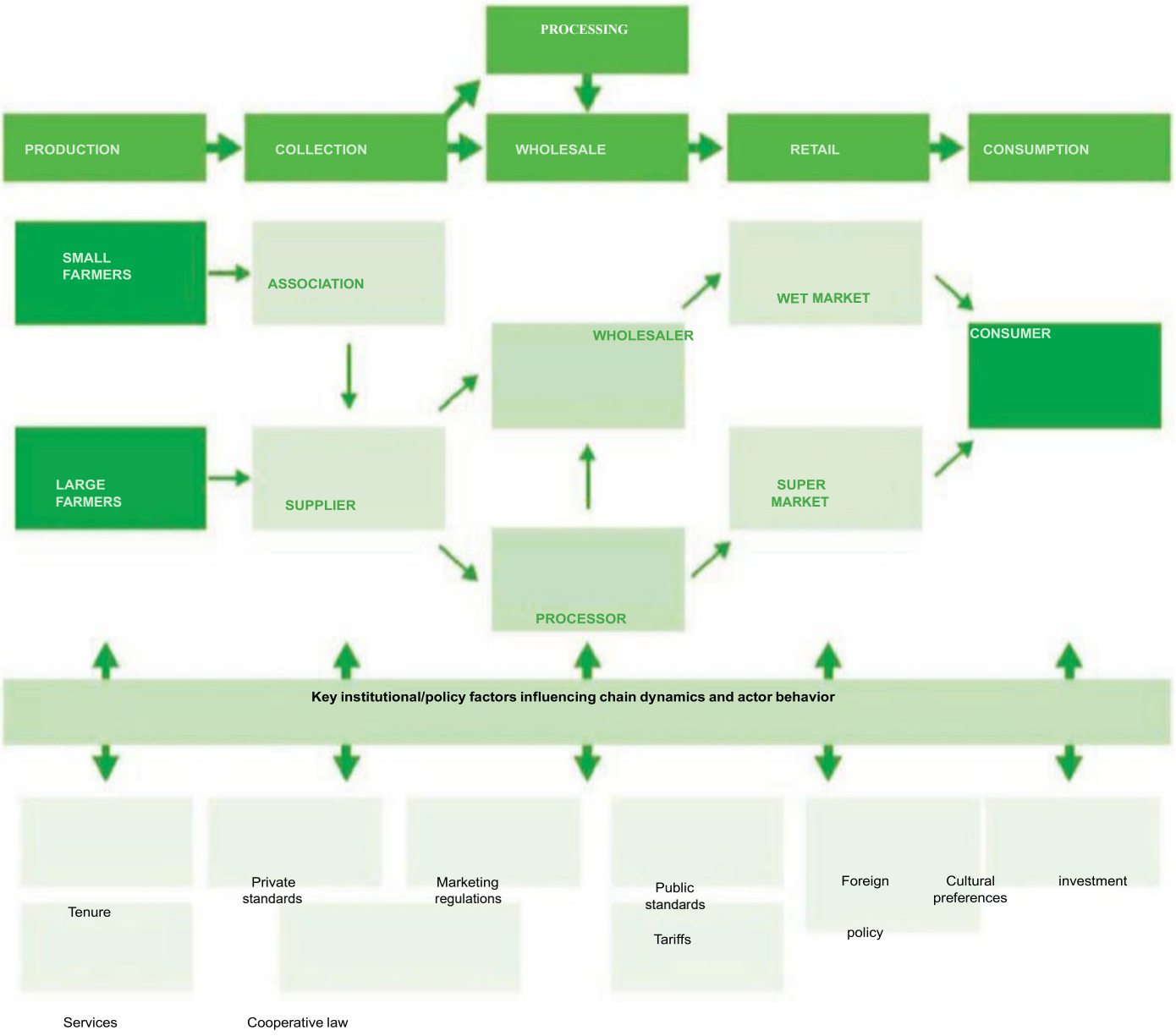


Figure 1.1. Agriculture value chain map showing key activities, actors and institutional/policy factors. Source (s): (Aidoo and Abdoulaye 2020; Vermeulen *et al.* 2008).

1.3 Conceptualisation

1.3.1 Food Security

To enable a healthy and active life, the Committee for World Food Security (CFS) established the food security standard as follows: every person must, at all times, have physical, social, and economic access to food that is safe, consumed in sufficient quantity and quality to meet their dietary needs and food preferences, as well as supported by an environment of adequate sanitation, health services, and care (Armghan *et al*. 2022: 1817; Ingram 2020; FAO 2012:41–42; FAO 1996).
A report in 2023 by the Higher-Level Panel of Experts on Food Security and Nutrition (HLPE-FSN) refers food security now as the availability, accessibility, sustainability, agency and use of food as well as the stability that supports it. It has evolved from the idea of food being available on the market to a term that acknowledges changes in the global food system, climate and environmental change, shifting global demography dynamics, and human rights (Acheampong *et al.* 2022: 3; FAO 2017, 2008; Ericksen 2008).

While accessibility examines how people can obtain the amount, quality, and variety of food they need given their level of purchasing power and the corresponding disparities according to the FAO (Acheampong *et al.* 2022:3; 2013 2017), food availability considers the quantity, calibre, and diversity of food that is easily accessible to an individual, family, or community. This helps to handle the supply side of food.

Food security cannot exist without food stability, which is defined as the uninterrupted availability, accessibility, and consumption of food throughout time without any political or economic distortion that would prohibit people from obtaining their preferred food in the appropriate quantity and quality (Afzal *et al.* 2023; FAO 2017). The three primary goals of food use are food intake, the nutritional and social characteristics it is associated with, and safety. Food security is therefore a complex and multidimensional concept that is closely linked to numerous development-related issues (Acheampong *et al.* 2022: 3; Vos 2015; Candle 2014). A household has food security when it has physical, social, and economic access to enough food that is safe, nourishing, and fits its dietary needs and food choices for an active and healthy life. This is according to the Ghana Ministry of Food and Agriculture's operational definition from 2022.

The phrase "food security" refers to the "ability to escape significant postharvest losses (PHL)" in this study, which is crucial to reducing hunger and malnutrition among the world's growing population, which is predicted to reach 9.7 billion by 2050 and 11.2 billion by 2100 (IISD 2023; FAO 2017:2; UNDESA 2015). Other essential components of the term include the nutritive quality of food, self-sufficiency, sanity/safety, and physical and financial availability such as ensuring safety and nutrition in post-harvests. The amount of food required to feed this massive population is growing linearly now, as opposed to exponentially.

1.3.2 Logistics Management

In the context of food production, Logistics management includes everything from seed selection and procurement to field planning and resource allocation, to harvest scheduling and product distribution (Driver 2023). In the broader context, *logistics management* is defined as the process of planning, implementing, and controlling the efficient, effective flow of goods (Mohsen 2022). Thus, it is essentially the organisation and upkeep of each asset in the logistics process to ensure that the values of products and assets are maintained and can generate profits or returns for the company (Anwar *et al.* 2023: 692–692).

All agree that reducing food loss and waste will strengthen food systems' sustainability, improve food security, and prevent costs from accumulating across the food supply chain (Russel 2022: 32). Food experts agree that there isn't a single answer that will address the issue of long-term, sustainable food security (McCarthy *et al*. 2018). A systems-based, comprehensive approach focused on policy and technological transformation as well as using current systems with state-of-the-art tools, procedures, and best practices will be necessary for truly sustainable global food security (McCarthy *et al.* 2018: 11).

Sugri *et al*. (2021:1) discovered that by giving farmers the appropriate technologies, PHL may be decreased to 3.1 percent from 36.7 percent for maize and 6.4 percent from 77.8 percent for cowpea during a 12-month storage period. In this context, technology acts as a mediator and integrates packaging, transport management, and efficient logistics management.

1.3.3: Conceptual Model of the Influence of Logistics Management on Food Security.

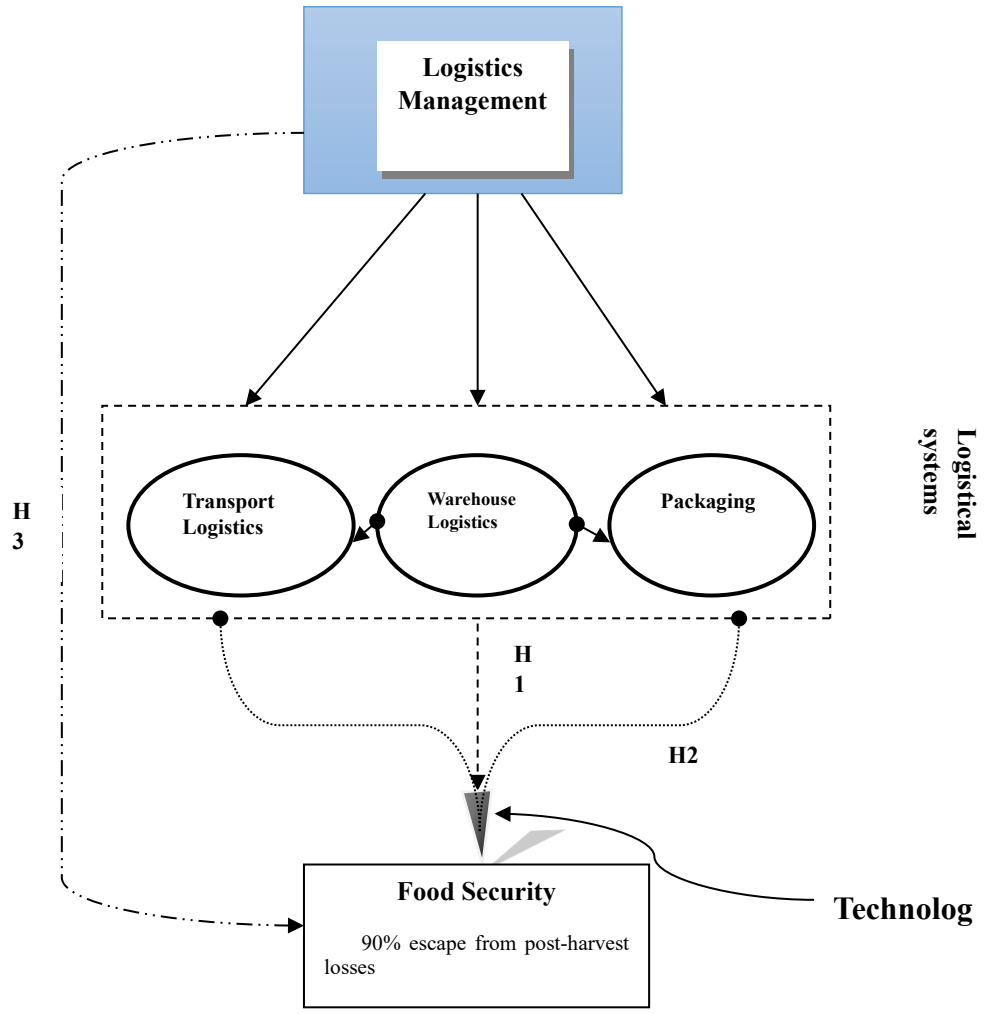


Figure 1.2: Influence of Logistics Management on Grain Post-harvest food security.

Author's conceptual Model (2024) based on Anwar *et al. (*2023); Raheem *et al.* (2021); FAO (2014), Manners-Bell (2012) and Fugate, Mentzer and Stank (2010:43)

The model in Figure 1.2 shows how postharvest food security is affected by

logistical management. It highlights the need to prevent postharvest losses by ensuring that at least 90% of grain harvests are supplied to customers in a nutrient-rich (quality) state. To achieve the proper degree of food security, it focuses on the effective management of transportation, warehousing, and packing (at the warehouse). Technology plays a vital role in effectively managing these logistics.

1.4 Justification of the Study.

Ghana's economy heavily relies on agriculture, which provides around 54 percent of employment, and accounts for 40 percent of income from export earnings, while feeding more than 90 percent of the growing populace (FAO 2023; GCA 2023). According to Kumar and Rameshchandra (2023), to ensure food security, a shift in the production and distribution of food is essential to meeting the need for agricultural produce in remote, rural areas. A person's ability to eat well depends critically on factors affecting both food production and imports. Because this logistics system affects numerous supply chain actors and is crucial to both businesses and daily lives, it needs to be extremely flexible. Therefore, using modern methods, such as ICT, will help provide better results. If given the correct attention, this can affect production and expand food security after harvest.

1.5 Problem Statement.

Due to continual post-harvest losses, the agriculture industry in Ghana is in a decline and among the countries in Sub-Saharan Africa with the highest post-harvest losses is Ghana (GSS 2019:3, Abdoulaye *et al.* 2016: 1). The high post-harvest losses in Ghana's agricultural supply chains seem to contribute to the deterioration of farmer economic wellbeing as either harvested farm produce are sold to buyers on the farm site (farm gate) immediately after harvest or spoil/rot beforehand to being sold, due to unavailability of transportation or inability to arrange transportation to market for sales, poor storage or lack of storage spaces and poor drying conditions, (Appiah 2024). Again, food loss increases the cost per unit for consumer, while at the same time diminishes farmers' and food value chain actors' income, increasing their expenses (Antwi n.d.). Inefficient logistics can translate into either higher food prices for consumers or a reduced ability of food producers to compete in the marketplace (Pinto *et al*. 2023). That said, inefficient logistics can lead to increased costs, delays in production, and even spoilage of goods (Driver 2023).

While the sector's growth rate in 2017 was 6.1 percent, in 2018 it expanded by 4.8 percent, and its GDP contribution decreased from 21.1 percent in 2017 to 19.7 percent in 2018 (GSS 2019:3). The statistics from the Africa postharvest losses information system (APHLIS) in 2018 indicated that, using the average exchange rate of US$1 to GH¢4.82, Ghana's losses from the three types of grain (maize, millet and rice) and sorghum were valued at approximately US$141.12 million, or more than GH¢680.19 million. The current rate of food losses is considered as one of the significant threats to sustainable development (Surucu-Balci and Tuna, 2021), because food loss has a negative impact on the economy, environment and society (Alamar *et al.* 2018, Halloran *et al.* 2014, Gustavsson *et. al.* 2011), particularly in Ghana where farmers have limited access to logistics services with significant challenges existing in handling, storage and transportation of agricultural produce at the farm level (Appiah 2024),

The lack of adequate infrastructure significantly hampers agricultural activities in Ghana (Atchulo 2024), hence improving the Ghanaian logistics infrastructure is needful (Hellmuth-Sander 2023). Ghana's (food) agricultural sector is constrained by several uncertainties from both internal and external sources, similar to those of Cameroon, Uganda, the United Republic of Tanzania, Turkey, and Liberia (Russell 2022: 3; Raheem *et al.* 2021; Elik *et al.* 2019; FAO 2017, 2015:6). These constrained several uncertainties/problems include inadequate or

inefficient physical/logistics infrastructures (such as warehouses, roads), lack of improved technologies, poor packaging materials, package designs, hygiene and food safety, weak institutional infrastructures, ineffective logistical systems and inefficient logistics management practices. One well-known outcome is that post-harvest losses cause an annual loss of around 318,514 tonnes of maize, or roughly 18 percent of the country's total yearly production (SESI Technologies 2021, Bruce 2016) impacting food availability, accessibility, utilisation and stability grimly.

The inefficiencies in logistics practices such as packaging, transport and storage are the major causes of food losses, especially in Ghana as an emerging economy (Xu 2021). Food systems in developing countries are largely characterised by unorganized, traditional supply chains and limited infrastructure (Yeshiwas' and Tadele 2021), akin to Ghana's food systems. According to FAO (2019), improper food handling and poor processing technologies are the main causes of post-harvest losses. Ghana as a developing country has inefficiencies in the transport and storage of food products causing food losses/post-harvest losses (Antwi n.d.) Poor transportation networks hinder the timely movement of goods/food, leading to post-harvest losses and reduced market access, which directly affects farmers' incomes restricting farmers' investment in improved farming practices, technologies and inputs in Ghana (Atchulo 2024). Poorly maintained mode(s) of transport, stunt agricultural productivity and food production potential (World Bank 2022) in Ghana.

Though successive governments have adopted policy interventions in the agricultural sector to boost access to finance, and production for food security and export like the setting up of the Agricultural Development Bank (ADB) to provide credit to crop/livestock and small farmers; as well as Rural and Community Banks to support rural agriculture (AFI 2018), these interventions are inadequate considering food insecurity rising in Ghana (WFP 2023). The Government ought to increase the budget for the agricultural sector as emphasised by Kijang and Dato'Onn (2018) that the main obstacle facing Ghana's agriculture sector is a lack of funding.

Due to global population increase, it is expected that food production will increase from the current 60 percent to 110 percent by 2050 (Antwi n.d). However, despite the growing population and literature assertions, Ghana's food security remains an earnest challenge in many households (Acheampong *et al.* 2022), though several attempts to curb the situation have

been made, the influences of these interventions are unknown (Kolog, Asem, and Mensah-Bonsu 2023: 1. That said, following the debate of whether food supplies can expand sufficiently to meet the demands of an ever increasing population (Arezki and Matsumoto 2017) particularly in the case of Ghana, how much of an impact logistics infrastructures/logistics management practices truly have on the agriculture sector and how effectively the government can change this scenario are still up for debate.

Food production is a vital part of the agricultural industry and efficient logistics management is essential to its success, as such a well-run logistics operation can make the difference between a successful harvest and a poor one (Driver 2023). As an emerging economy, Ghana's agricultural food industry has a lot of logistics related challenges, despite the fact that efficiency in logistics management contributes significantly to the competitiveness of the agricultural industries worldwide (Johnson, Nketia and Quaye 2015), inefficiency abound highly. Food security which logistics of food influences focuses on storage of produce, transportation and post consumption/packaging of food (Hadebe 2021), as such to address the food insecurity issue previous administrations have already built storage facilities in some parts of the country, the majority are unoccupied and inaccessible to farmers due to several factors, such as the high expense of storage and difficulties with transportation (Asiedu 2018). Addressing these infrastructural inefficiencies in previous storehouses to impact logistics infrastructures and logistics management practices as well as enhance food security is the goal of the newest Government policy/project IPEP logistics infrastructure/warehouse (Ministry of Special Development Initiative (2019).

The purpose of this study is to evaluate the influence of logistics packaging, transportation, and warehousing used at the IPEP warehouses by looking at the agriculture industry.

1.6 Aim of the Study.

This study aims to develop a framework of logistics management that can be recommended to enhance food security. To design the framework this study will measure the influence of logistics management on achieving food security in Ghana.

Research objectives provide forth the goals of the study and provide context for the author's pursuit of it. They aid in keeping the research focused by providing an overview of the project's methodology and purpose (Ryan 2022). The particular goals of this study are to:

i. Assess road transport type(s) achieving food security in Ghana.
ii. Measure warehouse packaging logistics contribution to attaining food security
iii. Examine the relationship between logistics management and food security in Ghana
iv. Analyse the influence of warehousing on Ghana's food security.
v. Examine the challenges of logistics management that affect agricultural food security
vi. Recommend a Framework the government can adopt for sustainable improvement in logistics management in the food industry.

1.7 Research Questions.

i. What type(s) of road transport achieve(s) agricultural food security in Ghana?
ii. How does packaging logistics at various warehouses contribute to attaining food security?
iii. What is the relationship between logistics management and food security in Ghana?
iv. How does warehousing influence Ghana's food security?
v. What are the challenges of logistics management that affect agricultural food security?

1.8 Hypotheses.

H1: Packaging logistics contributes massively to food security
H2: Warehousing has a positive influence on food security challenge
H3: Logistics management has a significant positive relationship with food security

1.9 Limitations and Delimitations of the Study.

Potential shortcomings known as limitations are typically uncontrollable and tightly linked to the research design used, the limitations of the statistical model, financial constraints, or other considerations (Miles 2019; Ross and Zaidi 2019).

The deliberate limits, that the researcher decided to establish from the limitations of the scope of the study are known as delimitations. To make the goals and objectives of the study clear, they are concerned with the definitions that the researcher chose to set as the boundaries of the activity (Coker 2022)

For these pragmatic factors, this study:

Focused on grain (rice, millet, and maize) due to their significant bulk production and consumption in Ghana. This focus is justified given the significant role of these grains in Ghana's food supply but limits the scope to a specific aspect of the food industry which the findings might not fairly represent as such recommended for future studies

Focused on packaging, transportation, and storage, while these are critical components, other logistical aspects might also impact food security, as such the findings might not be a fair representation of these other broader logistical influences, hence highlighted for posterity studies.

1.10 Summary of the Thesis Chapters.

This thesis comprises five interrelated chapters.

Chapter One is the introduction and provides a summary of the study's background, aim, and objectives involving: Assessing the road transport type(s) used to achieve food security in Ghana; Measuring warehouse packaging logistics contribution to attaining food security; Examining the relationship between logistics management and food security in Ghana; Analysing the influence of warehousing on Ghana's food security; Examining the challenges of logistics management that affect agricultural food security; Recommending a framework the government can adopt to ensure improvement in logistics management.

Chapter two focuses on the theoretical framework (food security), an overview of Ghana's agricultural food industry, agricultural food security in Ghana and an account of post-harvest losses, a synopsis of the infrastructure for the poverty eradication programme (IPEP), and then a general review of the study's objectives to settle the gaps. The literature also covers how

technology improves agriculture, warehousing, transport, and packaging elsewhere. This chapter will end with a summary after a review of some empirical work is done.

Chapter three addresses the research design and methodology used for the study. The population, sample method, measurement instrument, ethical considerations, data analysis techniques, and validity and reliability were discussed and the strategy to tackle the study's research problem presented.

Chapter four presents the primary analysis of the data collected from participants/respondents for this study. The quantitative data will be analysed using SPSSS package, and graphs, tables, and pie charts for the presentation of the data. The analysed quantitative and qualitative data in relation to this study's research objectives are presented, and the study's results interpreted and discussed in detail in relation to the reviewed literature.

Chapter five presents a conclusion, responds to the research aim and objectives, makes recommendations for stakeholders, including the government, farmers, policymakers and researchers, and then draws a general conclusion to the study.

1.11 Chapter Summary

This chapter serves as a guide for the focus and plan of the study being undertaken by outlining the goals, the problem description, and the research questions. Additionally, the study's backdrop was emphasised, which helps to understand the framework for the research study's conduct in Ghana. The chapter also expounds on the concept of food security and the agricultural supply chain, because of managing selected logistical system's influence on food security (Figures 1.1, and 1.2). The next chapter expands on theories on food security and the agricultural supply chain, considering how managing selected logistical systems influences food production/security and reviews scholarly works on food security and logistics management related to the selected objectives of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter contains a thorough review of various write-ups vis-a-vis the scope of the research. It highlights the theoretical foundation and reviews related materials towards the study's focus, capping with the chapter summary.

2.1 THEORETICAL FOUNDATIONS OF THE STUDY

Malthusianism, Boserupianism, Neo-Malthusianism, Access and Network Theories connection to food security and logistics management

Using theories used in and developed from the knowledge of the understanding of food security and logistics management, this study adopts Malthusian, Boserupian, Neo-Malthusian, Access and Network theories to shed light on the food security and logistics management concerns globally then in the context of Ghana. This would significantly contribute to building further synthesis on global food security challenges particularly the case of Ghana where, population growth, food prices, inadequate logistics infrastructure, inefficiency in the management of logistics, climate change, inadequate investment in agricultural activities/sector among other challenges have become a threat to food security. Thus, food security can be achieved ultimately through efficient logistics management, which is essential to food production/harvest success, guaranteeing food supply adequacy to cater/meet the ever-increasing population of Ghana's diet needs (Driver 2023; Aliyu *et al.* 2021).

The Malthusian theory developed in the 18th century in response to the imbalance between the increasing population and food supply predicted that if food supply rose more slowly than the population growth, then shortages would be severe, in his opinion, inaction to maintain the balance will lead to positive checks like famine, war, and disease. Having a pessimistic perspective on the relationship between population and resources (specifically food), per his assertion that population growth is increasing at a faster rate than food supply, there will be a

time when there will not be enough food to sustain the population, resulting in population growth stopping due to a Malthusian catastrophe like famine, disease or war known as positive checks as the death rate increases (Barrett and Quinn 2024).

Although the Malthusian theory predicted tragic outcome, the idea of a growing population finding it increasingly difficult to survive from existing resources (specifically food) certainly reflects Ghana's food production/supply meeting its growing population which is a challenge as Ghana's food insecurity keeps rising (WFP 2023) an indication of an inability to generate enough food for all Ghanaians, hence fundamentally valid evidentially but Ghana is yet to experience Malthusians positive checks which can be evidentially disproved for now. Malthusian graph depicting population growing potentially exponential while the growth of the food production/supply is linear to the point of triggering a population decline via point of crisis or positive checks is demonstrated graphically below:

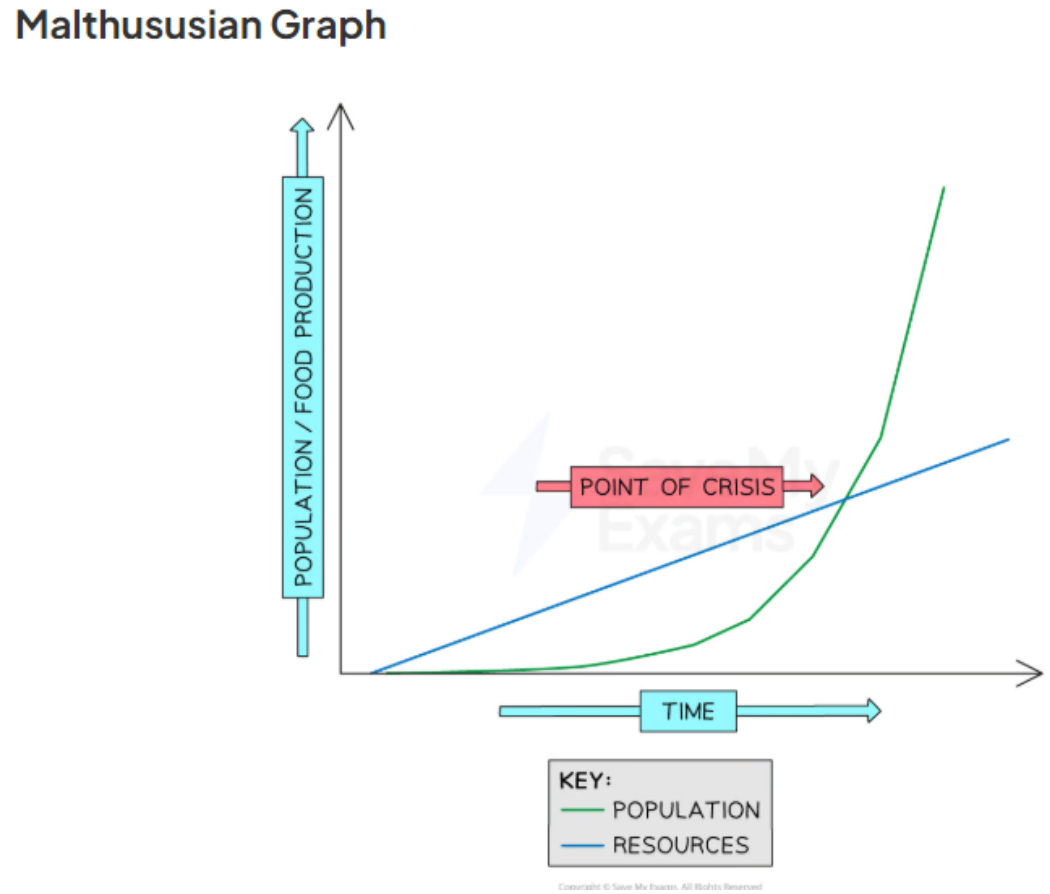


Figure 2.1 Malthusian Graph demonstrating Malthusian Theory (Barrett and Quinn 2024)

The Neo-Malthusians today argue that humans have now used most of the available agricultural land, with food prices increasing as the population continues to increase and that population control is essential in avoiding a Malthusian catastrophe (Barrett and Quinn 2024). Obviously, this theory extends the classical hypothesis developed/defended by Malthus that population growth will outstrip the agricultural production/food supply (Aliyu *et al*.2021). Therefore, the society is going to fail in its ability to address hunger challenges. In this case, Neo-Multhusians have a pessimistic perspective on agricultural production because they assert that the society cannot meet its ability to produce food to secure/feed inhabitants calling for controlled birth. In the 1960s and 1970s, the fundamental driving force for coercive laws reducing reproduction was the Neo-Malthusian panic, which eclipsed eugenics in importance.

Planning human population has been a key component of Neo-Malthusianism, which aims to protect natural integrity and provide resources for both present and future human populations. This is different from Malthus's theories primarily because it endorses contraception (Lesley 2000, Abdullah 2020), which would allow Africa, then Ghana have a common population control system. Although, some societal shifts like contraceptives have been put in place, most developed economies have been impacted significantly, but yet to be realised in the African continent (Aliyu *et al.* 2021) particularly Ghana. Despite the widespread use of contraceptives, which continue to be the main factor limiting family size, there are currently nearly 282 million or about 20 percent undernourished individuals in Africa, rising faster than in any other region (Rédaction Africanews and AP News 2020), additionally, 868 million people in Africa experience moderate to severe food insecurity, with 342 million, more than one-third of the total, living in extreme food insecurity (WFP, FAO, AUC, and ECA, 2023).

Ghana's agricultural industry is declining as a result of post-harvest losses (Boakye and Noluthando 2024; GSS 2019:3) not due to unavailable agricultural land as 57 percent of the country's total land area, which is 238,539 km^2, is classified as "agricultural land area" (FAO 2023; Przezborska-Skobiej and Philip-Quaque 2022: 87; SRID 2021). While the sector's growth rate in 2017 was 6.1 percent, in 2018 it expanded by 4.8 percent, and its GDP contribution decreased from 21.1 percent in 2017 to 19.7 percent in 2018 (GSS 2019:3). Food insecurity continues to impact close to 50 percent of Ghanaians, according to the GSS (2022) poll. Data from the 2022 Annual Household Income and Spending Survey shows that a stunning 49.1 percent of the population or 15.1 million out of 30.8 million, experienced food insecurity in the first three months of the year. This identifies with the assertion by

Acheampong *et al.* in 2022, regarding food security remaining an earnest challenge for many households in Ghana.

Keogh *et al*. (2021) report that, in 2017 the nationally representative survey of women found that contraceptives (like implants) are gaining popularity in Ghana. Despite a strong belief in neo-Malthusianism, with Ghanaians utilising contraceptives to control birth, food insecurity keeps intensifying in Ghana, as such hunger still exists in Ghana (Boakye and Noluthando 2024), hence this evidence disproving Neo-Malthusianism insights/ perspective in modern Ghana.

The Boserupian theory put forward in 1965 has an optimistic view of the relationship between population and resources (specifically food) which states that, population growth will stimulate developments in technology to increase food production with **m**ore efficient resources discovered/used as **r**enewable resources replaces non-renewable (Barrett and Quinn 2024). From this theory our food production does not determine how much our population can grow, instead, it is the other way around, our population growth determines our food production (Jacoby 2024). This basic idea behind Boserupian population theory is that while human population grows quickly, people have always adapted their agricultural practices to adjust. So, when food is short, people do not have to be killed off. Instead, they invent new ways to make food (Jacoby 2024). Boserup's theory is general and broad, but it is based on trends she observed in agriculture, that agricultural practices of various communities are determine by their population size and density (Jacoby 2024)

Though Ghana's population is growing, food security remains an earnest challenge in many households (Acheampong *et al.* 2022). Evidence from studies including (Appiah 2024; Atchulo 2024; Boakye and Noluthando 2024; Hadebe 2021; Kijang and Dato'Onn 2018; Antwi n.d) attest that Ghana's food security challenge is as a result of inadequate agricultural practices adjustments like poor post-harvest handling practices, lack/inadequate application of modern technologies, poor logistics of food systems, inefficient infrastructure, inadequate funds etc., which significantly hamper agricultural activities as well as integral activities like logistics activities/management practices, as such needful to stimulate developments/efficiencies in resources like technology and infrastructure as opportunities to enhance food production/security. Ghana recognises the potential of large-scale adoption of new and clean production technologies to facilitate the realisation of food security via agricutlutural

productivity increase (Forkuor *et al.* 2022). Therefore, in Ghana, these insights evidently validate Besorup's theory conceptualising that population growth will stimulate developments in technology to increase food production with **m**ore efficient resources discovered/used as **r**enewable resources replaces non-renewables.

Adopting evidence supporting Boserup's theory having an optimistic perspective to contribute significantly to better Ghana's food security challenge as Ghanaians invent new ways/methods to adjust their agricultural activities/practices will certainly result in an improved food production with logistics management practiced efficiently. To achieve such requires pursuing mechanisms/measures such as:
The implementation of radical transformation strategies/policies to improve access to finance/credit facilities (Forkuor *et al.* 2022) in support of the agricultural sector's swift/rapid growth especially small-holder farmers to invest in new technologies to improve their agricultural production. This will improve income levels, particularly for the 50 percent of Ghanaians with just two percent economic ownership.

The timely, safe, and cost-efficient transportation of agricultural products/food, could be facilitated via an increased political commitment to expedite effective development of the necessary new infrastructure, and renovating the current infrastructure to overcome ineffective distribution and transportation hurdles for food demand to be met reliably in distant urban regions (Kumar and Rameshchandra 2023), providing year-long trade accessibility locally, regionally or continentally, sustainably and inclusively, considering poor transportation networks hinder the timely movement of goods/food, leading to post-harvest losses and reduced market access, in Ghana (Atchulo 2024).

The government with the assistance and/or input of development partners, scientists, researchers and stakeholders must provide the needed information, instruction, and develop training programmes with relevant contents or modules that recognise and complement/integrate indigenous principles, processes and promises to equip Ghanaian Farmer Based Organisations/ farmers, agricultural extension officers and the logistics workforce with an effective organisation and improvement in productivity and sales skills allowing farmers to seize market opportunities, to reap the rewards that come from setting better prices and selling in volume. (World Bank 2022). Thus, supporting farmers to make relevant trading

arrangements to match their agrarian products to both the local and regional or continental markets (AU 2023). This will result in, the offering of comprehensive extension services as well as managing customers/farmers satisfactorily, so will warehouse assets be utilised efficiently to enhance productivity.

Moreover, all stakeholders should be trained on the adoption/utilisation of new large-scale production technologies for agricultural best practices to adapt well to aggravating impacts of climate-related shocks (World Bank 2022) from climate change which makes growing and harvesting cycles less predictable, contributing to food losses and insecurity (Safdie 2023).

Boserupian graph depicting population growing exponentially with food production upon stimulating development in technology to increase food production with **m**ore efficient resources discovery/usage is demonstrated graphically below:

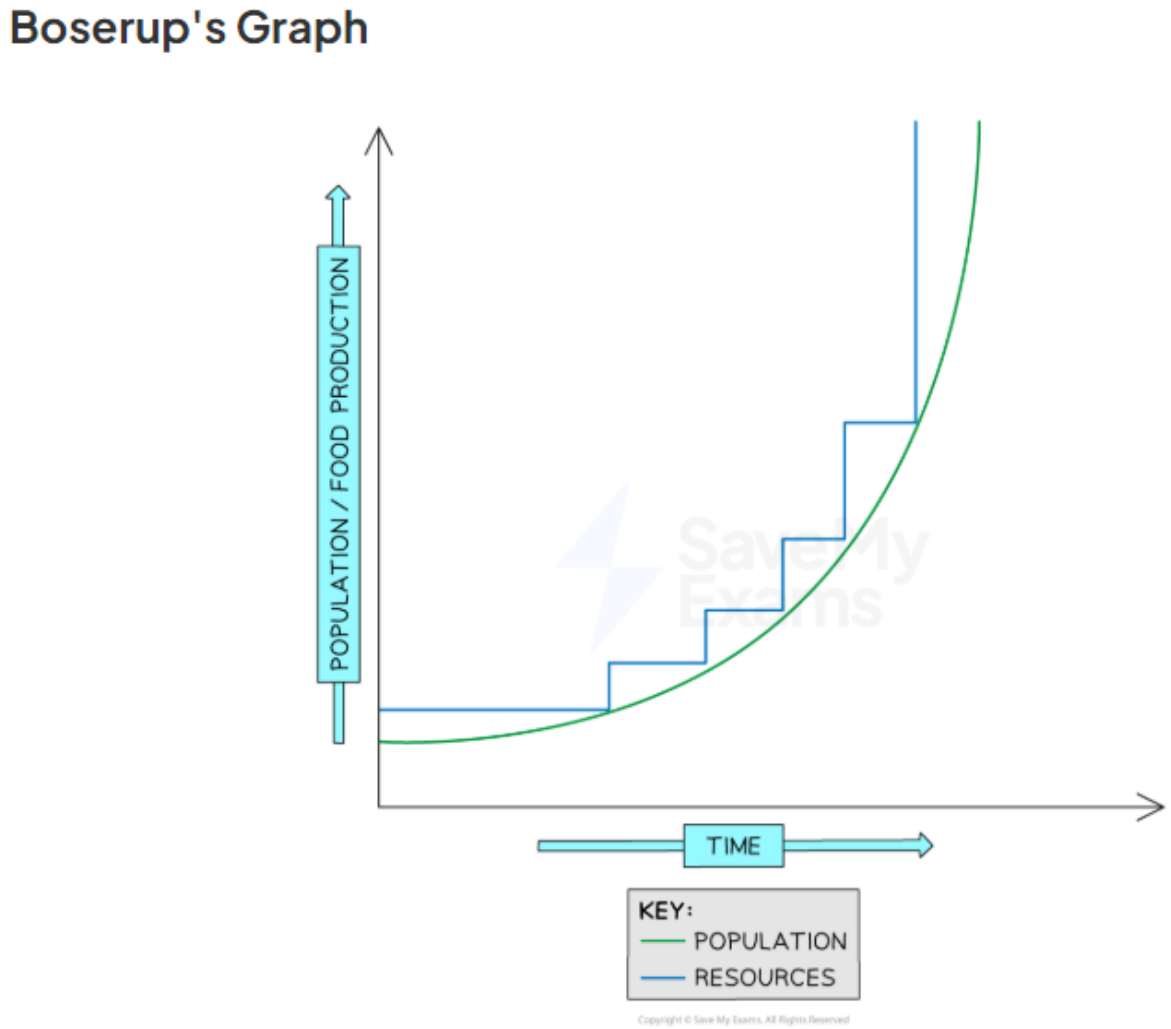


Figure 2.2 Boserupian Graph demonstrating Boserup's Theory (Barrett and Quinn 2024)

The theory of access hypothesises that "access" must be understood beyond the classical concept of "the right to benefit from things" but to the notion of" the ability to derive benefits from things" (Aliyu *et al* 2021: 9). Aliyu *et al.* (2021) and Ribot and Peluso (2003) argue that people may hold the right to access a certain resource, but may not necessarily have the ability to use the resource in a productive way to benefit from it due to a lack of structural and relational mechanisms such as capital, technology, labour, knowledge, authority, market mechanisms, social relations, and identity (Mutea, Rist and Jucobi 2020). However, this theory was incorporated due to its inclusive basis for investigating the significance of access in addressing smallholder farmers post-harvest losses/food security and logistics management issues along the two variables of right to access property (i.e., bundle of rights) and bundle of powers to access resources. (Aliyu *et al*. 2021). While the former embraces all types of formal and informal rules or norms, the latter, bundle of power intercedes in analogous to right-based

access mechanism to figure how resources users gain control and eventually claim benefits (Mutea, Rist and Jucobi 2020). For Ghanaian smallholder farmers, access to land is the most important resource for agricultural production, followed by water for irrigation. Irrigation infrastructure such as drip irrigation and community-managed water schemes can enhance water availability for crops like grains during dry spells reducing reliance on rainfall and increase crops (grains) growth/yield (Atchulo 2024; Mutea, Rist and Jucobi 2020) as agriculture in Ghana is mostly rain-fed (Acheampong *et al.* 2022). Access to logistics infrastructure and extension services is another important resource to enhance market competitiveness (Appiah 2024), reducing post-harvest losses and bettering post-harvest management. According to Mutea, Rist and Jucobi (2020), gaining access to productive resources can enable smallholder farmers to adopt sustainable land management approaches such as nutrient management and post-harvest management approaches which are needed to achieve improved livelihoods by increasing productivity and adapting to and mitigating climate change. However, inadequate access to productive resources can certainly expose the smallholder farmers to food insecurity and become vulnerable to poor livelihoods (Aliyu *et al.* 2021; Mckay and Colque 2016). Considering livelihood is a means of securing the necessities of life, one necessity or outcome is the achievement of food security (Mutea, Rist and Jucobi 2020). These insights on resources accessibility yielding gains including agricultural food production expansion/food security achievement evidently validate Ghana's context currently.

The Network theory is a widely used theory related to supply chain management (SCM) (Trivedi 2023). The idea of supply chain management (SCM) entails controlling the movement of goods, information, and funds both upstream and downstream as well as coordinating and working with channel partners that include suppliers, middlemen, outside service providers, and customers (Habib 2021, 2010:80; Ballou 2007). This perspective acknowledges that all businesses are involved in the movement of goods, services, funds and knowledge (both upstream and downstream) (Slam, Monjur and Akon 2023). No single corporation produces goods or services to suit customer wants or reach consumers away from implementing a supply chain management (SCM) strategy, which is the mainstay and plays a very vital role in organisational operations (Anwar *et al.* 2023:691).

The leading association of supply chain professionals, the Council of SCM Professionals (CSCMP), scholars, and researchers, define SCM as the network architecture integrating all logistics management activities. According to Trivedi (2023 and Bower (1981) the Network

Theory of Affect looks at the relationships and interactions between the many actors in the supply chain for robustness to explain the mood-congruency effect.

According to Trivedi (2023), the network theory aids in understanding how information flows, partnerships and collaborations among the various actors affect the supply chain's overall resilience and efficiency. In the context of food production, Logistics management includes everything from seed selection and procurement to field planning and resource allocation, to harvest scheduling and product distribution (Driver 2023). Logistics management in the food system is crucial, to support food availability for all. By reducing waste and maximizing the use of resources, logistics management can help farmers increase their yields and decrease their costs. (Driver 2023). Logistics services are critical to bridging the gap between agricultural production and consumption (Appiah 2024). According to Appiah (2024) high-quality logistics infrastructure and services accessibility is key to enhancing market competitiveness and enabling the creation of efficient and inclusive value chains.

The logistics of the food value chains comprise agricultural inputs, outputs, and services like transportation, warehousing, purchasing, packaging, and inventory management (FAO 2020), all of which contribute to preserving the balance between human population growth and natural resources and when managed efficiently plays a role in supply chain operations, as it truly unlocks maximum benefits through integration (Slam, Monjur and Akon 2023). Supply chain management and the connection between logistics impact a business' performance as well as the performance of the chain (network) by promoting long-term and voluntary collaborations, among independent suppliers (Slam, Monjur and Akon 2023; Schmoltzi and Wallenburg 2012; Cruijssen *et al.* 2007). Thus, the seamless connection between logistics and supply chain management plays a role in the success of businesses operating in today's changing global market (Slam, Monjur and Akon 2023). To ensure cost-effective fulfillment, supply chain management relies heavily on logistical operations (Slam, Monjur and Akon 2023).

Currently, Ghana's population largely dependents on food imports, including rice, wheat, chicken, and other items. Focusing on how producers/suppliers and logistics handlers (Figure 1.1) integration impacts supply chain management and logistics, Slam, Monjur and Akon (2023) assert that in the midst of business challenges like disruption which was profoundly

experienced during the COVID 19 pandemic and shifts in customer behaviour an integrated system for logistics and supply chain management can offer flexibility, cost-effectiveness and quick response times. Moreover, acknowledging the advantages of interconnected operations can enable corporations like the FBOs and IPEP warehouses harness advancements following transformations thereby guaranteeing competitiveness and facilitating growth. Considering Ghana's population large dependence on imports to control food insecurity, there is an immediate need to improve food production and the performance of intermediates in the agricultural supply chain (Muntaka *et al*. 2021:1). With this business enterprise expansion, emerging areas like logistics and supply chain management would facilitate the flow of goods/food and information, with the growing increasingly intricate supply chains due to factors like diverse consumer needs and digital transformations, as such having a coordinated and seamless logistics system is crucial (Slam, Monjur and Akon 2023).

However, this theory was incorporate due to its integral insights on the significance of network in addressing smallholder farmers, warehousing, packaging and transport logistics, packaging materials providers, extension officers, and logistics management issues, per their interdependence serving as an enabler for the corporation's (IPEP warehouse's) success and customer's (smallholder farmer's) happiness/satisfaction (Slam, Monjur and Akon 2023). Here the smallholder farmers, suppliers of the packaging materials, IPEP warehouse, transportation system, and the post-harvest produce sites among others form the supply chain with the warehousing, packaging and transportation as the logistics and the coordination of activities being the logistics management, hence this theory on network evidentially challenges Ghana's food supply network's overall resilience and efficiency to reducing waste and maximising the use of resources to unlock the maximum benefits of the food supply chain/network optimising food supply/ the successful realisation of food security contextually in modern Ghana.

Although these theories are not identical, but are more connected than studies have acknowledged thus far. Uncovering the trends from a point of global attention to a new and specific point of attention can definitely offer an idea of how post-harvest losses/ food security has been affected by population growth, access to resources, birth control, logistics management and supply networking in Ghana. Therefore, problems associated with food

security and logistics management should be addressed with immediate effect. Based on the foregoing theories, this study hypothesises that or seeks to test the following hypotheses:

H1: Packaging logistics contributes massively to food security

H2: Warehousing has a positive influence on food security challenge

H3: Logistics management has a significant positive relationship with food security

2.2 OVERVIEW OF GHANA'S AGRICULTURAL SECTOR

Legislative Framework

To improve access to financing and increase production for food security and export, the government of the first Republic of Ghana moved swiftly to implement policy interventions in the agricultural sector. Governments, after that, carried on with the policy intervention (AFI 2018). According to Kijang and Dato'onn (2018:5.) among the notable ones are: To support small farmers and the agriculture and livestock industries, the government established the Agricultural Development Bank (ADB) in 1965. By this, beginning in 1976, policies supported the establishment of rural and community banks to promote rural agriculture and other rural enterprises. Since then, these community and rural banks have expanded to over 500 communities with their branches, mobilising and supplying loans. The year 2000 saw the creation of an Apex Bank to supervise the operations of the Rural Banks (AFI 2018)

According to Kijang and Dato'onn (2018:5.) in an attempt to effectively manage the country's economy and generate prosperity for all Ghanaians, the government of Ghana launched the Poverty Reduction Strategy (GPRS) in February 2002. The main goals of the GPRS are to safeguard the weak, expedite poverty reduction and produce wealth through economic transformation.

2.2.1 The Ghana Export Import (Ghana Exim) Bank

To support the financing of initiatives, including agriculture, to facilitate the nation's international trade and promote its capacity and competitiveness in the global marketplace, three state-owned institutions were consolidated to form the Export Trade Agricultural and Industrial Development Fund (EDAIF), Export Finance Company Limited (EFCL), and Exim Guaranty Company Limited (ECL). This resulted in the establishment of the EXIM Bank. According to Kijang and Dato'onn (2018:5.) developing crops like avocado, cashew, oil palm, and cassava into major export products, lowering the country's import bill for poultry by USD 300 million, and increasing revenue from non-traditional exports from their current average of USD 2.4 billion to USD 5 billion are among its five-year strategic goals (2017–2022). For the successful execution of government projects like the One District One Factory (1D1F), this makes it a crucial financial partner.

Throughout history, governments have implemented agricultural financing schemes to broaden financial accessibility in alignment with the goals of the Green Peace Process. Three of the Bank of Ghana's (2004) agriculture sector policies are the notable and more recent ones that are covered below:

2.2.2 Planting for Food and Jobs (PFJ)

The PFJ programme intends to help modernise the farm sector, resulting in a structural transformation of the national economy through food security, job opportunities, and poverty reduction. The programme has taken a comprehensive, integrated strategy to significantly increase the availability of inputs (seeds and fertilisers) and access to input and output markets. It is nationwide in scope and includes all 216 districts in the country where priority food crops are farmed. Crops supported by the PFJ programme are chosen based on their relevance to national socioeconomic considerations such as: (a) food security (b) smallholder farm incomes (c) raw material supply for the livestock and industrial sectors (d) reduction in food import bill (e) job creation, and (f) economic activity from various actors along the value chain. Maize,

rice, sorghum, soya bean, tomato, onion, and chilli pepper were the initial value chains chosen for support under the PFJ programme.

According to Kijang and Dato'onn (2018:6.) the policy is based on five major pillars that include:

- The provision of improved seeds to farmers at subsidised costs (a 50 percent subsidy);
- Subsidised fertiliser supply to farmers (50 percent price drop);
- Free extension services for farmers (1200 extension officers from the five main agricultural universities have already registered in the programme, with an additional 4,000 extension helpers to be mobilised);
- Farmers participating in the campaign will have access to ready-made markets for their produce after harvest, as well as an e-agriculture platform to track their development and activities.

Kijang and Dato'onn (2018:6.) assert that for over four years (2017–2020), the programme is expected to cost USD 7.2 million, with funding from the government and a few development partners. In its first year of operation, the PFJ yielded crops valued at GH¢ 1.2 billion. This represented the production of an extra 485,000 MT of maize, 179,000 MT of rice, and 45,200 MT of vegetables through the utilisation of workers, better seeds, fertilisers, and extension services (AFI 2018). In addition, 745,000 new employments were created in 2017, most of which were in the rural sector (AFI 2018).

2.2.3 Development Partners Funded Interventions

There are additional finance schemes and projects backed by development partners. Here are a few examples:

The Out grower And Value Chain Fund (OVCF)

The OVCF offered medium-long-term lending for investments linked to outgrower programmes and technical support to outgrowers through the German Financial Cooperation through KfW. By creating jobs along agricultural value chains and generating money for rural

residents, the OVCF's initiatives seek to eliminate rural poverty. According to Kijang and Dato'onn (2018:6.) one (1) million euros in grants and 10 million euros in financial contributions make up the Fund. Small-holder farmers' integration into the development of commercial agriculture has improved thanks to the investment.

The Financing Ghanaian Agriculture Project (FINGAP)

An initiative by USAID called FinGAP aims to increase investment and financing for agricultural companies in Ghana's north that are involved in the rice, soy, and maize value chains. Since its launch in 2013, it has made it possible for agricultural enterprises to obtain up to USD 85 million in funding from financial institutions, with the majority of the cash going to farmers, dealers, and processors of agricultural inputs Kijang and Dato'onn (2018:6.).

2.2.4 The Rural and Agricultural Financing Programme (RAFIP)

The goal of RAFIP is to make sure that, through improved outreach, sustainability, and connectivity, the population in rural and agricultural areas has greater access to sustainable financial services. According to Kijang and Dato'onn (2018:6.) the Ministry of Finance is in charge of implementing it, and funding comes from a partnership with IFAD (USD 15 million), DANIDA (USD 8 million), and Italy (USD 1.5 million). By offering staff members of rural/community banks and microfinance institutions a range of capacity-building trainings, including technical training on finance and credit operation as well as management and governance on bank operation, it sought to develop rural financial systems. To encourage agricultural business investment, it also improved ties between the financial and agricultural/business sectors.

According to Kijang and Dato'onn (2018:7.) the Bank of Ghana (BoG) carried out a few direct agricultural development programmes through the government's intervention policy. Among them are:

- Cocoa Bill Financing Scheme (1958): The Cocoa Marketing Board (CMB), currently known as COCOBOD, needed a financing plan to buy cocoa when the crop's rapid rise made it impossible for it to finance purchases with its funds.

- Grains Bill Financing Scheme (mid-1970s): This was an aid package for buying agricultural products, especially rice and maize, in the years following the then-government's "Operation Feed yourself," which resulted in significant post-harvest losses. The purposes behind the Grains Bill

- The financing scheme included three goals: stabilising the price of grains to encourage farmers to continue producing; providing funds for the purchase of farmers' grains to ensure a ready market for their produce at all times; and supporting the purchase of grains for a national food security stock as emergency supplies or in times of extreme scarcity.

- Grains Warehousing Company (1975): This was a deliberate attempt to meet the GBFS's aforementioned goals. During the lean season, the firm sold the grains that it had bought and sorted. However, the management of the corporation also implemented unsuitable rules, which contributed to the GWC's failure.

In the 1970s, the Bank of Ghana implemented several agricultural programmes, albeit without explicit finance for agriculture (Kijang and Dato'onn 2018:6.). Among them, notable ones were:

- Founded in 1973, the Shai Cattle Ranch serves as a demonstration of the feasibility of commercial beef cattle ranching on the plains of southern Ghana and provides training for individuals involved in livestock ventures.

- The purpose of the Agricultural Development Company was to cultivate and market various agricultural and livestock products as well as to produce cotton on a big scale under irrigation for Ghana's developing textile manufacturing sectors;

- The JOFA Project was founded and funded by the Agricultural Development Bank (ADB) to develop 300 hectares of plantations in the areas within the central and eastern

regions. The Wulugu Livestock Company (1979) was established to run a ranch for cattle and sheep in the Northern Region on a scientific basis to serve as a model for local ranchers.

The three other programmes, apart from the marginally successful JOFA project, failed to meet their goals because their management implemented unsuitable policies (Kijang and Dato'onn (2018:7.). Following the implementation of the Structural Adjustment Policy (SAP) in 1983, BoG redirected its indirect schemes towards agriculture (AFI 2018). To supervise the operations of Rural and Community Banks, it established the Rural Finance and Inspection Department. Additionally, it managed some foreign and domestic funds and projects on behalf of the Ghanaian government, including the Special Rural Credit Scheme, the Ghana Women Fund Scheme, the Community Banks Refinance Scheme, and the Food Crops Development Project. According to Kijang and Dato'onn (2018:5.) the Bank of Ghana's Financial Market Department manages grants and project loans that the Ghanaian government obtains from organisations and nations that provide aid. The Ghana Private Sector Development Facility (GPSDF), the Rural Enterprises Programme (REP), the Private Enterprise and Export Development (PEED), and the Japanese Non-Project Type Grant are some of these initiatives.

2.2.5 Rural Enterprises Programme (REP)

The Bank of Ghana oversaw initiatives funded by the International Fund for Agricultural Development (IFAD) Scheme through the Rural Enterprises Programme (REP). In 1990, the programme got underway. The Upper West Agricultural Development Project, Rural Financial Services Project, Rural Enterprises Project, and Smallholder Credit Input Supply and Marketing Project (SCIMP) are some of the important initiatives. As of right now, BoG is in charge of just two REP facilities: the Matching Grant Facility for machinery purchases and the Rural Enterprises Development Fund. Donor Partners charged low-interest rates so that Participating Financial Institutions (PFIs) could lend money at rates below market.

2.2.6 Private Enterprise and Export Development (PEED)

The Ghanaian government and IDA worked together to fund the Private Enterprise and Export Development (PEED) initiative. It provides funding for projects like the cultivation and export of shea nuts, cashews, cassava, coffee, pineapple, and handicrafts. According to Kijang and Dato'onn (2018:7.) the facility consisted of two parts: a US dollar loan fixed at 1.375 percent over the current Eurodollar London Interbank Offered Rate (LIBOR) and a cedi loan denominated at the rate of 180-day Treasury Bills. However, this project has been shelved.

2.2.7 Ghana Private Sector Development Facility and Japanese Non-Project Type

The governments of Italy and Japan are sponsoring these two projects via a Coordinating Unit. The fact that the loans are being utilised to buy goods from Development Partner nations makes them commodities loans. Both initiatives provide SME loans at discounted rates. To establish the PFI repayment schedule, paperwork is sent to the BoG from the Ministry of Finance, where allocations are completed. The PFIs' clearing accounts, which are insured for Rural Banks, are debited on repayment due dates. After that, the debt is moved to the Rural Banks, which have accounts with the PFIs as well.

2.2.8 Central Banks' Role in Promoting a Risk-Sharing Scheme for Agricultural Finance - Bank of Ghana's Experience

With the primary goal of maintaining low and steady inflation to stimulate economic activity, the BoG has evolved into an operationally independent entity over time. The primary method by which the BoG anchors inflation expectations is through the monetary policy framework of inflation targeting. But in the last ten years, the BoG and other central banks have started to look beyond their specific mandates for macroeconomic stability and have started to link the financial system with objectives related to sustainable development. It is crucial to identify the types of risks associated with agricultural finance so that central banks may better encourage risk sharing in this area.

Africa is home to a wide range of common agricultural dangers, which the FAO and NEPAD have studied and categorised based on factors including frequency, impact, and origins. Among the risks associated with agriculture in Africa are fluctuations in the market prices of produce and inputs; fluctuations in yields and production losses; natural disasters like floods and droughts; inputs and market availability or unavailability; insufficient regulatory measures, policy decisions, and abrupt changes in government policies; foreign exchange risks; and insufficient access to financing.

2.2.9 Bank of Ghana's Most Current Initiative in Agricultural Finance

The Ministry of Finance and the BoG have been working together to boost agriculture in recent decades. The plan is to assist specific value chains in agriculture to boost output and achieve the nation's development goals of increasing export revenue and reducing imports to preserve foreign exchange. In 2014, the BoG sought agreement on the best way to finance agriculture under the topic of "Boosting Ghana's Foreign Exchange Resources" through a national stakeholders' forum that led to a dialogue on the subject in Accra. As a result, to leverage financial institutions' lending to agriculture in Ghana, the Ministry of Agriculture and AGRA (Alliance for a Green Revolution in Africa) collaborated to adopt the "Ghana Incentive-based Risk Sharing System for Agricultural Lending" (GIRSAL) (Kijang and Dato 2018:8).

According to AFI (2018), the purpose of GIRSAL is to alleviate the obstacles that actors in the agricultural value chain encounter when attempting to obtain credit from financial institutions by offering incentives and tools for risk mitigation. Six interconnected pillars will help achieve this. Agribusiness operators and banks participating in the agricultural value chain can benefit from the following: (1) Risk Sharing Fund; (2) Technical Assistance Programme; (3) Integrated Insurance Policy; (4) Financial Institutions' Rating System; (5) Bank Incentive/Reward Mechanism; and (6) Digital Financing.

According to Kijang and Dato'onn (2018:9.) with a focus on agriculture, GIRSAL aims to triple total financing to the industry by 13.6 percent in ten years and double the percentage of

banking sector lending to the sector in five years, from 3.4 percent (as of September 2015) to 6.8 percent. As previously announced, the BoG and its partners have committed to establishing GIRSAL by the end of 2018 with a seed capital of USD 100 million.

The Bank thinks that working in the industry, may influence how people see risk in agriculture and encourage more capital to be invested in Ghana's agricultural sector. The BoG and its partners have previously engaged in bilateral meetings with development partners who have demonstrated significant progress in risk sharing.

2.2.10 Leveraging Other On-Going Initiatives

The BoG has scheduled talks with the leaders of the following two organisations to institutionalise GIRSAL based on ongoing Government of Ghana initiatives:

1. The first is the recently created Ghana Commodity Exchange (GCX), which was created in response to the substantial and ongoing losses in agricultural output that negatively impact both farmers and society as a whole. Because dealing with the post-harvest loss by the ready market through competent market institutions will boost the activities of value chain actors, this will benefit the BOG-initiated GIRSAL. Some of the first crops to be displayed on the GCX, like paddy rice, soy, and maize, might be the same as some of GIRSAL's.

2. Second, an autonomous organisation called the Savannah Accelerated Development Authority (SADA 2) is in charge of organising a comprehensive development plan for Ghana's northern Savannah ecological zone. A proposal from the private sector is presently attempting to collaborate with the government to establish 50 Farm Centres as one-stop shops in the SADA-2 region. The main objective of these centres is to offer local farmers an all-inclusive package that includes crop inputs, consultancy services, farm machinery rental, and produce buy-back. Its main goal was to reduce risk in the agriculture value chain so that banks would find it very appealing.

2.2.11 Warehouse Receipt System

To lower the risk of postharvest loss for farmers and increase the likelihood that they would receive better pricing, GIRSAL is utilising Ghana's recently implemented Warehouse Receipt System. Proof of ownership for commodities (such as, cocoa, copper, and maize) kept in a warehouse, vault, or depository for safekeeping is provided via the Warehouse Receipt System, a tradable financial instrument. The ownership of the commodity can be transferred without the need to deliver the actual item thanks to the receipt, which is negotiable or non-negotiable. Since most of the receipts are issued in negotiable form, they may be able to be used as collateral to obtain loans from financial institutions.

2.2.12 Procedures and mechanisms to manage food security and logistics.

Specific initiatives in Ghana's agricultural and food industries are among the logistical improvement programmes that the government of Ghana and its development partners established:

To help with post-harvest processing in the horticultural sector, the Millennium Development Authority (MiDA) programme constructed three public warehouses in the districts of Yilo, Gomoa, and Akwapim South. The Millennium Development Authority also started building a sizable highway that connects to the Kotoka International Airport to facilitate the transportation of fresh fruit and promote the growth of Ghana's horticultural exports. From 2006 to 2011, eight districts inside the MiDA intervention zones also had feeder roads constructed (Millenium Development Authority, n.d.).

Under the MiDA programme, the Kotoka International Airport (KIA) underwent construction of a Perishable Cargo Centre (PCC) to handle and temporarily store perishable goods (vegetables and fruits) intended for export. The new shaded area includes freezers for palletized goods, a customs area, and a phytosanitary inspection area in addition to produce handling equipment.

The provision of equipment is the primary goal of the government's Agricultural Mechanisation Services Enterprise Centres (AMSECs) plan. Through the programme, the private sector can purchase agrarian machinery, including primary processing equipment like rice mills and

storage facilities, and construct financially sustainable AMSECs in strategic locations. The Ministry of Food and Agriculture received funding for the AMSECs programme from the Brazilian government as well as the Japanese Grant Assistance Programme. To store grain in the Brong Ahafo (now Bono, Ahafo and Bono East), Central, and Northern (now Northern, North East and Savannah) Regions, the National Food Buffer Stock Company built Grainpro cocoons (Ministry of Food and Agriculture, n.d.).

Young people are encouraged to pursue occupations in growing crops, fishing, raising chickens, and agro-processing by the GoG Youth in Agriculture Programme. Potential beneficiaries are credited with feed, fingerlings, fish cages, ponds, training, and other aquaculture inputs. Through various forms of processing and marketing ongoing programmes, the agricultural business component also aims to assist young people in starting their agricultural businesses by training them on how to add value to agricultural materials for both food and non-food products (Ministry of Food and Agriculture, n.d.).

Between 2002 and 2005, the Ghana Private-Public Partnership Food Industry Development Programme was carried out under the sponsorship of USAID. The goal of this initiative was to revive the Ghanaian horticulture sub-sector and raise the incomes of small and medium-sized farmers. Developing a logistical system to manufacture goods with the necessary consistency, quality, and safety was one of the programme's objectives. Among the companies that took part in this scheme were the Family Traditions Enterprises, Processed Foods and Spices, and the Integrated Tamale Fruit Company.

Rural enterprises centred on agriculture initiatives supported by the African Development Bank, the Ghanaian government, and IFAD included building feeder roads in food production areas, modernising agriculture with an emphasis on developing rural enterprises and expanding credit availability, among other objectives (Rural Enterprises Programme, n.d.).
Under the President's Special Initiative on Cassava, the Ghanaian government is working to transform small-scale agricultural methods and prepare cassava for export to dramatically boost foreign exchange earnings. This project led to the founding of the Ayensu Starch Company in Ghana's Central Region.

The Tema Export Processing Zone and the Multipurpose Industrial Park are two of the 238 new free zone companies established nationally under the Ghana Trade and Investment Gateway

Project's Free Zones Programme. Funding for this project came from the World Bank. When beneficiaries are working on projects that are strategically important to the Ghanaian economy or when the primary project lays the groundwork for more efforts down the road, they are free from paying taxes. Customs, direct, and indirect taxes do not apply to imports into a free zone that is made by a free zone developer, subcontractor, or business.

The Export Development and Investment Fund (EDIF) and Competitiveness and Investment Climate Strategy were created to give industries with export potential access to financing for retooling and rehabilitation. The Ghana Commercial Agricultural Project (GCAP) enhances the investment climate for the expansion of agricultural businesses by adding value in certain value chains and utilising a Private-Public Partnership (PPP) strategy to smallholder-large scale links. (Ministry of Agriculture and Food n. d.)

The aforementioned initiatives tackle the issues raised by respondents regarding cold chains and storage systems, free zones and tax exemptions, as well as a lack of infrastructure, credit availability, and equipment. Still, only agricultural enterprises focused on exports can take advantage of the majority of current measures. Problems with various taxes and levies, lack of financing, inadequate supplies of raw materials, access to modern technology, and unfair competition (market oversupply of imported goods) are particularly harmful to agricultural businesses aiming at local and sub-regional markets, and these issues still require serious attention. To promote growth in the agricultural food business, additional logistical problems such as the poor farm-to-road system, the high cost of packing materials, and the high-interest rates on loans will need to be resolved.

2.2.13 The Agricultural Sector Contribution and Data on Selected Grains

The agricultural sector provides a living for about 45 percent of Ghana's population (WFP 2019). Providing for more than 90 percent of the nation's food needs, the industry makes up over 40 percent of export revenues and contributes 54 percent of Ghana's GDP (FAO, 2023). Rain-fed, smallholder and traditional agriculture makes up the majority of Ghana's agricultural sector (Przezborska-Skobiej and Philip-Quaque 2022: 87; SRID 2021). The term "agricultural land area" refers to roughly 136,000 km^2 or roughly 57 percent of the country's total land area of 238,539 km^2. Of this, 58,000 km^2 (24.4 percent) are under cultivation, and 11,000 hectares are under irrigation (Przezborska-Skobiej and Philip-Quaque 2022: 87, FAO 2023; SRID

2021,). Roughly 60 percent of all farms in the nation are smaller than 1.2 hectares, 25 percent are between 1.2 and two hectares, and only 15 percent are larger than two hectares. The average farm is not more than 1.6 hectares. Fifty-five percent of the cultivated land is made up of small and medium-sized farms with a maximum area of 10 hectares (FAO 2023; Przezborska-Skobiej and Philip-Quaque 2022: 87; SRID 2021).

Nonetheless, the majority of farmers practise subsistence farming, which makes it impossible to cultivate sustainably and generate revenue due to huge yield gaps and poor soils, among other issues. Ghana's Statistical Services, Economist Intelligent Unit, estimates that imports of agricultural and other related products reached a value of $1.9 billion in 2021. Ghana is still a major importer of food products. Imports of food and agricultural products may keep rising since Ghana's undeveloped food processing industry is unable to keep up with the rising demand. For the majority of people in Ghana and the SSA, cereals like millet, wheat, maize, and rice are the main sources of staple nutrition. The main subjects of this study are rice, maize, and millet.

As is the situation throughout the SSA, the majority of Ghanaians solely eat these cereals. In SSA, maize is a major source of protein, calories, food security, and economic stability for an estimated 208 million people. Out of the estimated 200 million hectares of cultivated land in the SSA, maize accounts for more than 33 million hectares (Raheem *et al.* 2021: 1; Macauley 2015: 2). The challenge of satisfying the predicted growth in demand for maize grain in Africa is similar to that of millet, given the poor average yield of maize grain that are still common in farmers' fields. Nineteen percent of the SSA's total grain land coverage is made up of millet (pearl and finger) (Raheem *et al.* 2021: 1; Macauley 2015: 1).

The pattern of growing millet acreage in Africa over the past 50 years indicates the crop's ongoing need. Sadly, crop output has not kept up with rising demand, primarily because millet production has not improved as much as other cereals due to crop development initiatives lag, harsh environmental conditions, and farming system low-input, resource-constrained farming practices. Furthermore, because of neglect, isolation, and weak national institutions, there has been little progress in addressing the serious problems of land degradation, climate variability, and change in these dryland ecosystems. Notwithstanding these obstacles, there is a compelling

argument for stepping up efforts to develop markets, institutions, and technologies (agronomic management, improved germplasm) to advance the cause of millet in the dryland tropical regions of Africa (Raheem *et al*. 2021: 1-5; Macauley 2015: 1), and Ghana for that matter.

A crucial and very strategic commodity for Africa's food security is rice. Due to increased urbanisation, significant population growth, and changes in eating patterns, consumption is expanding faster than that of any other important staple on the continent (Raheem *et al*. 2021:1; Seck *et al.* 2013).

It is the third most significant source of dietary energy for Africa and the most vital for Ghana. While there was a sharp increase in local rice output following the 2007–2008 food crisis, a fundamental issue plaguing the rice industry in Ghana and Africa at large is that local production has never kept up with demand. To satisfy its growing need for rice, the continent still depends on imports. In 2017, the Forum for Agricultural Research in Africa (FARA) released a paper indicating that Ghanaians' annual rice consumption has increased significantly over time, with an estimated 45 kilogrammes consumed annually. Consumption greatly outpaces local output, creating a sizable shortfall that is mostly countered by significant imports of rice. In 2012, for example, the average yearly production of rice was 145,000 mt, compared to an annual consumption of approximately 800,000 mt (SESI Technologies 2021; Amikuzuno *et al*. 2013). In the meantime, PHL is leading in every crop season.

2.3 FOOD SECURITY IN GHANA - ACCOUNT ON PHL

According to APHLIS (2018) data on PHL the total losses in 2014 of rice, maize, millet, and sorghum from the point of harvest to their retail/wholesale outlets in market centres was estimated at 337,932 tonnes - enough to feed nearly one million Ghanaians.

Annual postharvest losses of around 318,514 tonnes of maize account for roughly 18 per cent of the nation's total annual production of grain (SESI Technologies 2021; Bruce 2016).

The statistics from the Africa postharvest losses information system (APHLIS) in 2018 indicated that, using the average exchange rate of US$1 to GH¢4.82, Ghana's losses from the three types of grain (maize, millet and rice) and sorghum were valued at approximately US$141.12 million, or more than GH¢680.19 million. From the moment of crop harvest, until the food is delivered to the customer, many interconnected activities make up the postharvest

chain (Sibanda and Workneh 2020: 562; Affognon *et al.* 2015:62). The type of diet has a substantial impact on activities, and plant goods such as grains have notable variations.

Three primary forms of losses can arise as a product, progresses through the supply chain:

i. physical or quantitative losses in the product's weight
ii. loss of quality, modifies the product's look, flavour, texture, or nutritional content
iii. loss of the product's value opportunity

Postharvest loss is defined in this study as the loss of quality that alters the quality, i.e., the nutritional content and appearance of grains under discussion. The harvesting, handling, storage, processing, packing, marketing, and usage of the food are all directly impacted by the primary, secondary, and tertiary causes of PHL. The dealing causes are the genetic makeup of the produce itself, biological factors like pests and diseases, physiological factors like respiration, ripening, and dormancy, environmental factors like weather temperature and humidity, storage infrastructure like warehouses, cold chains, and methods of storage, and processing facilities, whether conventional or advanced. The secondary elements are consumer behaviour and ancillary services that facilitate the transfer of goods from farm gates to markets and consumers (such as market information, road network access, handling expertise, and the cost of postharvest infrastructure and services). The exterior factors (e.g., government policies and investments in agriculture, private sector engagement and investments, advocacy groups and lobbying in agriculture) that directly impact on the availability and delivery of postharvest technology and services are considered the tertiary causes

Scholars generally believe that the amount of PHL at any point after harvest is determined by the combination of primary, secondary, and tertiary variables. The majority of research focuses on the variables affecting the primary and secondary causes. To minimise losses, Sugri *et al.* (2021:1) take an integrated approach to reducing the elements that influence PHL's primary to tertiary causes. They discovered that to reduce losses, farmers still required higher technological and resource capacities, even with the high PHL. Small-scale production and the high expense of new techniques customised for the same smallholders leading to PHL (Sugri *et al*. 2021: 1).

Most research has focused on the causes of PHL; however, very few, if any, academics have explicitly addressed the impact of logistics management on food security, or the capacity to avoid PHL.

2.4 RELATED LITERATURE

2.4.1 Road transport Achieving Food Security

- *The Use of Road Transport Logistics*

In Ghana, transportation is one of the most important functions of logistics management (Nangpiire, Narsam and Beduwa 2023) and the use of road transport is the most basic method at the level of business transportation adopted for simply moving goods from one place to another. Scholars alluded to diverse methods of road transportation. This covers the transportation of the completed product to the client as well as the delivery of components and raw materials to the manufacturer. Air, rail, road, water, cable, pipeline, and space are examples of modes of transportation. Infrastructure, vehicles, and operations comprise the field. The common transport infrastructures in Ghana are ports, roads and railways which need improvement to meet the increasing import and export demands (Hellmuth-Sander 2023).

In reference to "the alternative mechanism for ensuring food security," Britchenko (2023) stated that a substantial amount of grain was moved by river, instead of by sea when Ukraine was under martial control. This is the least expensive way of cargo logistics when compared to other approaches, and it is more profitable than rail. Although it is substantially smaller, Ukraine's potential for grain transportation by rivers surpasses the threshold of over 15 million tonnes (Bezpartochnyi and Britchenko 2022). The requirement for large-scale river dredging, primarily the Dnieper, for cargo ships, and for the development of river port infrastructure as a whole are the main causes of the incomplete realisation of this logistical direction's potential. Under the existing circumstances, market players and Ukrainian authorities are still looking for ways to reroute export supplies to the European Union via other channels, like river transportation to Romania via the Danube River. According to Bezpartochnyi and Britchenko (2022), a ship carrying 71,000 tonnes of Ukrainian corn has already left the Romanian port of Constanta. It is being considered whether Ukraine may ship grain to buyers via ports in Lithuania and Latvia. About 1.5 million tonnes of grain and 250,000 tonnes of oil from Ukraine can be handled monthly by European ports (Bezpartochnyi and Britchenko 2022).

The most challenging problem is still how to convey grain crops by automobiles. Domestic roadway conditions, particularly in Ukraine's central and southern regions, have become a major national concern. The bad states of the roads are causing Ukraine to suffer enormous

losses. This is partly due to agricultural producers not adhering to the regulations governing the maximum load limits for grain delivery via automobiles. Many farmers purposefully break the regulations governing the transportation of grain crops by overloading vehicles with grain, due to their attempts to cut costs and the challenge of traversing areas with damaged roads. While many head straight to the docks, others go to the granaries/lifts. An increasing number of farmers are realising that owning a fleet of grain trucks greatly increases their capacity, lessens their reliance on outside businesses, and lowers the cost of transporting grain by motor vehicles. On the other hand, Ayodele and Oluwagbenga (2023:77) noted that the four categories of roads that still serve Osogbo, Nigeria's farming community are Trunk 'A' (Federal Roads), Trunk 'B' (State Roads), Trunk 'C' (Local Government Roads), and Directorate of Food Roads and Rural Infrastructure (DFRRI) Roads. Notably, the majority of local roads lack pavement, and a tiny portion of DFRRI roads are in poor condition. This affects agricultural enterprises and accessibility for different modes of transportation.

About 38 percent of the studies under this theme report that in horticultural value chains, the quality of delivered produce and means of transport used during distribution and marketing are dependent on the distance to market (Alulu *et al.* 2023:04; Suraraksa and Shin 2019; Lenn and Ward 2010). The majority of studies identify bicycles, motorcycles, trucks, pick-ups, passenger buses, animal carts, wheelbarrows, and human porterage as available means of transport (Alulu *et al.* 2023:04; Suraraksa and Shin 2019; Lenn and Ward 2010). Along with wheelbarrows, animal carts and motorcycles, trucks, pickups, and buses are some of the common road transports used in the agricultural sector (Alulu *et al.* 2023:04, Britichenko 2023, Sathyabama, Suraraksa and Shin 2019, Lenn and Ward 2010). The current study should present Ghana's current transport logistics as a categorical variable.

- *Transport logistics achieving food security*

According to studies by (Elik *et al*. 2019:5, Ayodele and Oluwagbenga 2023:77), road transport infrastructures are essential for improving the movement of food products to different markets. Pinto *et al.* (2023) assert that, improved all-season road infrastructure and the availability of transport services can reduce transport costs and time which are directly related to the price and quality of agricultural products, contributing to food affordability for consumers and ability of farmers to compete in the international market place. Again, it enables lower fuel consumption rates and reductions in wastage and damage of products during transportation, facilitating access to farming-related resources like fertilizers and agricultural extension

services to reach farms more easily, increasing agricultural productivity and farm income (Pinto *et al.* 2023).

According another study by Atchulo (2024) poor transportation networks hinder the timely movement of food, resulting in post-harvest losses and reduced market access, which directly affects farmers' incomes restricting farmers' investment in improved farming practices, technologies and inputs also poorly maintained mode(s) of transport, stunt agricultural productivity and food production potential in Ghana (World Bank 2022).

None of these studies were able to identify the type of conveyance that avoids food losses. Researchers discovered that the most remote districts' traditional method of delivering agricultural products was head porterage, even though alternative options included using tricycles, bicycles or motorcycles; minibuses, taxis and trucks were the most common modes of transportation. The high frequency of head porterage as a mode of transportation for farm produce can be ascribed to Ghana's inadequate road network, particularly in the more isolated districts, as well as the general absence of feeder roads that facilitate the transportation of agricultural products (e.g., Alulu *et al.* 2023:04; Britichenko 2023; Suraraksa and Shin 2019; Lenn and Ward 2010; NDPC 2010:56).

The high post-harvest losses in Ghana's agricultural supply chains are due to unavailability of transportation or farmers inability to arrange transportation to market for sales (Appiah 2024). The lack of adequate infrastructure significantly hampers agricultural activities in Ghana (Atchulo 2024). On the other side, Ayodele and Oluwagbenga (2023:77) agree that bad and unusable roads cause accidents, which in turn encourage theft and banditry on the highways, making it more difficult for food products (groceries) to go from the farm to different markets and other nearby cities.

Those involved in Ghana's agricultural value chain have bemoaned the state of the country's highways, which they believe is a major factor in the current high cost of food in urban areas. They claimed that although food costs have been declining globally for over a year, local food prices are still skyrocketing, making it harder for Ghanaians to make ends meet (Otoo and Mills 2023). In a situation like this, farmers may turn to antiquated transportation methods like donkeys and head/human porterage; however, the risk is in harvesting over long distances and

a prolonged time, which increases the chance of food deterioration, shrinkage, and loss during transit (Baumel and Hayenga 2021).

In summary, the head porterage and the car are the most common modes of road transport in the agriculture industry; nevertheless, none of them provides evidence for food security in the course of the evaluation. Farmers in other parts of Ukraine who use different types of cars are suffering significant losses. This allows for the inclusion of road transport in the body of existing literature that has empirical support for achieving food security in the modern period.

2.4.2 Contribution of Packaging Logistics to Food Security.

A coordinated system of handling, securing, distributing, storing, retailing, recovering, reusing, or disposing of goods while optimising customer value, sales, and profit is known as packaging (Anand and Popa 2022: 1, Saghir, 2002).

Above and above its primary duties of safeguarding, enclosing, and keeping the product, packaging serves a multitude of intricate purposes. The three primary categories that are covered by this definition are the environment, marketing, and logistics. An outline of the key roles of packaging is provided below:

Logistical Function	1. Make distribution easier 2. Preserve the environment and the product. 3. Give details about the environments and places
Marketing Function	4. format, graphic design 5. Lawsuit demands and advertising 6. Customer specifications and convenience for both distribution and final use
Environmental Function/ aspect	7. Recuperation and recycling 8. Dematerialization

	9. One-way toxicity versus reusable packaging

Table 2.1: Overview of different packaging functions (Anand and Popa 2022, 2016:1; Saghir 2004:6; Jonson 2000)

Logistics and packaging systems interact, support, and adjust to one another in what is known as an integrated approach to packaging. Adopting an integrated strategy would highlight the possibilities for improvement overall. Figure 2.1 identifies three distinct ways to enhance the adoption of package logistics. These strategies serve to differentiate potentials and highlight eligible opportunities.

Figure 2.3: Packaging logistics strategies (Anand and Popa, 2022:4, Saghir 2004:12)

It is essential to adapt the packaging system to the current or future logistical system to improve and enhance it.

- refining and expanding the logistical system utilizing packaging system adaptation, whether current or future (see logistics adaptation).
- altering the packaging and logistics systems to improve and develop packaging logistics (see integrated packaging logistics strategy).
- According to Aydin (2023) logistical packaging is the science, art, and technology of enclosing or protecting things for usage, sale, distribution, and storage. Packaging contains, protects, preserves, transforms, informs and sells giving us a familiar brand or package, so we can identify the contents of the package right away. Its main purpose

is for keeping the safety, wholesomeness and quality of the contents (Amponsah and Qibing 2020).

2.4.2.1 The purposes of packaging are:

- Physical Protection - Protection from shock, vibration, compression, temperature, and other factors may be necessary for the objects contained within the package.
- Barrier Protection - Oftentimes, one needs a barrier against airborne particles, water vapour dust, etc.
- Containment, also referred to as agglomeration, is the process of efficiently assembling tiny items into a single package.
- Information Transmission - Labels and packages explain how to use, transport, recycle, and discard a product or package.
- Marketing - Marketers can use the product's packaging and labels to persuade potential customers to buy it. For many years, package design has been a significant and ever-changing phenomenon.
- Security - One important factor in lowering the security concerns associated with shipping is packaging. Enhancing tamper resistance and adding tamper-evident features to packages can help prevent tampering and detect it when it occurs.
- Convenience - Features that improve package distribution, handling, presentation, sale, opening, use, reclosing, and reuse are possible.
- Portion Control - Packaging for a single serving or dosage has a set amount of ingredients to regulate consumption. It is possible to separate bulk goods, like salt, into more suited packaging for individual homes. Additionally, it helps with inventory control by, for example, offering sealed one-litre milk bottles instead of requiring customers to bring their bottles and fill them.
- Three primary goals are associated with packaging:

1. Protection: The goal of packaging industrial products, such as machinery and components, is to keep the item safe throughout transportation. However, the purpose of packaging for consumer items is more expansive.
2. Recognisability: The product needs more protection than just its package. The product must also make the specific brand, recognised and appealing to consumers because it is intended for sale in its finished state to the ultimate customers. This holds significant weight when it comes to packaged meals and other products regularly bought from supermarkets and self-service kiosks.

Here, some product brands are arranged side by side on the shelves. The colour and style of a package must grab the attention of buyers and play a big role in the promotional strategy. The product's packaging accentuates its appeal and upholds the brand name. All prior marketing efforts to set these brands apart are in vain if the packaging does not persuade the buyer to choose the branded commodity/commodity's brand in this scenario. Packaging is therefore a tool for advertising.

3. Storage and use: Proper packaging makes it easier to store and use things. Consequently, packaging may be made to make it easier for customers and members of the distribution channel to handle.

2.4.2.2 Types of packaging materials:

The industry uses a vast range of packaging materials, from low-cost, lightweight materials like cardboard boxes or plastic films to complex, reusable structures made of different packaging materials, like those used by the aviation industry to transport aircraft parts before assembly. One criterion for classification is the quantity of materials required to make each kind of packaging:

Mono-material: Those constructed from a single type of packaging material.

Multi-material: Those made of two or more different types of materials.

Mono-materials simplify the classification process, making it a vital packaging and recycling procedure. Conventional materials are mostly used for structural purposes, as was previously mentioned. On the other hand, more complex materials are used in unique applications—like with inert gases—to avoid oxidation-related degradation.

Defining packaging solutions:

The cost of the materials and the packaging process, which are frequently deciding factors in their choice, must be added as another typical attribute for selection in addition to the functional criteria of the package.

With expenses, shipping and packaging typically account for a more significant portion of the cost of each unit in sectors like the bottled water industry.

Meanwhile, it is a nearly incidental expense in technical sectors like jewelry or telecommunications. When specifying the materials utilised in a particular packaging, it is imperative to take the product's specifications into account. For liquid or gaseous products, for instance, bottles or containers are required. The following factors need to be considered while designing packaging solutions:

1. Dimensions of the item.
2. Fragility and transport dimensions.

The following are the potential dangers to the product packaging system during the distribution cycle: vibrations, shocks, falls, length of storage, and weather conditions.

However, other requirements might not be directly related to the distribution cycle that could affect the properties of packaging materials. Examples of these requirements could be marketing criteria, local legal requirements, labelling requirements, or other limitations on the choice of packaging materials because of environmental concerns. The packaging alternatives selected will depend on several factors, including the product's dimensions, fragility during transportation, risk exposure during the distribution cycle, and other requirements.

2.4.2.3 Varieties of packaging materials available.

There are multiple ways to categorise the various packing materials and the perspectives around according to Chesshir (2024)**;** Triton (2024); Onay (2023) and Sathyabama (n.d.: 8). Some examples of the types of packages are as follows:

1. Containers (bottles, carafes, and drums).
2. Stiffening materials (corners, corner pieces, etc.)
3. Grouping materials (include shrink films and grouping boxes)
4. Cushioning components (EPS blocks, airbags).
5. Points of sale (exhibitors, SRP).
6. Materials that block light (such as those used in lampshades, etc.)
7. Materials for extending the life cycle of a product (barrier materials, active packaging).

Shipping material solutions are typically used for tertiary packaging. Typically, it consists of cardboard handles, plastic appliqués, ropes, and other materials, along with wooden and plastic pallets. In tertiary packing, it is typical to use plastic or metal slings or straps to gather items and cases to protect them from bad weather, dust, sunlight, or even pests.

Contemporary packaging offers what is referred to as active packaging, among other things, the future is already here and here to stay. Some goals of contemporary packaging are as follows:

1. By lowering theft incidences, they can make trade more secure.
2. They can provide information as well. When a product reaches the proper temperature for consumption, for example, some active packaging can change colour.

3. Others increase the content's information or send users to places to check the product's information.

The appearance of microorganisms in products that require sanitation is one of the characteristics of modern active packaging. By utilising compounds that trap deteriorating elements or subjecting things to altered atmospheres, it is also possible to lengthen the product's life cycle. Materials for very advanced packaging, particularly nano-materials like silver, are employed with this objective in mind. With the advancement of 3D printing technology, customised solutions, mostly cushioning materials, product supports, or even specific packages are starting to be developed for products with lesser circulation. Reduced circulation products are beginning to receive customised solutions, primarily in the form of cushioning materials, product supports, or even special packaging.

The supply chain will benefit from innovations in packaging technology, but more will be required for optimal storage, leading to food shortages and higher pricing. Given the dire circumstances, the FOA (2021) has called for an increase in food products that are abundant in all essential micronutrients, readily available in sufficient quantities, and year-round accessible to people.

2.4.3 Relationship Between Logistics Management and Food Security in Ghana

Incorporating elements of creative management into food security while fully using its true meaning, the term "logistics" has gained popularity recently. Supply chain management, or SCM, and logistics are closely related nomenclatures, which is why they are commonly confused. The coordination of procedures and operations within and within the fields of information technology, finance, product design, marketing, and sales is fueled by supply chain management.

In the context of food production, Logistics management includes everything from seed selection and procurement to field planning and resource allocation, to harvest scheduling and product distribution (Driver 2023). Logistics management, generally is the part of the supply chain that organises, carries out, and regulates the storage, forward, and reverse flow of goods, services, and related data between the point of origin and the point of consumption to satisfy

the needs of the consumer (Rouse 2018; CSCMP n.d.). Thus, the process of planning, implementing, and controlling the efficient, effective flow of goods" (Moshen 2022; Puri 2022). Logistics management is essentially the organisation and upkeep of each asset in the logistics process to ensure that the values of products and assets are maintained and can generate profits or returns for the corporation (Anwar *et al.* 2023: 692–692).

Every person agrees that reducing food loss and waste will strengthen food systems' sustainability, improve food security, and prevent costs from accumulating across the food supply chain (Russel 2022: 32). According to Anwar *et al*. (2023:691), businesses including farms can effectively control supply networks, like the food supply chain, by putting in place a robust logistics and supply chain management system. Puri (2022) states that supply chain management (SCM) is a broader notion and scope encompassing logistics activities exclusively while logistics management is a subdivision of supply chain management (Anwar *et al.* 2023) Two major categories can be used to categorise logistics or logistical activities:

I. Inbound logistics - Inbound logistics ensures that supplies arrive at the manufacturing site efficiently and cost-effectively. These supplies include materials and other inputs from suppliers. The procedures involved in placing an order, receiving, storing, transporting, and managing incoming materials are known as inbound logistics. Effective management of inbound logistics requires ongoing communication with suppliers.

II. Outbound logistics (physical distribution management) – Moving completed goods and other pertinent data from the company to the client is the main goal of outbound logistics. It alludes to the operations related to moving products from the warehouse, storing completed goods, and delivering goods to clients or other companies.

To effectively manage outbound logistics, management must be in continual touch with distribution networks and transit suppliers.

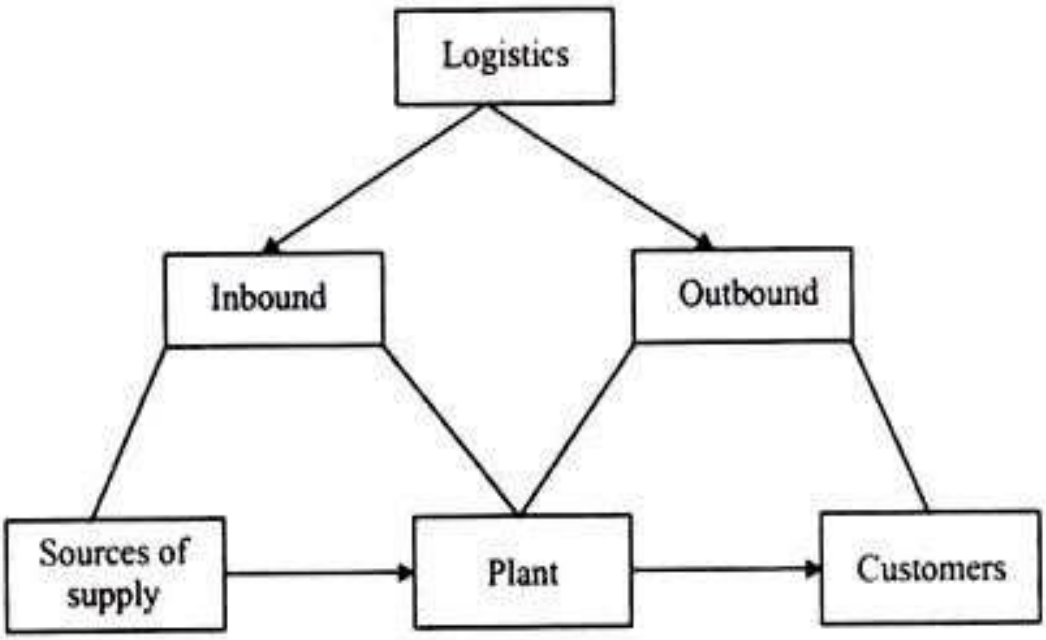


Figure 2.4 Scope of logistical Activities (Sathyabama n.d.: 5).

Logistics management is essential to the agriculture industry, which plays a key role in food production and security as an article titled ‘‘the impact of Logistics on four dimensions of food security in developing countries’’ by Subramaniam, Masron and Naseem in 2022, observed that improvement of all food security dimensions can be attained, bettering logistics, furthermore, countries with a higher logistics performance level are improving in the level of food security, thus managing logistics better. Then, Driver (2022) emphasises in their paper "the Role of Logistics Management in the Agri-Business" that the agricultural sector is the foundation of many economies because it produces food and raw materials for other businesses. Nonetheless, the industry frequently faces challenges and concerns related to logistics. One of the most important issues in lowering hunger and improving food security is food waste. Up until recently, the focus has primarily been on boosting output; yet, minimising losses in the food supply chain has received less attention. Production setbacks, cost increases, and even product spoiling can result from ineffective logistics.

A more sustainable food system must prioritise increasing the effectiveness of agricultural logistics. Driver (2022) lists a few methods to do this.

- To understand the performance of your supply chain, use powerful data analytics. Additionally, equip whatever you travel with GPS tracking.
- Employ a variety of supply chain optimisation techniques, such as automation and digital technologies, in addition to on-farm activities like animal health management and field management.
- Enhance productivity by using distribution, inventory, and transportation strategies that reduce shipping costs and the time it takes to receive goods or services from suppliers or clients.
- Improve the coordination of accounting, acquisition, production, and logistics management departments as well as with suppliers and consumers following their needs (i.e., seasonal fluctuations) to optimise logistical operations. Remember cold chain logistics: if you can get your food into stores sooner, it may be able to sell. You could also save money on needless shipping expenses and losses from spoiling or other issues (such as refrigeration problems) along the way. This study is interested in inbound operations related to transportation, storage, and packaging.

The following justifies the significance of logistics management:

2.4.3.1 Cost Reduction and Profit Maximisation:

It accomplishes these goals mainly because of:

1. Improved material handling
2. Quick, affordable, and safe transit
3. The ideal quantity and arrangement of warehouses, etc.

2.4.3.2 Efficient Flow of Manufacturing Operations:

Owing to timely material delivery and appropriate use of raw materials and semi-finished items in the production process, inbound logistics contributes to the smooth operation of manufacturing processes.

Competitive Edge: An organization's competitive edge is created, preserved, and enhanced via logistics through:

1. Increasing revenue by offering superior customer support
2. Making plans for a dependable and quick delivery
3. Preventing order processing mistakes, among others.

Effective Communication System: For effective logistics management, a reliable information system is required. Therefore, logistics management aids in the creation of an efficient communication network for ongoing supplier interaction and quick customer service. **Sound Inventory Management:** Effective logistics management leads to sound inventory management. Ensuring proper inventory management is a problem that logistics management solves, which is a big pain point for production, financial, and other management disciplines.

2.4.4 The Influence of Warehousing on Food Security

Like other storage structures, a warehouse is a place used to store items//inventory (Sathyabama n.d.:2) Most tasks that occur in a warehouse are related to goods management. Furthermore, warehouses are large facilities for the regulated and supervised movement of commodities (Union Galvasteel Company 2022). In Ghana traditional/ village methods of grain storage are done temporary or long-term. With the temporary, storage of grain can be by aerial, ground, or on drying floors and open timber platforms. Then with the long-term, storage of grain can be by baskets, calabash, gourds, earthenware pots, jars and solid wall bins (FAO n. d.). According to Arthur *et al.* (2023) hermetic bags and cold storage are the modern methods for grain storage in Ghana.

Annual production of grains exceeds two billion tonnes worldwide. At various points in the grain distribution chain, these grains are kept in designated spaces like bags, silos, warehouses, containers, and even ground mounds. You can treat a single unit or a collection of units as artificial ecosystems, with interactions between physical, chemical, and biological elements causing the stored grain to deteriorate. In the agricultural sector, proper storage is crucial because it makes seasonal items year-round available, protecting farmers' or businesses' revenue flow while lowering the risk of food spoiling or pest infestation. Safe storage prolongs the shelf--lives of products, which helps reduce hunger worldwide.

Ghana acknowledges the importance of storage and has started working pragmatically to find a solution. To guarantee food security and protect farmers from losses brought on by projected increases in production, the National Food Buffer Stock Company (NAFCO) was most recently established in March 2010. After the Ghana Food Distribution Corporation (GFDC), which

was responsible for the majority of the excess food that Ghanaian farmers generated going to waste, collapsed, NAFCO now operates four-pack homes in three districts. The Ghana Commodity Exchange (GCX), an electronic marketplace governed by the Securities and Exchange Commission (SEC) that allows buyers and sellers of agricultural products and other commodities to trade efficaciously and orderly within predetermined guidelines, is the most recent intervention to minimise PHL. There is a chamber under the GCX that guarantees farmers access to the market while also serving as a place for storage. Because it is supported by a Warehouse Receipt System (WRS), farmers can be guaranteed that the commodities stored there are of the right quality and quantity.

There has also been the introduction of a controlled Warehouse Receipt System (WRS) project endeavour The Swiss State Secretariat for Economic Affairs (SECO) is funding the implementation of this controlled WRS project by International Finance Corporation (IFC)/World Bank Group as a financial inclusion programme, which aims to help farmers get access to credit and a market for their chosen harvests. Given that farmers often require access to market information and are unable to adequately cope with/repurpose the excess produced during harvest, it is projected that they may decide to delay sales until the market becomes more profitable. That has not always been the case, though. Low farm-gate prices, less income for impoverished households and smallholder farmers, and increased risk of food insecurity are the outcomes of a glut.

Some of these issues can be resolved by a properly administered Warehouse Receipt System (WRS), as intended with the IPEP. The increase in net yields that follow encourages greater production, which raises returns and improves farmers' quality of life. In Africa's agricultural value chain, warehouse receipt systems are becoming more and more common. They are now used in Ghana, Nigeria, Tanzania, Ethiopia, and Kenya. When agricultural commodities are kept in a warehouse and adhere to certain storage and retrieval requirements, they become the property of the institution holding the WRS financial instrument. Warehouse receipts can serve as security for loans to farmers if they are negotiable. These loans give farmers cash flow during harvest and allow them to keep their products safely in warehouses for subsequent sale at a greater price later in the marketing year.

Development experts praise warehouse receipts for offering a practical answer to the marketing challenges African small-holders encounter. According to a pilot study conducted by the

International Fund for Agricultural Development (IFAD), Tanzania saw a 300 percent rise in farm gate prices after a WRS was implemented. The main justification for a WRS is that farmers would have to sell their produce during harvest when prices are often at their lowest owing to temporary excess considerations if there were no inexpensive and safe storage methods for agricultural commodities. According to Sarfo *et al.* (2023); USAID (2013); Onumah (2010) and Weisemann (2000), one of the more basic marketing issues marginal agricultural farmers in the developing world experience is inter-seasonal price instability. In theory, warehouse receipt financing solves this problem by ensuring food security through the safe storage of crops that would be used as collateral for loans to help with family needs and crop financing. However, development economists and practitioners have yet to see the smallholders reap the rewards hoped for from warehouse receipt finance. Present-day warehouse receipt financing users in Africa are primarily large traders, processors, and exporters. Only a limited number of smallholders who are involved in the industrial value chain for processed foods have, at most, indirectly profited from the programme.

According to the minister of agriculture in 2022, several farmers expressed dissatisfaction over massive debts they incurred as a result of their inability to sell output on schedule due to lack of warehouses to hold the products until they found purchasers. He asserted that finished IPEP warehouses would allow farmers to increase good marketing, decrease post-harvest losses, store enough food, and improve farmer incomes.

There is an indication that there is a market need for throughput centres close to market centres, whether new warehouse building or renovation. In the north, storage facilities have enough space to meet demand, but there is a shortage of "supply near market" centres, which drives up rents and puts pressure on privately owned facilities.

Long-term storage-focused facilities, however, appear optional. From temporal speculation producers and dealers in northern Ghana, for example, have not profited in recent years, a tendency that seems to be structural, this is especially true concerning maize. Traders are understandably cautious due to government interference (NAFCO and other procurement programmes, as well as unpredictable trade policy and intermittent market involvement). In addition, the distinct timing of the staggered maize harvests in the north and south implies that, for example, there is market pressure on northern farmers to ship their harvested grain south, and the staggered harvests result in comparatively stable pricing all year round.

Smallholders play the market as they often store grain to take advantage of market fluctuations, however farmers especially in northern Ghana desire to feel secured about the purchaser of their grain (Ghana News Agency 2023). One of the factors contributing to the success of certain well-managed trader-driven out-grower models in the north is producer preference.

Outside producers' preferences lay the truth that demand for warehousing continues to outstrip supply even at the industrial level. In 2022, the Logistics Managers Index (LMI) reported that warehouse capacity registered the lowest value among all the indicators for the second time in a row. There is an actual demand for larger warehouses and facilities for client fulfilment, particularly in Kumasi and the industrial zones of Accra and Tema (Quansah, Boso, and Muntaka 2022:3). As a result, companies are putting in maximum effort to utilise limited available warehousing spaces efficiently. The need for efficient warehouses is apparent in studies. Four kinds of warehouses exist, public warehouses, private warehouses, distribution centres and cross-docking facilities (Subaih 2023)

According to Subaih (2023), American Warehouses (2023), and Michael (1999), public warehouses are duty-paid warehouses. Because most businesses cannot afford to maintain their perfect warehouses due to the huge capital cost, public warehouses are very helpful to the business community. Losses during surpluses and spoiling of extra produce have always been the results for such deprivation. Despite being a public institution, not much was known about the IPEP warehouse until a recent study. To attain food security in Ghana, Boakye (2019:1) discusses cultural behaviours that support the effective management of warehouses. After thoroughly examining, the researcher suggested conducting an experimental study using the IPEP model. Grain storage is known to occur at several points in the distribution chain and takes place in designated spaces such as silos, warehouses, bags, containers, and even ground mounds. The following theory is based on pundits' opinions that efficient grain storage affects everyone's life and helps to reduce total food losses for small-holder farmers (Ghana News Agency, 2023):

2.4.4.1 Infrastructure for Poverty Eradication Programme (IPEP)

The Ministry for Special Development Initiatives, through the IPEP programme, establishes the framework for allocating special funds, valued at one million US dollars annually, to each of the 275 constituencies in the nation for use in priority initiatives like one village, one dam, one district, and one warehouse (www.msdi.gov.gh).

With the introduction of the government's flagship policy, "Planting for Food and Jobs (PF&J)," in April 2019, the IPEP officially began. Grain was a key component of the PF&J's 2017 implementation, and domestic grain cultivation rose noticeably.

The country reaffirmed the government's plan to build "1-District-1-Warehouses," or warehouses with a 1,000 metric tonnes capacity, in each of Ghana's 216 districts. Under the "Planting for Food and Jobs" project, the warehouses are meant to hold products and serve as storage for any surpluses that may arise (Ministry of Special Development Initiative, n.d.).

2.4.4.2 Operation of the Warehouse

According to reports, the warehouses' construction was done to enhance agricultural commodity selling as well as reduce PHL, all in line with Ghana's Global Food Security Strategy (GFSS). To solve subpar farming methods, handling, and storage techniques that expose farm food to moulds, mice, and other pests, the warehouses are set to be equipped with contemporary machinery, such as freezing or drying systems. For the warehouses to take part in the Warehouse Receipting System, which was put into place as part of the Ghana Commodities Exchange project, they needed to be accredited.

The purpose of this method was to encourage smallholder farmers' financial inclusion. The Warehouse Receipt System will allow the farmers to store their agricultural products and utilise them in a variety of ways to meet their financial demands. It is anticipated that many smallholder farmers will no longer be forced to sell their agricultural produce as soon as it is harvested if the Warehouse Receipt System is successfully implemented, particularly during times when market prices are often low. This will assist in addressing price volatility concerns even more. According to the president, the warehouses also help Ghana's non-traditional exports since they allow farmers to effectively and efficiently store their produce, which enables them to export, generate income, and earn foreign exchange (Ministry of Special Development Initiative n. d.).

2.4.4.3 Warehouse Receipts in Africa and the Use of Technology

Warehouse receipts are either paper or electronic titles that list the goods deposited in the warehouse together with their location, ownership, quality rating, and description. Transferable or non-transferable receipts are both possible. Transferable warehouse receipts let the owner pass ownership to another person if they can access the title. If a title is non-transferable, someone has to go through a certain procedure, frequently overseen by a regulator, to transfer ownership. Regulator-certified warehouses are often the ones that issue warehouse receipts, and the regulator oversees the procedures that handle their issuance, management, liens, and cancellation. In a commodities exchange, the receipts can be used to facilitate transactions between buyers and sellers. The receipts can serve as a stand-in for the actual items, which can be relocated once the transaction is over from warehouses. ICT gains value with rising transaction volumes. To increase transaction speeds and enable round-the-clock trading, a WRS largely uses ICT (unconventional techniques and technologies).

An overview of the Warehouse Receipt System (WRS) experiences in five Sub-Saharan African countries—Ghana, Tanzania, Ethiopia, Côte d'Ivoire, and Uganda, reveals that Tanzania possesses one of the continent's most sophisticated WRSs. Consider the late 1990s, when WRS for coffee first appeared. The system handles between 25 and 30 percent of the nation's exported coffee crop (UNCTAD 2020, 2009). North Tanzania has long utilised the Warehouse Receipt System for cotton. This enables farmers to produce more and make more money. An attempt to implement microfinance-linked WRS for grains as a pilot project failed. The primary causes of this failure were government actions, including export limits on maize, and farmers' incapacity to forecast changes in prices. Nonetheless, the technique has been effective in paddy rice aggregation, as prices are typically more stable. Banks decided to finance the crops because of the paddy rice WRS's success. As the top bank financing paddy rice WRS, the Co-operative Rural Development Bank (CRDB) states that the loans in its portfolio total TSH 2.9 billion, or roughly 10,000 tonnes of paddy rice (UNCTAD 2020,2009).

To guarantee effective WRS operations, Tanzania established institutional frameworks throughout their commodities value chain. These function at the primary production levels and in villages. To guarantee that farmers and end users gain from the WRS, they work together

harmoniously. Players at the village level are in charge of gathering goods at the farm gate. Agrégation of commodities and quality standard adherence fall under the purview of the main-level participants. To provide farmers with agricultural inputs and markets agricultural produce, the main stakeholders at the primary and village levels established Agricultural Marketing Cooperatives (AMCOs). In addition, these cooperatives provide transportation, insurance, and finance services. For instance, AMCOs in the cashew nut subsector borrow money from banks to pool raw cashew nuts for sale in an auction that includes thirty exporters and processors. According to estimates, AMCOs need to finance $85 million worth of merchandise each season (CRDC 2021; FAO 2014). The largest private bank in Tanzania, CRDB, is the top financial institution in WRS. AMCOs, who oversee Tanzania's agricultural production, processing, marketing, and transportation, are other important participants.

Ethiopia primarily employs the Warehouse Receipt System (WRS) to finance the export of cash crops and deliver and pay its commodities exchange. Warehouse managers provide an electronic warehouse receipt to customers upon receiving products at the warehouse. It is theoretically possible to trade the receipt on the exchange or use it as collateral for loans from banks. The low expiration dates on the receipts, 30 days maximum for coffee and 60 days for sesame and pea beans, do not, however, promote long-term storage (IFC 2022; AFD, CTA AND IFAD 2014). This policy restricts the collateral usage of WRS receipts. According to the International Finance Corporation (IFC), in 42 borrowers obtained credit through the WRS in 2012, 122 warehouse receipts were issued, and 114 disbursements were made (IFC 2022). The WRS's brief certification period in Ethiopia deters long-term storage. Farmers cannot postpone sales to receive greater prices due to this policy. For the majority of commodities kept in Ethiopian WRS, the main sales channel is the Ethiopia Commodity Exchange (ECX). To improve coffee's marketing and grading procedures across the country, the Ethiopian government founded the Ethiopian Commodity Exchange (ECX) in 2008. Addressing issues of Ethiopia's coffee industry and reducing poverty by raising producer incomes are the primary goals of ECX. The ECX (which took the place of the previous auction centres) has been the gateway for all commercialised coffee in Ethiopia since October 2008, and it grades coffee according to official criteria. When selling green coffee, growers, cooperatives, or dealers are required to transport it to one of the 14 ECX warehouses situated throughout the growing regions.

Collateral managers are the main participants in field storage activities by big trading corporations involved in exporting, and there are no public warehouses or computerised warehouse receipts in Ivory Coast. The World Bank Group and commercial players are helping the government, though, as it develops a warehouse receipts system. Cashew nuts are the project's intended starting point. Cashew production in the nation is increasing. According to CAS (2024) the annual production of cashew is 45,000 tonnes in Ivory Coast, making it the world's second-largest producer, behind India. Utilisng aggregation and public storage, the nation aims to enhance the local processing of raw materials and provide access to these services for farmers and co-operatives. The government has collaborated with the IFC and industry participants to write the Warehouse Receipts Bill, which will regulate public warehousing. A wide range of stakeholders, including banks, insurance firms, producers, co-operatives, processors, collateral managers, and ministries of trade, industry, and finance, have evaluated and helped develop the bill. Following the implementation of the WRS, the nation intends to develop a commodity exchange.

Farmers who deliver their produce to approved warehouses in Uganda, receive warehouse receipts. The farmer may apply for bank loans using the receipts. Lending limits set by banks often range from 60 per cent to 70 per cent of the warehouse receipts' total value (Katunze, Kuteesa, Mijubi and Mahebe 2017). Banks have different policies on this, however. The data in the warehouse receipts is published by the Uganda Commodities Exchange (UCE). Subsequently, the UCE releases the weekly pricing and available quantities of commodities in the press. The UCE traded without a network of approved warehouses until 2006. Exchange employees would usually physically sample the goods being offered for sale to verify their quality and quantity. This may have been a more dependable and efficient approach that resulted in contract non-performance, especially from sellers, which weakened trust in the UCE and caused trading volumes to be shallow (with only 11 contracts transacted between March 2002 and June 2004). To improve its viability, the EC supported the restructuring of the UCE. The Common Fund for Commodities (CFC) financed a project in which the UCE created a warehouse (WRS) for cotton and coffee. This process allowed the government to implement warehouse legislation, which regarded warehouse receipts as negotiable evidence of title. The Ministry of Trade assigned the UCE to provide regulatory monitoring of the receipt system, which Uganda also implemented. The UCE was unable to attain operational viability and ultimately failed despite all these efforts and investments. WRS is operational in Malawi,

Madagascar, and Mozambique, even though the creation of infrastructure and a regulatory framework is ongoing.

2.4.4.2 Ghana's WRS and Current State of The IPEP Warehouse.

The Agricultural Development Bank (ADB) and Barclays Bank Ghana Limited provided funding for state-owned storage facilities run by the Ghana Food Distribution Corporation (GFDC), and the unrestricted warehouse inventory credit that the government of Ghana had started in the early 1990s marked the beginning of Ghana's warehouse receipt system. Initially, the system just recorded the amount of grain in storage on the receipts that farmers (mostly nucleus farmers) and traders received when they stored their grains in public warehouses. A steady increase in finance and deposits led to 5,500 MT in 1996 (USAID 2018). At first, the value chain and supply of grains expanded as well. Less than a year later, the new warehouse inventory credit system failed. A deficiency of insurance coverage and inadequate stock security were among the operating problems. Ad hoc government interventions on import taxes at the national level decreased the possibility of price increases later in the season when market supply was limited. A group of grain-related enterprises in Ghana (farmers, traders, processors, and financial institutions) established the Ghana Grains Council (GGC) in 2008 as a controlled cooperative warehouse receipt system, with funding from USAID projects (Agribusiness and Trade Promotion (ATP) and Agricultural Development and Value Chain Enhancement (ADVANCE)). The goal of the GGC was to support commercialisation by enhancing production and quality through value-chain interventions in grains. Its primary objectives were to:

i. Create an operational organisation,
ii. oversee the creation of a better method for storing grains,
iii. Become a well-known, impartial defender of the grain system, assisting in the growth of a positive public-private conversation.
iv. Assist smallholders in integrating into markets with increased competition.

To comply with Ghanaian contract law, the GGC, which serves as both the certifying and regulatory body, established a controlled warehouse receipt system in 2012. With a total storage capacity of 2,480 mt and 54,600 mt, respectively, the GGC had 22 community warehouses and 12 certified warehouses in the Northern Region by 2019 (GGC, 2019). Under norms and

regulations devised and authorised by members, the cooperative runs the warehouse receipt system. All participants must register and follow these guidelines. A variety of value chain participants are included in membership, such as banks, traders, producer associations, and grain and agricultural corporations. They collaborate in a special way to create markets for Ghana's grains.

The issue of GGC warehouse receipts is subject to numerous regulations. The principal prerequisites consist of:

i. Grain storage in the approved warehouse is permitted for a maximum of five (5) months. The minimum volume required to be eligible for a warehouse receipt is around fifty bags (50 kg bag sizes).
ii. Grain that needs more drying or cleaning cannot be given a GGC Warehouse Receipt.

Smallholder farmers cannot participate individually due to these constraints; instead, they must organise into groups. The Ghana WRS now involves a large number of important players. First, there is no connection between the WRS and the recently established Ghana Commodity Exchange. The largest aggregators, farmer-based groups, warehouse operators, processors, input suppliers, insurance companies, banks, and non-bank financial institutions are among the more than 120 active actors in the Ghanaian WRS. According to the IPEP, smallholder farmers in Ghana have not participated directly in WRS for decades.

The effort looks promising, though the Government’s programmes have suffered inefficiencies over the years, and it seems the IPEP will not differ. An early examination of the warehouses from the chosen regions, the upper west (Nadowli-Kaleo) and upper east (Garu), does not suggest that adjustments will be made soon.

First, a 1500mt warehouse in the Garu region has unappealing resources; the space capacity has already developed some cracks, and the facility is under-equipped. The warehouse has a cleaning machine made dormant due to a lack of electricity and the available administrative block is devoid of appropriate furniture.

The warehouse

Cleaner Machine

Zerofly Hermatic bag

Inside

Sample stocks stored on ground

Sample stocks on a wooden pallet. Saved in normal sack

Packaging material being used with the normal sack

Garu multigrain Warehouse –Authors Preliminary survey (2023)

The state of Nadowli-Kaleo district's 250mt warehouse at Doung was no different, having unappealing resources.

The warehouse

Stocks found in normal sack

Inside

Packaging material
used with normal sack

Nadowli-Kaleo multigrain warehouse at 'Doung'–Authors Preliminary survey (2023)

If this is the case in multiple districts, one cannot be sure that Ghana is running an excellent WRS with the IPEP. The warehouses are now under-resourced and plagued by a lax culture of upkeep, further depleting already scarce resources. According to the review, Tanzania has one of the most complex WRS as per the IPEP targets. The AMCOs are one of the WRS actors responsible for growing, processing, transporting, and marketing various crops in Tanzania. In contrast, farmers sell their extra produce quickly after harvest to pay for most of their food expenses later (de Jager *et al.* 2018). The scenario is revolting because one would expect the warehouse to have a legitimate stake in coordinating other logistics systems to keep farmers' surpluses. It is thence obscured justifying the set theory in the context of the IPEP until tested.

2.4.5 Logistics Challenges Affecting Agricultural Food Security

The unintentional introduction of the storage pest Prostephanus truncates, or Larger Grain Borer (LGB), into Eastern and Western Africa in the late 1970s and early 1980s has resulted in escalating post-harvest maize losses in Sub-Saharan Africa reaching the highest level in recent history (Jones *et al*. 2019:1; Jones *et al.* 2011). With limited use of modern equipment or fertiliser, small-scale farmers rely heavily on rainfall patterns to increase harvests. Consequently, there are 10 to 12 percent post-harvest losses before crops reach markets since most post-harvest systems are either nonexistent or inoperable. Returns to smallholder farmers are severely constrained by some other value chain concerns. These include adequate storage systems, high transport costs, limited market access, and poor finance access. An absence of transparent market information leads to spatial price distortions and high inter-seasonal price variability. A need for proper storage, transport and a low level of knowledge on modern ways of advancing agricultural business, especially with IT, is contributing to PHL (Jones *et al.* 2019:1)

Most developing countries are unsupportive of small-scale grain producers, and due to the inability of many small-scale grain producers to access modern technologies and facilities they, end up mishandling produce logistically like mishandling grain production by storing in containers with no weather fluctuations control (Ariong, *et al.* 2023)

According to Ariong *et al.* (2023) and Erden, Dellal, and Bayramoğlu (2017:20), farmers' traditional methods, habits, and practices are the biggest cause of losses in the agricultural production stage. Farmers who are unwilling to look for information on agricultural output often lose out. Moreover, as young individuals from rural areas are inclined to migrate to urban areas and desire to work in fields other than agriculture, older people typically engage in agricultural production. Older farmers are uncomfortable embracing and using new technologies because they want to stick to agricultural techniques, they learnt from earlier generations rather than keeping up with the times.

Another factor contributing to food losses at this point in the agricultural production process could be the lack of intermediate staff.

Low precipitation and dry farming across large areas of land are two other major contributing factors. Reducing losses, particularly in cereals, will require increasing irrigated farming and making investments to guarantee more effective and efficient irrigation water usage. The special factor in this case was the lack of funding for pertinent logistics, which led to distortions in PHL's management.

Tuffa (2019) and Tuffa, Amentae and Gebresenbet (2017:17) have contended that inadequate processing techniques, perishable packaging materials, subpar transportation, and unsuitable storage and market circumstances are the primary causes of food loss in other parts of Ethiopia. The main obstacles found in the chain were inadequate information exchange, a lack of collaboration among participants, inadequate road and warehouse services, and inadequate regulations about the Warqe food market.

Stepping into the debate are Ariong *et al.* (2023); Yeshiwas and Tadele (2021) and Pawlak (2017:12-13) to prove that food losses occur mainly at the early stages of the food supply chain (agricultural production, post-harvest handling, and storage) in developing countries. In general, this is related to the low level of technological advancement in agricultural production, inappropriate storage conditions, no refrigeration equipment, and lack of transport infrastructure (Russell 2022; Sri *et al.* 2022; Ishangulyyev, Kim and Lee 2019). Rich/high-income or developed countries waste food the most which occurs at sales and consumer levels rather (Safdie 2023; Russel 2022: 6; Sri *et al.* 2022: 1873). Food overproduction and unfavourable consumer behaviours are among the other causes of this (Onwude *et al*. 2020; Ishangulyyev, Kim and Lee 2019). In light of the aforementioned information, it is important to emphasise that improving global food security will require a collaborative effort by farmers, the food business, merchants, and consumers using resource-efficient production methods, sustainable food choices, and decreased food waste (Ariong *et al.* 2023, Pawlak 2017:12-13, EC 2011)

The majority of logistics studies were carried out in many locations, including Africa, and cannot be applied to national context-specific problems. According to one suggestion, inadequate processing techniques were once considered a logistical difficulty in the agriculture industry and correlated with low investment (Elik *et al.* 2019: 30, Erden, Dellal and Bayramoğlu 2017:20), in Turkey. Storage issues and a lack of knowledge (e.g., on market conditions) and transport (Jones *et al.* 2019:1; Erden, Dellal and Bayramoğlu 2017:20), remain

upstanding, whilst packaging (Garba 2023; Roy *et al.* 2023; Versino *et al.* 2023; Shoue Chen *et al.* 2020) issues highlighted crave for further research. Key factors are brought forth in literature; like Jones *et al.* (2019:1); Erden, Dellal, and Bayramoğlu (2017:20) and Pawlak (2017:13), agree that storage issues, a lack of knowledge, and inefficiencies in transport infrastructure cause PHL.

In summary, Russell (2022), Onwude *et al.* (2020), and Erden, Dellal, and Bayramoğlu (2017:20) assert that the adoption of new technologies by supply chain enterprises and recent advancements in transportation, processing, and storage technologies have contributed to a decrease in losses. However, at present, there is no significant proof in Ghana. The scholars, again, stereotyped their work with no specific crop in mind to pinpoint the exact constraints facing small firms, but the review proves that logistics challenges overwhelming smallholder farmers/ firms involve storage issues, knowledge deficiency, and transport in the agricultural industry (Jones *et al.* 2019:1; Erden, Dellal, and Bayramoğlu 2017:20). These along with other subjective variables will then be tested.

2.4.6 Framework for Sustainable Improvement in Logistics Management in the Food Industry.

A nation must implement an integrated policy to guarantee that, all populations have physical and financial access to enough food to meet their dietary needs. Globalisation, the food system's evolving nature, and the growing acknowledgement of previous policies' ineffectiveness have also influenced the necessity for policy changes. The idea that the food system should be practical and competitive in a more competitive environment is one of the main elements contributing to the creation of these ideas, (Aji 2020:7, 8).

2.4.6.1 Improving the operations of a warehouse receipt system.

WRSs and CEXs have incorporated information technology to enable 24-hour trade and transition from paper-based administration to electronic systems. This shortens transaction times, under a paper-based warehouse receipt paradigm, ownership transfer could take up to 14 days, and, in cases of large quantities, lowers back-office administrative expenses. Remote traders can also take part in a CEX by using ICT. Only Ethiopia, Uganda, and South Africa, three of the roughly six WRSs in sub-Saharan Africa, use electronic receipts and linkages to CEXs; Ghana and Kenya, on the other hand, plan to make investments in electronic systems.

Software: Connected financial spreadsheets and more sophisticated software are among the software applications created for CEXs. The software might be off-the-shelf (i.e., created for and utilised by several users) or custom-developed (i.e., UCE) or a mix of the two. Cost estimates begin at approximately $80,000 in either case. The majority of the software engineering know-how come from outside of Africa or within South Africa (such as Sandbox Projects, which created software for SAFEX and UCE). The ECX developed their system locally, and ACE is developing the extra World Food Programme (WFP) ICT platform that connects ACE and ZAMACE utilising local talent. In reality, the ACE assisted its first WFP acquisition which was successful by projecting a straightforward spreadsheet onto a screen for simultaneous viewing by all bidders and the WFP representative. After submitting their written offers on paper forms for evaluation by the ACE representative, the bidders gave them to the spreadsheet updater. Here's an example of how minimal technology can help introduce new trade processes and have a big effect on bidders. Prior to this, the WFP employed a closed paper tender procedure (with extra limitations on bidders), and vendors were not allowed to raise their offers in response to what rivals were bidding. This fundamental ICT approach's worst flaw was how almost difficult it was for bidders from other places to participate in the process. Utilising software, the WRSs oversee a secure interface that connects the financial institution with a lien on the receipts, the buyer, the owner, and the warehouse receipt issuer.

Telecommunications: When using electronic receipts, WRSs send title documents online to banks, buyers, and owners, and, if necessary, to a central register that keeps track of ownership transfers, liens for financial transactions, and location-based stock reconciliation. Such electronic transactions can be exchanged through relatively inexpensive data exchanges via cell phone networks, the majority of which now offer internet access, as they do not require broadband internet connection. Any system must have protections built in to ensure that data transfers have been performed properly, given the possibility of losing connectivity (this is a normal procedure for reliable software programmes that rely on telecommunications). Exchanges can also provide market pricing information to producers or merchants in remote areas using SMS (text messaging via cell phones).

To register warehouse receipts with the regulator, for instance, Kenya's WRS communicates with warehouse receipt owners via SMS. To distribute pricing information, the Ethiopian ECX uses SMS codes. At the moment, these technologies are basic and not intended to send users information based on their profiles. A high-volume, well-functioning commodity exchange will

produce standardised pricing data that the market can use. African exchanges, except for SAFEX, do not currently trade enough staples in sufficient quantities to provide a strong system for price discovery. Despite having websites, none of the CEXs in Africa are using them for economic purposes. For each given commodity, real-time (or nearly real-time) reporting of bids, offers, and trade prices is available to traders who are not close to the CEX through online access. Additionally, Ethiopia's ECX offers electronic feeds of prices that have changed across the country's markets. Different kinds of brokers can access trading platforms. These brokers can do so virtually or physically in pits at exchange locations where they trade with one another on behalf of their clients.

Radio and television: When educating people about CEXs and WRSs, including how to collaborate with these new market institutions and distribute traded prices by commodity, radio and television can be quite beneficial. For this kind of thing, the ECX uses television while the UCE uses radio. There is currently no information available in Africa demonstrating how ICT applied to commodity exchanges and warehouse receipt systems benefits smallholder farmers or boosts the competitiveness of the continent's agricultural commodity value chains.
Systems for uniform grading and weighting, uniform storage facilities, expert storage management, appropriate insurance products, enforceable uniform contracts, and market research are essential preconditions for WRSs and CEXs.

It is crucial to have a reliable regulator who makes sure that the systems are open and that users follow the regulations. Either a government agency or a private company may serve as the regulator; nevertheless, it must be free from outside interference and fully trusted by the private sector (especially the banking industry). There are more essential criteria.

- Volume: Approximations differ, but in Africa, a self-sustaining WRS would need to recover costs beyond 120,000 metric tonnes at the very least. For instance, the EAGC Kenyan Warehouse Receipt Programme calculates that 150,000 mt will be required to pay the expense of system regulation, which includes staffing and routine warehouse inspections.
- Periodic Price Increases for the Seasons. In most seasons, the commodity price should rise from harvest to later in the season to offset the extra expenses of financing and depositing the product in a regulated warehouse receipt programme, which includes processing, storage, and regulation.

- The use of ICT-enabled WRSs and CEXs, which are only permitted in countries where electronic documents and transactions are legally enforceable, will negate much of the benefits that electronic receipts offer in terms of faster transaction speeds. Electronic transactions are recognised as legal.

In Africa, the only countries that accept electronic warehouse receipts are Ethiopia, Uganda, and South Africa. To settle future contracts, SAFEX declared in 2004 that it would accept both paper and computerised warehouse receipts. This came about following the clarification of the legal force of agreements reached by data messages by the Electronic Communications and Transaction Act (ECTA). Old preferences persist, despite discussions about covering more commodities.

In emerging markets, WRSs and CEXs have been particularly effective in India, according to (GGC 2019; USAID 2010:6), where there is infrastructure, a high level of rural education, huge volumes, and a culture of speculation (gambling). Since the foundation for success is still being developed, WRSs and CEXs have not yet found success in Africa outside of South Africa. The application of ICT and its effects on commodities exchange activities and warehouse receipts have not been examined. Additionally, there is a dearth of helpful analysis on WRSs and CEXs that synthesises experiences, lessons learned, models, ICT usage, and comparisons between various operating environments, such as those in Africa and India, which are said to have successfully integrated large numbers of rural smallholders and greatly benefited from ICT solutions.

ICT is not likely to be a crucial success element, especially in the beginning, but any effective warehouse receipt system or a commodity exchange (national or regional) will require progressively complex ICT systems. It could be an expensive factor impeding any effort's progress towards sustainability if not executed following best practices. Furthermore, donor support for ICT-based systems supporting these systems should have quantifiable, intermediate goals (e.g., six-month intervals and usage metrics, not process metrics), and funding for ICTs should be contingent upon achieving these goals (GGC 2019; USAID 2010:6).

RFID

According to Kumar and Srivastava (2018:00121), Radio Frequency Identification (RFID) is assisting in improving supply chain information flow management and security in the agricultural food sector in India. In addition to helping growers overcome spoiling difficulties, Radio Frequency Identification technology, when paired with the right infrastructure, can provide end-to-end tracking and traceability in the supply chain at comparatively cheap prices. An RFID-enabled warehouse can keep an eye on perishables' temperature and shelf-life at every point of the cold chain, informing buyers and producers about the conditions and custody of shipments. In the agricultural food business, radio frequency identification technology has triumphed over safety concerns, global supply chain dynamics, regulatory constraints, and competitive pressures (Kumar and Srivastava, 2018:00123).

It is possible to transfer the data from an RFID tag immediately to a computer before agricultural items enter the warehouse. When it comes to selecting the right rack and slots, the computer will output the warehousing instructions. It is also possible to select the appropriate inventory pattern based on the needs and specifications of the product. As soon as it gets the customer's order, the agricultural product's logistics information system will generate the picking and slotting task. Based on the data on the RFID tag, the operator could select the appropriate product right away. During the distribution process, the RFID tag has enhanced additional information, such as the distribution vehicle, route, schedule, etc. Applications of RFID in sales can be advantageous to both sellers and buyers. With the use of RFID tags, merchants can verify the authenticity of goods, particularly perishable goods.

However, customers could learn some basic information from the point of origin to the point of destination along the supply chain. Radio Frequency Identification can assist consumers in verifying the safety of agricultural products. Thus, the integration of RFID technology throughout the entire logistics chain for agricultural products will also contribute to the advancement of the smooth exchange, reading, and writing of agricultural product data (Srivastava 2018:00123; Gan, Zhu, and Zhang 2011:405).

Among the most trolled technologies in global warehousing are software, telecommunications, radio and television, and RFID (Kumar, and Srivastava 2018:00123; Gan, Zhu, and Zhang 2011:405; USAID 2010:6). To provide pertinent advice and ensure flawless inclusion in the

literature, it is imperative to investigate the actual use at the IPEP (Ghana government intervention) warehouse.

2.4.6.2 Improving Transport Logistics

Masoumi and Abdul-Rashid (2019: 1) likewise Speranza (2016) write that, current technology and automobile advancements are fast transforming the way supply chains and items are delivered. Economic pressure forces businesses to become more efficient and effective, while simultaneously taking advantage of technical advancements. Simultaneously, institutions are motivated by the goal of sustainability, which is to meet current needs without jeopardising future generations' ability to meet their own. Although private cars continue to be the primary means of transportation for the majority of people, mobility options are increasing. Uber, Bolt, Grabtaxi, BlaBlaCar, Blackride, and Zipcar are just a few of the companies that provide individuals with alternate modes of transportation, some for short trips and others for longer ones.

The Western-style logistics system was introduced in Africa decades ago, but it hasn't produced the same outcomes as it has in other parts of the world. Despite African governments' commitment to increasing commerce and manufacturing through the implementation of the African Continental Free Commerce Area (AfCFTA) agreement, the continent still faces challenges related to inadequate logistics infrastructure and limited intra-African trade. So, it is imperative to create a logistics system that takes into account the unique socioeconomic conditions of Africa and its population (Adeleke 2022:1).

On the part of agricultural business, the reigning challenge may be internet access, which seems very poor in most remote areas of Africa, and Ghana could be more exceptional. Consequently, smallholder farmers may not benefit should similar systems be set in the agricultural sector, adding to most farmers' low ability to read between letters. According to Adeleke (2022:11), the Indigenous Logistics System (ILS) of Nigeria, also referred to as the waybill or message system, uses motor park passenger buses and other vehicles to move goods, items, paperwork, and commodities to different locations both inside and outside of Nigeria. This concept primarily draws influence from the nation's car parks. All interstate and intercountry vehicle parks in Nigeria follow this strategy, and when needed, intracity motor parks will also use this distribution system. This logistics system isn't new; rather, it's just an advancement and modification of previous local logistics methods made possible by easily available, modern

technology. It is comparable to the ILS system from the days before cell phones and automobiles. ILS used to ride camels and donkeys across pre-colonial Nigeria (Adeleke 2022: 11).

Moreover, drivers and motor park administrators now run the ILS. They ensure the protection and prompt delivery of the items entrusted to them, just as traders and security guards did in the previous ILS. The indigenous logistics system is operational twenty-four hours a day, seven days a week. Park administrators are always willing to receive items brought in by drivers from other states or countries, even if certain parks may prohibit the sending of items throughout the night. Sending products continues late into the night until the final bus departs in the early hours of the morning, especially in parks that are popular with visitors during the night. Stakeholders describe the current ILS procedures in Nigeria as follows: You meet the driver face-to-face and haggle with him while you are sending your bags. Either you or the recipient can make an immediate payment. The driver will pay a commission to a third party that meets you at the gate and takes it from you following negotiations (Adeleke 2022: 12). There are options for the supplier, sender, and driver to pick up the items with an empty bus if the products are heavy or the sender or supplier is unable to transport the goods to the parking lot.

This usually applies to goods stored in remote areas, farms, and warehouses. Following a discussion about the cost of shipping the goods with the driver at the motor park, the sender or motor park official "collects" the driver's phone number and gives it to the recipient, who then gives the driver the recipient's phone number and the item to load into the vehicle. Then, according to law, before an item is sent, it must be checked to see what is inside, whether it is lawful or illegal, and who is entitled to receive it (Adeleke 2022: 12). Typically, the driver dials the number of the recipient provided by the sender for confirmation. It is common practice to do this with the sender present. Sometimes, before delivering the driver's phone number to the recipient, the sender dials the driver to make sure it is correct. Building system confidence involves the driver and the recipient communicating while the sender is present. Upon reaching its maximum passenger capacity, the bus either leaves the motor park with its full load of goods or both people and products. According to Adeleke (2022: 12), "the phone numbers collected are used to track goods in transit." The sender or recipient can contact the driver at any time before or after leaving the car park to inquire about the current status of the trip, any obstacles that may cause delays, and the anticipated time of arrival. Along their travels and to the intended destination, the drivers deliver items. As a result, products are identified by clearly

writing the intended recipient's name and phone number on the packaging. Storekeepers at the car parks receive the products from the driver if the receiver is not present to accept them. After that, the storekeeper gets in touch with the receiver to verify that the items have arrived at the vehicle park and to inform them of the new phone number they need to use to pick up the products. Before receiving the goods, the recipient is required to pay an additional cost for storage. When delivering products along a route and the recipient is not there, the driver transports the items to the central parking lot at the destination and notifies the recipient of the updated pick-up location.

In addition, motor park buses can deliver goods directly to merchant stores, supplier warehouses, production units, or final customers based on the sender and driver arrangement. Furthermore, after the goods are delivered to the parks via the ILS, recipients can schedule the conventional logistics providers to pick them up from the vehicle parks. An essential component of the entire motor park operations is the Indigenous Logistics System. The National Union of Road Transport Workers (NURTW) recognised motor parks, the transport buses or vehicles registered with the NURTW, and the payment of motor park taxes on each workday are the fundamental prerequisites for the operation of the ILS. Every motor park has a designated office and representative who oversees all the ILS-related issues.

While some workplaces are real buildings, others are just areas with umbrellas or tree canopies to give shade. These offices feature basic registers with space for the details of the products received, as well as the phone numbers and names of the sender and recipient. There is no need for identification; the sender's name will work just fine. The crucial information included in the ILS registers in motor park offices is the mobile phone numbers of senders and recipients as well as a description of the products to be sent. The ILS operations at the motor parks are not exclusively under the control of the motor park offices. In a mutually reliant manner, drivers and motor park administrators cooperate and show respect during Indigenous Logistics System operations at the parks. As a result, senders do not need to register in advance for transporting products through the motor parks at the motor park offices. To negotiate and provide the drivers with the products to deliver, senders can meet with the drivers in person. To ensure that their goods are in excellent hands and will be delivered, many senders, however, prefer to use motor park offices (Adeleke 2022:1). It also implies that vehicle park personnel will quickly address and settle any disagreements that arise following payment. But when it comes to disagreements involving senders who have approached drivers directly, motor park officials also become

engaged in the resolution process when they receive reports about them. They take these actions to maintain the ILS's standing as a reliable system.

In addition, motor parks feature storehouses where delivered products are held awaiting pickup. The storekeepers there record an updated inventory of the goods as well as the details of the intended recipients. In motor parks without storehouses, people use the motor park official's office or another secure location inside the park. "Unofficial" storekeepers in certain roadside motor parks (also known as pick-up/drop-off locations) accept merchandise from drivers and get in touch with the recipients. To supplement their income, bus drivers and motor park administrators are willing to deliver goods in addition to passengers (Adeleke 2022: 1). Motor Park officials do not pay taxes on the money they receive from the ILS. Furthermore, when bus owners obtain an account of daily earnings, money made to drivers for ILS services is excluded and considered personal earnings.

However, in pre-colonial northern Nigeria, camels, oxen, donkeys, and horses were employed exclusively for the logistics industry by their owners, whereas traders and guards in the south handled the business by carrying goods on their heads and shoulders. Traders and ILS operators transported goods to far-off markets and trading locations across the continent utilising humans or animals. The current ILS was created by applying indigenous environmental knowledge and making effective use of the available resources. Nigeria's Indigenous Logistics System (ILS) benefits from its cultural origins, affordability, speed, and availability. These factors also contribute to its efficacy. On the other hand, sporadic delays, inadequate communication, risky tracking techniques, and a lack of insurance coverage are some of the system's shortcomings. It is necessary to enhance and expand the ILS procedures to better meet the demands of enterprises and adjust to changing circumstances.

Simple technology can improve Nigeria's ILS procedures, according to Adeleke (2022:16). It is possible to create basic phone apps that connect ILS users to neighbouring vehicle parks. Additionally, by connecting all motor parks, these apps can increase the reach of ILS from any motor park. Additionally, vehicle park associations might collaborate with respectable insurance providers to offer product insurance coverage to ILS users at a reasonable price.
Nigeria’s existing ILS for transportation in a limited way works in Ghana, the coverage may be the only distinction, if any. The same procedures that Adeleke outlines are used in Ghana to send packages across cities, nations, and distances with access to transportation via reliable

station cars. There is no information available regarding the existence of such services in the agricultural industry or the function of the IPEP WRS in facilitating farmer access in the case regions. Other couriers, such as FedEx, ARAMEX, DHL, etc., also provide door-to-door deliveries, employing motorcycles when required. When it's time for harvest, farmers in some parts of southern Ghana with access to motorised roads typically establish contacts with independent transport (of any kind) or drivers as a cultural practice. This has been the case for decades and is still unproven in the context of the IPEP framework.

Obeng (2015:5) acknowledges that smallholder and commercial farmers in the majority of Ghanaian farming communities face a variety of difficulties, but two primary obstacles have impeded their ability to become economically empowered: the high cost of transporting farm animals and produce as well as the lack of timely access to vehicles for getting produce from farms and villages to even marketing centres. Due to the bad states of the roads during the dry season, transporters charge exorbitant rates. This problem is exacerbated during the rainy season when vehicles break down frequently and the cost of labour with spare parts to fix them are frequently passed on to farmers or market women. In certain cases, the breakdown occurs while the vehicle is transporting food produce, which poses a risk to the safety of both the drivers and the farmers or marketers involved in the transportation of such farm produce especially at night time.

Transportation is a bottleneck in Ghana's agriculture industry, which has an impact on the year-over-year (y-o-y) inflation rate, which rose to 42.2 percent in May from 41.2 percent in April for the first time since the year's beginning. Food is found to be one of the key causes of the rising inflation rate, along with housing and transportation (WFP 2023).

Rehabilitating 1,200 to 2,000 kilometres of roads annually was the goal of the 1990s Medium-Term Agricultural Development Plan; however, the actual yearly performance is just 212–1,080 km. Produce from farms is transported to villages in about 90 percent of cases, mostly on the heads of women and children. As a result, Obeng (2015:5) developed an ICT-linked system that aids in the fight against PHL across a variety of food industries, including animal husbandry. The project team assembled and created a database that contains the names and mobile numbers of registered members, farming associations, transport owners, and the drivers in charge of moving farm produce from the farms to the villages and from the villages to the

marketing centres. The database is kept at a data centre, when a member asks for transport, text or SMS messages and notifications are delivered to their mobile phones, and confirmation is issued (using a short code for confirmation) to satisfy the request. To function as mobile data centre agents, field agents tasked with gathering this kind of information undergo specialised training. They transmit data, including registered member information, to the headquarters for processing, archiving, and administrative uses. The primary objective of their project's design and execution was to offer a locally created solution to address the urgent transportation and marketing demands of agricultural products, an issue that Ghana's farming communities face. At the same time, Obeng hopes to replicate the model in other African and developing countries that rely on agriculture for both commercial and subsistence purposes.

According to Obeng (2015: 7), his project had a very beneficial impact, with considerable measurable results in Ghana's catchment communities and implementation areas. The project resolved the issue of sourcing and attracting qualified consumers for certain farm produce, including farm animals. Farmers in the Ashanti, Bono, and Ahafo areas have advanced knowledge of their produce from various districts; they are receiving fair market rates for their produce, providing much-needed revenue to farmers and improving their economic situations. This creates direct and indirect employment opportunities for other actors who are import stakeholders in the agriculture industry, such as the trucks responsible for short-distance journeys.

The researcher’s preliminary survey found the IPEP warehouse working with actors involving management, FBOs, farmers (members of the FBOs), and aggregators in some cases. With interest in farmers’ direct storage, there is expected to be a similar integration or a more simplified system than Obeng (2015: 5), in the WRS, where transport coordination is done from the warehouse. The concept by Obeng was generalised to the agricultural sectors and was not rolled with a warehouse in the fulcrum, meaning it cannot holistically fit the supposed IPEP WRS. The present study will base this argument on a proposal for use at the IPEP, a specific and simplified system in benchmark to Obeng (2015).

Scholars (Adeleke 2022:16; Raheem *et al*. 2021:5; Yawson and Frimpong-Wiafe 2018; Obeng 2015:5) endorse the use of simple technology to enhance Indigenous Logistics System processes making it necessary to simplify these prior ideas.

2.4.6.3 Improving Packaging Logistics Management

According to Regattieri, Santarelli, and Piana (2019), advancements in materials, technologies, and Internet communication have enhanced the packaging industry in recent years. One example of this is the development of intelligent packaging, which can interact with products or communicate with consumers, enabling the traceability of a single item throughout the entire supply chain. There are various ways to store grains, such as using insecticides, hermetic systems, and traditional/local methods. The primary goal of the storage systems is to maintain the grain's integrity for a predetermined amount of time while minimising loss of both quality and quantity.

Recently, farmers, the commercial sector, governments, and development organisations have shown a great deal of interest in hermetic technology as an alternative to conventional and chemical control approaches. The airtight conditions established during storage are the reason why hermetic technologies work so well. The presence of insects and other living activity that causes the depletion of oxygen and release of carbon dioxide inside hermetic containers is what primarily drives biological processes including respiration and metabolic activities (Baributsa and Ignacio 2020:2; Murdock *et al.* 2012,). Therefore, the hypoxic conditions that these technologies provide make it difficult for insect pests to grow and reproduce, which reduces or eliminates grain damage. Hermetic technologies that are frequently employed include plastic and metal silos, drums, cocoons, plastic bags, and other containers. The sizes and shapes of these hermetic containers vary. Hermetic bags are the most extensively used hermetic technology among Asian and Sub-Saharan African smallholder farmers. The Purdue Improved Crop Storage (PICS) bag's creation has led to a notable surge in the use of hermetic bags for grain storage during the last ten years. Hermetic bags are becoming more and more popular due to some reasons, including (i) the severity of storage losses at the farm level; (ii) the technologies' effectiveness; and (iii) additional advantages such as their accessibility, affordability, and ease of use. When grains are stored using the traditional technique of applying insecticides, the level of risk from the food safety hazards are adequately controlled by using hermetic bags.

Commercially available hermetic bags come in three varieties: single-layer (like Grainpro Inc.'s SuperGrainbags), double-layer (like AgroZ bags produced by A to Z), and triple-layer (like PICS bags produced by multiple licenced plastic companies in South America, Asia, and Africa) (Baributsa and Ignacio, 2020:2, Coffi *et al.* 2016, Murdock and Baributsa, 2014, Jonfia-

Essien *et al.* 2010, Villers *et al.* 2006). The majority of these hermetic bags resemble the transport or storage containers, plastic polyethene (PE) liners and polypropylene (PP) weave bags, that farmers frequently use. They are available in a variety of shapes and sizes. Hermetic bags are suitable substitutes for conventional storage techniques because they preserve the quality of goods kept in storage, give smallholder farmers flexibility to sell their grain at a premium, and ensure food security.

Since grain was kept underground in pits during the Palaeolithic era, hermetic storage has been known about (Baributsa and Ignacio 2020:2; Navarro *et al*. 1994). An adaption of conventional hermetic storage methods such as subterranean pits, clay pots, jerrycans, silos, or drums are hermetic bags. According to Baributsa and Ignacio (2020:2) and Navarro *et al.* (1994), underground pits are a conventional technique of crop storage that offers an airtight, chemical-free, and secure way to store dry crops. The PICS in Africa and the Cocoon in Israel were the pioneers in the 1980s in the invention of hermetic bags (Baibutsa and Ignacio 2020: 2, Murdock and Baributsa, 2014, Navarro *et al.* 1993, Kitch and Ntoukam, 1991). A product of this endeavour to create solutions for smallholder farmers is GrainPro's SuperGrainbags. The purpose of hermetic bags was to assist smallholder farmers in poor nations in minimising insect-related postharvest losses. In contrast to alternative hermetic storage solutions like drums or jerrycans, hermetic bags are readily and affordably scaled up. To combat storage pest infestations on cowpeas (Vigna inguiculata, L. Walp.) in West and Central Africa, Purdue University developed the PICS technology (Baributsa and Ignacio, 2020:3, Baributsa *et al.* 2014a, 2010). Insect pests (Callosobruchus maculatus, Fabricius) cause cowpea farmers in West Africa to lose a significant percentage of their crop during storage (from 10 percent to as high as 100 percent after only a few months) (Baributsa and Ignacio 2020:3; Moussa *et al.* 2014, 2011).

The purpose of PICS bags is to give farmers an economical and chemical-free way to store their produce. There were drawbacks to the existing storage techniques, which included granaries, ash, sand, botanicals, metal drums, jerrycans, and insecticides. A few of these techniques were risky for your health, expensive, inefficient, and unscalable. In addition to enhancing food security, offering a practical and safe way to store grain would enable farmers to take advantage of higher grain prices during the lean season. PICS bags are available in three distinct sizes: 25 kilogrammes, 50 kilogrammes, and 100 kilogrammes. The construction of each bag consists of two PP woven bags fitted with high-density polyethene (HDPE) liners.

Fifteen plastic manufacturers worldwide produce PICS bags. As Latin America and Asia are freshly growing markets for PICS technology, the remaining producers of PICS are primarily based there, accounting for 80 percent of the total.

GrainPro began creating hermetic bags by implementing large-scale plastic storage structures called cocoons to store grains for an extended time. These cocoons range in size from 300 tonnes to other sizes. GrainPro has created small and intermediate hermetic storage systems over time. SuperGrainbags, a type of storage container ideal for subsistence farmers, are part of GrainPro's small-scale hermetic storage system (Baributsa and Ignacio 2020:3; Jonfia-Essien *et al.* 2010). Originally introduced to the market in the early 1990s, GrainPro hermetic systems are currently in use in over 32 nations worldwide (Baributsa and Ignacio 2020:3; Villers *et al.* 2008). As part of a five-year project in the Philippines, the International Rice Research Institute (IRRI) first employed SuperGrainbagsTM to store rice seeds (Baributsa and Ignacio 2020:3; Villers *et al.* 2006). Every SuperGrainbag is a translucent, thin, single-layered plastic liner with minimal oxygen permeability. SuperGrainbags come in a range of capacities, with 60 to 90 kilogrammes being the most popular (Baributsa and Ignacio 2020:3; Villers *et al.* 2008, 2006). Produced in Subic Bay, Philippines, GrainPro bags are distributed globally.

Over the past five years, many new hermetic bag brands have developed, either by copying or innovating upon pre-existing ones (Table 2.1 and Figure 2.2). These consist of the Elite bag, the AgroZ bag, and the ZeroFly hermetic storage bag. Africa is home to Elite and AgroZ. The realisation that smallholder farmers were becoming more and more in need of safer and more economical storage solutions was a major driving force behind the invention of these hermetic bags. A to Z Textile Mills Limited (Tanzania) invented AgroZ bags, which are double-layer bags consisting of one woven bag and one-liner. Low-permeability barrier layers that prevent oxygen from passing through are co-extruded with HDPE and Metallocene Linear Low-Density Polyethylene (MLLDPE) to create the liner. AgroZ bag plus, a high-end, insecticide-treated hermetic storage bag created especially to fight bigger grain borer (Prostephanus truncates, Horn), is another hermetic bag created by A to Z Textile Mills Limited. A multi-layered PE bag with a gas barrier inside and an outside PP bag impregnated with deltamethrin makeup Vestergaard's ZeroFly hermetic storage bag. Elite Innovations (K) Limited, based in Kenya, also developed a double-liner hermetic bag made from HDPE called Elite Bag Light Duty Double Liner.

Table 2.1: Characteristics of hermetic bags being sold in Sub-Saharan Africa in 2019.

Type of hermetic bags	Woven bag (PP)	Liners	Examples
Triple bag	One PP bag	2 HDPE inner Liners	Perdue Improved Crop Storage (PICS)
	One PP bag	2 HDPE inner Liners	Elite bag light duty Double liner
Double bags	One PP bag One PP bag impregnated with insecticides	1 Liner with multiple layers 1 liner with multiple layers impregnated with insecticide 1 liner with multiple layers	Agro Z Agro Z plus ZeroFly Hermetic storage bag
Single bag	No	1 liner with multiple layers	GrainPro Bag Zipper

Polypropylene/woven bag is impregnated with Deltamethrin to prevent the infestation from outside the bag.

Figure 2.5 Hermetic storage bags commercially available in Kenya in 2019.

How hermetic bags work:

A single or double inner liner and an outer bag are the two main parts of most hermetic bags. Since a gas barrier is the most important part of a hermetic bag, the inner liner may be a single layer or a combination of layers of film. Strong and protective while handling, the PP bag serves as the outer bag. The concept underlying the hermetic bags' operation is that the commodities contain the bio-generated modified atmosphere produced by organisms' metabolic processes. The environment becomes low-oxygen when insects and microbes emit carbon dioxide and use oxygen (Figure 2.3). The resulting hypoxic conditions stop moulds and insects from growing and developing, which stops grain deterioration. To keep the low oxygen environment within the bag at levels that impede the development of insects in all life stages, the plastic inner liners of the hermetic bag are made to limit or considerably reduce the permeability of gases. In the event of a single, double, or triple hermetic bag piercing, the technology becomes ineffective and the bag needs to be replaced. Triple-bag hermetic brands have an additional layer of safety in case one of the two liners breaks. The method is still able to safeguard grain during storage because insects rarely harm the second liner of the triple-layer bags. Adhesive tape is useful for repairing small damages like holes, if not, reusing or recycling the bag is necessary (Baributsa and Ignacio 2020:3).

Currently available hermetic bags all rely on natural mechanisms to produce hypoxia. There hasn't been any research done on creating technology that could reduce the amount of oxygen inside hermetic bags after the containers are closed. As the application of these technologies, spreads to new crops or commodities that require a sharp reduction in oxygen levels not only to kill insects but also to maintain food quality, such as vitamins, the idea of adding oxygen scavengers to hermetic bags will become essential. A Purdue University study found that pro-vitamin A degradation in biofortified orange maize was slowed down by including oxygen scavengers in grain stored in PICS bags (Baributsa and Ignacio 2020:3; Nkhata *et al.* 2019). In industrialised nations where tolerance for insect presence in grains is limited or nonexistent, the use of a controlled atmosphere to create a low-oxygen environment also has to be investigated.

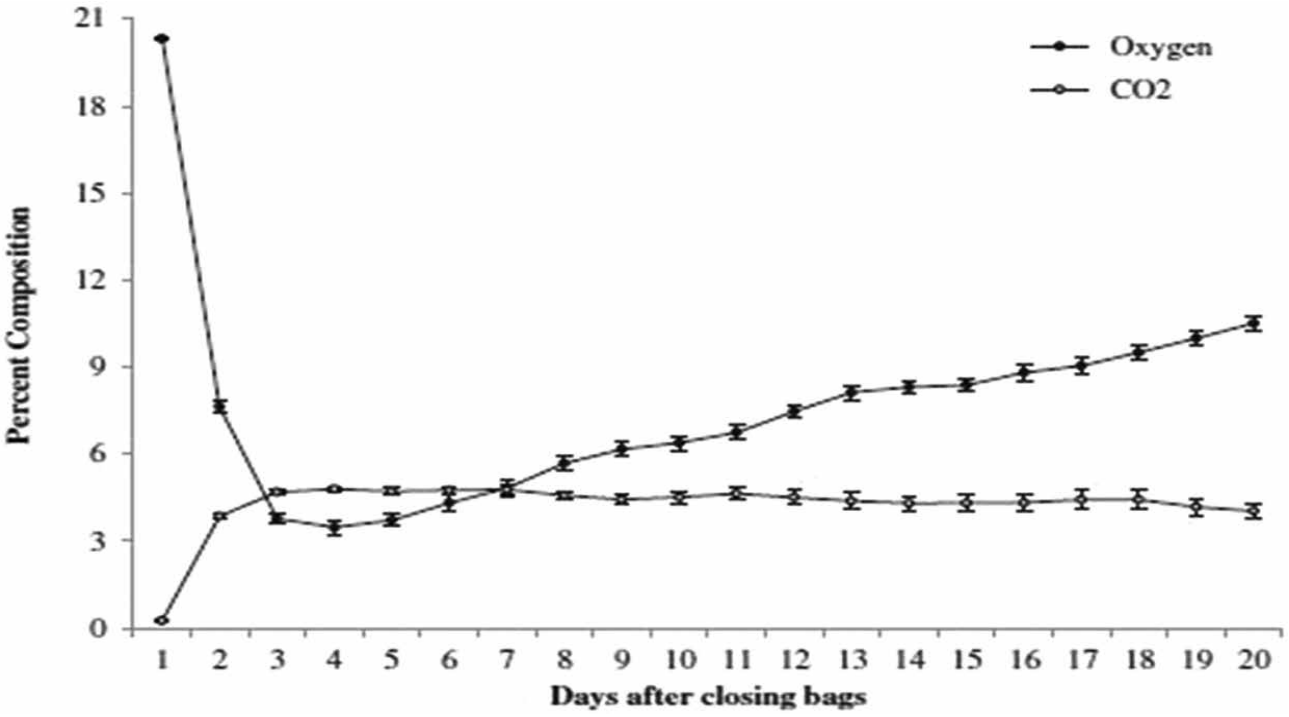


Figure 2.6 Changes in the concentration of oxygen and carbon dioxide inside a PICS bag containing slightly infested cowpea grain. Gas levels were tracked for 20 days using a Mocon Headspace analyzer. (Baributsa and Ignacio, 2020:5; Murdock and Baoua 2014).

As Adeleke (2022:16) points out, even though this appears straightforward, using basic technology can improve Indigenous Logistics System operations. The packaging industry has improved recently due to advancements in materials, technologies, and Internet communication technologies. One example of this is intelligent packaging, which can interact with products or communicate with consumers, enabling the traceability of a single item throughout the entire supply chain (Regattieri, Santarelli, and Piana, 2019). In terms of packaging materials, the International Trade Centre (ITC) has divided them into four categories: (1) glass (carboys, bottles, and other glass containers); (2) paper (packing containers of paper, paperboard, cellulose wadding, webs); (3) plastic (plastic packing goods or closures, stoppers, lids, caps, closures); and (4) wood (packaging materials of wood). These categories can include the International Rice Research Institute's special bag for storing grains in developing nations like Ghana, while still utilising the best technology possible to expedite the packaging process.
Again, the packaging industry is transforming almost every day with new technologies, better than before, replacing of old ones (Global Market Insights Inc. 2023, Packaging Trend-The

Future Outlook 2010). The cost of materials, their availability, and safety are key to consider in packaging material choice.

Technology and materials that enclose or protect goods for usage, sale, distribution, and storage then attest to the packaging notion (Pulidindi and Ahuja 2023, Blakeney 2019, Wohner 2019, Soroka 2002) and this evolution must follow the use of packaging at various buffer stores. Packaging for the warehouse should, therefore, be well positioned in literature towards spanning food shelf life and making relevant recommendations for enhancement.

2.5 EMPIRICAL REVIEW, OPERATIONALISATION AND MEASUREMENT OF CONSTRUCTS

In Ethiopia, Tuffa (2019) and Tuffa, Amentae, and Gebresenbet (2017:16–17) analysed warqe foods supply chain logistics practices in light of food losses. Both kocho and bulla supply networks showed high food losses, and losses occurred throughout all phases of the systems. From the overall marketed product, it was estimated that 46 percent of bulla and 45 percent of kocho were lost in the supply chain. The retailer and processor tiers saw the biggest kocho (24 percent) and bulla (29 percent) losses, respectively.

Survey studies were conducted in Ethiopia in 2014 and 2015, and again from 2013 to 2018, to assess the food losses of kocho and bulla as well as the logistics practice of warqe food commodities. The primary warqe-growing regions of the country hosted the first survey. Then, focusing on the two main supply routes for warqe foods, namely Haro Wanchi in the West Shoa Zone and Maruf in the Southwest Shoa Zone, in two important warqe-producing areas.
The food chain based on wholesale was examined using the supply chain management approach. The supply chain was mapped, the players' activities and relationships were examined, the actors' relationships and practices were described, the actors' restrictions were noted, and upgrade options were suggested. This analysis was done using a stage-wise process. Utilising (Tuffa 2019; Tuffa, Amentae, and Gebresenbet, 2017:16–17; LaGra's 1990) Commodity System Assessment Methodology (CSAM), food loss was evaluated.

Research conducted via a variety of lenses has revealed that more than one-third of the 1.3 billion tonnes, or thirty percent, of food produced for human use, is lost or wasted annually

worldwide (Safdie 2023; FAO 2021). A research study by Russell 2022 titled ‘‘Reducing Postharvest Loss in Liberia: Toward a Framework for Reducing Food Loss in Liberia’’ identifies with other research studies titled "Food Losses and Waste in Cereals Agri-Food Chain in Turkey," by Erden, Dellal, and Bayramoglu (2017:20) and ‘‘Strategies to Reduce Post-harvest Losses for Fruits and Vegetables’’ by Elik *et al.* (2019: 3) also in Turkey as they evaluated food losses and waste at key stages in the agricultural food chain/food supply chain for cereals and fruits as well as vegetables. Per that, the general impact of food losses and waste on Turkey's food security and supply was evaluated. Additionally, significant loss spots throughout the agricultural food chain/ food supply chain for grains and fruits as well as vegetables were found and examined. The researchers discovered that, when looking at the entire agricultural food supply chain/ food supply chain in agricultural production, the system's first link, experiences the highest rate of loss. Turkish agriculture is experiencing structural issues such as tiny, dispersed farms and weak levels of cooperation which are the main causes of the losses.

For the cereal study, the FAO and the Swedish Institute for Food and Biotechnology developed a methodology. Cereals that significantly influence Turkey's food security and supply are those that, were taken into account individually, and the production area, yield, value, and export contribution of wheat, barley, and maize were calculated. Additionally, one commodity from the agricultural food business that is thought to be wasted and lost was selected. Flour and its byproducts made up this product. Focus group meetings were organised using semi-structured questionnaires with the assistance of stakeholders from the flour and flour product industry to identify significant loss areas along supply chains as well as food loss and waste.

The study's restriction is an important restraint because it qualitatively evaluates food losses in addition to being Turkey-specific. The design of this study conflicts with Tuffa (2019); Tuffa, Amentae, and Gebresenbet's (2017:16–17), seemingly quantitative findings. To address this, Pawlak (2017:12–13), looked at the "Regional Diversity of Food Losses and Food Waste in the Food Supply Chain." It was discovered that North Africa, West and Central Asia, and Sub-Saharan Africa have the highest rates of food losses and waste across the entire food supply chain (36 percent of the initial production available for human consumption), while South and Southeast Asia have the lowest rates (28.2 percent).

The World Resources Institute, the Statistical Office of the European Union (Eurostat), the Food and Agriculture Organisation of the United Nations (FAO), and the Economist Intelligence Unit (EIU) provided the data used in the study. Europe, North America, Oceania, Industrialised Asia (Japan, China, South Korea), Sub-Saharan Africa, North Africa, West and Central Asia, South and Southeast Asia, and Latin America were the geographical areas considered by the investigation. In the research, descriptive analysis, analogies and comparisons, the deductive method, and meta-analysis techniques were all used.

Similar to Tuffa (2019); Tuffa, Amentae, and Gebresenbet (2017:16–17) and Pawlak (2017:12), explored quantitative food loss by referring to physical food loss in gauging food security, as opposed to Erden, Dellal, and Bayramolu (2017:20). While it is interesting that researchers have evaluated food security from the perspective of their interest in addition to their geographical distinctions across which the studies were done, there does not appear to be any particular model to examine food security in research from a methodological standpoint. As a result, the current study uses correlation and regression analysis to analyse food security quantitatively. The PHL in this study will be measured using a five-point Likert scale.
On the other hand, (Wajszczuk 2018:344) evaluates the logistical sustainability of family farms in terms of the Logistics Social Responsibility (LSR) concept. Case studies carried out in five farms have revealed an increasing level of logistical sustainability as the area increases; both in terms of individual LSR processes as well as in social, environmental, and economic sectors. Thus, as a business grows, so does the degree of logistical sustainability as measured, by LSR concepts (Wajszczuk 2018: 347). To maintain openness, agricultural businesses, and businesses that purchase raw materials from small farms were thought to be forcing the implementation of LSR rules due to the growing public pressure to improve food supply chain safety.

It is reasonable to conclude that even small businesses, such as farms, should increase the use of LSRs in their development strategies in light of this rising trend. Only 9.8 percent of LSR practices, on average, were used in small businesses, compared to 20.3 percent in intermediate businesses and 69.9 percent in large businesses, according to Wajszczuk (2018). A prior study notes the importance of excellent logistical management in the agricultural industry and finds it to be profitable. According to Onwude *et al.* (2020) and Erden, Dellal, and Bayramolu (2017:20) recent improvements in storage, processing/packaging, and transportation technologies as well as the desire of supply chain enterprises for new technologies are assisting

in the reduction of food losses. With effective management of logistics systems, losses that occurred in one step of this study were relatively fewer than those that occurred in the agricultural production stage.

For the study, five family farms (F) from Poland's Wielkopolskie region were chosen. The farms operated in the following regions: (F1): 32 ha AL; (F2): 58 ha AL; (F3): 64 ha AL; (F4): 71 ha AL; and (F5): 131 ha AL. The primary focus of the farms was mixed production (plants and animals). In terms of the five key areas of the LSR concept, the study used the logistics sustainability estimation adopted technique for family farms. These are reverse logistics (RL), sustainable warehousing (SW), sustainable packaging (SP), sustainable transportation (ST), and purchasing social responsibility (PSR) (Wajszczuk, 2018: 344, Ciliberti *et al.* 2008). All of these processes, including the social, environmental, and economic ones, have been placed inside a sustainable sphere. Sub-processes of the LSR's primary processes were assessed. The points were then combined into the several LSR main processes as well as the sustainable spheres. The scoring aggregation system allowed for the individual evaluation of the key LSR processes (five indicators) as well as the determination of the concept's level of sustainability in the social, environmental, and economic domains (three indicators). According to the LSR concept, the degree of sustainability of the main process was evaluated using a five-level scale that the researcher used as a benchmark (Wajszczuk, 2018: 344).

Contrarily, taking into account the complexity of food security, Subramaniam, Masron, and Naseem (2020:1) evaluated the "Impact of Logistics on Four Dimensions of Food Security in Developing Countries." To better understand the four distinct dimensions of food security, this study looked at the effects of logistics performance on food security in 51 developing nations between 2010 and 2016. Utilising the Generalised Method of Moments (GMM), the findings offer corroborating proof that nations with superior logistics efficiency typically have higher levels of food security. It has been found that better logistics can increase every aspect of food security, including food supply, accessibility, use, and stability. The overall finding shows that policymakers should raise the level of logistics performance, which is typically much lower than in industrialised nations, to provide the groundwork for reducing hunger and enhancing the availability of food.

Academics establish logistics managerial criteria and analytical models in line with the area of their research. Wajszczuk's (2018) model for LSR differs from that of prior researchers, maybe

as a result of the objectives of the study. Speaking with specialised practitioners, such as operation managers, is a better approach to explaining various supply chain management concepts and logistics (Anwar *et al.* 2023, Emberson *et al.* 2006:1). This may have to do with putting a subjective scale around their area of responsibility.

A study by Johnson, Nketia, and Quaye (2015:164), investigated the logistics management practices currently in use in 20 selected Ghanaian agro-food companies in their study. The title of the report is "Evaluation of Logistics Management Challenges in Ghana's Agro-Food Industry Sector." The paper used an in-depth case studies approach to examine logistics-related areas such as fleet management and transportation, infrastructure and equipment, customer service quality, order management, and the degree of ICT usage. Numerous challenges confront small enterprises, such as the requirement for capital to buy new equipment to replace obsolete ones, inadequate cold storage facilities, and a deficiency of logistics management knowledge. For medium to large businesses, logistical issues included a lack of financial backing, high fuel costs for power generation, inadequate refrigerated trucks, and bad road systems.

Once more, a writer uses a range of methods to assess logistics concerning their research objective. Despite their focus on Ghana, the companies of interest were involved in the food commodities industry. These included grains (cereals and oilseeds), fresh foods (fruits and vegetables), cold-stored products (such as milk and meat), modern retailers, and the food services sector. Therefore, the companies that were part of this research were split into groups according to the kinds of goods and/or services they offered; the categories were cold foods, fresh foods, and grains and oilseeds, which accounted for 25 percent of the total. The questionnaire covers important factors that are essential to business success, such as transportation and fleet management, infrastructure and equipment, quality of customer service and order administration, and level of ICT usage.

Their primary focus was not cereal or grains. The authors may not be usefully categorising their method to different logistics more so where the objective of the study differs as they had in mind a particular logistics of interest on mixed activities in the agricultural business. It's crucial to understand that logistics is a wide term and that by breaking it down into individual agriculture activities, one can obtain details that are relevant to those activities. Given the diverse nature of the current study goal, the researcher believes there is no need to limit the

assessment of logistics effectiveness to a single model. As a result, a subjective scale and parameters are used for the assessment of warehousing, transport, and packaging logistics.

The researcher is conducting this research on certain crops with an identified logistics bottleneck that has been shown to threaten their security. A five-point Likert scale, from strongly disagree to strongly agree, is used to measure the logistical systems as continuous variables. The operational definition of constructs and their range of measurements are summarised in Figure 2.4

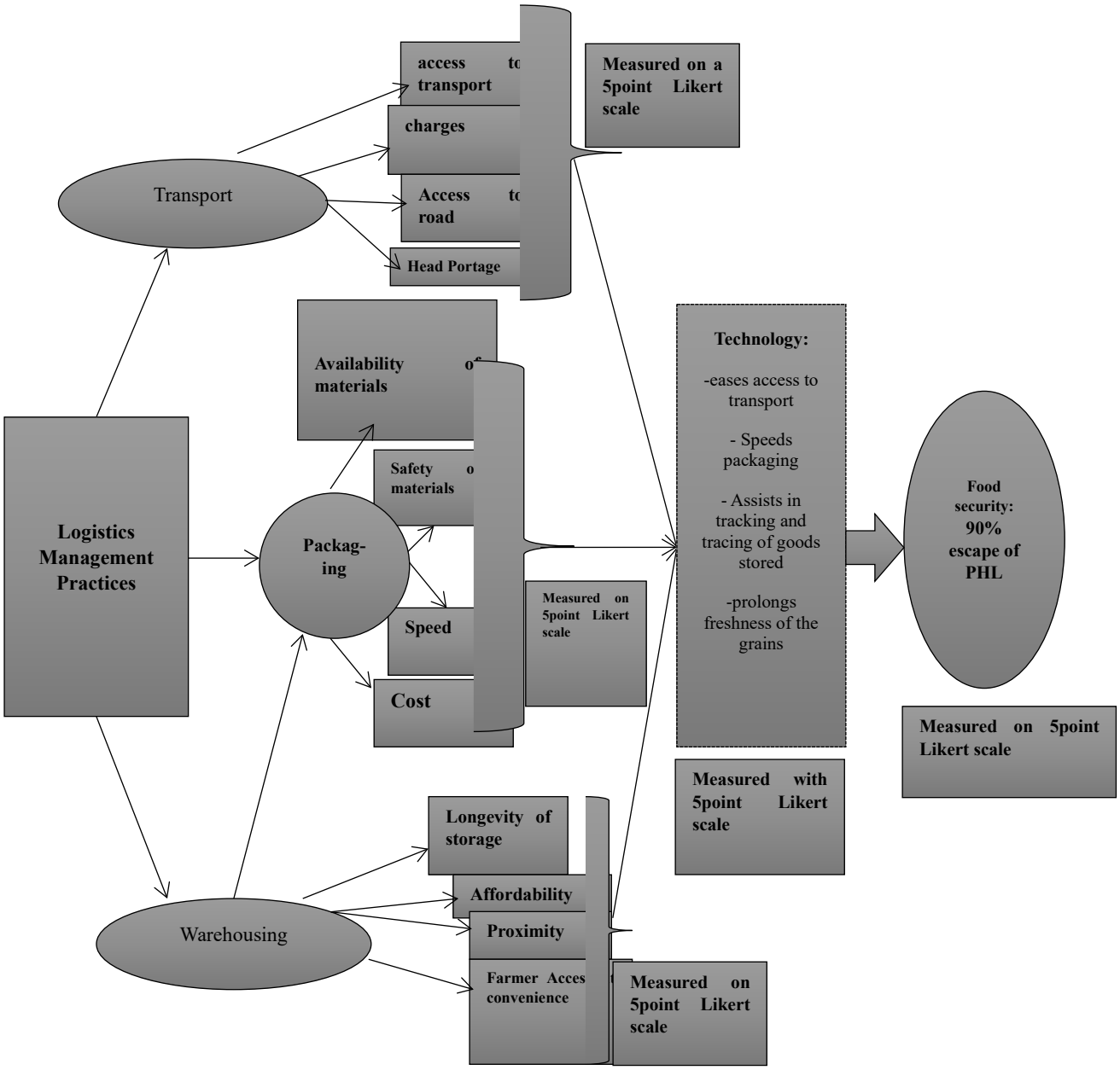


Figure 2.7: Operational definitions of constructs and Measurement (Author's model)

Wajszczuk (2018: 344) uses logistics sustainability estimation (an adopted approach) for family farms while analysing logistics sustainability in terms of the five primary LSR concept areas. According to Wajszczuk (2018: 344), the approach includes sustainable warehousing (SW), reverse logistics (RL), sustainable packaging (SP), sustainable transportation (ST), and socially responsible purchasing (PSR). Threshold parameters were chosen to range from less than 20 percent for low sustainability in a certain sphere/LSR main process to more than 80 percent for

good sustainability in that same sphere/LSR main process. He concluded by noting, "As the size of the business grows, the degree of logistics sustainability, in terms of LSR concepts, increases" (Wajszczuk 2018:347). The focus of the paper was sustainable methods rather than logistical management difficulties.

WJCI (2022:1) and Johnson, Nketia, and Quaye (2015) use factor ranking to argue their way on logistics management difficulties in Ghana. Based on their weighted average responses, several challenges were graded. Although this rating has been accepted, a consensus analysis can be performed on a phenomenon of this nature, this is because factor analysis is used for factors explaining a range of outcomes on multiple tests. It might be argued that factor analysis is not a useful approach for determining the respondents' consensuses of logistics difficulties. Kendall's coefficient of concordance (W) for this investigation is primarily used to measure raters' agreement. The coefficient is linearly related to the average spearman rank correlation coefficient between all potential pairs of raters, allowing for accurate knowledge of all the variables respondents agree to as a challenge. This study assumes concordance to pick the challenges facing Ghana's food security.

2.6 CHAPTER SUMMARY

Food security is getting worse as reported by the World Food Programme in 2023 Ghana's food insecurity is mounting in number and intensity, leaving succeeding administrations to adopt contemporary policies that involve the establishment of the IPEP facilities in Ghana. It is said that nearly 50 percent of Ghanaians still experience food insecurity, according to the GSS 2022 Annual Household Income and Expenditure Survey. In the first three months of the year, 49.1 percent of Ghanaians suffered from food insecurity. This equates to 15.1 million of Ghana's 30.8 million citizens, corroborating with the assertion by Acheampong *et al.* in 2022, regarding food security remaining an earnest challenge for many households in Ghana. Despite, unwavering commitment to neo-Malthusianism, many still go hungry thus, becoming apparent that if the fundamentals are faulty, contraception is also a grossly oversimplified solution to a nation's food crisis. There is a need for robust/reliable logistics.

The logistics of food value chains include agricultural inputs, outputs, and services like transportation, warehousing, buying, packaging, and inventory control. If there is a disturbance in the activity, different methods will be required to address supply chain logistics. The Council

of Supply Chain Management Professionals further defines logistics management as "the process of planning, implementing, and controlling the efficient, effective flow of goods." Logistics management is essentially organising and maintaining each asset in the logistics process to prevent the values of products and assets from declining and to generate returns or profits for the company.

Everyone agrees that cutting down on food loss and waste can greatly enhance food security, fortify the sustainability of food systems, and prevent financial expenses from arising across the food supply chain. Furthermore, food specialists assert that no single action can ensure future food security. A comprehensive systems-based approach that combines technological and policy reform with the utilisation of cutting-edge technologies, methods, and best practices will be necessary for achieving true sustainable global food security.

Despite the growing population, postharvest technologies are essential for maintaining the food supply and seasonal prices. As technology plays a moderating role, effective logistics management in this chapter encompasses packaging, warehousing, and transport management. Significant amounts of grain are known to be lost after harvest, which worsens hunger and wastes expensive inputs like fertilizer, irrigation water, and labour. As a result, the IPEP programme was developed to end poverty and reduce inequality, particularly in rural and underprivileged populations, by providing the necessary infrastructure to boost output and reduce PHL. The research focuses on this objective of reducing PHL to question the operational procedures at the purported Warehouse Receipt System (WRS) and its dedication to coordinating packaging and transportation logistics in the agricultural sector. If 90 percent of the season's grain production avoids this PHL, food security has been attained. Post-harvest loss (PHL) is the term for the loss of quality that alters the nutritional value and look of grains (millet, maize, and rice).

In the chapter, three theories that strive to be validated in the light of the study are examined (see sections 2.4.2, 2.4.3, and 2.4.4).
H1: Packaging logistics contributes massively to food security
H2: Warehouse has a positive influence on food security.
H3: Logistics management has a significant positive relationship with food security
Due to the diverse nature of the study goal, a subjective scale is being used to evaluate warehouse, transport, and packaging logistics. A five-point Likert scale, ranging from strongly

disagree to strongly agree, is used to measure these variables as continuous variables (Figure 2.4). All of the listed theories will be tested using regression and correlation analysis.
The head porterage and tracks are traditionally the common means of transport in the agricultural sector, but none of them has proven responsible for a nation's food insecurity throughout the review, leaving room to incorporate the transport logistics into the existing literature with empirical support for achieving food security in the modern era. This variable is categorically measured (Section 2.4.1)

Smallholder farmers face many logistical difficulties, including storage problems, a lack of information, and transportation problems in the agricultural business. Utilising Kendall's coefficient of concordance (W), these were discovered during the review and will be cross-checked with other subjective variables. (Section 2.4.5). The chapter found that software, telecommunications, radio and television, and RFID are among the most utilised technologies in international warehousing for enhancing the performance of a warehouse receipt system like the IPEP. For context inclusion and literature recommendations, it is required to investigate the actual technology being used at the government warehouses. (Section 2.4.6.1.)

Again, it is emphasised that the application of basic technologies can improve Indigenous Logistics System operations. So, this study has highlighted a similar or more straightforward approach to facilitating transport coordination from the IPEP warehouse (Section 2.4.6.2) after carefully examining (Raheem *et al's.* 2021:5; Yawson's and Frimpong-Wiafe's 2018; Obeng's 2015) recommendation on coordinating agricultural transport with ICT.

The evolution of materials, technologies, and internet communication technologies in recent years has also improved packaging. For instance, intelligent packaging that can interact with products or communicate with customers has made it possible to track a single item throughout the entire supply chain. Packaging is evidenced by technology and materials used to enclose or protect goods for distribution, storage, sale, and use, this evolution must blend with the use of packaging at various buffer stores. In this regard, the chapter argues for the well-positioning of warehouse packaging in literature to extend the shelf-lives of foods and also provide pertinent recommendations for improvement.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 INTRODUCTION

Chapter three confers the study's methodology. It discusses the research approach, paradigm, design, study area, population, sample size, and sampling techniques, as well as the data collection technique, research equipment, and data analysis tools.

3.1 RESEARCH APPROACH

There are different approaches in the research field, such as qualitative, quantitative, and mixed methods. The quantitative approach results in data that can be interpreted and condensed into numbers. Quantitative data usually consists of closed-ended information such as that found to measure behaviours, and performance instruments (Blackstone, 2018:7), however it can also include open-ended information or both closed-ended and open-ended informations as in the case of this study (Bhandari 2023). The analysis of this type of data (mix information) involves statistically analysing data collected using tools such as questionnaires or checklists to address the research objectives or test the research hypothesis (Creswell and Creswell, 2017:145) as well as involving textually aggregating data into categories and presenting the diversity of ideas collected during data gathering (Creswell and Creswell, 2017:173; Bryman, 2017).
Survey research is probably the most common quantitative approach in sociology, but approaches such as content analysis and interviews can also be carried out to generate quantitative data (Blackstone, 2018:8)

A qualitative approach is one in which the investigator (researcher) frequently makes claims about knowledge, based primarily on constructivist perspectives, such as, the multiple meanings of individual experiences or meanings socially and historically constructed are used to develop a theory or pattern. Advocacy and participatory perspectives (i.e., political, issue-oriented, collaborative, or changeoriented) can also be considered, in isolation or in conjunction with constructivist perspectives (Mohajan, 2018:25). Qualitative data consists of open-ended information that the researcher usually gathers through interviews, focus groups, and observations. Typically, analysing qualitative data follows a path of aggregating it into

information categories and presenting the diversity of ideas collected during data gathering (Creswell and Creswell, 2017:173; Bryman, 2017).

This study adopted a mixed-methods approach based on pragmatic grounds guided by the research questions having both exploratory and confirmatory components (IMOTIONS 2024; Creswell 2016), considering the core premise of this approach, lies in the belief that by combining quantitative and qualitative approaches, a more comprehensive understanding of research problems can be gained than by using either method in isolation (IMOTIONS 2024). This study explores both the breadth (quantitative data) and depth (qualitative data)) of the research problem to achieve a more comprehensive understanding of the context, diversity and complexity of logistics management and food security in Ghana's relationship that would not be possible through a single qualitative or quantitative approach as the qualitative component combines/complements the quantitative components. In essence, this research approach characterised by its methodological pluralism involves the integration, analysis and interpretation of the quantitative and qualitative data types for a more robust and nuanced perspective on the research questions (IMOTIONS 2024). That said, this integration where the qualitative components will mix/complement the quantitative components allows the unveiling of layers of understanding that might remain obscured under a mono-methodological lens, such as providing the possibility of investigating the research questions, so as to identify aspects more accurately using different methods and techniques, from different points of view. Successful integration/triangulation needs a thorough assessment of each qualitative and quantitative method's type of information, including its strengths and flaws (Creswell and Clark, 2018:38; Ness, 2015). Furthermore, this mixed-methods approach influences all phases of this research, from the formulation of the research questions, to the study's design, data collection and analysis and the interpretation of results. This fosters a dynamic interplay between numbers and narratives, allowing for a fuller, more holistic understanding of the research phenomena (IMOTIONS 2024; Creswell 2016).

3.2 RESEARCH PARADIGM

A paradigm, according to Saunders, Lewis, and Thornhill (2023: 142) is a collection of rudimentary and unquestionable presumptions that support a group's frame of reference, method of theorising, and operational procedures. Having said that, a research paradigm is the

framework that a discipline's theories and practices fit into to create a research plan. It acts as the cornerstone for all other aspects of a research plan, such as the study's goal, research question, tools or measurements used, and analytic techniques. (Ulz 2023). Paradigms provide important frameworks of ideas for research methodology (Somekh and Lewin, 2011).

Mixed-Methods Research (MMR) which is the methodology of this study is more than merely a combination of research techniques, nevertheless it's also deeply rooted in specific philosophical underpinnings and paradigms that inform its principles, strategies and goals. Understanding these philosophical foundations is crucial for comprehending the rationale behind MMR, its implementation, and its potential to generate rich, multifaceted insights into research questions. Among the most influential philosophical underpinnings of MMR are pragmatism, constructivism, positivism and post-positivism. Each contributes unique perspectives and justification for the use of mixed methods. The paradigm suitable for this mixed-methods research is pragmatism considering the research problem and the key research questions. The significance of pragmatism as this study's selected paradigm has been clearly expounded on in 3.1.1 following Ryan's (2018:1) indication that "the significance of a selected paradigm should be clearly explained.

3.2.1 Pragmatism

There are a variety of research philosophies, however this study assumed the practical and action-oriented philosophical position of pragmatism, encouraging flexibility and innovation of this study's research design and implementation, making mixing of the quantitative components and qualitative components an increasingly popular choice as acknowledged in this research (IMOTIONS 2024).

Pragmatism emphasises views and eschews the dichotomy between positivist and constructivists paradigms. A pragmatist evaluates theories, concepts, ideas, hypotheses, and research findings not in an abstract manner but rather in terms of their roles as tools of thought and action as well as their practical implications in specific contexts (Saunders, Lewis, and Thornhill 2023: 153). This study evaluated the influence of logistics management on food security in terms of their practical implications focusing on local grains (rice, millet and maize), post-harvest productions and logistics activities (warehousing, packaging and transportation) logistics management as particular contexts. This research has practical implications for policymakers, agricultural practitioners, and logistics managers, as insights gained can guide

interventions to optimise logistics activities/processes and agricultural food production activities to enhance the impact of logistics management on food security in Ghana.

According to Miller & Sullivan De Estrada (2017:27) pragmatists avoid debating about concepts of truth and reality and focus on researching the issues of interest and value and finding different ways to bring positive consequences (IMOTIONS 2024). Pragmatists can integrate qualitative and quantitative approaches within the scope of a single research according to the nature of the research question (s), embracing plurality of methods, such as mixed methods (Walsh and Kaushik 2019) as in this study's approach.

From a pragmatic perspective this research methodology integrated qualitative insights from the semi-structured interview schedule and quantitative findings from the structured interviewer-administered questionnaire within the scope of this research based on their utility in answering the research questions specifically, driven by the research objectives and the practical implications of the findings (IMOTIONS 2024). This perspective encouraged flexibility and openness in the research design and allowed the selection and integration of the quantitative and qualitative methods in a manner that best addressed the complexity of the research problem (IMOTIONS 2024). In this study, pragmatism was adopted to explain and explore the impact of logistics management on food security in Ghana (Saunders, Lewis, and Thornhill 2023; Mastin 2017).

3.3 RESEARCH DESIGN

The framework or strategy that a researcher selects to carry out the study's research methods and techniques is known as the study's design. (Bhat 2024). A well-crafted study design serves as the project's glue, giving the investigation direction and structure that will lead to positive results (Jain 2022). That said, in designing mixed-methods research the quantitative and qualitative components are guided by a strategic framework, enabling the leveraging of the strengths of both approaches to achieve a comprehensive understanding of the research questions. Mixed-methods research designs can vary widely depending on the research objectives, the nature of research questions and the specific way in which the quantitative and qualitative components are integrated. There are three main types of mixed-methods research designs: Explanatory sequential; Exploratory Sequential, and Convergent Parallel, having

unique characteristics, application and processes on how gathered and analysed data will be integrated (IMOTIONS 2024; Skidmore and Kowalczyk 2023; Richters and Melis 2017: 146).

This mixed-methods study carefully considered and adopted the most appropriate and feasible design for answering the research questions (Bhandari 2023, McCombs 2021), by following the direction of an explanatory sequential design. This design assumed on pragmatic grounds is characterised by two distinct phases. The first phase involves collecting and analysing quantitative data, with findings informing the second phase which involves qualitative data collection and analysis, using strategies sequentially, to better understand the research problem/questions. The collection of data will include both numerical information (e.g., structured interviewer-administered surveys) as well as text information (e.g., semi-structured interview schedules) so the final database will be both quantitative and qualitative (Bhandari 2023; Creswell 2016). The decision to follow explanatory sequential design was driven by the research aim, theoretical orientation, practical constraints and ethical considerations, ensuring that the chosen design optimally supports the study's goals. More so, the design was based on the alignment with the research questions, objectives and the overall context of the investigation of the study. Thus, not only addressing the research questions comprehensively but also maximising the potential for meaningful and impactful findings, via effectively harnessing the strengths of both quantitative and qualitative methods (methodological pluralism) of the study.

The purpose of this design is to explain or expand upon the quantitative results/insights by exploring the warehouse managers' and senior staffs' perspectives, motivations and experiences in more detail based on the research questions *on* the strategies being adopted to improve logistics at the agricultural food industry to gain new insights, discover new ideas, and increase knowledge that might not be captured through surveys alone *presenting* a comprehensive picture on the integrated insights/findings on logistics management and food security relationship in Ghana using triangulation protocol technique (Dovetail 2024).

3.4 STUDY AREA

The Upper East and Upper West Regions of Ghana are the study's focus areas. The fact that both terrains had access to the IPEP warehouse and had grain variation cropping made them

seem ideal. Situated in the northeastern region of the nation, the Upper East Region is defined by latitudes 100 30" N and 110 N and longitudes 00 and 10 West. Burkina Faso borders it on the north, the Republic of Togo borders it on the east, the Sissala District in Upper West borders it on the west, and the West Mamprusi District in the Northern Region borders it on the south. Approximately 8,842 square kilometres, or 2.7 percent of the entire country, make up the land area. Approximately 80 percent of the economically active population in the Region works in agriculture, cultivating common crops such as dry season tomatoes and onions, guinea-corn, millet, rice, peanuts, beans, and sorghum (GSS 2021: 95; Ministry of Food and Agriculture 2021).

The following administrative districts and their capitals were part of the region at the time of the 2010 Census: Builsa (Sandema), Kassena-Nankana West (Paga), Kasena Nankana Eest (Navrongo), Bolgatanga Municipal (Bolgatanga), Talensi Nabdam (Tongo), Bongo (Bongo), Bawku West (Zebila), Garu Tempane (Garu), and Bawku Municipal (Bawku". Following the 2010 Census, four new districts were established: Nabdam (which was formed by dividing Talensi-Nabdam), Builsa South (which was formed by dividing Builsa), Binduri (which was formed by dividing Bawku East), and Pusiga (which was formed by dividing Bawku East) (GSS 2013:2).

A recent government decentralisation proposal divided the Garu and Tempane districts into distinct ones, similar to a few other districts. This study selected the Garu district (thus Garu and the adjacent villages) because of its accessibility, close proximity, and availability to/of IPEP storage in addition to its varied crop output.

In contrast, the Upper West borders Burkina Faso to the north, the Upper East Region to the east, the Northern Region to the south, and Côte d'Ivoire to the west. The region is 18,476 square kilometres in size, or roughly 12.7 percent of Ghana's total land area (GSS 2021: 96, Ministry of Food and Agriculture 2021). The Guinea Savannah contains the area. Wa has served as the capital and administrative hub of the Upper West Region since its establishment in 1983. The Regional Minister is in charge of the Regional Coordination Council (RCC), which is the main administrative body. Representatives from the Regional House of Chiefs, regional heads of decentralised ministries, and members of each district assembly are additional members of the RCC. Nine administrative districts make up the region: Lambussie/Karni, Wa West, Wa Municipal, Wa East, Sissala East, Nadowli, Jirapa, and Lawra. Peasant farmers make up the

bulk of the population in the Upper West Region. Farmers typically own 25 acres of land, and farming is a daily family activity, except for their leisure days. Farmers work their fields for both profit and subsistence. For the cultivation of crops such as guinea corn, maize, millet, rice, soybeans, groundnuts, cotton, yam, cowpea and sorghum, the population mostly depends on rainfall. Nadowli Kaleo, as it is now named, was deemed worthy of study in this region, notably the Doung community and nearby villages, for the same reason as the Garu district.

The decision to choose the districts, thus Garu then the adjacent villages and Nadowli Kaleo notably the Doung community then adjoining villages, was based on the two districts inhabited farmers growing mass variety of crops including grains to cater for the high consumption needs of Ghana's populace, as such requiring logistics infrastructures to aid in the successful harvest/ post-harvest handlings to facilitate mass food supplies. Hence these districts are in close proximity to the IPEP warehouses to enhance/realise food security. Therefore, considering this study's purpose, objectives and questions focus on logistics management's influence on food security it was relevant selecting farmers from these districts as the study's respondents for a comprehensive perspective/insight based on the most authentic responses/collected data from the specific research questions.

3.5 TARGET POPULATION

The population of a study is the entire group or universe of elements with the necessary properties to answer the research questions posed and draw conclusions about (Bhandari 2023, McCombes, 2021, Levy and Lemeshow 2013: 125). The overall population for the research is Agrifamers in Ghana. The population for the selected regions is 901,502 and 1,301,226 people, respectively, in the Upper West and Upper East, according to GSS (2021: 36). The World Bank (2017) states that 40 percent of Ghana's population works in the Agricultural sector; in essence, an average of 40 percent of the said regions are assumed farmers growing various crops, including maize, millet, and rice. This would make an assumed total of 881,091 farmers.

3.5.1 Sampling

A sample is a result of gathering information from a subset of the population and then applying that information to make generalisations about the complete set (Ravikiran 2023). Furthermore, a sample is a smaller group of people from whom the researcher will gather data, or the process of choosing a subset of the population to reflect the entire population (Bhandari 2023, McCombes, 2021, Polit and Beck 2017:743). The two primary sampling methods utilised in research are non-probability sampling and probability sampling.

Probability sampling works best in quantitative research because it tries to obtain a sample that has access to the best data by applying bias or preference (Bhandari 2023; McCombes, 2021; Vehovar, Toepoel and Steinmetz 2016: 329; Mathieson 2014: 1-2). Next, for two regions in Ghana, the Upper East and Upper West, where comparable grain varieties are farmed in large amounts, multi-stage sampling was used. Because of their high production and consumption in the nation, a sample of grain growers who grow rice, millet, and maize was selected and taken into account for the study. A cluster of two districts (described above), one from each chosen region, comprised the purposive sample of 384 commercial farmers overall. Two hundred and twenty-seven (227) farmers from the Upper East region's Garu District and 157 from the Upper West region's Nadowli Kaleo District made up this group. To strengthen the credibility of the quantitative data/insights/findings contact was made with the leadership of the farmers' associations thus Farmer Based Organisations (FBOs) for data on the farmers' crop type(s) grown/produced and capacity/acreage of farm land, then farmers that met the requirements of the inclusion criteria were chosen, and to double validate the selection process these potential respondents were filtered per their type(s) of crop(s) and acreage upon farmers' declaration. This practice helped in addressing the potential biases in the selection process. Survey Monkey (2017) modified a formula by Cochran (1977:25–27) which was used to determine the sample size.

Where:
s= Sample size
Actual population of study (**Agrifarmers**) = 2202728 x 40% = 881091
The margin of error at the chosen level of confidence (95% or 0.95) is 0.05, depicts an average confidence level and a medium confidence interval, with a fairly precise estimate, hence likely to capture/include the true value, thus the true value falling within the interval is certain.

P= Infinite population proportion (assumed at 0.5)

$S = \approx 384$ respondents

Proportional representation by sample areas:

Upper West = [901502 /2202728] *384 = 157

Upper East = [1301221 / 2202728] * 384 = 227

3.5.2 Inclusion and Exclusion Criteria

Grain commercial farmers for this study comprised farmers cultivating two acres of land or more in a crop season. Such farmers growing rice, millet, or maize participated in this study, excluding those growing otherwise. The warehouse officials, including the manager and senior staff in charge of routine operations, excluding those into other operations, were engaged as they know the cycle Farmers' surpluses go through at the Warehouses.

3.6 RESEARCH INSTRUMENTS

Research instruments are devices that are used to gather, measure, and analyse data related to a topic of study or research (Haruna 2023). The research used a broad range of data collection tools (Haruna 2023, Simplilearn 2023, Six and Bellamy 2012: 245, Adams *et al.* 2007). Structured questionnaires and semi-structured interviews, using audio recording devices provided the best tools for the researcher to gather sufficient data. The Department of Agriculture in the chosen districts was issued with a gatekeeper's letter to seek authorisation and direction to reach the potential respondents/participants comprising the management of the warehouses and farmers of various Farmer Based Organisations (FBOs) in the districts. The recruitment process was based on a direct personal approach to the operating manager and senior staff of the warehouses in the chosen districts, as well as members of the mentioned associations who are the primary users of the warehouses. The researcher, solicited consent from every respondent and participant through the department's guidance, utilising the DUT IREC participant letter of Information and an informed consent form after a comprehensive

interpretation of the letter and the form's contents to the prospective participants and respondents for the research.

Questionnaires: structured interviewer-administered questionnaires were distributed to the consented respondents by hand, and each was engaged privately to answer/tick respondents' views on all questions until all 384 responses were gathered from the respondents. A direct response was expected due to the straightforwardness and simplicity of the tool. The survey was divided into four segments, with a section identifying the socio-demographic variables of respondents. Section B recorded respondents' views on managing logistical systems in the agricultural sector. Segment C, however, inquiries about the logistics management challenges confronting food security. Section D questions the extent of post-harvest loss escape among grain growers. Most questions were put on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5) to enable the explicit collection of respondents' views on the study focus, after which the completed questionnaire was immediately retrieved from each respondent. This was possible since the instruments were already held by the researcher of the research team, that is, right after each respondent completed his or her questionnaire before leaving the meeting venue.

In the interview, two managers and two senior staff were sampled from the warehouses, two from each selected region, using a semi-structured interview schedule to understand the management practices displayed at the IPEP facilities. Per the qualitative analysis and scope of the study a sample size of four was worthwhile as the sampled participants were the key players or ultimate workforce with their operations having a comprehensive bearing on the study, as such measured up to the kind/volume of qualitative data required/sought to buttress/explain the core of this mixed-methods write-up. This qualitative data collection/interview lasted for an hour (60 minutes) and was conducted in the morning at the chosen warehouses, where sufficient attention from the management was obtained. Policies, frameworks, strategies, and other related documents were collected to complement the semi-structured interview data. This segment will help the researcher in suggesting an improved framework for sustained logistics management practices. The questionnaire and interview schedule are included in the appendices.

3.7 VALIDITY

The design and validation of the instrument consists of a multistage process in which piloting; expert qualitative and quantitative reviews; and observation training are inclusive (Brewer and Jones 2002; Palao, Manzanares, Ortega: 2015; Larkin, O'Connor and Williams 2016; Torres-Luque *et al.* 2018; Fernandes *et al.* 2019; Wilkie *et al.* 2023:03). Nevertheless, when doing research, pragmatists aim to satisfy both internal and external validity, believing that if variables other than the independent variable influence the result, the study's conclusions will not be internally legitimate (Bhat 2024; Jain 2022). Therefore, to enhance internal validity of the study, the methods of the study were strategically formulated and implemented gingerly to minimise the influence of extraneous variables, ensuring the study's findings accuracy. The standardisation strategy employed involved (Appinio 2024; Hollister *et al.* 2023):

- Formulating standardised protocols for data collection and respondents'/participants' instructions to select the respondents per the inclusion criteria using farmer data on crop type(s) grown and farming acreage capacity upon engaging the FBOs leadership, then filtered the potential respondents/participants to recruit/select those that qualified per the inclusion criteria to authenticate the selection process.introduced.
- Training of research team to follow standardised procedures consistently to minimise variability in data collection like proper conduct so as not to influence respondents'/participants' responses.
- Validating the measurement instruments by submitting them for experts in the field to review, assessing the content and revising accordingly, ensuring the measurement instruments accurately and reliably measured the constructs of the study.

This employed strategy ensured that the results of the research study accurately reflected the causal relationship between logistics management and food security without the influence of confounding variables or biases (Appinio 2024).

The degree to which the study's conclusions/results may be extrapolated to bigger populations, settings and situations is another factor that determines external validity, thus assessing whether the results/findings can be applied to other conditions beyond the specific conditions (Appinio 2024). To enhance the external validity of this study the strategy pursued involved:

- Methodological triangulation makes it possible to examine the research questions from mixed methods angles generating rich, multifaceted insights into the research questions (IMOTIONS 2024). Thus, each method's type of information, including its strengths and flaws were thoroughly assessed (Creswell and Clark, 2018:38; Ness, 2015). This also strengthen this study via following up the qualitative approach with the quantitative component, ensuring the results generalised to a broader respondents/participant to enhance the external validity of the study. (Anderson-Stanier 2024; and Turner, Cardinal, and Burton 2017:1)

Given the variety of measurement instruments available, to choose the best to aid in assessing the findings following the study's objectives, for the generated instruments designs to be valid (Bhat 2024; Jain 2022), a pilot study was conducted quantitatively and qualitatively to help refine the structured interviewer-administered questionnaires and semi-structured interview schedule to gain a general understanding of how the questionnaire and interview schedule would proceed in the field during the actual study based on the feedback and observations from the pilot study (Kopper and Parry 2023; Zarokanellou *et al.* 2017:36). This helped to iron out some of the questionnaire and interview schedule issues, such as improving the clarity of the questions and eliminating repetitions before proceeding with the actual sample (Kopper and Parry 2023; Whitehead *et al.* 2016:1061).

Trained/skilled enumerators sampled a trial group of thirty respondents/farmers to test the questionnaire and two participants/warehouse officials for the interview schedule, from the two selected regions, under study (Kopper and Parry 2023). The respondents/participants for the pilot study did not participate in the actual study. After conducting the pilot study, questions were submitted to subject experts again to ascertain relevance, accuracy, and alignment with the research objectives. Moreover, this helped to measure the validity and reliability of the research instruments used in this study. According to their proportionate representations, the piloted respondents /participants were as follows:

Upper West
Respondents = [901502 /2202723] *30 = 12;
Particpants = (2/4)*2 = 1

Upper East
Respondents= [1301221 / 2202723] * 30 = 18;
Participants = (2/4)*2 = 1

3.8 RELIABILITY

Reliability is all about consistency. Thus, the degree to which a research instrument gives consistent outcomes (Lee and Boyd 2023). To guarantee this, a trained research team first carried out the pilot test on 30 farmers and two warehouse officials, thus, exposing the instrument to potential flaws for amendment before fully scaling the actual data collection
More so, the reliability test was carried out on latent variables to measure the predictor (logistics management) construct as shown below;

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.552	0.763	4

At Cronbach's alpha =0.763=0.80 > 0, the latent tends worthy of predicting food security (the criterion) in the specified regions

Also, this study used conformability and dependability to ensure reliability qualitatively and quantitatively. With the conformability, for the interview sessions, an audio recording device was used to ensure that the findings from the interviews were not biased or based on the researcher's own beliefs or interests but were a true reflection of the participants' views, ensuring that the findings are confirmed or disconfirmed by the literature. The researcher used the member check system which encompasses asking participants to reading the researchers' notes and conclusions and comment on whether the researcher described exactly what was said (Mckim 2024; Wimmer and Dominick 2014).

For the dependability, it was maintained by ensuring that the questionnaire and semi-structured interviews were designed in a way that allowed future studies to produce similar results. Therefore, subject experts were asked to validate the semi-structured interview schedule and structure-interviewer administered questionnaire questions (Ruslin *et al.* 2022; Connelly 2016).

3.9 DATA ANALYSIS

Quantitative data was analysed using regression Pearson's correlation coefficient and Sorensen's co-occurrence coefficient for the qualitative data towards investigating the set hypotheses. The recovered questionnaires were coded and broken down using factual instruments, including the IBM Statistical Package for Social Sciences (SPSS) 28.0 and Excel. Decoded information was presented in tables and percentage responses to clarify the dialogues. Kendall's coefficient of concordance (W) was employed to pick logistical challenges to food security, whereas a chi-square test was run on transport logistics to achieve the criterion. The QDA miner software was used to analyse the qualitative (Interview) section.

Considering the explanatory sequential design of this mixed-methods study which involves the sequential collection, analysis, and integration of quantitative and qualitative research data (Creswell and Clark, 2017:2). This mixed- methods research design will combine the strengths of the quantitative and qualitative data, deepening and enriching the quantitative results with the explored qualitative data on participants perspectives, motivation and experiences in more detail as well as validating the quantitative findings with qualitative insights.

The qualitative findings that helped *in gaining new insights, discovering new ideas, and increasing knowledge on the strategies the government is adopting to improve logistics in the agricultural food industry was integrated* with the quantitative findings from the surveys, recounting the influence of logistics *infrastructure on Ghana's agricultural food industry, then the challenges of logistics management practices affecting food security* for a deep and wide understanding on the actual meaning of the combined results to draw comprehensive conclusions that would not have been possible with a single method alone. Triangulation protocol technique was used for the integration of both quantitative (numerical and statistcal) and qualitative (textual and narrative) insights/perspectives to generate one unified answer (Dovetail, 2024, Petrat 2022)

The integrated findings were interpreted in the context of the research questions, theoretical framework and existing literature, then presented in a manner effectively communicating the integration of the quantitative and qualititaive results with the quantitative findings in tables and charts interpreted first, complemented by the qualitative findings in narratives, with categorised interactive themes then the cohesive narratives from the bridged numeric outcomes and narrative insights offered a wholistic view of the research questions. Furthermore, the implications of the findings for theory, practice and future research were considered (IMOTIONS 2024).

3.9.1 Quantitative Segment

Assessing the Type(s) of Road Transport Achieving Food Security in Ghana

Descriptive statistics such as frequency distribution table and non-parametric Pearson chi-square test were carried out to test the association between food security and logistics management.

Examining Hypotheses, answering objectives 2 to 4 with correlation and regression analysis

- H1: Packaging logistics contributes massively to food security.
- H2: Warehousing has a positive influence on food security challenges.
- H3: Logistics management has a significant positive relationship with food security.

*Correlation i*s a statistical term that indicates how much two or more variables vary. A positive correlation means that the variables rise or decrease concurrently, whereas a negative correlation shows that one variable increases, while the other falls (Wigmore 2020; Ahmed Zaid 2015:2).

There is frequently a propensity to believe that changes in one variable cause changes in another when the volatility of one variable accurately predicts a comparable fluctuation in another. When two values rise simultaneously, there is a positive or direct correlation; when one value falls while the other rises, there is a negative correlation, also known as an inverse or opposing correlation.

One can assign a value to correlation:

- A perfect positive correlation is 1.
- A complete negative correlation is -1;
- 0 indicates no correlation at all (the values do not appear to be related).

a. X and Y have a high positive association. The points are near to a straight line, with y increasing as x increases.
b. There is a weak but positive association between x and y. The pattern is that y increases as x increases, but the points do not form a straight line.
c. There is no association between x and y; the points are randomly dispersed across the graph.
d. X and Y have a weak, negative connection. The graph shows a reduction in y as x grows, but the dots do not form a straight line.
e. Strong, negative connection. The points are near to a straight line, with y decreasing as x increases. The Pearson correlation coefficient is calculated using the equation i=1 where x represents the mean of the variable and $\bar{y}$ represents the mean of the variable.

$$r = \frac{\sum (xi - \bar{x})(yi - \bar{y})}{\sqrt{\sum (xi - \bar{x})2 \sum (yi - \bar{y})2}}$$

However, correlation does not imply causation. An unknown factor may influence both variables similarly, hence the need for regression. Regression analysis is used to anticipate or predict a dependent variable's value based on the values of independent variables or to use one or more independent or control factors to explain the variability in dependent variables. To

determine how one variable affects another (i.e., how much the dependent variable changes with changes in each of the independent variables) and whether the researcher can predict one variable based on the values of others, it also analyses relationships among variables (Simplilearn, 2024, Ahmed Zaid 2015:13). Making a linear relationship between a response variable and explanatory factors for prediction is the primary objective of regression, assuming that there is a functional linear link and that functional regression is superior to other techniques. Simple linear regression evaluates the relationship between two variables, whereas multiple regression studies one dependent variable for numerous independent factors. Either set of hypotheses uses a simple linear model to explain the cause-and-effect relationship in the viewing variables. In a cause-and-effect relationship, the outcome is the dependent variable, while the logistical systems are the independent variable. Less squares linear regression is a method for estimating the value of a dependent variable (y) based on the value of an independent variable (x) (Simplelearn 2024; Zaid 2015:14).

The regression model can be quantitatively represented by the following equation:

$\mathbf{y} = \beta 0 \pm \beta 1\ \boldsymbol{x} 1 \pm \varepsilon 1$

Where:

- x is the independent variable.
- y is the dependent variable.
- $\beta 1$ is the Slope of the regression line • $\varepsilon 1$ = random error component.
- $\boldsymbol{\beta 0}$ is the intercept point of the regression line and the y-axis

Challenges and Constraints to Logistics Management that Affect Food Security

Used Kendall's coefficient of concordance, also referred to as Kendall's W, to evaluate Ghana's food security constraints. Kendall's coefficient of concordance is an indicator of how well respondents agreed on a particular set of limitations (Legendre 2022:2, 2005). Consequently, Kendall's W is an index that determines the difference between the total ranks' observed variance and their maximum likelihood. Using this index, one can find the total rankings for each restriction under consideration (Jumpah and Adams 2020: 4; Mattson 1986). If there is complete agreement in the ranking, the diversity within this quantity will be at its highest (Jumpah and Adams 2020: 4; Mattson, 1986). According to Legendre (2022:2, 2005), utilising the following formula, one may get Kendall's W or Kendall's coefficient of concordance:

W = - Pt

$P^2(n^2-n)$

Where:

W - Kendall's coefficient of concordance

P - Number of respondents that ranked the constraints

n - Number of constraints ranked, and

S - Sum of squares statistics over the row sum of ranks

Interpretation of Kendall's W (Kendall's Coefficient of Concordance)

Kendall's W (Coefficient of Concordance) r

anges from zero being equal to or less than W or W being equal to or less than one. A value of zero means perfect disagreement among the raters of the constraints identified, while a value of one means perfect agreement among the respondents on the rated constraints. The higher Kendall's value, the stronger the association.

Testing the Significance of Kendall's W

The condition for testing the value of Kendall's W that is to test for Kendall's W, the number of observations or respondents must be greater than or equal to fifteen ($p \geq 15$), or the number of constraints being ranked must be greater than or equal to five ($n \geq 5$).

Hypothesis Testing

H0: There is no agreement among respondents on the ranking of the constraints

H1: There is agreement among respondents on the ranking of the constraints

3.9.2 Qualitative Data Analysis

A QDA miner (Qualitative Data Analysis Software) was used to analyse, the warehouse management view on the influence of logistics on food security. Sorensen's co-occurrence test was run to affirm similarity among the views shared by the respondents. Sorensen's similarity coefficient/index (DSC) measures the similarity between the themes and the level of food security expressed by the participants.

$CC = S1 + S2$

Where:

C = species in common

$S1$ = species in common 1

$S2$ = species in common 2

The model cites the observed relationship between codes (of various themes) and the management opinion on what the government can do to improve agricultural logistics management in Ghana. The emphasis here is solely on the codes proving viable in respondents' claims.

3.10 LIMITATIONS AND DELIMITATION

Limitations are possible shortcomings that are usually uncontrollable and directly associated with the chosen research design, the statistical model's constraints, the funding source, or other elements. Nonetheless, as they could affect the study's design, findings, and conclusions, it is crucial to specifically mention them in the thesis (Ross and Zaidi 2019).

According to Coker (2022) delimitations are essentially the boundaries that writers intentionally establish for themselves. The definitions that researchers decide to set as the boundaries or limits of their work are what they are concerned with to achieve the study's aims and objectives. In this sense, the researcher has the authority to set delimitations. Therefore, the main topics covered by delimitations include the study's theoretical framework, objectives, research questions, variables under investigation, and study sample.

According to Drew (2023), there are rarely any perfect studies; researchers must make trade-offs during the development of their research, which is frequently based on pragmatic factors like participant breadth versus depth of insight, and methodology preference. For these pragmatic factors, this study's focus introduced limitations and delimitations of the field investigated as follows:

• **Focus on Grains:** The delimitation to grains (rice, millet, and maize) ensured a concentrated analysis but excluded other critical food items also affecting food security. This focus was due to the significant role of these grains in Ghana’s food supply, thus, restraining the scope to a specific aspect of the food industry as such the findings of this write-up may not be a fair

representation of other crops or agricultural context in Ghana, hence highlighted for posterity studies.

• **Specific Logistics Facets:** The study focuses on packaging, transportation, and storage. While these are critical components, other logistical aspects such as distribution networks, market access, and post-harvest processing might also impact food security. The delimitation ensures clarity and feasibility, but these broader logistical influences could not be considered as such this study's findings may not represent other logistical aspects fairly, hence, highlighted for posterity studies.

• **Practical Considerations:** Time and budget constraints are significant limitations. These factors influence the depth and breadth of the research. The study's focus on grain logistics within these constraints is a pragmatic approach, though limits the potential for a more comprehensive analysis of the broader logistics landscape.

• **Defined Boundaries:** The theoretical framework and objectives are specifically set to address grain logistics. This deliberate focus helps maintain clarity and relevance but may limit the exploration of other theoretical perspectives or variables that could enrich the understanding of logistics management and food security, as such future studies in other theoretical perspectives or variables that could enrich the understanding of logistics management and food security has been recommended.

• **Administration of Questionnaire:** The decision to administer the questionnaire face-to-face could introduce interviewer bias, as such the research team were well trained on the data collection process' acceptable conduct in order to understand and behave satisfactorily so as not to influence the repondents/participants responses (Hecker and Kalpokas n.d.). This helped in addressing the bias the data collection process could have introduced.

• **Recruitment:** The choice of a purposive sample of 384 commercial farmers, though statistically grounded could introduce bias in the selection process as such to strengthen the credibility of the collected data and findings, the sample of 384 commercial farmers were chosen upon contacting the leadership of the Farmer Based Organisations (FBOs) for data on the crop type(s) grown and farming acreage capacity, then the potential respondents were filtered to recruit/select those that qualified per the inclusion criteria to authenticate the selection process.

• **Exclusion and Inclusion Criteria:** Excluding other crop growers was key considering the focus of this study and the centrality of grains to Ghana's food security, though such exclusion might limit the generalisability of the findings or fair representation to other agricultural

contexts in Ghana, this has been acknowledged as such highlighted for posterity research to gain the needed influential insights.

3.11 ETHICAL CONSIDERATION

This study involves people as such considered ethics in light of several challenges or issues that could have occurred (Bhandari 2023; McCombes 2021; Greenfield and Greener 2016:46). That said, this study observed the standard requirements of the Durban University of Technology research ethical principles and guidelines.

The following ethical principles were upheld:

- **Informed Consent**: The researcher obtained voluntary informed consent (Mirza, Bellalem and Mirza 2023; BERA 2004) from every participant and respondent through the IREC Participant/Respondent Letter of information and informed consent form after comprehensively interpreting the content, including the aim and objectives of the research to participants before the data collection session thus participating in an interview or responding to a questionnaire. In explaining the ethics of the research during the confidentiality and anonymity briefing, the prospective research subjects were informed of having a choice whether or not to be involved in the study through the informed consent ethical code (Kang and Hwang, 2023), so they could freely opt out if they felt awkward about their involvement to this study (Gatekeeping and ethics approval from DUT 2023, Dwivedi and Weerawardena 2018). Therefore, as the research subjects enthusiastically accepted to be involved due to the influence of the established trust and rapport (Kang and Hwang 2023)., the researcher ensured that the research was free of any deception, as such no participant and respondent was misled and every participant's and respondent's consent and agreement was sought before proceeding with the collection of data (Bellalem 2023). That said, every participant and respondent made an informed decision to assist with the required information (Sage 2019: 90)
- **Preserving participants' anonymity and confidentiality**: The researcher made every effort to safeguard the anonymity of the research participants and respondents as well as the privacy of the data (Mirza, Bellalem and Mirza 2023; Dane 1990; Miles and Huberman 1994). The researcher respected the privacy rights of the respondents and

participants which was highly relevant for genuine evidence to be acquired from them (Kang and Hwang, 2023; Sekaran and Bougie 2009). Since the research process produced beneficial results for the researcher as well as the participants, it is essential to comprehend and follow confidentiality and anonymity principles and norms in the research (Kang and Hwang 2023). Therefore, the researcher gave utmost importance to confidentiality and maintained anonymity, to obtain reliable information and research credibility. Furthermore, it is against ethical and legal norms for research methods for researchers to misuse sensitive information (Kang and Hwang 2023, Christen *et al.* 2020), the researcher pursued adherence to ethical rules and standards related to confidentiality and anonymity in this mixed-methods study by addressing privacy concerns and assuring privacy to the respondents and participants during the data collection session, hence, the researcher ensured that the research subjects' personal identifying information and sensitive data were safeguarded and not disclosed (Kang and Hwang 2023). That said**,** participants and respondents felt empowered to participate and respond voluntarily, they made an informed decision not to reveal their names upon completion of the questionnaires, and the researcher kept confidential data safe during the research process.

- **Protection of participants against harm and mental stress**: The researcher prioritized the well-being of the study participants and respondents so as not to put them in harm's way or danger (Mirza, Bellalem and Mirza 2023) as such shielded them from potential harm (Kang and Hwang 2023), by assuring the study participants and respondents of their safety, influenced by privacy (Kang and Hwang 2023; Brandimarte *et al.* 2013). Considering the adverse effect respondents and participants would experience in worrying about getting hurt or being at risk of harm to their dignity due to the disclosure of their private information as a result of their involvement in this mixed-methods study (Kang and Hwang 2023). Furthermore, the preserved and implemented anonymity and confidentiality principles fostered autonomy and provided the research subjects with the required control and freedom, allowing them to feel free to communicate their thoughtful expressions on the subject matter, make a correction or retraction of the wrong utilisation of expressions, without hindrance intervention or fear, (Mirza, Bellalem and Mirza 2023), resulting in more engagement, and effective contribution of highly enriched data for the study.
- **Truth and honesty:** The researcher, practised the guiding principles of openness and transparency in this research endeavour and gained a deeper understanding of the

respondents' and participants' thoughts and emotions (Mirza, Bellalem and Mirza 2023; Flick 1998; Boulton and Hammerseley 1996; Lincoln and Guba 1985; Miles and Huberman 1994) which established trust and rapport between the researcher and the research subjects (Kang and Hwang 2023, Bolderstone 2012, Joinson *et al*. 2010, Karnieli *et al.* 2009), resulting in effective communication, and preservation of the integrity of the research processes. Also, the trustworthiness and validity of the research findings were increased with the researcher utilising triangulation (Aransiola 2024; Mirza, Bellalem and Mirza 2023) to gather information from diverse sources (Mirza, Bellalem and Mirza 2023; Flick 1998; Boulton and Hammerseley 1996; Miles and Huberman 1994; Lincoln and Guba 1985)

No	**Ethical Issues**	**Participants Right**	**Compensation Available**
I	Preserving participants anonymity	Right to privacy	Modification by researcher
Ii	Exposing participants to mental stress	Right to health/safety	Right to be heard Right to redress
Iii	Use of special equipment and technology	Right to privacy Right to choose	Right to redress
Iv	Use of deception	Right to be informed	Right to be heard right to redress
V	Causing embarrassment or offence	Right to respect	Right to redress

Table 3.1 Ethical Consideration: Based on (Sage 2019: 91; Smith and Quelch 1992:162)

- **Storing data Information:** Collected data were stored on an external hard drive and USB whilst keeping cloud storage on a Google drive or bond storage for a backup. All

records both written and audio have been housed in a secured location (Mirza, Bellalem and Mirza 2023).

THE LOCATION OF THE STUDY

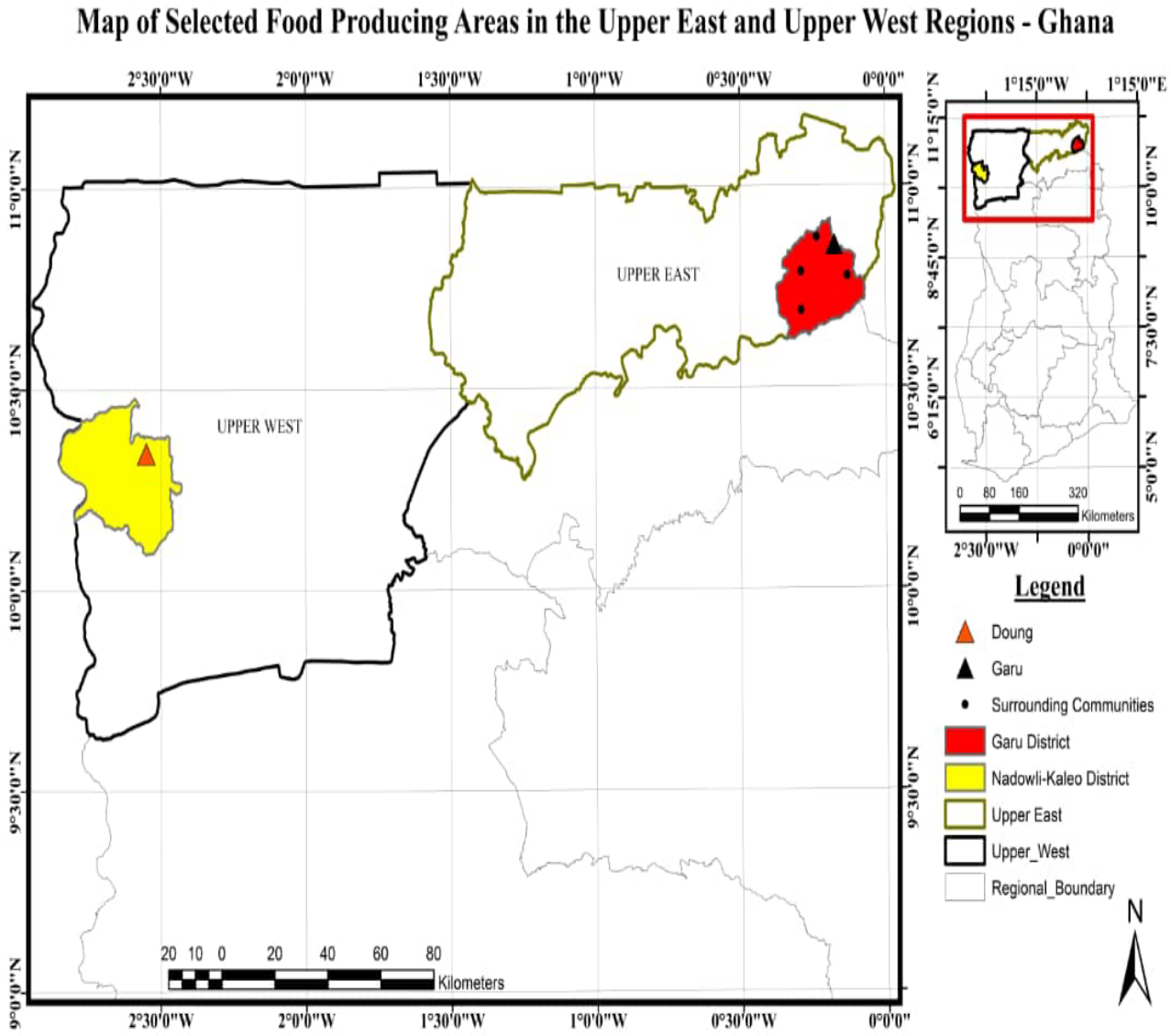


Figure 3.1: Target Regions/Areas: Upper West with Nadowli-Kaleo shown in yellow and Upper East with Garu shown in red in the map of Ghana

3.12 CHAPTER SUMMARY

This study, which employs mixed methods, is predicated on the pragmatic paradigm put forth by Kelly and Cordeiro (2020). This paradigm is deemed especially valuable for directing research, such as this one, that aims to improve practice and policy for the benefit of the public while upholding the quality-driven rigours of academic research. Following the direction of a descriptive exploratory design based on its central goal, the study areas for this project are the Upper East and Upper West regions of Ghana. Both terrains were thought appropriate owing to the grain variant cropping and access to the IPEP warehouse. The populations for the selected regions are 901,502 and 1,301,226 people, respectively, in the Upper West and Upper East, according to GSS (2021). The World Bank (2017) states that 40 percent of Ghana's population works in the agricultural sector; in essence, an average of 40 percent of the stated region's residents are assumed farmers, growing various crops, including maize, millet, and rice.

The overall sample of 384 commercial farmers was purposively sampled from a cluster of two districts (aforementioned), one each from selected regions. This comprised 227 farmers from the Garu District (Upper East region) and 157 from the Upper West, Nadowli Kaleo District. Data were collected via a structured interviewer-administered questionnaire and interviews (with four warehouse officials) and analysed mainly using regression, correlation, and Sorensen's co-occurrence models. These are modelled with the help of IBM SPSS 28 and QDA Miner Lite software.

CHAPTER FOUR

RESULTS PRESENTATION AND DISCUSSION

4.0 INTRODUCTION

This chapter provides an analysis of the research findings from the primary data that were collected from the respondents and participants using interviews and questionnaires. This mixed-methods study thoroughly considered and adopted an explanatory sequential design deemed appropriate for shaping the approach to inquiry and analysis, linked to the research questions and objectives (IMOTIONS 2024). Quantitative data analysis was adopted as a process of applying statistical techniques to describe, clarify, summarise, outline, and evaluate data, with the use of QDA miner software for the qualitative data.

The integrated mixed-methods findings, are presented sequentially to effectively communicate the integration of the quantitative and qualititaive results with the quantitative findings numerically and statistically in tables and charts interpreted first, complemented by the qualitative findings textually and narratively, and categorised themes then the cohesive narrative bridging the numeric/statistics outcomes and text/narrative insights offers a wholistic view of the research questions, unveiling layers of understanding that might remain obscured under a mono-methodological lens. To address the research objectives, the research data have been analysed and discussed below:

4.0.1. Socio-Demographic Detail of Respondents

Variables	**Variable Definition**	**N**	**%**
Gender	Male	75	18.75
	Female	309	81.25
Age	Age of respondent (years)		
	18-25	2	0.52
	26-33	15	3.91
	34-41	246	64,06

	42-49	5	1.30
	50 above	116	30.21
Education	Below SHS	357	92.97
	Above SHS	27	7.03
Grain	type of grain planted		
	Maize	128	33.33
	Millet	128	33.33
	Rice	128	33.33
Acre	Farm acreage cultivated		
	2-5acres	244	63.54
	above 5acres	140	36.46
District/ region	District and region of respondents		
	Garu (Upper East)	227	59.00
	Nadowli (upper west)	157	41.00
years of experience	years of expertise in grain farming		
	1-5yrs	59	15.36
	6-10yrs	119	30.99
	above 10yrs	206	53.65
The warehouse usage	whether the respondent uses the warehouse		
	Yes	287	74.7
	No	97	25.3
Bags	number of bags harvested in a season		
	1-10bags	193	50.26
	11-20bags	51	13.28
	21-30	9	2.34
	31-40	12	3.13
	41-50	70	18.23
	51-60	49	12.76
Why stop using the Warehouse?	Insufficient harvest	69	17.97

	Have my own storage	24	6.25
	Lack of prior Knowledge	4	1.04

Table 4.0.1: Socio-Demographic Detail of Respondents

Source**:** Authors Original Field Survey, 2023.

Gender of Respondents

A majority of the 384 sampled respondents were female, making up 81percent (N=309) and male, comprising 19 percent (N=75) of the total. Given the high work intensity, it has been claimed that men predominate in logistics and contract management (Deyi and Zenda 2022), nonetheless, the sample under observation was twisted towards men. According to research from the Food and Agriculture Organisation (FAO, n.d.: 4) article "The Status of Women in Agricultural Systems Overview," women work in agricultural food systems worldwide and, in many cases, are the primary source of income for them, rather than males. Reducing hunger, increasing earnings, and enhancing resilience are all benefits of empowering women and narrowing gender disparities in agricultural food systems for women and their households. Agricultural food systems employ 66 percent of women in sub-Saharan Africa, compared to 60 percent of men in the same field. In southern Asia, women make up 71 percent of the labour force working in agricultural food systems, compared to 47 percent of men (FAO n.d.: 12). There is a global push to reduce the gender gap in the logistics and food security sectors.

Age Distribution of respondents

According to Table 4.0.1, 236 farmers, or 64.06 percent, were between the ages of 34 and 41, indicating a large number of late youths involved in Ghana's agricultural industry. 1.30 percent (N = 5) are in the 42–49year range, 3.91 percent (N = 15) are in the 26–33year range, and 30.21 percent (N = 116) are in the 50 and above year range. The early youth, who are between the ages of 18 and 25, provide the least amount, of responses (0.5 percent, N = 2). According to Raheem *et al.* (2021), few young people are entering the logistics and food security industries, among the several reasons for their underrepresentation, are low attractiveness and urbanisation. Since its 2017 edition, the FAO State of Food Security and Nutrition in the World 2023 report, has shown that this might have a disastrous impact on the entire food chain, not just in Ghana. With the world moving away from achieving the SDG 2 targets due to the

intensity and combination of violence, harsh weather, economic downturns, extremely expensive healthy food, and rising inequality (Sporchia *et al.* 2024; IISD 2019), to completely comprehend the obstacles and possibilities for achieving the SDG2 aim, one must consider additional megatrends, such as urbanisation. Food purchases are becoming common among rural as well as urban households in various countries, according to new data (FAO 2023). Soon, the global issue of rural-urban drift, which is destroying the agriculture industry, may have even more severe effects (Guresci 2022) on logistics and food delivery (Dzudzor 2019). The observation in this article supports FAO (2023) by highlighting the need for additional youth development programmes that can motivate and direct the employment of young people in the production and security of food.

Grain type grown by respondents and farming acreage

Each of the three studied grains rice, millet, and maize contributes 33 percent (N=128) to the responses gathered. Of these, 64 percent (N=244) cultivate 2.5 acres of land, and 36 percent (N=140) grow more than 5 acres annually—a trait shared by peasant farmers.

Less than 1.2 hectares make up around 60 percent of all farms in the nation; 1.2 to 2.0 hectares make up 25 percent and 2.0 hectares or more make up just 15 percent (Przezborska-Skobiej and Philip-Quaque 2022:87; Tractors Ghana 2022: 1; SRID 2021). The average farm size is less than 1.6 hectares and 95 percent of the cultivated land or 136,000 km^2 is made up of small and medium-sized farms with a maximum size of 10.0 hectares. This represents roughly 57 percent of the country's total land area, which is 238,539 km^2, which is classified as "agricultural land area" (FAO 2023; Przezborska-Skobiej and Philip-Quaque 2022: 87; SRID 2021). The foundation of Ghana's agriculture is smallholder farming, which makes up the majority of the industry.

Usage of the IPEP warehouse and reason some stopped using

Table 4.0.1 shows that although 25 percent (N=97) of the respondents had claimed they had stopped utilising the warehouse due to insufficient harvest, 75percent (N=287) of the respondents had used the facility up to this point. On the reason for the respondents not using the warehouse, replies representing 71 percent of the total responses collected, have insufficient harvest, twenty-five (25) percent (N=24) of respondents said they had storage and didn't see the need to use the IPEP warehouse going forward, while 4 percent (N=4) said they were unaware of the facility's existence until they joined the FBOs.

One of the participants in Garu had this to say:

"After all, at the moment the facility is indifferently resourced" **R1a.**

To ensure national food security, the Ministry of Food and Agriculture said in 2022 that the government had finished the construction of 80 warehouses throughout the nation, each of which could hold up to 1,000 metric tonnes (mt) of food (Arthur 2022). The Ghanaian Times in Accra, which was listening in on the radio station Peace FM in Accra, reported this (Arthur 2022).

In furtherance to the reasons for quitting IPEP usage, it seems less can be said of farmers' ignorance of the IPEP existence; a senior manager at Garu accentuates

"Our extension officers inform farmers in their jurisdictions aside the media's infrequent assistance" R1b

In northern unimodal rainfall areas, harvesting operations of 2023 cereal crops for instance went on until December. The Food and Agricultural Organisation (2023) recounts that overall production prospects in the north were favourable, reflecting adequate cumulative rainfall amounts between May and September. Weather forecasts point to average rainfall amounts between November 2023 and January 2024 over most cropping areas, bolstering yield expectations for the 2023 cereal crops

For example, the total amount of cereal production for 2023 was predicted to be 5.3 million tonnes, which is 4 percent more than the previous year's output and 18 percent more than the five-year average. This is due to both a minor increase in planted area and generally favourable weather. However, crops in parts of the region have been affected by below-average rainfall amounts (ASI map), likely resulting in localised production shortfalls (FAO 2023).

The paradox of insufficient harvest causing avoidance of the warehouses is justified by the FAO for some parts of North involving sampled areas that saw below-average rainfall in the year of data collection, 2023. Irrigation is less practised in Ghana, especially in the north (Atchulo 2024) suppose, farmers choose not to use the IPEP for poor yield in a season; then few do self-storage also.

Education

About 93 percent (N=357) of the farmers are below SHS with 7 percent (N=27) schooled above SHS, according to Table 4.0.1. Not only does the data tell of the high participation of illiterates and semi-literates in the research but it also shows that farming in the north of Ghana is vastly dominated by the less educated. In contrast to the claim made by GIPC (2022:5) that government initiatives like free basic and secondary education have ensured a 69.8 percent literacy rate for citizens who are 6 years of age and older as of 2021, the observation challenges data cited by Oxford Economics, Ghana Statistical Service, United States Geological Service, Global Peace Index, World Bank, Visit Ghana (Tourism Report 2020), Ghana Investment Promotion Centre, and Ghana Bauxite Company Ltd.

District / Region

Garu district of Upper East recorded 59 percent (N=227) participation against 41percent (N=157) from the Nadowli Kaleo district of Upper West, Ghana (refer to Table 4.0.1).

The northeastern part of the nation is home to the Upper East Region. The land size is roughly 8,842 sq km, which is 2.7 percent of the entire country's area and lower than the Upper West's area. Eighty percent of the Region's economically active population works in agriculture, raising common crops such as dry season tomatoes and onions, guinea-corn, rice, groundnuts, millet, and beans (GSS 2021: 95, Ministry of Food and Agriculture 2021).

However, the Upper West occupies 18,476 square kilometres, or roughly 12.7 percent of Ghana's total land area (GSS 2021: 96, Ministry of Food and Agriculture 2021). Peasant farmers make up the bulk of the population in the Upper West Region.

Comparatively, the Upper West surpasses the East in terms of land size nonetheless the Upper East is over the West with population density hence the sample size disparities.

Years of Experience

Of the farmers, 15 percent (N=59) had 1–5 years of experience in grain growing, while 31 percent (N=119) had 6–10 years of experience. A significant portion of the participants had cultivated for ten years or more, and fifty-six percent (N=206) demonstrated proficiency in both grain production and storage (refer to Table 4.0.1). There is strong evidence that the nation's farmer population is ageing, and this issue needs to be handled to support sustainable

agriculture production. In Ghana, the average age of farmers is 55 years old, while the average life expectancy is between 55 and 60 years old (MoFA 2024). The MoFA data however supports that many farmers in Ghana are highly experienced in the agricultural industry so that matters contiguous with planting and storage post-harvest are not new, especially in northern Ghana. Competent class they are (in this regard) to have participated in this survey.

Number of Bags harvested

Table 4.0.1, shows about 50 percent (N=193) of respondents harvest 1-10 bags of either grain, 13 percent (N=51) 11-20 bags, 2 percent (N=9) 21-30 bags, 3 percent (N=12) 31-40 bags, 18 percent (N=70) 41-50 bags and 13 percent (N=49) 51-60 bags, communicating that most farmers in the northern Ghana obtain a maximum of 10 bags of sampled grains a season. Buttressing this is a recent study by Darfour and Rosentrater (2022) which saw participating farmers basically as smallholder farmers cultivating 25 acres of land. Smallholder farming like peasant is eminent in Ghana and it is no surprise of the yield recorded as justified by the FAO (2023); the year 2023 saw parts of the North involving selected areas suffer poor rain patterns, perhaps this phenomenon also had a stride on farmer harvest under observation.

4.0.2 Empirical Data Analysis

Management of Logistical Systems

This section accounts for the response to the likert scale indexed to latent variables on the major constructs

4.0.2.1: Transport Logistics

Around this construct were conjectures put forth for respondents' opinions surrounding the latent variable (boldened) in a five-point Likert scale.

- **Access to transportation:**

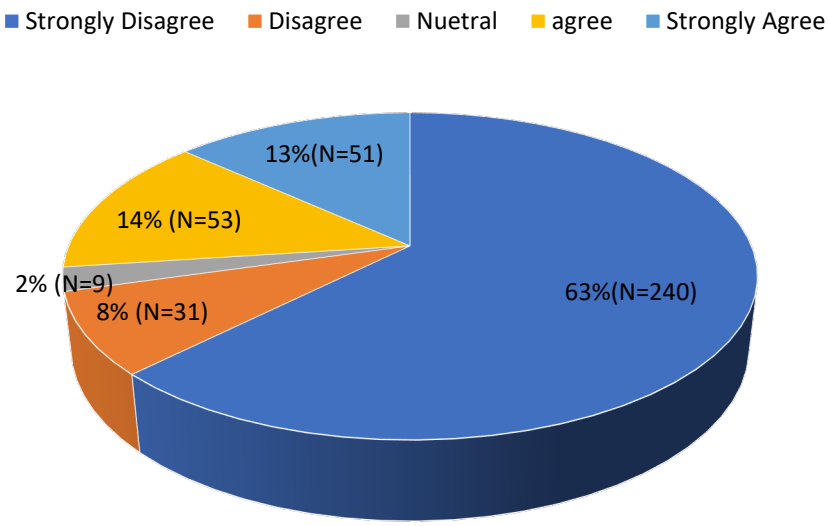


Figure 4.0.2.1.1_ Easy access (source: Field Survey 2023)

Participants were probed to rate the access of farmers to transport produce after harvest. Figure 4.0.2.1.1 shows that sixty-three percent (N=240) of farmers strongly disagree with easy access to transportation conveying their harvest to the warehouse and they represent the majority. 14 percent (N=53) agree, 13 percent (N=51) strongly disagree, 8 percent (N=31) disagree and 2 percent (N=9) hold a neutral view on this front. The perspective of respondents suggests that uneasy lies with most farmers transporting their food post-harvest. Known it is that access to transport networks is the backbone of any modern economy, as they enable mobility, trade, tourism and industry. Ghana needs to invest in this sector, by not just building roads or bridges (Hellmuth-Sander, 2023) but also making accessible vehicles to remote places to help fix this deficit. The extant literature attests to the findings of this study. One of the farmers has this to say:

There is an easy access to vehicle to transport produce after harvest. (Refer to appendix 1, questionnaire B1i)

- **Charges in conveying harvested produce:**

Participants were probed to rate the charges farmers incur in conveying produce. Over sixty-seven percent (N=261 of 384) of respondents opposed paying fewer charges when transporting their harvest. Thirty-two percent (N=123 of 384) accept paying fewer charges when conveying

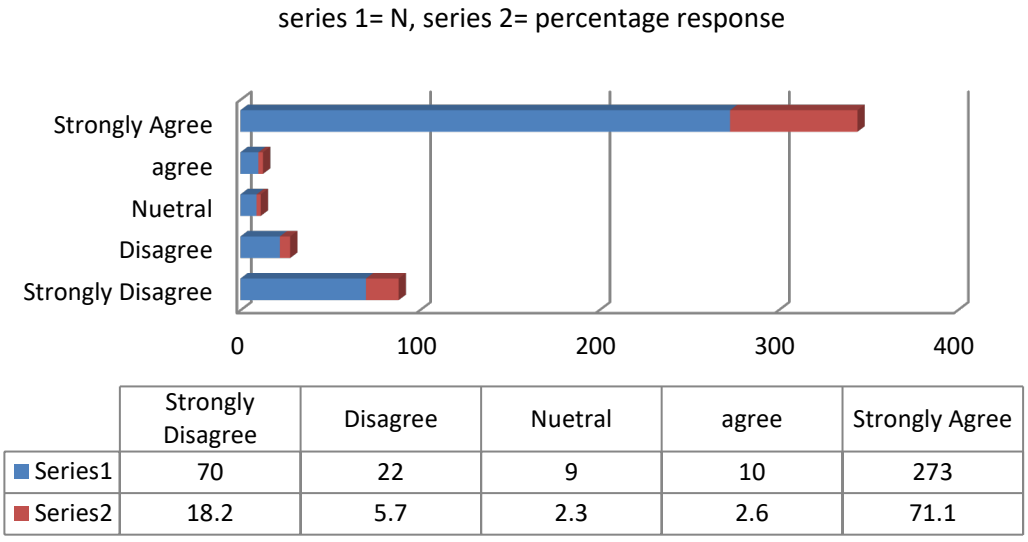
harvest to the warehouse (refer to table 4.0.2.1.2). There is doubt about the affordability of transport costs carrying food produce to the IPEP warehouse. Neri (2022), who is an Agriculture and Food Security Consultant (2022) evidence that Ghana is currently facing inflation at an 18-year high as food prices and transport costs surge. Inflation is quoted at 27.6 percent. One of the farmers conversed that:

I incur very less charges in conveying my produce (Refer to appendix 1, questionnaire B1ii)

Table 4.0.2.1.2_ less charge (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	245	63.8	63.8
	Disagree	16	4.2	68.0
	Agree	87	22.7	90.6
	Strongly Agree	36	9.4	100.0
	Total	384	100.0	

- **Road linking farm areas**



	Strongly Disagree	Disagree	Nuetral	agree	Strongly Agree
Series1	70	22	9	10	273
Series2	18.2	5.7	2.3	2.6	71.1

Figure 4.0.2.1.3 _Poor-road linkage (source: Field Survey 2023)

Participants were probed to rate the road linking the farm areas of farmers. Seventy-three percent plus (N=283) of farmers support poor road linkage affecting transport logistics in the agricultural sector. Barely 23.9 percent (N=92) refutes this claim. Ironically, the Minister of Food and Agriculture in 2022 reported in the media as saying foodstuffs are left to rot in some parts of the country due to poor roads (Neri 2022), attesting to the current finding. Some of the farmers conversed that:

Road linking the farm areas is poor (Refer to appendix 1, questionnaire B1iii)

- **Route for connection to the IPEP warehouse/storage**

Participants were probed to rate the route for connection of farmers farm areas to the IPEP warehouse/storage. According to Table 4.0.2.1.4, over thirty-one percent strongly disagree whereas 41 percent disagree that the foot route is the only road available to their farm yards. A total of 72.4 percent (N=278 of 384) of the sample respondents disagree with the notion. Be that as it may, 21 percent strongly agree whilst 2.3 percent agree summing to 23.3 percent (N=88 of 384), conformable to the assertion made. Response from the table highly supports that farmers discard the idea that only the foot route connects their farm zones. Harvests are usually carried by the head for lack of access to good/motorable routes (Neri 2022). One of the farmers had this to say:

Only foot routes connect my farm area and the storage center. (Refer to appendix 1, questionnaire B1iv)

Table 4.0.2.1.4_ Foot route (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	120	31.3	31.3
	Disagree	158	41.1	72.4
	Neutral	18	4.7	77.1
	Agree	9	2.3	79.4
	Strongly Agree	79	20.6	100.0
	Total	384	100.0	

- **Shortages of vehicles to transport harvest**

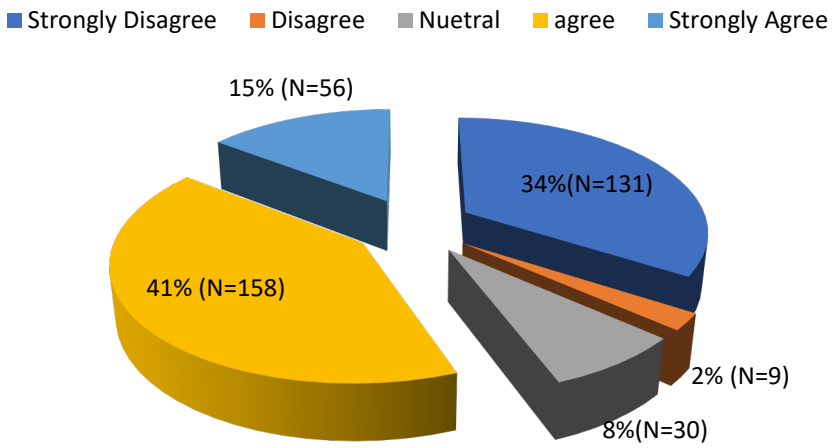


Figure 4.0.2.1.5_ No Vehicle (source: Field Survey 2023)

Participants were probed to rate the availability of vehicle to transport farmers' harvested products to the warehouse. Forty–one percent agree, with 15 percent strongly agreeing that no vehicle is available to transport their harvest when ready. A sum of 56 percent (N=214) of the response accorded to the absence of a movable van, a yardstick for effective management of transport logistics in the agricultural sector. 34 percent strongly disagree with this claim with 2 percent disagreeing to sum 36 percent (N=140) doubting this theory. Availability of transport is a challenge to farmers especially in the remotest part of the country, in instances where transportation is made available; most of them are not appropriate (Neri 2022). One of the farmers said:

There is no vehicle to transport my harvested products to the warehouse (Refer to appendix 1, questionnaire B1v).

4.0.2.2: Warehousing Logistics

Around this construct were also conjectures put forth for respondents' opinions surrounding the latent variable (boldened) on a five-point likert scale.

- **Exhaustion of personal storage space.**

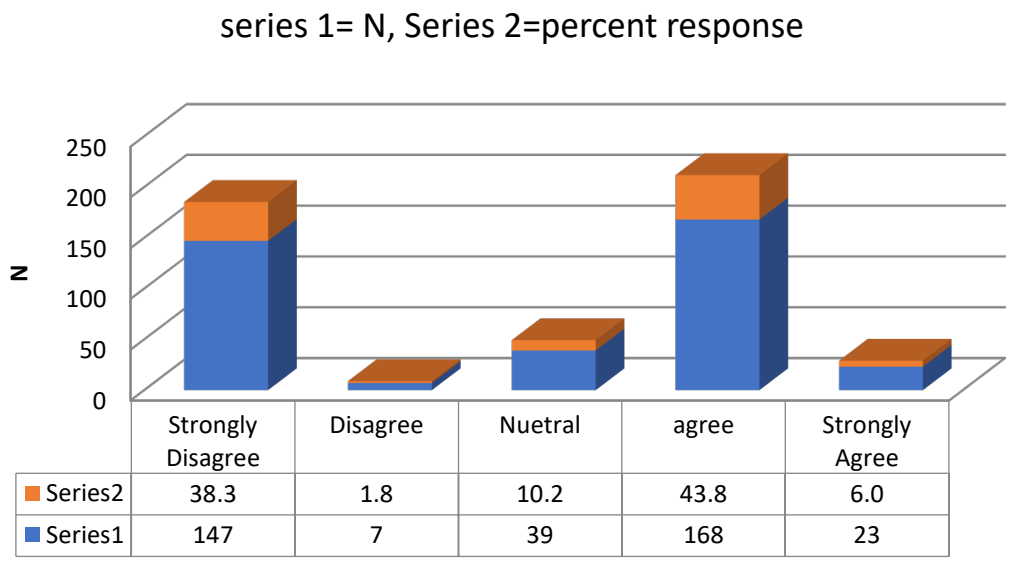


Figure 4.0.2.2.1_Exhaustion of personal Storage space (source: Field Survey 2023)

Participants were probed to rate when storage of farmers harvested produce at the IPEP warehouse is done. From Figure 4.0.2.2.1, a little over forty percent (N=157) (i.e. 38.3 percent strongly disagree with 1.8 percent disagree) of the farmers disagree with patronising the IPEP storehouse if their own storage spaces are exhausted. Forty-four percent agree to this claim with 6 percent expressing earnest agreement tallying 49.8 percent (N=191) of the response. A fair number of farmers have shown that storing with the IPEP is considered if their self-storage spaces are exhausted. It has been recorded that farmer dry produce on a bare floor in a corner, ranging from a kitchen to the top of a roof and this practice often affects grain quality (Anafu-Astanga 2023) but all in effort of doing home storage. An appreciable number of the respondents have the IPEP as a secondary option to their self-keeping. Perhaps the cost to transport their produce, availability or access to appropriate vehicles not discarding road network contributes to this stride. Some of the farmers had this to say:

Storage of harvested produce at the IPEP warehouse is done only after exhausting storage in another facility (Refer to appendix 1, questionnaire B2i)

- **Affordable storage with IPEP**

Participants were probed to rate the affordability of farmers harvested produce storage with the IPEP now. From Table 4.0.2.2.2, 2.9 percent (N=11) of the respondents argue on the

affordability of storing at the IPEP storehouse, whilst 96.6 percent admit it is cheap. The use of the warehouse is virtually free confirmed by Section 4.1.6 relaying only 0.50ghc per month paid on a 100kg bag stored (refer to R18), making it almost free to the poor farmer. A farmer has this to say:

Storing my harvest is very affordable now with IPEP (Refer to appendix 1, questionnaire B2ii)

Table 4.0.2.2.2_Very affordable (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	2.9	2.9
	Neutral	2	.5	3.4
	Agree	79	20.6	24.0
	Strongly Agree	292	76.0	100.0
	Total	384	100.0	

- **Close Proximity to IPEP storage.**

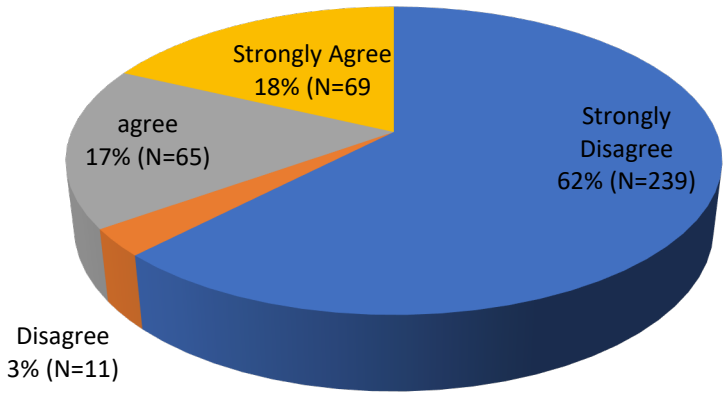


Figure 4.0.2.2.3 _ Close Proximity (source: Field Survey 2023)

Participants were probed to rate the close proximity of farmers to the IPEP warehouse/storage. Close proximity to the warehouse seems questionable since 65 percent of the respondents disagree with 35 percent favouring the claim that the warehouse is close to them. Strategically

the warehouses seem not positioned well because many farmers conversed of close proximity as a challenge to their patronage to the warehouse (refer to Figure 4.0.2.2.3). The Fourth Estate (2024), maintains at Hain in the Upper West that a farmer's house is just 500 meters away from an abandoned warehouse built by the government as part of the One District, One Warehouse policy known as "the IPEP warehouse". The bottom line is that the warehouse is unresourced if not uncompleted to ease farmer storage thus, farmers cannot boast of close proximity to storage dwelling on this. Some farmers converse that:

There is close proximity to storage because of the IPEP (Refer to appendix 1, questionnaire B2iii)

- **Preservation of produce**

Participants were probed to rate the longevity of farmers harvested produce preserved in the IPEP facility. Table 4.0.2.2.4 shows 2.9 percent (N=11) of respondents disagreeing with the warehouse's ability to ensure the longevity of farmer harvests' however, 96.6 percent agree with this quality of the IPEP. Perhaps the packaging material adopted at the facility ensures this benefit to farmers. One of the farmers has this to say:

"The IPEP facility preserves my produce for a longer period". (Refer to appendix 1, questionnaire B2iv)

Table 4.0.2.2.4: Longevity of produce (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	2.9	2.9
	Neutral	2	.5	3.4
	Agree	195	50.8	54.2
	Strongly Agree	176	45.8	100.0
	Total	384	100.0	

- **Access to IPEP warehouse**

Participants were probed to rate the accessibility of farmers to the IPEP warehouse. No complex process one goes through to access the warehouse. Table 4.0.2.2.5, scores 94.2 percent, of the farmers agreeing to easy access to their goods anytime though 2.9 percent debate. Further

engagement with a few farmers proves that at least two managers dish out their contacts for their dialing whenever they want to keep their goods or dispatch them from the storehouse. One of the farmers has this to pronounce:

I am allowed to access my goods with ease at any time of choice (Refer to appendix 1, questionnaire B2v)

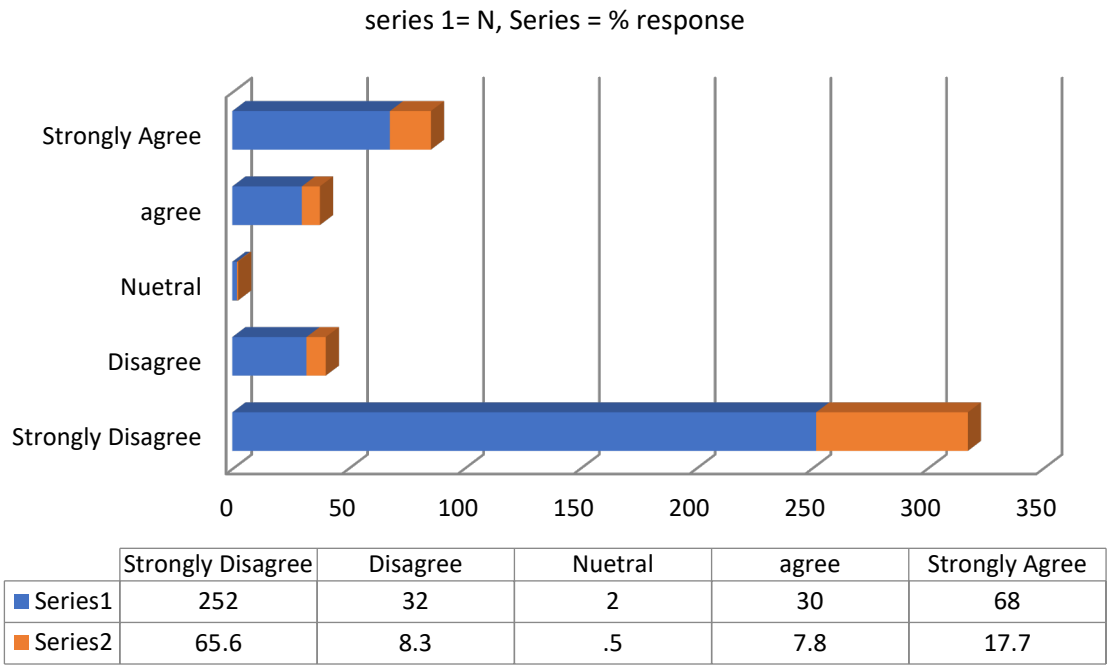
Table 4.0.2.2.5: Easy Access (source: Field Survey 2023)

Response		N	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	2.9	2.9	2.9
	Neutral	11	2.9	2.9	5.7
	Agree	12	3.1	3.1	8.9
	Strongly Agree	350	91.1	91.1	100.0
	Total	384	100.0	100.0	

4.0.2.3 Packaging Logistics

Conjectures surrounding the latent variable (boldened) in a five-point likert scale to this construct are as follows;

- **Packaging Material Availability**



	Strongly Disagree	Disagree	Nuetral	agree	Strongly Agree
Series1	252	32	2	30	68
Series2	65.6	8.3	.5	7.8	17.7

Figure 4.0.2.3.1: Packaging Material Availability (source: Field Survey 2023)

Participants were probed to rate the availability of farmers produce packaging materials at the IPEP warehouse. Figure 4.0.2.3.1, shows that 73.9 percent of the farmers unveiled a persistent shortage of packaging materials at the warehouse. 25.5 percent contrasts this view saying, materials are always available. A significant number of the respondents have spoken of a continual shortage of materials at the IPEP warehouse that needs a cursory look. One of the farmers has this to declare:

Packaging materials are always available at the warehouse to secure my harvest. (See Appendix 1, Questionnaire B3i)

- **Packaging Material safety**

Participants were probed to rate the safety of the packaging material farmers use at the warehouse to store harvested produce. Packaging materials used at the warehouse are safe according to the respondents. Table 4.0.2.3.2 saw 50.5 percent favouring this claim with 49.2 percent debunking this. Well, staff at the warehouse said, during data collection that grain stored using ZeroFly or a hermetic bag (ideally) should not be left for more than 6month thus, affirming the response from the farmers that the ZeroFly bag is safe but not for storage in years

maybe, due to excessive heat. It is not surprising that there is a very narrow difference between the opposing replies; this could support the body of existing research that claims all hermetic bags on the market now rely on natural mechanisms to produce hypoxia. A Purdue University study found that incorporating oxygen scavengers into grain stored in PICS bags helped slow down the degradation of pro-vitamin A in bio-fortified orange maize. However, research efforts to develop technologies that could deplete oxygen inside hermetic bags once the containers are closed have not been developed. (Nkhata et al. 2019, Baributsa and Ignacio, 2020:3). Some of the farmers had this to say:

Packaging material used at the warehouses is safe to guarantee longer shelf-life and avoid contamination. (See Appendix 1, Questionnaire B3ii)

Table 4.0.2.3.2: Material safety (source: Field Survey 2023)

Response		Frequency	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	189	49.2	49.2
	Neutral	1	.3	49.5
	Agree	40	10.4	59.9
	Strongly Agree	154	40.1	100.0
	Total	384	100.0	

- **Speed in packaging/repackaging**

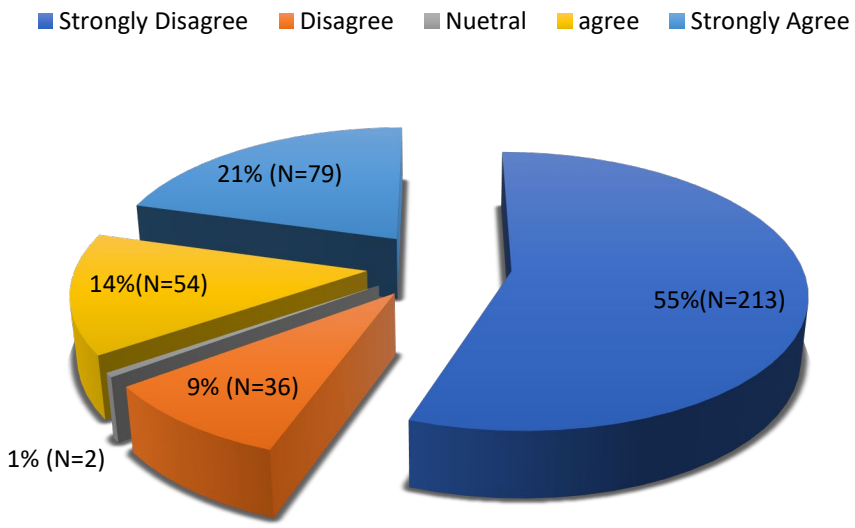


Figure 4.0.2.3.3: Speed in the packaging/repackaging (source: Field Survey 2023)

Participants were probed to rate the speed of packaging/repackaging farmers harvested produce at the warehouse. Sixty-nine percent (N=267) of the respondents agree that packaging/repackaging at the warehouse (where the need be) is of no complications however 30 percent (N=115) disagree with the conjecture put forth. The implication is that at the warehouse, farmers are at ease when asked to repack their harvest into hermetic bags before storage. Some of the farmers pronounce that:

There is speed in packaging/repackaging at the warehouse (Refer to appendix 1, questionnaire B3iv)

- **Cost of packaging material**

Participants were probed to rate the cost of the packaging materials farmers use to store harvested produce at the warehouse. Ninety-four percent (N=361) of the respondents agree that the cost of packaging harvest is high though 4.2 percent (N=16) refutes (Refer to table 4.0.8). Almost all respondents share concerns about the rising cost of hermetic bags approved for storage at the warehouse. Evidence from the Nadowli district (participants) infers that the cost of the bag far exceeds 10ghc for a 100kg being in regular use at the grain market and the poor farmer sees it as a worry. Some of the farmers pronounce that:

There is high cost of packaging material (Refer to appendix 1, questionnaire B3v)

Table 4.0.2.3.4: Cost of packaging (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Disagree	16	4.2	4.2
	Neutral	7	1.8	6.0
	Agree	78	20.3	26.3
	Strongly Agree	283	73.7	100.0
	Total	384	100.0	

4.0.2.4 Technology Utilisation.

Akin to former constructs, conjectures were put forth around this for respondents' opinions surrounding the latent variable (boldened) on a five-point Likert scale.

- **Technology to access transport**

Participants were probed to rate the access of farmers to transport produce immediately after harvest using technology. As seen in Table 4.0.2.4.1, among the valid responses collected 82.8 percent (N=318) of the farmers disagree with the IPEP employing technology to ease farmer transportation. Over nine (9.1) percent(N=35) admits to the use of technology by the warehouse. Generally, the warehouse was found not to have any peculiar system to coordinate farmer transport except for the use of staff self-phones they (sometimes) intervene voluntarily to aid a farmer get his/her goods to the warehouse. Officially as of yet, ensuring transport access is not a designated duty to the logistician/warehouse operator, a staff divulged. One of the farmers has this to say:

I use technology to ease access to transport, immediately after harvest. (Refer to appendix 1, questionnaire B4i)

Table 4.0.2.4.1: Easing access to transport (source: Field Survey 2023)

Response		N	Valid Percent	Cumulative Percent
Valid	Missing System	9	2.3	2.3

	Strongly Disagree	309	80.5	82.8
	Disagree	9	2.3	85.2
	Neutral	22	5.7	90.9
	Agree	35	9.1	100.0
	Total	384	100.0	

- **Technology adoption to prolong freshness**

Participants were probed to rate the IPEP warehouse's adoption of technology to prolong freshness of farmers produce during storage. Of the 384 sampled respondents, 97.7 percent (N=375) responded to this conjecture, 53.6 percent (N=206) agreed that by prolonging the freshness of their harvest, the warehouse adopts technology; 42.2 percent (N=162) disagreed with this claim saying they see nothing done by the IPEP. Considerably, more of the farmers commend the IPEP for employing a modern technique for storage.

The warehouse management encourages farmers to store using ZeroFly bags believed to keep the freshness of the produce till a certain time and from insects' distortions. As said earlier a staff of the warehouse has said the ZeroFly bag is not ideal for above 6 months of storage so it's obvious that within 6 months a farmer is likely to have his harvest in good quality and this might be the culture maintained among most farmers leading to their support to the conjecture. Otherwise, the only preservative technique used in the selected warehouses is the use of the hermetic bag. One of the farmers pronounces that:

The IPEP warehouse adopts technology to prolong freshness of my produce during storage (Refer to appendix 1, questionnaire B4ii)

Table 4.0.2.4.2: The IPEP warehouse adopts technology to prolong freshness

Response		N	Valid Percent	Cumulative Percent
Valid	Missing system	9	2.3	2.3
	Strongly Disagree	113	29.4	31.8
	Disagree	49	12.8	44.5
	Neutral	7	1.8	46.4
	Agree	40	10.4	56.8
	Strongly Agree	166	43.2	100.0
	Total	384	100.0	

- **Technology enhancing packaging**

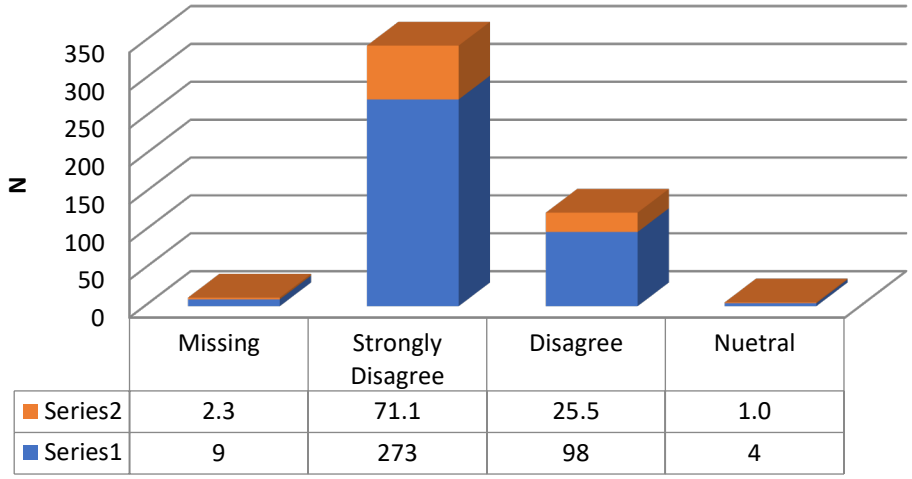


Figure 4.0.2.4.3: Enhance packaging (source: Field Survey 2023)

Participants were probed to rate the use of technology to enhance packaging of farmers harvested produce at the IPEP warehouse. Thus, whether the warehouse employs any technology to ease packaging of their harvest (when the need be); Out of the 97.7 percent (N=375) valid responses given were 96.6 percent (N=371) disagreeing with the conjecture as one percent (N=4) remain neutral. This implies that the warehouse does not employ any technology, enhancing packaging in-house, everything is manually done. Some of the farmers have this to say:

Technology is not being used to enhance packaging at the warehouse ***(Refer to appendix 1, questionnaire B4iii)***

- **Technology for tracking and tracing of stored products**

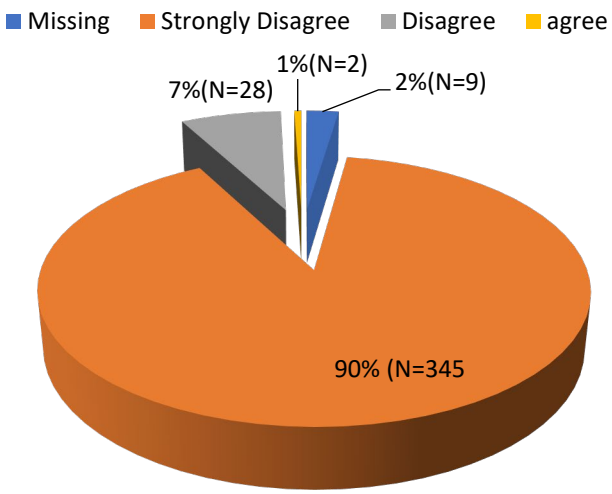


Figure 4.0.2.4.4: Ease tracking and tracing of stored products (source: Field Survey 2023)

Participants were probed to rate the technology used to track and trace farmers stored products at the IPEP warehouse. A whopping 97 percent (N=373) of respondents disagree with the conjecture whilst one percent (N=2) agrees. There is virtually no technology for tracking and tracing inventories logged at the IPEP warehouse. This seems a discredit to this IPEP model meant to be a WRS. The main purpose of an ICT (unconventional methods and tools) warehouse receipt system (WRS) is to increase transaction speed and enable 24-hour trading. To summarise, according to the literature, a WRS is a paper or electronic record of title that specifies the type of product, its quality grade, its location, and its owner when it is put in a warehouse. In a commodity exchange, the WRS can be used to facilitate transactions between buyers and sellers. The receipts can be used to represent the actual items, which can be transported once the transaction is finished from warehouses. ICT gains value as transaction volumes rise, as researchers with USAID 2010; Awuah-Gyawu *et al.* (2015: 28) demonstrate. One of the farmers converses that:

There is technology to ease tracking and tracing of stored products at the warehouse (Refer to appendix 1, questionnaire B4iii)

4.1 Data Analysis and Interpretations

4.1.0 Data Analysis, Triangulation and Interpretation in Themes

The data from the questionnaires and interviews were analysed, interpreted and integrated via triangulation protocol technique for a complementary and cohesive meaningful narrative of the research questions/objectives. Different themes comprising the type(s) of road transport achieving food security, the packaging logistics relation to food security, the relationship of logistics management and food security in Ghana, the impact of warehousing on Ghana's food security, and logistics challenges to Ghana's food security emerged from the sequential data analysis of this mixed-methods research and are revealed below:

Theme 1 Type(s) of road transport used to achieve food security in Ghana

This study confirmed that tricycle and head/human porterage are of primary essence in the agricultural sector (Table 4.1 a and b) with tricycles (t (38) = 0.66, p= 0.51> level 0.05, n^2 >0.01) achieving food security with more assurance, not deriding the usefulness of head/human porterage (t (38) =-1.57, p=.12, n^2>1%) proving 99 percent safe to farmer PHL (Table 4.2 a and b). This finding supports Alulu *et al.* (2023:04); Britichenko (2023); Suraraksa and Shin (2019); NDPC (2013: 56, 2010) and Lenn and Ward (2010), assertion that settled that, the traditional means of transporting farm produce were head porterage across most remote areas and other means of transporting farm produce include tricycles, bicycles or motorcycles, minibuses, taxis, and trucks in that order. The present finding, however, further highlights the exact transport to achieve food security among the notable forms of transportation. It is worth knowing, that the finding partly contravenes Bezpartochnyi and Britchenko (2023:173-174) observation in Ukraine that tells automobiles contribute to food losses owing to poor road networks.

Theme 2 The contribution of packaging logistics to Ghana’s food security.

The study found a regression model significant at p=0.029, despite a modest connection between food security and the predictor (R=0.135) that the packaging logistics might influence only one percent of the current food security proving that statistically, packaging has less impact on food security. By implication, the packaging system has a crucial influence on food security, withal, a sluggish integration of technology into this system is denying its effectiveness in curbing food security in the Ghanaian context and this has affected the benefits Ghana could reap from packaging logistics. The minor impact (Table 4.3 c, and d) could be traced to inefficiencies in the packaging system caused by a lack of technological engagement.

This contemporary write-up clarifies the magnitude of savings that packaging makes to the nation's PHL, which is low. Having R^2 equaling one percent indicates that inefficiencies in the country's packaging system threaten 99 percent of the nation's food security and explains that inefficiencies in packaging at the warehouse allow the variable to make just a little impact in the quest to combat food losses. According to Versino *et al.* (2023:1), packaging design and material advances provide significant prospects to reduce food waste throughout the supply chain. However, Ghana's food security is essentially not secured due to packaging. According to Anand and Popa, (2022:1) and Saghir (2004:2), an understanding and awareness of the necessity and potential of packaging logistics activities along the supply chain is low. If packaging is to be adopted effectively, lurking variables influencing supply chain participants' knowledge and awareness are crucial. Because the constant β0 has a p =0.001 significant value, the data in Table 4.3 blows the lid off this contention of latent variables by informing food security's relationship with packaging logistics. Other hidden variables are influencing the criterion's behaviour, and these must be investigated to reap the benefits of packaging logistics.

Theme 3 Logistics management and food security relation.

The data shows that the association between logistics management and food security is modest, with a regression coefficient of R^2 adj equal to 1 percent (roughly) and an R= 0.149 value. The criterion that indicates that 99 percent of the nation's food security is unaccounted for by the predictor variable has very little influence from logistics management. The constant p=0.001 (significant) suggests the presence of other implicit variable(s) that are driving the criterion's behaviour, indicating a need for more investigation.

This study essentially confirms the literature's hypothesis that there is a positive correlation between efficient logistics management and food security (Driver 2023) as well as infrastructural limitations and food insecurity (Subramaniam, Macron, and Naseem 2023:3431-3435; Acheampong *et al.* 2022; Bozsik *et al.* 2022). Similar to Driver (2023), this study confirms that efficient logistics management ensures farmers' food security. However, the observed association, as in Ghana's instance, suggests that logistics systems are insufficiently efficient in reducing farmers' PHL.

Theme 4 Warehousing influence on Ghana's food security

The IPEP warehouse has a weak, insignificant link with food security in the selected locations, as evidenced by Pearson's correlation 'R=0.130'or r=0.067, with a p=0.188. This explains the predictor's favourable influence on PHL with only one percent (approximately) proof better still the relationship is positive. Upon a critical look, the warehouse's state appears beyond comprehension, with technology demonstrating significance at p=0.029, testifying to its inefficiency. Meanwhile, the total facility score is insignificant (p=0.215). The constant variable in the regression model at p=0.874) is however an implicit decree to the non-importance of the effect of the omitted factors, if any attempts, to justify the impact of Ghana's WRS on the food security the country experiences today. The effectiveness of the facility is non-existent whilst pundits opine that effective grain storage contributes to reducing overall food losses for the smallholder farmer and has an impact on livelihoods for all (Ghana News Agency, 2023), this finding is in contrast with the cited literature.

Theme 5 Challenges of Logistics Management Affecting Food Security

At a Chi-Square value of 1668.080, Kendall's coefficient (W) of 0.388 is obtained, indicating that food security status depends on the ranking of enumerated challenges (Section 4.1.5). According to Kendall's concordance, 39 percent (approximately) (Table 4.6b) of respondents agree with the ranking meaning all of the farmers agree with the fair rankings provided.

Smallholder farmers generally agree on the ranking of logistical challenges impeding food security in the agricultural sector indicating the most severe issue to be "high transportation costs" falling in line with (Bezpartochnyi and Britchenko 2023:173; Otoo and Mills 2023; Jones *et al.* 2019:1).

Theme 6 Framework for improving various logistics management

- *Transport logistics*

The high cost of transport is a significant challenge affecting food security; therefore, setting up an efficient transport system may require the government to supply tricycles (be self-owned or under a private partnership), integrating ICT to ease farmer access economically. A more locally responsive system to engineer Ghana's contemporary needs e.g., Adeleke (2022:11). It must be remembered that tricycles were found to achieve food security with more assurance

- *Warehousing*

The IPEP model is to be an effective WRS kind of warehousing, therefore, the study advocates for the provision of warehouse management/operational technologies (e.g., RFIDs), transport equipment (e.g., lift-trucks), unit load formation equipment (such as, pallets), storage equipment (e.g., pallet-racks), dryers, cleaners, timely fumigation, and consistent/stable electricity. This, compliments prior studies pronouncing software, telecommunications, television and RFID as among the most utilised technologies in global warehousing (Kumar and Srivastava 2018:00123; Gan, Zhu and Zhang 2011:405; USAID 2010:6).

- *Packaging logistics*

The ongoing study finding establishes the use of hermetic bags a common bespoke counsel farmers receive from the warehouse management.

The necessity to lower grain storage losses from insect pests and the shortcomings of existing storage techniques have piqued the attention of smallholder farmers to hermetic bags. Plastic bags with one, two, or three layers are examples of hermetic bags that are commercially available for storing grains. Over the past 12 years, smallholder farmers and other customers, mostly in Asia and Africa, have purchased more than 20 million hermetic bags. The scalability of supply chain initiatives to boost availability through the private sector and awareness campaigns, such as training to generate demand, is what accounts for the sharp rise in the use of hermetic bags.

Numerous hermetic bags offer various advantages, such as (i) eliminating the need for pesticides to preserve grain, (ii) maintaining grain quality for several months (iii) giving farmers the freedom to sell when prices are high, and (iv) enabling farmers to store seed and grain using the same technology (Baributsa and Ignacio 2020: 1). It should come as no surprise that the management of the IPEP organisation is very happy to promote the use of these bags. According to management, better packaging is possible if the government controls or subsidises the price of the bags, manages the supply, and provides packaging and repacking machines to expedite packaging/repackaging at the warehouses. These strategies should help ensure effective packaging at the warehouse falling in congruence with Pulidindi and Ahuja (2023) extrapolation that agricultural packaging plays an important role in preserving the quality, freshness and safety of these products and that these strategies might help extend their

shelf-lives, ensuring products reach consumers in good condition. That said, only a few districts do fumigation for the safety of these packaging materials (Table 4.7), and it is seemingly not appealing if the bags are to remain safe for long.

4.1.1 Type(s) of Road Transport Achieving Food Security

Participants were requested to rate the mode of diverse transport types used to achieve food security, and was found that farmers moving their crops by head to the warehouse accounted for a large proportion of the responses. Despite their dislike, most (44 percent, N=89) recorded regular changes in post-harvest loss (PHL).

The warehouse management at Garu and Kaleo recounts seeing farmers often with harvest by head for storage**. "*These are mostly farmers less than 2 miles away from us" R2***

The observed oscillation is less influenced by this mode of transport testing insignificant at a p = 0.06 compared to all modes except van/truck. Tricycles are a second alternative employed by farmers in the event of a large harvest, with 44 percent (N=89) indicating that many are losing money. Farmers' seasonal loss patterns are less influenced by tricycle use (p=0.534).

According to Table 4.1, changes in farmers' PHLs appear to be dependent on their usage of vans/trucks (p=0.001), although relatively few (N=2) producers seem to have access to this mode of transportation. Motorbikes, appeared insignificant, bicycles and donkeys have a strong influence on PHL with p=0.049 and p=0.072, respectively; however, only a few farmers utilise these modes of transportation. Van/truck being significant in (Table 4.1a) has less influence on the PHL (p=0.66) although few farmers using vans may not have timely access to them, resulting in their loss dependence. Evidentially, poorly maintained mode(s) of transport, stunt agricultural productivity and food production potential also poor transportation networks hinder the timely movement of food, leading to post-harvest losses in Ghana (Atchulo 2024; World Bank 2022).

a.		Pattern of Seasonal Losses					Chi-square(χ^2)	
		Same	Reduce	Increase	Sometimes reduce/increase	Total	Value	p
Means of transport	H.porterage	10(6%)	21(2%)	60(33%)	89(49%)	180	7.419	0.06
	Motorbike	0	1	5(42%)	6(50%)	12	1.691	0.639
	Bicycle	0	6(21%)	4(14%)	19(66%)	29	6.189	0.103
	Tricycle	6(4%)	17(12%)	35(24%)	89(44%)	147	2.188	0.534
	van/truck	2(100%)	0	0	0	2	19.294	0.001
	Donkey	0	3	2	8(61.5%)	13	2.662	0.447
Total		18	48	106	211	383		

b.		Frequency of seeing post-harvest losses			Chi-square(χ^2)	
		every harvest season	not every season	Total	Value	p-value
Means of transport	H.porterage	81(45%)	99(55%)	180(47%)	4.229	0.04
	Motorbike	3(25%)	9(75%)	12	1.065	0.302
	Bicycle	21(72%)	8(28%)	29	15.776	0.049
	Tricycle	42(28%)	106(72%)	148(39%)	12.146	0.001
	van/truck	2(100%)	0	2	0.193	0.66
	Donkey	2(15%)	11(85%)	13	3.232	0.072
Total		151	233	384	7.419	

Table 4.1 Cross-tabulation of the mode of transports used and behaviour of farmers' PHL

Source**:** Authors Field Survey, 2023

Participants rated the mode of transportation used and behaviour of farmers PHL as presented in the above table. Forty-seven percent of the sampled respondents use head porterage, from the response in Table 4.1b, however, 55 percent escape losses every season, according to the three primary types of transport identified. A significant number (45 percent, N=81) record PHL every season while seventy-two percent of the tricycle farmers suffer constant losses, accounting for 39 percent of the sample size (384). Just 28 percent (N= 42) experience losses every season. The two main modes of transportation (tricycle, p=0.001, and head porterage, p=0.04) were shown to be significant, indicating a substantial dependence of farmer frequency of PHL on the two transports.

A participant from Garu was asked about the support they get from the warehouse, ensuring the availability of the transports;

"*Nothing,*" she said. R3

In fact, the warehouse management confessed this saying that

"For now, we do not contribute to farmer transport issues" R4

This implies that the transports are organized by farmers independently, to the dismay of some farmers. According to some:

"In inactive harvest seasons, it becomes scarce sometimes to get transport and some of our harvests get stacked in the bush for days" R5

Rain could fall, rodents and thieves could attack the harvest in such times making it unappealing to hear.

The majority of studies identify automobiles involving motorcycles, and trucks, as among the common road transports in use in the agricultural sector together with animal carts, bicycles, wheelbarrows, and human porterage (e.g., Alulu *et al.* 2023:04; Britichenko 2023; Suraraksa and Shin 2019; Lenn and Ward 2010; Sathyabama n.d.: 11), which this study buttresses, further unveiling the weight of each transport on farmers PHL; nonetheless, neither does the IPEP warehouse contribute to farmers' access.

American Warehouses 2023, third quarter (Q3), Public Warehousing Review and Outlook asserts that by keeping abreast of efficiency-driven technology changes, public warehouses will continually serve as a critical link within the transport and logistics infrastructure however the converse is being witnessed here. Tricycles and human/head porterage are Ghana's agricultural industry's most important road transporters. However, the paramount is to be unveiled with an independent sample T-test.

Test for Difference in Food Security Based on the Prime Road Transports

H0: there is no statistical difference in the decision on road transport used by farmers and their food security status.

a. Group Statistics

Human/Head Porterage		N	Mean	SD	SEM
Food security	0	203	3.94	1.269	.089
	Yes	181	4.14	1.257	.093
Tricycle					
Food security	0	238	4.07	1.284	.083
	Yes	145	3.98	1.239	.103

b. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of MD	
Human/Head Porterage		F	Sig.	T	Df	Sig	MD	SED	Lower	Upper
Food security	Equal variances assumed	.00	.99	-1.57	38	.117	-.203	.129	-.457	.051
	Equal variances not assumed			-1.57	377.81	.117	-.203	.129	-.457	.051
Tricycle										
Food security	Equal variances assumed	2.21	.14	.66	38	.511	.088	.134	-.1746	.350
	Equal variances not assumed			.66	312.86	.507	.088	.132	-.173	.348

Table 4.2 Independent sample T-test: Type of road transport achieving food security

Source: Authors Field Survey, 2023

Participants were also asked to rate the variation in food security. First, the t-test looked for variations in food security experience among farmers using head/human porterage and those not using it, and then that of tricycle users was evaluated.

Statistically, there is no difference in food security between farmers who use head/human porterage (M=4.14, SD=1.26, n=181) and those who do not (M=3.94, SD=1.27, n=203). Indeed, the effect of the porterage n^2>0.01 on a farmer's ability to avoid PHL is relatively minor. Only one percent of their food security status may be explained by their decision to use or refuse to transport their produce directly to warehouses. However, farmer food insecurity is not caused by using human/head porterage.

The F (38) =0.01, p=0.99 result of Levene's test suggests that the variance of the two replies (Yes/No) was considered fit to be substantially equal, connoting an actual application of the standard t-test results.

Justifying the level of influence using the t-statistic;

t (squared)/t (squared) + (N1+N2-2) n2> 0.01 or (roughly) 1%

Similarly, the decision to use a tricycle resulted in an insignificant (t (38) = 0.66, p=.51> level.05) difference in food security between farmers who used one (M=4.07, SD=1.28, n=238) and those who refused (M=3.98, SD=1.24, n=145, with a weak effect [n^2 >0.001]). Farmer food security is described by their option to utilise or refuse to employ tricycles to transport their products to warehouses. Farmer food insecurity, by extension, has little to do with trike use.

The F (38) =2.21, p=.14 result of Levene's test suggests that the variance of the two replies (Yes/No) was considered fit to be about equal by assumption also indicating that the standard t-test was used correctly.

Justifying the degree of influence using the t-statistic;

t (squared)/t (squared) + (N1+N2-2) n2> 0.001 or (roughly) 0.1

Tricycles seem to achieve food security with greater assurance than any other mode of transportation. Human/head porterage is 99 percent safe for reducing PHL as evidenced by more responses from participants when probed. A variety of transports are being used in the

agricultural sector, such that among the many responses collated was one of the participants affirming that:

"We are still using the old ways of transporting the food to the storage using the donkey-sleigh old transport and head porterage, but we are planning to change and use new modern transports" R6

A respondent said:

"The use of tricycle has been very helpful following the expansion of my farm acreage" R7

By implication, tricycle and head/human porterage are of primary essence in the agricultural sector (Table 4.2 a and b) with tricycles [t (38) = 0.66, p=.51> level.05, n2>0.01] achieving food security with more assurance, than other forms of transportation. Head/human porterage (t (38) =-1.57, p=.12, n^2>1%) proving 99 percent safe for reducing farmer PHL (Table 4.2 a and b); this finding supports (Alulu *et al.* 2023:04; Britichenko 2023; Suraraksa and Shin 2019; NDPC's 2013, 2010: 56; Lenn and Ward, 2010) assertion, that settled that, traditional means of transporting farm produce were the head porterage across most remote areas in Ghana, and other means of transporting farm produce included tricycles, bicycles or motorcycles, minibuses, taxis, and trucks, in that order. The present finding, however, further tells the exact transport to achieving Ghana's food security among the notable forms of transportation.

It is worth noting that the finding partly contravenes Bezpartochnyi and Britchenko (2023:173) observation that automobiles contribute to food losses owing to poor road networks.

4.1.2 Packaging Logistics Contribution to Attaining Food Security

Packaging at the warehouse is important (p=0.008) in providing food security, though the moderator (technology) is found insignificant (p=0.892), casting doubt on the efficiency of this packaging system. The IPEP currently does not have a robust packaging system; instead, they use a hermetic bag (a modernised sack) which is advised for storage at the facility though most farmers are unable to purchase enough of these bags for storage (see pictures under 2.4.6.3).

a. Descriptive Statistics

	N	Min	Max	Mean	SD
	Statistic	Statistic	Statistic	Statistic	Statistic
FS	384	1	5	4.036	1.2656
Packaging	384	1	6	3.12	1.115
Valid N (listwise)	384				

b. **Coefficients[a]**

Model		Unstandardized Coefficients		Standardized Co	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.550	0.193		18.355	0 .001
	Packaging	0.156	0.059	0.135	2.666	0.008
	Technology	0.010	0.071	0.007	0.136	0.892

a. Dependent Variable: HarLosses6i

c. **Model Summary**

Model	R	R Square	Adj R Square	Std. Error of Estimate
1	0.135[a]	0.018	0.013	1.2573

a. Predictors: (Constant), packaging technology, Packaging

d. **ANOVA[a]**

Model		Sum of Squares	Df	Π^2	F	Sig.
1	Regression	11.248	2	5.624	3.558	0.029[b]
	Residual	602.242	381	1.581		
	Total	613.490	3			

a. Dependent Variable: Food security

b. Predictors: (Constant), packaging technology, Packaging
Moderator Zscore (PackageAver, Zscore (WareAver) Zscore (TransAver)

Table 4.3: Packaging logistics contribution to attaining food security

Source: Authors Field Survey, 2023. Significant at 0.05% level

H1: Packaging logistics contributes massively to food security

Overall, the facility virtually lacks a packaging system to assist farmers with proper packaging. Everything is left to the farmer, with extension agents from the District Agriculture Department holding timely meetings with farmer-based organisations (FBOs) over optimal practices. This alliance in itself shows inefficiencies in warehouse packaging practices.

The regression model is significant at p=0.029, despite a modest connection between food security and the predictor (R=0.135). The IPEP packaging logistics might influence only one percent of the current food security proving the null hypothesis to indicate that, statistically, packaging has less impact on food security.

By implication, the warehouse packaging system has a crucial influence on food security, withal, a sluggish integration of technology into this system is denying its effectiveness in curbing food security in the Ghanaian context and this has affected the benefits Ghana could reap from packaging logistics. The minor impact (Table 4.3 c, and d) could be traced to inefficiencies in the packaging system, caused by a lack of technological engagement. Food loss and waste are caused by a variety of factors, according to research, ranging from crop processing to domestic leftovers. While some waste creation cannot be prevented, a significant portion is brought on by inefficiencies in the supply chain and damage sustained during handling and transportation. Innovations in materials and packaging design offer viable chances to cut down on food waste throughout the supply chain (Versino *et al.* 2023:1).

This claim validates the results of studies by Shoue Chen *et al*. (2020) and John Manner-Bell (2012), on "The-Role-of-Logistics-in-Reducing Post-harvest Food Losses", and "The Role of Smart Packaging Systems in Food Supply Chain", claiming that upgrading packaging with better transportation infrastructure, vehicles, and power supplies would immediately benefit the supply chain, meanwhile Ghana's agricultural, supply chain packaging is ineffectual. This supports (Versino *et al.* 2023:1) declaration of this challenge in the supply chain. Damage from several environmental conditions, including moisture, oxidation, thermal degradation, and microbiological contamination, result in a significant loss of food along the supply chain (Atta *et al.* 2022). The supply chain loses or wastes more than 30 percent of the edible portion of the world's food production (Safdie 2023). Consequently, many studies and initiatives have attempted to lower these losses (Wohner 2019, Blakeney 2019). Right now, a measured impact of packaging on food security is crucial.

This contemporary write-up clarifies the magnitude of savings that packaging makes to the nation's PHL, which is low. Having R^2 equaling one percent indicates that inefficiencies in the country's packaging system threaten 99 percent of the nation's food security and explains that inefficiencies in packaging at the warehouse allow the variable to make just a little impact in

the quest to combat food losses. Ghana's food security is essentially non-existent due to packaging, which goes against the findings of Versino *et al.* (2023:1), who claims that improvements in packaging design and materials offer genuine chances to cut down on food wastage/losses throughout the supply chain.

According to Anand and Popa (2022:1) and Saghir (2004:2), an understanding and awareness of the necessity and potential of packaging logistics activities along the supply chain is low. If packaging is to be adopted effectively, lurking variables influencing supply chain participants' knowledge and awareness are crucial. Because the constant β0 has a p =0.001 significant value, the data in Table 4.3 blows the lid off this contention of latent variables by informing food security's relationship with packaging logistics. Other hidden variables are influencing the criterion's behaviour, and these must be investigated to reap the benefits of packaging logistics.

4.1.3 Relationship Between Logistics Management and Food Security

The respondents' affirmation (Mean=4, SD=1.27) that they can prevent PHL to at least 90 percent despite sporadic losses illustrates Ghana's present progress towards greater food security.

During the interview, the two managers and two senior staffs of the IPEP warehouses revealed that, in contrast to the GSS 2022 Annual Household Income and Expenditure Survey, which indicates that approximately 50 percent of people lack access to food, Ghana's food security is increasing thanks to fumigation techniques (in certain warehouses), zero-fly/hermetic bags, and communications services like SMS and phone calls (Figure 4.1).

It was intriguing to learn from a manager in Garu who also serves as an extension agent for agriculture the assertion below:
"I can say boldly that over 90 percent of foods produced now escape post-harvest losses indeed, and I look forward to better, if farmers keep adhering to optimal practices, we teach them as extension agents" R8

Existing research suggests that Ghana's post-harvest losses do not appear to be improving (SESI Technologies 2021), supporting the country's 2016 annual loss of roughly 318,514 tonnes of maize, or roughly 18 percent of its total annual production (SESI Technologies 2021;

Abdoulaye *et al*. 2016: 1; Bruce 2016). In 2018 losses from cereals valued at approximately US$141.12 million, or more than GH¢680.19 million when applying the average exchange rate of US$1 to GH¢4.82 for that year. The new study presents a clear image of the PHL across the nation, so perhaps farmers are following the best practices that the agricultural extension team has unleashed.

According to IFPRI's 2023 Global Food Policy Report: Rethinking Food Crises Responses, South Africa has a population that experiences food insecurity that is more than twice that of any other region in the world. There are over 282 million individuals Nearly 20 percent of people living in sub-Saharan Africa were undernourished and facing food insecurity in 2021. Assuming that 20 percent of either nation in the sub-Saharan region experiences food insecurity is a reasonable interpretation for such a number, but this does not appear to be the case. Nearly all (384 Ghanaian farmers sampled) were able to avoid PHL by at least 90 percent. Hence, until an issue of unequal distribution or inaccessibility is further demonstrated, it is insufficient to state that food insecurity affects twenty percent of the population.

For example, for the last 20 years, Ghana's population has seen a decrease in poverty and hunger (WFP 2023). Nevertheless, hunger and malnutrition are still prevalent throughout the country, particularly in northern Ghana and many rural and peri-urban regions (WFP 2023). The current research, conducted in the northern regions, disproves this hypothesis to postulate that the north is producing more food and reducing false cultural practices that worsen PHL.

a. Descriptive Statistics

	N	Min	Max	Mean	SD
	Statistic	Statistic	Statistic	Statistic	Statistic
Food security	384	1.0	5.0	4.036	1.2656
TransAver	384	1	5	2.59	.918
WareAver	384	1	5	2.91	1.000
PackageAver	384	1	5	3.11	1.097
Valid N (listwise)	384				

b. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.149[a]	.022	.012	1.2580

a. Predictors: (Constant), moderator, Zscore(Packaging), Zscore(Transport), Zscore(Warehouse)

c. Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.037	.064		62.876	.001	3.910	4.163
	Zscore(Packaging)	.232	.091	.183	2.547	.011	.053	.411
	Zscore(Warehouse)	-.074	.091	-.059	-.817	.414	-.253	.105
	Zscore(Transport)	.040	.077	.032	.521	.602	-.112	.192
	Moderator (Technology)	-.029	.052	-.035	-.566	.572	-.130	.072

a. Dependent Variable: Food security

d. ANOVAa

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	13.681	4	3.420	2.161	.073[b]
	Residual	599.809	379	1.583		
	Total	613.490	383			

a. Dependent Variable: Food security

b. Predictors: (Constant), moderator, Zscore(Packaging), Zscore(Transport, Zscore(Warehouse)

Table 4.4: Relationship between logistics management and food security

Source: Authors Field Survey, 2023. Significant at 0.05% level

H3: Logistics management has a significant positive relationship with food security

Food security and logistics management have a poor link, as indicated by R= 0.149. A further implicit variable (s) that are in charge of the criterion's behaviour and are indicated by the constant p=0.001 (significant) can account for 99 percent of the food security in the sampled regions instead of the predictor variable, according to the coefficient of determination (R^2 adj = 1 percent (approx.)). It begs for more investigation.

The coefficient table indicates that the only logistics that has a direct impact on the regression model is packaging (p=0.011). The model may be affected by one percent depending on the usage of hermetic bags (for packaging), access to them, and safety. Tables 4.4b and d demonstrate how little the other logistics contribute to the model (p=0.073). The moderator's actions convincingly suggest (p=0.572 with = -0.029) that the IPEP warehouses' management practices are no longer efficient. The null hypothesis is not acceptable even though there is a small but positive correlation between logistics management and food security (p=0.073, Pearson's R=0.149; see Tables 4.4b, and d). Pearson's R-value suggests a weak connection.

During data collection a respondent fancily said

"*We may not know what goes into managing these logistics otherwise I will say it's being done abysmally. For me, I do not see management*" R9

The statement appears to support the outcome of the tested theory. Ghana's agricultural sector lacks a strict logistics management roadmap, and the results of the study show that even after five years of the IPEP, the warehouse effort has not yet significantly increased food security. Regarding logistics, not much is known about how well the complete network architecture functions in the agricultural supply chain.

Ssennoga, Mugurusi, and Olukac (2019:1) investigated supply chain limitations in Ugandan banana cultivation. The results show that inadequate logistical management causes smallholder banana growers to lose 29 percent of their total banana yield across the supply chain. Due to some issues, including malfunctioning logistical systems, poor roads (especially during rainy seasons), a lack of handling equipment, inadequate storage facilities, and expensive transportation to agricultural areas, food insecurity is expanding quickly throughout Sub-

Saharan Africa (SSA) (Ssennoga, Mugurusi, and Olukac 2019:1; Adenyi and Ojo, 2013). Thus, the current study does not offer a variety of perspectives.

Effectiveness in the Entire Network Architecture in the Logistics of Agricultural Supply Chain.

The present analysis confirms the literature's findings that there is a positive correlation between infrastructural limitations and food insecurity (Subramaniam, Macron, and Naseem 2023:3431; Acheampong *et al.* 2022; Bozsik *et al*. 2022). Efficient management of logistics in the agriculture industry guarantees the food security of farmers (Driver 2023). The found correlation, however, is modest (bad) in lowering PHL, suggesting that the criterion's management is insufficient in lowering farmers' PHL.

The other manager from Garu buttresses this in a lengthy comment;

"Our difficulty is that we do not have the resources needed to run this facility effectively. For example, we are currently doing nothing to address farmer transportation concerns; there are no mechanisms in place to assist us in this regard; and we have a cleaner machine in this warehouse that has been lying idle due to our failure to pay the electricity bill. Farmers bring their harvests and pay as little as 50 pesewas each day to store a 100kg bag of their food at the facility, which does not help the storehouse run smoothly. Packaging is the farmer's complete responsibility, in addition to purchasing hermetic bags from our distributor at any market price. In reality, some may acquire zero, if not the required quantity, to our disappointment." R10

Elsewhere in Nadowli Kaleo of the upper west, the managers' report;

We lack pallets to aid storage, though we have no support system in this facility. As you can see, the storehouse is built with no resources as of yet" R11

These responses proved beyond a shadow of a doubt that warehouse-level logistics management is inefficient. The fact that resilient logistics management (LM) practices, which are partly confirmed to have a shaky impact on Ghana's food security, cannot be directly attributed to active food security is crucial to understand. There is a high correlation between other latent factors and food security among farmers. The significance of β0 (the constant variable in the regression model; p=0.001) speaks for itself.

4.1.4 Warehousing influences Ghana’s food security

The IPEP warehouse has a weak, insignificant link with food security in the selected locations, as evidenced by Pearson's correlation 'R=0.130'or r=0.067, with a p=0.188. This explains the predictor's favourable influence on PHL with only one percent (adjusted R^2 =1 percent (approx.)), (Table 4.5b) proof.

a. Correlations

		Food security	Warehouse logistics
Food security	Pearson Correlation	1	.067
	Sig. (2-tailed)		.188
	N	384	384
Warehouse	Pearson Correlation	.067	1
	Sig. (2-tailed)	.188	
	N	384	384

b. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.130[a]	.017	.012	.994

a. Predictors: (Constant), warehouse-tech, Zscore(Warehouse)

c. ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.502	2	3.251	3.290	.038[b]
	Residual	376.498	381	.988		
	Total	383.000	383			

a. Dependent Variable: Zscore(HarLosses6i)

b. Predictors: (Constant), warehtech, Zscore(WareAver)

d. Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.008	.051		-.159	.874	-.108	.092
	Zscore(WareAver)	.063	.051	.063	1.242	.215	-.037	.163
	Warehtech	.121	.055	.112	2.196	.029	.013	.229

a. Dependent Variable: Zscore(HarLosses6i)

Table 4.5: Warehousing influence Ghana's food security

Source: Authors Field Survey, 2023. Significant at 0.05% level.

H2: Warehousing has a positive influence on food security challenges.

Upon a critical look, the warehouse's state appears beyond comprehension, with technology demonstrating significance at p=0.029, testifying to its inefficiency. Meanwhile, the total facility score is insignificant (p = 0.215). The constant variable in the regression model at p=0.874) is an implicit decree to the non-importance of the effect of the omitted factors, if any attempts, to justify the impact of Ghana's WRS on the food security the country experiences today. The facility, while providing farmers with simple access to stored goods in close proximity, ensuring the lifespan of storage (via the zero fly, also known as the hermetic bag), and affordability, does little to induce the observed food security in the agricultural sector (Table 4.5). The significance of the regression model (p=0.038) attests to the ability of the independent variables to drive the criterion as they change. It also attests to the warehouse's overall significance as it relates to how technology should play a crucial role in its management.

Indeed, warehousing favours food security in the sampled regions, as evidenced by Pearson's correlation 'R=0.130' or r=0.067. The insignificant influence at p=0.188 is explained by the R^2 (adj) predicting only one percent (approximately) (p=0.038) impact on Ghana's PHL due to the limited use of technology at the warehouses (Table 4.5 a, b and c). Ninety-nine percent of food security is not championed by the IPEP initiative, no wonder influences of the interventions made to achieve food security are unknown (Kolog, Asem, and Mensah-Bonsu 2023) perhaps due to their inappreciable effects. This is a call for the government to step up.

The IPEP warehouse is to be a receipt system and the farmers were informed therefore a participant quizzed during the data collection that:

"Is the current warehouse a Ghanaian version of WRS? No! … In my view, it is an ordinary storeroom that may be meant for future upgrade" R12.

Despite experts' opinions to the contrary, that proper grain storage raises everyone's standard of living by reducing overall food losses for smallholder farmers, the facility is useless (Ghana News Agency, 2023). This observation runs counter to the literature that has been quoted. The use of modern technology of various kinds is a common feature in a standard WRS therefore, a warehouse receipt system (WRS) theoretically guarantees food security, and the current analysis confirms a favourable link. Nonetheless, it's also known that small-holder farmers profit little from WRS in Africa, and the current study exhibits that WRS has only a one percent

influence on Ghana's food security. Ninety-nine percent of farmers' harvest is exposed to postharvest losses due to inefficiencies in grain storage explaining that warehousing is doing extremely little in fighting food insecurity, especially in Ghana. This somewhat corroborates a 2023 Ghana News Agency report that emphasised how crucial appropriate storage is for both commercial and small-scale farmers to ensure no post-harvest losses. The nation as a whole, as well as homestead communities, districts, and regions, must improve their storage practices if farmers are to continue providing food for the country.

4.1.5 Challenges of Logistics Management that Affect Agricultural Food Security

Storage issues regarding warehouse condition (Mean=8.76, SD=3.58), space insufficiency (Mean=10.13, SD=2.03), and cost (Mean=7.83, SD=3.42) appear to be considerably less pressing to the agricultural sector, evidenced in Table 4.6a. There is a more considerable disparity in the responses offered by those postulating the condition of the warehouses and storage costs to mitigate the ongoing PHL. Slow packaging processes (Mean=7.78, SD=2.30), ineffective warehouse administration (Mean=7.63, SD=3.26), poor packaging materials (Mean=6.59, SD=2.06), a lack of packaging materials (Mean=6.28, SD=2.17), the high cost of packaging materials (Mean =6.41, SD=2.90), and the knowledge of the farmers (Mean=6.66, SD=3.05) seem to be the less pressing constraints in the industry and trigger the reigning PHL the country has witnessed over the decades. Variations in response to the solicitation of these restrictions are observed. Among all the issues, poor road networks (Mean=3.54, SD=2.63) and a lack of transportation (3.12, SD=2.85) are the most pressing, while transportation cost exorbitance (Mean=2.94, SD=1.99) is considerably the most pressing.

"The current cost of living is so high that the rise in fuel costs goes undetected. This phenomenon has an impact on the fees we pay while transporting our harvests to the warehouse." **R13**. This a participant said in an interview.

The variance in the replies collected on this limitation was low.

Descriptive Statistics					
	N	Min	Max	Mean	SD
Poor storage condition	384	1	12	8.76	3.58
Inadequate storage space	384	2	12	10.13	2.03
High storage cost	384	1	12	7.83	3.42
Lack of transport	384	1	11	3.12	2.85
Poor road network	384	1	10	3.54	2.63
High transport cost	384	1	11	2.94	1.99
Farmers lack sufficient education	384	1	12	6.66	3.05
Slow packaging/repackaging process	384	4	12	7.78	2.30
High cost of packaging material	384	1	12	6.41	2.90
Lack of packaging materials	384	1	12	6.28	2.17
Poor packaging materials	384	2	12	6.59	2.06
Ineffective administration	384	1	12	7.63	3.26
Valid N (listwise)	384				

Table 4.6a: challenges of logistics management affecting agricultural food security

Source: Author's Field Survey, 2023

Challenges	Mean	Rank
Poor storage condition	8.86	11th
Inadequate storage space	10.12	12th
High storage cost	7.89	10th
Lack of transport	3.20	2nd
Poor road network	3.63	3rd
High transport cost	2.97	1st
Farmers lack sufficient education	6.60	6th
Slow packaging/repackaging process	7.86	9th
High cost of packaging material	6.41	5th
Lack of packaging materials	6.26	4th
Poor packaging materials	6.63	7th
Ineffective administration	7.59	8th
Kendall's W[a]	0.388	
Chi-Square	1639.735	
Df	11	
Asymp. Sig.	0.001	

a. Kendall's Coefficient of Concordance

Rule: w=0-00, disagreement, 0.00<=w<0.20- slight agreement, 0.20<=w<0.40- fair, 0.40<=w<0.60 substantial, 0.60<=w<0.80- moderate. 0.80<=w<1.00- almost perfect, w=1.00, perfect agreement.

Table 4.6b: Ranking of challenges of logistics management affecting Agricultural food security

Source: Author's Field Survey, 2023

According to an article by Otoo and Mills (2023), "Bad roads contributing to high food prices" reported in the Business and Financial Times, stakeholders in the agriculture value chain have lamented the poor nature of roads contributing to the current high food prices in urban settlements. They reported that food prices have been on a downward trend in the global market for more than a year now, while domestic food prices continue to skyrocket, making it difficult for Ghanaians to cope. According to Osei-Asare (2023), "bad roads play a major role in price

hikes as drivers have to spend more on servicing their vehicles when transporting food items from farms to the market, a cost that is passed on to the final consumer". These assertions are consistent with the present finding showing high transport cost' with a mean rank = 2.97 an ultimate threat to farmers' food security (Table 4.6b).

With few farms within driving distance, transport providers spend so much on fuel that, according to participants;

"They *charge ten to 20ghc for each sack on carriages to the warehouses. And because sales are yet to be made, we regard this as a 'burden'."* R14

Postharvest losses of 10 to 12 percent occur before crops reach markets, according to Jones *et al.* (2019:1). This is because postharvest systems are primarily dormant or nonexistent. The profits to smallholder farmers are severely limited by several additional value chain constraints, including high transport costs.

According to research conducted elsewhere, the problem of car transportation of grain crops is still the most significant (Bezpartochnyi and Britchenko 2023:173–174). Thus, one of the main factors being addressed is the effort being made to lower the cost of transportation. The rising costs of transportation appear eminent across borders.

The overall shortage of transport (with a mean score of 3.20) was the second constraint. Even when they are ready to pay, respondents report a shortage of transportation to carry their harvests. Although this is not a common occurrence, Table 4.1a provides a glimpse of it; farmers employing a van/truck, for example, have their PHL dependent on the availability of this mode of road transportation, which is indicative of the scarcity of particular modes of road transportation. This should add to the increased cost mentioned above.

Jones *et al.* (2019:1) identify a shortage of transportation as a logistical barrier, which the current study supports. Ariong *et al.* (2023), Yeshiwas and Tadele (2021) and Pawlak (2017:12-13), add to the discussion by stating that in less developed countries with inadequate transportation infrastructure, food losses mostly happen in the early phases of the food supply chain (agricultural production, postharvest handling, and storage).

When asked to rate their challenges in moving crops from their farms, the majority of respondents ranked inadequate road networks third, giving them a mean score of 3.63.

According to Bezpartochnyi and Britchenko's study (2023:173), the most troublesome issue still involves the delivery of grain crops by car. Domestic highway maintenance has become a major issue, particularly in the central and southern regions of Ukraine, where roads in poor condition are costing farmers a lot of money. Due to the challenge of traversing routes with damaged roads, a large number of farmers willfully break the regulations governing the transportation of grain crops and packing transports to capacity. Jones *et al.* (2019:1) discovered a lack of appropriate storage leading to PHL, similar to this study's findings. In reality, logistics are mismanaged in the food business since it is primarily in the hands of farmers.

A lack of packing supplies ranks fourth with a score of 6.26, indicating the uncommon shortages farmers encounter with these materials. Because the primary material, hermetic bags, is imported and sold by private enterprises, farmers may need a higher supply, impacting their PHL. WJCI (2022:1) and Johnson, Nketia, and Quaye (2015: 174), classify the primary logistics challenges and constraints confronting Ghana's agricultural food industry and state the high cost of packaging materials as impactful, which supports the aspect under consideration. The fifth constraint, however, is the cost of the packaging material.

Respondents attribute their dissatisfaction to the high cost of packing material, to the possibility of the substance being scarce, or its monopolistic supplier is causing it to be overpriced. To the dismay of the poor farmer, the cost of a hermetic bag is 20 to 25ghc per unit; as a result, some utilise ordinary, antiquated sacks when they cannot afford the hermetic ones. This point is shared by (WJCI 2022:1; Johnson, Nketia, and Quaye 2015: 174). Other less critical restrictions are ordered accordingly in (Table 4.6b), with the least essential ranking 12th (insufficient storage space, with a mean score of 10.2). Given the districts' current production capabilities, the warehouse space is sufficient for farmers. As previously stated, Nadowli Kaleo (Doung) has 250mt of storage, while Garu has 1500mt. As a result, it is not surprising that it is currently of little interest. Scholars such as Pawlak (2017:13), Erden, Dellal, and Bayramolu (2017:20), and Jones *et al.* (2019:1) concur that poor storage is a significant limitation influencing agricultural food security. However, their assumption contradicts the current study's observation. A storage deficiency is the least essential element influencing smallholder farmers' PHLs in Ghana.

At a chi-square value of 1668.080, Kendall's coefficient (W) of 0.388 is obtained, indicating that food security status depends on these issues. According to Kendall's concordance, 39 percent (approx.) of respondents agree on the ranking of logistical problems affecting their food security. All of the farmers agree with the rankings, and the weight of their agreement is fair. This could be due to the more prominent differences noticed in the evaluations provided by respondents (standard deviations (SD) in Table 4.6a).
Smallholder farmers generally agree on the ranking of the logistical challenges impeding food security in the agricultural sector in Ghana. The most severe issue is high transportation costs.

4.1.6 Ensuring Sustainable Improvement in Logistics Management

To achieve this section, the warehouse influence on packaging and transport logistics were further queried by two managers and two senior staffs, one staff and one manager from each of the chosen regions/districts. All were male with a minimum of two years of experience working with the five-year-old IPEP. The effectiveness of the warehouse was observed from the use of technology of any kind in storage, packaging, and coordination of transport logistics.

	Count	% Codes	Cases	% Cases
Warehouse				
RHBPSD	4	6.6%	4	100.0%
ECBM	4	6.6%	4	100.0%
PoS	2	3.3%	2	50.0%
Packaging logistic				
CSBH	4	6.6%	4	100.0%
WEMS	1	1.6%	1	25.0%
Food security				
PSE	3	4.9%	3	75.0%
PRR	4	6.6%	4	100.0%
FS	4	6.6%	4	100.0%
FHAR.	4	6.6%	4	100.0%
AGTF	1	1.6%	1	25.0%
Technology				
HB	4	6.6%	4	100.0%
PCS	8	13.1%	4	100.0%
Fum	2	3.3%	2	50.0%
Transport logistic				
No contribution	4	6.6%	4	100.0%
Innovation expected of government				
ITT	4	6.6%	4	100.0%
ITP	4	6.6%	4	100.0%
ITW	4	6.6%	4	100.0%

Table 4.7: Shows the warehouse operation, management's view on improving it, and food security issues.

NOMENCLATURE

RHBPSD recommends the usage of a hermetic bag and proper drying
ECBM – Managers of the warehouse communicate effectively via phone calls
PoS – proximity of storage
CSBH – contact supplier before harvest
WEMs – fumigation done at the warehouse
PSE –PHL still experienced
PRR- PHL relatively reduced
FS (food security) - possible to cut PHL to 10%
FHAR – farmers have a role-playing
AGTF – Advice given to farmers
HB – Hermetic bag
PCS = Phone call & Sms
Fum = Fumigation
ITT – Innovation by the government on transport
ITP – Innovation to better the packaging logistics
ITW – Inventions to improve the IPEP warehouse

Table 4.7 specifies the various technologies used at the warehouse and seems elementary. The management is poised to warrant food security in the agricultural sector, is only a result of financial resource constraints

"We are willing to modernise this facility provided we get enough support." **R15.** This was *said by senior managers from Nadowli and Garu.*

Hermetic *bags* (n=4, 100 percent) aid packaging at the warehouse, whereas *cell phone calls and SMSs* (n=4, 100 percent) help management communicate with farmers in due time. Untimely *fumigation* (n=2, 50 percent) is done at the warehouse to prevent bugs, millipedes, cockroaches, and other unwanted pests from accessing the storage. The practice of fumigation was heard of in the Garu (upper east) division. It was cited by the manager when asked about the means used for the safety of packaging materials and storage longevity. It seems to be an infrequent engagement of the said practices by the warehouse. Nonetheless, the Doung (Upper West) division is more conservative in using 'ashes or DDT' to deal with destructive insects

and growths. Post-harvest losses are still impactful in these regions, 75 percent of the respondents (N=3) attest to this. Some respondents claimed that:

"Relative to prior years, PHL has reduced" (PRR in Table 4.7 and Appendix 2, Table 6). R16

Food security is rising compared to the previous years, thus confirming farmers' opinions in the quantitative segment (Table 4.4a). However, the managers are convinced of a further cut in PHL across the districts.

A respondent from Garu strongly asserts that:

"*It is* possible that *farmers PHL be cut to less than 10 percent even, if they adhere to our counsel and guidance", a sentiment mirrored by an extension agent. R17*

Management is making extra efforts on the food security issues, the fruitfulness of which is to be verified. First, the facility does not contribute to farmer transport, inconsistent with the WRS best practices identified in Tanzania, where the main and village-level stakeholders forming the Agricultural Marketing Cooperatives, or AMCOs supply farmers with agricultural inputs and establish markets for agricultural products. According to literature sources, this AMCOs handle the production, processing, marketing, and transportation of a variety of crops, leading to effective WRS.

The IPEP management recommends identified technologies involving using hermetic bags for packaging before storage, ensuring preservation via fumigation practices in some districts.
Of course, this is only seen in some areas across the country, only one of the two divisions selected confessed to this practice (Table 4.7, Fum, and Appendix 2, Table 6). It was revealed after the interview that the practice of fumigation is spontaneous. Aside a direct approach by extension agents in the District's Department of Agriculture, phone calls and SMSs are the communication channels between management and the Farmer-based Organizations (FBOs).

So, the use of technology is essential in managing the warehouses. Much effort is required in these areas if post-harvest losses are to drop again, resting on the culture of the warehouse. For now, the facility requires proper sun drying to allow storage, implying that a farmer has to hold back his or her stock and dry it properly if the warehouse notices the stock is moist. Likewise,

farmers unable to store in the warehouse for a reason are advised by management to buy the storage bags for self-keeping.

The stewards argue that “the farmers minimise their PHL, not only by acquiring zero fly bags and proper sun drying but also through timely harvests,” according to a senior staff from Garu (Appendix 2, Table 6, cites Case 4)

Farmers that employ traditional practices should store grains for less than 60 days, or they should adopt improved storage practices to assure food safety and increase shelf life. This is an attestation by Ariong *et al*. (2023:1) per the fact that some cultural practices assist farmers in managing their PHL.

Relationship Between Relevant Themes Under Sorensen’s Coefficient

Participants were asked to rate the relationship between logistics and food security. Figure 4.1 records a path quotient DSC1.000 for HB, indicating a perfect similarity/correlation with rising food security. Fumigation also records a DSC of 1.000, highly influenced by the anticipated rising FS (Figure 4.1). Indeed, there is a perfectly significant similarity between PCS (DSC=1.000) and the present FS situation across both regions.

Dynamics in How the Usage of Farmer Warehouse Communication Parallelly Affects Food Security.

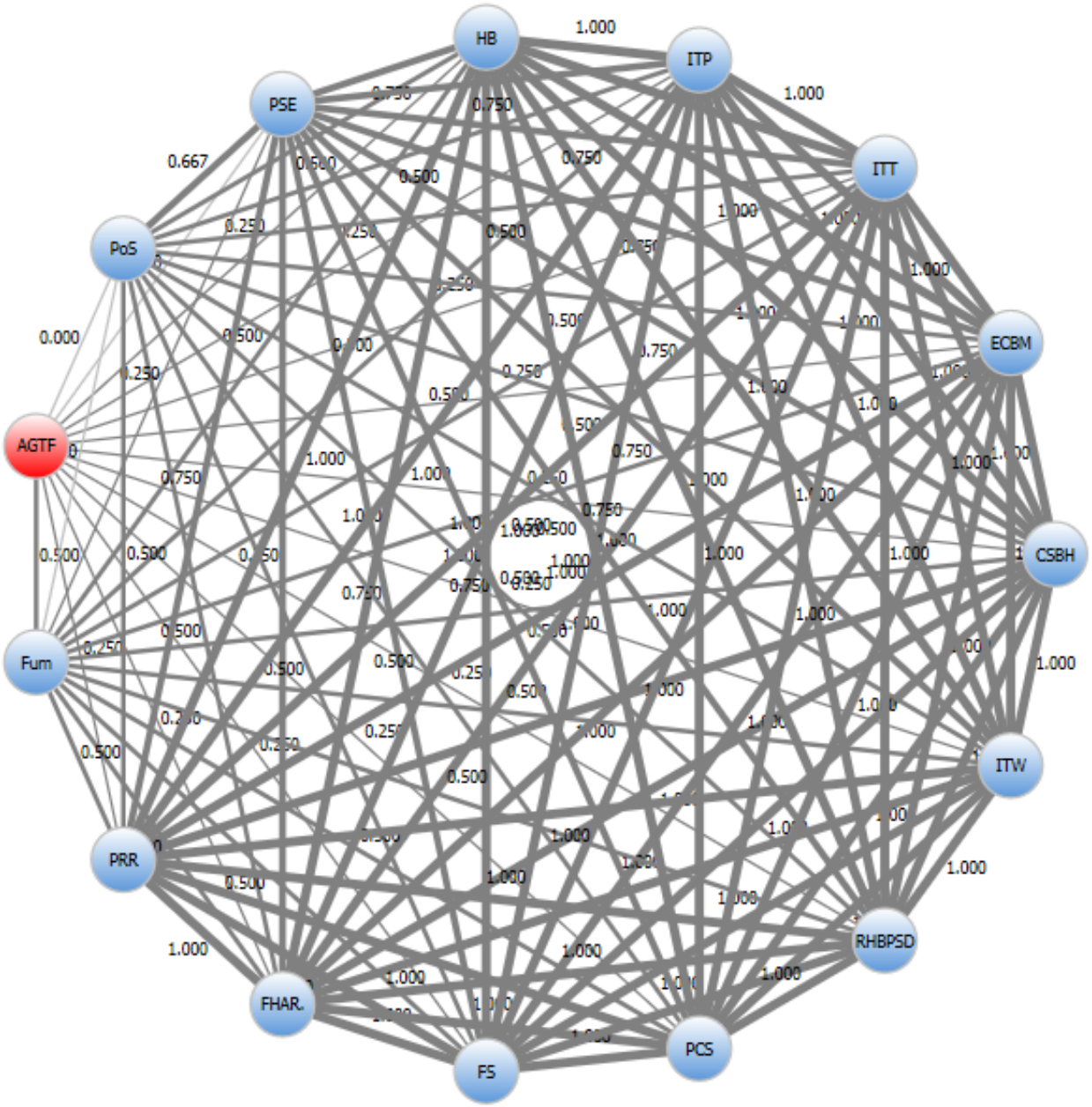


Figure 4.1: Relationship among themes in Sorensen's Coefficient Framework

Source: Author's Field Survey, 2023

Note: DSC is the quotient of similarity between variables and ranges between zero and one.

Food security is rising (Section 4.1.6) in the country (Table 4.7, and Figure 4.1) credit to using hermetic bags (DSC= 1.000) with a perfect influence on PHL across the districts selected. Present fumigation also yields a DSC =1.000 reduction in PHL, but only a few districts take part in this practice. Table 4.7 'Fum' recalls one of two regions/districts selected practising this and it is spontaneous in execution (Appendix 2, and Table 6, FUM).

Most districts seem to not be undertaking proper fumigation in their share of the warehouses; the evidence is bare at Doung, where the orthodox approach of 'ashes or DDT, is sometimes used to prolong the shelf-lives of grains. The perfect influence of fumigation justifies this practice's impressive effect on food security if management could commit to doing it.

Towards improving logistics management, management suggests interventions the government should adopt at the warehouses. These are modelled in Figure 4.1 for their relation to food security.

The co-occurrence of the inventions ITW, ITT, and ITP tests perfect at DCS=1.000 (see fig 4.1) for the ITW with FS parallel to ITT. Adopting the ITP strategy will present a strong relation (DCS = 0.750) with the government's ability to lessen farmers' PHL to barely ten percent.

With credence, the underlying interventions will succeed in assuring food security for grains (Table 4.7, and Figure 4.1).

Note:

ITT - supply tricycles to the facility

ITW- provide unit load formation equipment, transport equipment, storage equipment, and display screen equipment to maintain the ideal condition at the facility

Case 4 (a senior staff at Garu) reports that "many things are getting damaged here, so I believe we need CCTV camera to aid monitoring, dryer, electricity is also needed at the facility". On the electric power issue, it was observed that the Garu division has an idle grain cleaner machine due to a disconnection of their electricity.

One unique response that came forth, inquiring into this matter was when the research team was told that:

"The warehouse cannot pay the bills to use this machine because we charge just 0.50ghc per month for each 100kilogram bag of grain stored, so maintenance and other recurrent expenditures are unaffordable to management" **R18**

This seems not an optimum practice, operating the warehouse amidst such distressing conditions, makes sustainability questionable, as such the fee should be reviewed considerably to promote the sustenance of the IPEP warehouse and improve the additional services offered for a more functional IPEP warehouse. A public warehouse offers warehousing services for a fee, depending on the amount of storage space occupied (Saravanakumar 2023).

One important aspect of employing public taverns such as the IPEPs is to charge a fee. But in addition to providing consumers with storage space, public warehouses also offer other services like picking, packing, and returns management (Saravanakumar 2023). This has been the global norm yet the IPEP seems playing too magnanimous thus, affecting efficiency, perhaps this consideration is due to the facility's inadequate furnishing, hence farmers might not see value for money, paying much. Again, incorporate the ITP by regulating/subsidising the cost of hermetic bags or the government to take charge of its supply. Packaging and repacking machines should be made available to fast-track packaging at the warehouse (Appendix 2, Table 6).

In **SYNOPSIS** the following are worth noting for improvement in logistics management:

- ***Transport Logistics***

Tricycles assure food security, thus, resorting to ITT is vital to downsizing farmers' PHL meaningfully (Table 4.7).

Adeleke (2022:11), who studied Nigeria's Indigenous Logistics System (ILS), also known as the waybill or messaging system, proposed a concept that is comparable to this action (Adeleke 2022). The waybill or message system transports commodities, products, items, and documents to various locations both within and beyond the country using motor park passenger buses and trucks. The logistics system is not new; rather, it is only an improvement and adaption of earlier

native logistics techniques using widely accessible, contemporary technology. One can design a system that is more suited to Ghana's current requirements on a local level.

Table 4.6b of this chapter identifies the high cost of transport, as a significant challenge affecting food security; therefore, setting up an efficient transport system may require the government to supply tricycles (be it self-owned or under a private partnership), integrating ICT to ease farmer access economically. According to Onwude *et al*. (2020:1) and Speranza (2016) recent developments in technology and automobiles have had a rapid impact on the management of supply chains and the movement of people and commodities. Businesses are under pressure from the economy to use technology advancements to increase their effectiveness and efficiency. Due to their perceived financial vulnerability, smallholder farmers are likely to benefit from any system that is (by the warehouse) accommodating of their financial situation.

- ***The Warehouse***

WRSs and CEXs have used information communication technology to enable 24-hour trading and transition from paper-based administration to electronic systems. According to USAID (2018, 2010), Ghana and Kenya plan to invest in these electronic systems. The IPEP model is to be an effective WRS kind of warehousing, therefore, the present study adds that there, should be provision of warehouse management/operation technologies (such as, RFID tags, scanners, display screen equipment, radios and walkie-talkies), unit load formation equipment (like pallets and skids), transport equipment (such as sack trucks, pallet-trucks and conveyor belts), storage equipment (such as pallet-racks, shelves and cupboards), access equipment (like ladders), weighing bridges and machines (Saravanakumar 2023), dryers, cleaners, timely fumigation, and consistent power supply. This complements prior studies, pronouncing software, telecommunications, television, and RFID as among the most trolled technologies in global warehousing (Kumar and Srivastava 2018:00123; Gan, Zhu, and Zhang 2011:405; USAID 2010:6).

- **Packaging Logistics**

Due to ongoing innovation in packaging materials and technologies for the creation of more effective and sustainable solutions, the size of the agricultural packaging market is expected to rise at a compound annual growth rate (CAGR) of more than 5.8 percent between 2023 and 2032. The packaging industry is transforming almost daily with new technologies, better than before, replacing old ones where ordinary sacks were employed (Global Market Insights Inc

2023; Packaging Trend-The Future Outlook 2010). The ongoing study attests to this, finding the use of hermetic bags a common counsel farmer receives from the warehouse management.

Moreover, only a few districts do fumigation for the safety of these packaging materials (Table 4.7), and management believes that an improvement in packaging is feasible should the government regulate or subsidize the cost of hermetic bags or take charge of the supply, and provide packaging and repacking machines to fast-track packaging at the warehouses.

In line with Pulidindi and Ahuja's (2023) extrapolation that agricultural packaging is crucial for maintaining the quality, freshness, and safety of agricultural products, these strategies should aid in ensuring effective packaging at the warehouse. They may also help extend the shelf-lives of these products, ensuring that they reach consumers in good condition.
Pulidindi and Ahuja (2023) are witnesses to the fact that the main challenge faced by manufacturers of agricultural packaging is cost pressure due to fluctuations in raw material prices, energy costs, and labour expenses. In other words, it can be challenging to balance the demand for cost-effective packaging solutions while maintaining quality and performance, necessitating government intervention in the form of subsidies for poor farmers.

4.3 CHAPTER SUMMARY

As a result of the use of telecommunications (text messages and phone calls), zero-fly/hermetic bags, and fumigation (in certain areas), which all benefit farmers' PHL. Ghana's food security is rising, even though the GSS 2022 Annual Household Income and Expenditure Survey reports that 50 percent of the country's population faces food insecurity. Approximately 90 percent of foods produced now can evade postharvest losses (Table 4.7; Figure 4.1).
The use of a tricycle ($t(38) = 0.66$, $p= 0.51>$ level 0.05, $n^2>0.01\%$) is proven to be more likely to achieve a massive cut in PHL (Table 4.2a and b), however, the IPEP warehouse does not contribute to resolving farmer transportation challenges (Table 4.7). The burden of organizing for transport during harvests is put on the poor farmer.
Packaging logistics have a critical but small (one percent) impact on Ghana's food security at $p=0.008$ (Table 4.3b). According to statistics, the minimal impact can be inefficiencies caused by a lack of technological engagement in the logistics at the warehouses (Table 4.3b and c).
Generally, the IPEP warehouse has a positive impact on food security ("R=0.130" or "r=0.067"), however, this was considered insignificant at $p=0.188$ explained by R^2 (adj)

equaling only a one percent (approximately) (p=0.038) impact on Ghana's PHL, the IPEP initiative, is thus, not guaranteeing 99 percent of the country's food security.

It has been demonstrated that the nation's logistics management and food security have a marginally favourable relationship (p=0.073, Pearson's R=0.149) (Table 4.4 b and d). Food insecurity and infrastructural constraints are positively correlated, according to the literature, and this is confirmed by the current study's findings (Table 4.4b and d). Food security-related logistics management problems were investigated using Kendall's coefficient of concordance. According to Kendall's concordance "W", the respondents' agreement on ranking the problems is fair at 39 percent. High transport cost was rated as the most significant limitation with a mean score of 2.97, followed by a lack of transportation (3.2), a poor road system (3.63), a lack of packaging materials (6.26), and a high cost of packaging materials (6.41).

Among the most utilised technologies in global warehousing are software, telecommunications, radio, television, and RFID (Kumar and Srivastava 2018:00123, Gan, Zhu, and Zhang 2011:405, USAID 2010:6). The additional steps that must be taken to provide a sustained improvement in logistics management from the IPEP warehouse are assumed in Section 4.1.6.

According to the study, other factors contributing to a more effective WRS include the availability of warehouse management/operations identification and communication devices (such as, RFID tags, scanners and display screen equipment), unit load formation equipment (pallets), transport equipment (such as sack trucks), storage equipment (pallet-racks), dryers, cleaners, timely fumigation, and consistent/stable electricity at the warehouse.

To express the facility's concern about farmer transportation, the management believes that tricycles are required at various divisions. (Table 4.7, Appendix 2, and Table 6).

They also think the government should take the following actions to improve the warehouse's packaging: control the cost of hermetic bags, subsidise their purchase, and make packaging, and repacking equipment readily available (Table 6 in Appendix 2)

CHAPTER FIVE

SUMMARY OF FINDINGS, POLICY RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

In the food supply chain, more than 30 percent of all edible components produced globally, making up almost one-third are lost or discarded (Safdie 2023; FAO 2021; Ishangulyyev, Kim and Lee 2019). More than anywhere else on the planet right now, 282 million people are undernourished on the continent of Africa, according to an AP and Rédaction Africanews report from 2020. A logistics system must be developed that specifically suits the socioeconomic conditions in Africa and the distinctive characteristics of its population following the implementation of logistics management best practices to resolve associated hurdles and the earnest challenge of food security. The Western-styled logistics system has not yielded the same results in Africa as it has in other parts of the world a century after it was introduced; this shortcoming may be partially attributed to inadequate/inefficient management.

The portion of supply chain management known as logistics management (LM) organises, carries out and controls the forward flow and storage of products, services, and related data between the point of origin and the point of consumption to satisfy the needs of consumers (Rouse 2018, CSCMP n.d.). In the context of food production, logistics management includes everything from seed selection and procurement to field planning and resource allocation, to harvest scheduling and product distribution (Driver 2023). Since there isn't a clear link between the idea and food security, it is possible to evaluate how logistics management affects food security in Ghana by giving special attention to how well the infrastructure for poverty eradication programme (IPEP) warehouses/logistics infrastructures handle packaging, transportation and storage logistics.

This research involved 384 smallholder farmers, 128 cultivating rice, maize, or millet, and was conducted as an explanatory sequential mixed-methods survey in Ghana's Upper West and Upper East regions. Two management members were polled from each warehouse.

Three hypotheses were tested using regression and Pearson's correlation models, investigating logistics challenges with Kendall's coefficient of concordance. The warehouse management's qualitative opinions were examined with Sorensen's coefficient (DSC) framework. The theories tested include:

- H1: Packaging logistics contributes massively to food security
- H2: Warehousing has a positive influence on food security challenge
- H3: Logistics management has a significant positive relationship with food security

Six distinct goals were investigated as follows:

- Assess road transport type(s) achieving food security in Ghana
- Measure how the packaging logistics used at various warehouses contribute to attaining food security
- Examine the relationship between food security and logistics management.
- Analyse the influence of warehousing on Ghana's food security.
- Evaluate the logistics management difficulties that affect the security of agricultural food.
- Propose a framework the government can adopt to ensure sustainable improvement in logistics management in the food industry.

The latter is addressed in the recommendations section. The following sections provide the summary, conclusion, policy recommendations, and suggestions for additional research.

5.1 Findings Summary

5.1.1. Findings from the Literature Review

Road Transport(s) Achieving Agricultural Food Security in Ghana

The review identifies head porterage and automobiles as the prevalent road transport in the agricultural sector, albeit none justifies food security throughout the research. With poorly maintained mode(s) of transport, stunting agricultural productivity and food production potential (World Bank 2022) and poor transportation networks hindering the timely movement of food, resulting in post-harvest losses and reduced market access in Ghana (Atchulo 2024), farmers elsewhere, using various automobiles are also experiencing massive losses due to poor road network (NDPC 2010:56, Lenn and Ward 2010, Sura raksa and Shin 2019, Baumel and

Hayenga 2021, Bezpartochnyi and Britchenko 2023:173-174, Alulu *et al*. 2023:04, Ayodele and Oluwagbenga 2023:77, Otoo and Mills 2023). This gives credence to incorporate in literature with empirical backing, the road transport to achieving food security at the present age (Section 2.4.1).

Contribution of Warehouse Packaging Logistics to Food Security

The quality, freshness, and safety of agricultural products are significantly enhanced by agricultural packaging (Garba 2023). By doing this, the items' shelf lives are extended and they are guaranteed to reach consumers undamaged (Pulidindi and Ahuja 2023). In light of the fact that a quantifiable impact on food security is now crucial, some studies and strategies have concentrated on packaging to minimise losses (Pulidindi and Ahuja 2023; Blakeney 2019: Wohner 2019) (Section 2.4.2).

Relationship of Logistics Management with Food Security

Many nations rely heavily on the agricultural sector to supply food and raw resources for other businesses. Nevertheless, the industry is frequently plagued by logistical challenges and problems that compromise food safety (Driver 2022). The literature (e.g., Subramaniam, Macron and Naseem 2023:3431; CARISCA 2022; Kabue 2022; Quansah, Boso, Muntaka 2022:1; Uganda, Ssennoga, Mugurusi and Olukac 2019:1) clearly shows the relationship and assurance that enabling logistics provisions minimise food insecurity; however, a quantified impact of logistics management on food security was unknown (Section 2.4.3).

The influence of warehousing on food security

It is often known that efficient grain storage improves everyone's livelihood by helping smallholder farmers lose less food overall (Ghana News Agency 2023, Quansah, Boso, and Muntaka 2022:3, de Jager *et al*. 2018 etc.), that said, there is no prove that warehouses have a legitimate stake in coordinating other logistics systems to keep farmer surpluses making it obscured in literature (Section 2.4.4)

Logistics Challenges Affecting Agricultural Food Security

A brief account of the review proves that logistics challenges overwhelming smallholder farmers involve storage issues, knowledge deficiency and transport in the agricultural industry (e.g., Jones *et al.* 2019:1, Erden, Dellal and Bayramoğlu 2017:20) (Section 2.4.5). These needed trial in the Ghanaian context.

Improving logistics management in the agricultural sector

Warehousing; Software, telecommunications, radio and television and RFID tags are among the most utilised technologies in international warehousing for enhancing the performance of a warehouse receipt system like the IPEP (Section 2.4.6.1).

Transport; Adeleke (2022:16) concurs with the application of basic technologies improving Indigenous Logistics System operations. This study highlights a similar or more straightforward approach to facilitate transport coordination from the IPEP warehouse (Section 2.4.6.2) after careful examination of the effects of Obeng's (2015) model on transport coordination.

In conclusion, advancements in materials, technologies, and/or information transmission technologies have resulted in enhanced packaging in recent times. For instance, intelligent packaging that interacts with products or communicates with customers has made it possible to track a single item throughout the entire supply chain (Regattieri, Santarelli and Piana 2019, Soroka 2002). Packaging is the technology and materials used to enclose or protect goods for distribution, storage, sale, and use. Post-Harvest Losses' evolution must blend with the use of packaging at various buffer stores. In this context, this research makes the case for the strategic use of warehouse packaging in academic works to increase food shelf-lives and offers useful suggestions for enhancement. (Section 2.4.6.3).

5.1.2 Findings from Empirical Data

Ghana's food security is increasing as a result of technological advancement in the IPEP warehouse regarding communications services (such as phone calls and SMSs), packaging designs such as zero-fly/hermetic bags, and fumigation efforts (in certain locations). This insight/finding is in contrast to the GSS 2022 Annual Household Income and Expenditure Survey, which reports nearly 50 percent food insecurity. Ninety percent of foods produced

today are free of post-harvest losses, and PHL has benefited from all of the technologies mentioned (Table 4.7 and Figure 4.1).

Road Transport Type(s) Achieving Agricultural food Security in Ghana

When the results of an independent sample T-test were reviewed, the use of tricycles (t (38) = 0.66, p=.51> level.05, n^2 >0.01 percent) appeared to have the highest impact on attaining food security than other forms of road transportation (Tables 4.2 a and 4.2b). Still until now, the warehouse has yet to contribute to resolving farmer transportation issues (Table 4.7).

Contribution of Warehouse Packaging Logistics to Food Security

Packaging at the warehouse is important (p=0.008) in providing food security, though the moderator (technology) is found insignificant (p=0.892), casting doubt on the efficiency of this packaging system. The IPEP currently does not have a robust packaging system, instead, they use a hermetic bag (a modernised sack) which is advised for storage at the facility though most farmers are unable to purchase enough of these bags for storage, pictures of the modernised sacks have been displayed in section 2.4.6.3 (Figure 2.5). At p=0.008, packaging logistics proves to have a vital but small impact on Ghana's food security (Table 4.3 b). According to data, the minimal impact may be due to inefficiencies induced by a lack of technological engagement in the logistics at the warehouses (Table 4.3 b).

Relationship Between Logistical Management and Food Security

According to Table 4.4, there is a negligible positive correlation between Ghana's food security and logistics management (p=0.073, Pearson's R=0.149; see Tables 4.4b and 4.4d). The current analysis confirms the positive association between infrastructural restrictions and food insecurity from a literary perspective (Tables 4.4b and 4.4d) This could be attributed to logistical inefficiency, weak institutions and inadequate infrastructure. Prevailing reductions in Ghana's post-harvest losses however cannot be attributed to a well-rounded logistics management or a well-run logistics operation in the food sector since it has just one percent effect on the country’s PHL.

Warehouses Influence on Ghana's Food Security

Table 4.5, demonstrated a beneficial influence of the warehouse on food security ("R=0.130" or "r=0.067"), however, the impact was modest at p=0.188 explained by R^2 (adj) equaling only

a one percent impact (approximately) (p=0.038) on Ghana's PHL; the warehouse does not ensure 99 percent of the country's food security.

Logistics Management Challenges Affecting Agricultural Food Security

Based on Kendall's concordance "W", the farmers ranked constraints to their food security and were in fair agreement with the rankings established, at 39 percent. With a mean score of 2.97, high transportation expense was judged to be the most pressing, followed by a lack of transportation (mean score=3.2), a poor road system (mean score=3.63), a shortage of packaging materials (mean score=6.26), and the high cost of packaging materials (mean score=6.41). (Tables 4.6a, and 4.6b).

5.1.3. Analysis of the Hypothesis

- ***H1: Packaging logistics contributes massively to food security***

In trying this claim the regression model is significant at p=0.029, despite a modest connection between food security and the predictor (R=0.135). The IPEP packaging logistics might influence only one percent of the current food security proving the null hypothesis to indicate that, statistically, packaging has less impact on food security.

- ***H2: Warehousing has a positive influence on food security challenge***

The IPEP warehouse has a weak, insignificant link with food security in the selected locations, as evidenced by Pearson's correlation 'R=0.130'or r=0.067, with a p=0.188 (Tables 4.5a and 4.5b). This explains the predictor's favourable influence on PHL with only a one percent (approximately) (Table 4.5b, adjusted r^2=0.012) evidence, better still the relationship is positive to accept the null hypothesis.

- ***H3: Logistics management has a significant positive relationship with food security.***

The Pearson correlation coefficient (R) equaling 0.149 supports the weak link between logistics management and food security. This minimal impact on the criterion is confirmed by the coefficient of determination (R^2 adj one percent, approximately), which shows that 99 percent of the food security in the Upper East and Upper West regions cannot be explained by the

management techniques on the predictor variable. It is necessary to investigate any other implicit variable(s) that may be influencing the criterion's behaviour based on the constant p=0.001 (significant). It is not possible to accept the null hypothesis even though there is a slight but positive correlation between logistics management and food security (p=0.073, Pearson's R=0.149) (Tables 4.4b and 4.4d). Pearson's R-value suggests a weak connection.

5.2 RECOMMENDATIONS

In the context of this study's findings, food experts, a multifaceted approach is necessary to guarantee food security in the future. A comprehensive strategy that is based on policy and technological advancement is required to achieve true global food security, which involves integrating cutting-edge technologies, methodologies, and best practices with current systems (McCarthy *et al.* 2018:11). Based on the findings the following recommendations are suggested to enhance the impact of logistics management on food security in Ghana:

• In a warehouse

This study adds for further consideration making available warehouse management/operations identification and communication technologies (such as, scanners, display screen equipment, radios and walkies-talkies), unit load formation equipment (like pallets, and skids), transport equipment (such as pallet-trucks and conveyor belts), storage equipment (such as racks, shelves and cupboards), access equipment (like ladders), weighing bridges and machines (Saravanakumar 2023), dryers, cleaners, timely fumigation, and consistent/stable power supply as well as vital technologies and amenities in warehousing (See Section 4.1.6).

• Transport

To convey the warehouse's concern about farmer mobility, tricycles are necessary at a district level (Table 4.7, Appendix 2, and Table 6), modernising access by emulating extant studies (e.g., Raheem *et al.* 2021:5; Yawson and Frimpong-Wiafe 2018; Obeng 2015). Precision agriculture, which enables farmers to employ clever techniques and cutting-edge technology in agricultural output, is one of the most significant techniques that has gained popularity recently (Raheem *et al*. 2021:5; Yawson and Frimpong-Wiafe 2018). Drones, etc. are all being utilised to improve input and output mobility in the agricultural sector; one example of this is Obeng's ICT model, whose goal was to develop a locally constructed solution to meet the

pressing need for agricultural produce transportation and marketing, a problem facing Ghana's farming communities. The concept, however, was focused outside the warehouse.

As the AMCO coordinates the transportation in Tanzanian WRS, a body can be aligned with the IPEP warehouses to coordinate transportation logistics via the Obeng 2015 model. This could involve tricycle drivers and owners. Farmer-based organisations and their members can select their phone contact details assign a basic code to each farmer, and distribute central phone number(s) to call or SMS when a farmer's produce is ready for harvest. Because the quantitative component demonstrates that many farmers are illiterate, if not less educated (Appendix 2 and Table 2), a request form is filled out electronically for the farmer. The document should let the warehouse follow up with the farmer and connect him/her to available transportation services as soon as possible. This straightforward phase can be pushed out to allow for future upgrades. In the long term, a mobile application should be developed to digitise the available transportation services for tracking and transparency so that the less educated farmer can use the warehouse as an escrow. The farmer can phone or text the coordinating body, and they can take over reserving transportation for the farmer.

• Packaging

The technology and materials used in packaging are employed to encapsulate or protect commodities for usage, sale, distribution, and storage (Pulidindi, and Ahuja 2023; Blakeney 2019; Wohner 2019; Soroka 2002) and PHL's development needs to align with the assistance of packaging at these different buffer stores. The investigation also concludes that the government must take the following steps to enhance the packing of the warehouse: control the cost of hermetic bags, subsidise their purchase, and make packaging and repacking equipment readily available (Table 6 in Appendix 2)

5.2.1 Policy Recommendations

- A conscious effort is required nationally to furnish the warehouses with relevant technologies (software, telecommunications, television, cameras, RFID, etc.) as deemed fit for WRS (Table 4.5) as technologies support logistics (warehousing) with efficiency and are key in post-harvest handlings and food security (Ariong *et al.* 2023). Furthermore, since post-harvest losses in developing nations like Ghana are even higher as a result of subpar food handling and storage technologies, (Yeshiwas & Tadele

2021), outfitting the warehouse with unit load formation equipment, storage equipment, transport equipment, access equipment, such as, pallets, cupboards, sack trucks, pallet-trucks, ladders, pallet-racks, shelves, Scanners, weighing bridges and machines (Saravanakumar, 2023), and display screen equipment, dryers, cleaners, timely fumigation, and consistent power for efficiency is imperative. Correspondingly, the government should put in every effort to engage and collaborate with scientists and researchers as well as stakeholders aimed at supporting farmers to adopt improved technologies and climate-smart agriculture to make gains like conserving soil nutrients, and mitigating or preventing waste of precious resources as well as adapting well to aggravating impacts of climate-related shocks (World Bank 2022).

Also, agricultural logistics actors or workforce such as those running the warehouses should be trained on logistics technologies, cost management, utilisation of warehouse assets, and operational productivity. Establishing a strong alliance with the extension office at the Department of Agriculture would help farmers receive extension services, as farmers are less likely to adopt new techniques like post-harvest technology when they cannot access such services (Pera, da Rocha & Filho 2023). Thus, the high purchase cost, limited access to extension services, and the requirement to comprehend potential benefits, result in small-scale producers encountering difficulties when attempting to use new technologies. It is worth commending and touting the utilisation of cellphones (phone calls and SMSs) to interact with farmers and suppliers of packaging materials as a good technique.

- High transport cost emerged as the most pressing constraint to farmers' food security, perhaps owing to the scarcity of transport for the farmers. Setting a coordinating body becomes a necessity to ease transport access. In contrast, by aligning with feeder roads, the government should resource the coordinating body with tricycles, mobile applications, and funds, if not equipment, to assist farmers with routes to their farm zones. Not having access to motorable roads can also be a reason for the mass usage of head/human porterage (Tables 4.1 and 4.2). The coordinating body should recruit for readily available casual engagement, those willing to assist in the conveyance of farm produce by head porterage. Reward to these may be in kind (e.g., part of the food carried, etc.) or cash to the head porters. The idea is to ease the carrying harvests made available at river-bound or rough locations that tricycles cannot reach.

- Packaging logistics has a crucial but infinitesimal impact on Ghana's food security, and the cause is not only limited resources but also the cost and availability of hermetic packaging materials, which are the ideal packaging materials recommended for grain storage. There is a clarion call to government and regulatory agencies to control the cost of airtight bags, subsidise their purchase, and make packaging and repacking equipment readily available to the warehouse. Donors can aid the latter.

- Key prerequisites for WRSs are not limited to professional storage management, systems for standardised grading and weighing and a standardised storage facility, but also to market knowledge, enforceable standardised contracts, and appropriate insurance products. Ghana's global food security strategy seems to have a plan for these, but then, the implementation is moribund. It is, hence, imperative that the work of the coordinating unit does not end at transportation, but also ensures market availability for farmers' surpluses while management considers product insurance and contractual relations with farmers a necessity.

5.2.2 Future research

Upon critically reflecting on the research processes, including the integration of methods and the challenges encountered as well as considering how the insights gained from the processes can inform posterity studies, the trend of this study can be pursued following these areas:

- To reevaluate the key factors influencing the food security that smallholder farmers currently enjoy. This should be a quantitative work
- To review the roadmap (the white paper) of the IPEP programme to see if there exists a national will to resource the warehouses and how this can be achieved.
- To carry out research on the same topic, "assessing the influence of logistics management on Ghana's food security," in other regions of Ghana, other food crops, or other logistical aspects with a possible increase in sample size.
- To Research on other theoretical perspectives or variables that could enrich the understanding of logistics management and food security with a possible increase in sample size.

5.2.3 Contribution to the Discipline

5.2.3.1 Framework for Long-term food security and Logistics Management Improvement

This study, based on field evidence, proposes a national framework to enhance food security and logistics management relationship in Ghana with a focus on the IPEP warehouses or logistics infrastructures. The model proposed based on the findings is grounded in four dimensions as National plan, IPEP WRS, Packaging logistics, and Transport logistics.

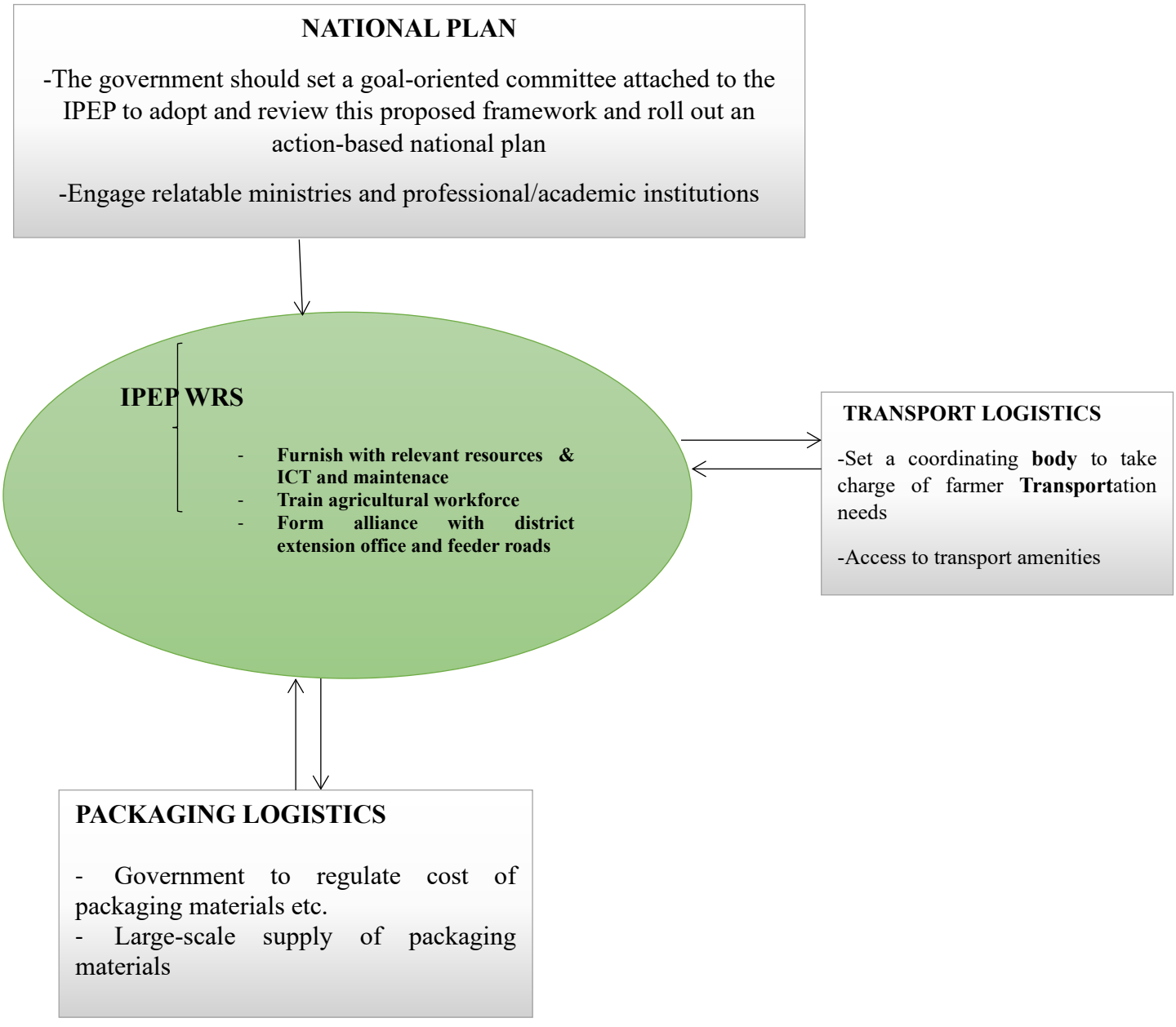


Figure 5.1 Improving logistics management via the warehouse (author's original framework, 2023)

In the context of the framework/blue-print proposed above for improving the impact of logistics management and food security in Ghana, the dimensions below should be pursued:

NATIONAL PLAN: The insights/perspectives of this study confirm that Ghana's agricultural sector lacks a strict logistics management roadmap/blue-print. Hence, even after five years of the establishment and operations of the IPEP warehouses or logistics infrastructures, food security is yet to increase significantly. Based on this field evidence a sustainable national plan serving as an indispensable tool of action/ blue-print in Government's intervention arsenal to address the food-security-related logistics management inefficiencies resulting in the marginally favourable relationship with food security in Ghana (Table 4.4b and d) ought to be rolled out.

Evidence from Table 4.4 identifies a positive correlation between efficient logistics management and food security (Driver 2023). making it uniquely suited for the Government to invest resources substantially, setting a goal-oriented committee attached to the IPEP warehouse or logistics infrastructure with a national strategy to be adopted and reviewed so as to roll out an action based national plan/blue-print. Relying on the expertise of Academics, the Ministry of Finance and Economic Planning, the Ministry of Food and Agriculture, the Ministry of Roads and Transport, the Ministry of Energy, the Chartered Institute of Logistics and Transport (CILT) and the Chartered Institute of Supply Chain Management (CISCM) or at the very least their representatives to contribute comprehensively/cohesively to better the current state of the food-security-related logistics management inefficiencies/ issues.

Looking to the future a sustainable resilient/efficient food-security-related logistics management practices hold the promise of stimulating/fostering agriculture food production to cater for the high dietary demand/needs of the ever-growing populace of Ghana (Barrett and Quinn 2024; Boserup 1965)

TRANSPORT LOGISTICS: Insights/perspectives from this write-up prove that the use of tricycles assures food security realisation the most, than other forms of road transportation. Thus, resorting to innovation by the government on transport (ITT) is vital to downsizing farmers' PHL meaningfully (Table 4.7). A system can be designed that is more suited to the socioeconomic conditions in Ghana and the distinctive characteristics of its farmers populace, based on the logistics system concept propose by Adeleke in 2022. Therefore, setting an efficient logistics/transport system may require the government to supply tricycles (be it self-owned or under a private partnership), integrating ICT to ease farmer access economically. This will also involve the setting of a coordinating body attached to a well-informed management team for the warehouse to take care of transport and/or other prowling activities in the agricultural supply chain for farmers to have easy access to transport amenities, in their farm produce movement. Based on evidence from Table 4.6b identifing high cost of transport, as a significant challenge affecting food security, smallholder farmers, are likely to benefit from such a system /coordinating body (by the warehouse) accommodating their financial situation in their farm produce movement, due to their financial vulnerability perception.

PACKAGING LOGISTICS: This research attests to the packaging industry transforming almost daily with new technologies, better than before, finding the use of hermetic bags which is a common counsel farmers receive from the warehouse management, replacing antiquated sacks. From (Table 4.7), results fumigating packaging materials for safety is not standardised and the IPEP warehouse management believes that an improvement in packaging is feasible should the government regulate/subsidise the cost of hermetic bags or take charge of the supply to support these poor farmers, considering hermetic bags' contribution to food security with twofold functionalities, firstly as storage containers and secondly as pest control methods, and providing packaging and repacking machines to fast-track packaging at the warehouses. These strategies should aid in ensuring effective packaging at the warehouse and extending the shelf-lives of food, to reach consumers in good condition.

IPEP WRS: Evidence from this research identified the IPEP warehouse model to be an effective WRS kind of warehousing, therefore, adding that, there should be provision of warehouse management/operation identification and communication technologies (such as,

RFID tags, scanners, display screen equipment, radios and walkie-talkies), unit load formation equipment (like pallets and skids), transport equipment (such as sack trucks and pallet/lift-trucks), storage equipment (such as pallet-racks, shelves and cupboards), access equipment (like ladders), scanners, weighing bridges and machines (Saravanakumar 2023), dryers, cleaners, timely fumigation, and consistent/stable power supply as deemed fit for WRS to allow efficiency in the IPEP warehouse functionality/operations which is key in post-harvest handlings and food security betterment.

5.3 Conclusion

This study evaluated the impact of logistics management on food security, focusing on the effectiveness of storage, transportation, and packaging logistics used at the Infrastructure for Poverty Eradication Programme (IPEP) warehouses or logistics infrastructure. It did this by using a conceptual model to show the impact of packaging, warehousing, and transport logistics with technology acting as a moderator on post-harvest food security.

The GSS 2022 Annual Household Income and Expenditure Survey asserts that approximately 50 percent of the population experiences food insecurity. However, Ghana's food security is increasing because of fumigation techniques (in certain public warehouses), zero-fly/hermetic bags, and communications services like phone dials and SMS. Over 90 percent of food produced now escapes post-harvest losses, according to the study (Table 4.7, and Figure 4.1). Nonetheless, p=0.073 and Pearson's R=0.149 show a negligible positive association between logistics management and Ghana's food security, suggesting that the IPEP warehouses have little impact on food security (p=0.188; R^2 = equal to one percent) and that recent advancements in food security cannot be associated with resilient logistics management or a well-run logistics operation. The suitability for establishing the IPEP as the pivot point for carrying out this administrative duty depends on the successful execution of a national plan. Section 5.2.3.1 provides an overview of this plan.

Currently, the warehouse has no impact on farmer transportation and its in-house packaging logistics need to be more efficient (p=0.008) to avoid food insecurity; the overall impact (R^2 equaling one percent, and Table 4.5b) is minimal meaning a concerted effort is required if the IPEP initiative is to achieve its goal of minimising post-harvest losses!

5.4 Chapter Summary

This chapter outlined the summary of the findings. The chapter also provides recommendations to guarantee sustainable food security based on a comprehensive strategy on policy and adoption of a large-scale new/modern technologies to restructure the IPEP warehouse management operations and improve the experiences of the IPEP warehouse users. The need for Posterity studies with suggestions offered on how to undertake them is highlighted in this chapter. Furthermore, a national framework was suggested based on the findings and field analysis of this study. The framework will assist in better managing the logistics of the IPEP warehouses to ensure considerable reduction in grain post-harvest losses sustainably and food security success.

Areas of improvement noted were the need for government to efficiently implement the model on the national strategy to enhance the IPEP warehouse management operations, by creating adequate infrastructure, revamping and advancing the utilisation of existing ones over a few years and developing a proper and required training programme with an indigenous touch for grain storage managers to develop their competency via a robust extension service for the IPEP warehouse management. Further, easing farmer access to transport logistics, by setting up a coordinating body to take charge of farmer transport logistics requirements. More so, supporting farmers in the availabilility and affordablility of packaging materials by favourably regulating the costs for farmer packaging logistics requirements. This will significantly increase grain availability sustainably, streamline management operations in the IPEP warehouses and benefit the farmers using the IPEP warehouses, which will improve their trust in the IPEP warehouse functionality and facilitate their full patronage and appreciable utilisation payment for the sustainability of the IPEP logistics infrastructure.

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APPENDIX 1

A DESCRIPTIVE-EXPLORATORY STUDY ON THE INFLUENCE OF LOGISTICS MANAGEMENT ON FOOD SECURITY IN GHANA.

This study is purely for academic purposes and earmarked to contribute to global understanding of the influence of Logistics management on food security attainment in emerging economies like Ghana. The survey is mainly to appraise transport infrastructure, packaging and warehouse logistics being used in the Agricultural food industry. Probing their effectiveness in light of technology applications. The author in effect assures prospective respondents of the confidentiality and anonymity of the data being Solicited.

SECTION Ai: SOCIO-DEMOGRAPHICS OF RESPONDENTS

1. Gender: Male [ ] Female [ ]
2. Educational level? No formal education [ ] below Senior high [ ] Senior High [ ] Tertiary [ ] postgraduate [ ]
3. Age: 18-25 [ ] 26-33 [ ] 34-41 [ ] 42-49 [ ] 50 and above [ ]
4. Which of these grains do you grow most?
   Maize [ ] millet [ ] Rice [ ]
5. How many acres do you cultivate?
   2acres [ ] 3-5acres [ ] above 5acres [ ]
6. An average of how many bags do you harvest in a season? ……
7. Your district?
   Garu [ ] Nadowli Kaleo [ ]
8. Your region
   Upper East [ ] Upper West [ ]
9. Years in grain farming:

a) Less than a year [ ] b] 1-5years [ ] c) 6-10years [ ] d) above 10years [ ]

SECTION Aii OTHER INFORMATION

10. Do you store your produce with the IPEP warehouse? Yes [ ] No [ ]
11. If Yes, why did you choose storing there?.....
12. If No, please why? ……
13. How do you keep your excess produce currently, if you have ever stored it in the

warehouse before?……

SECTION B: MANAGEMENT OF LOGISTICAL SYSTEMS

From your experience in using the warehouse kindly tick against alternative assertions under the constructs. Kindly propose your view whether you Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) or Strongly Agree (SA) to the claims by checking in the appropriate box **[√]**

B1	**TRANSPORT LOGISTICS**	**SD [1]**	**D [2]**	**N [3]**	**A [4]**	**SA [5]**
I	There is an easy access to vehicles to transport produce after harvest.					
Ii	I incur very less charges in conveying my produce					
Iii	Road linking the farm areas is poor					
Iv	Only foot routes connect my farm area and the storage centre.					
V	There is no vehicle to transport my harvested products to the warehouse					
Vi	The warehouse coordinates farmers' access to transport					
B2	**WAREHOUSING LOGISTICS**	**SD [1]**	**D [2]**	**N [3]**	**A [4]**	**SA [5]**
I	Storage of harvested produce at the IPEP warehouse is done only after exhausting storage in another facility					
Ii	Storing my harvest is very affordable now with IPEP					
Iii	There is close proximity to a storage because of the IPEP					
Iv	The IPEP facility preserves my produce for a longer period.					
V	I am allowed to access my goods at any time of choice					
		SD	**D**	**N**	**A**	**SA**

B3	PACKAGING	[1]	[2]	[3]	[4]	[5]
I	Packaging materials are always available at the warehouse to secure my harvest.					
Ii	Packaging materials used at the warehouses are safe to guarantee longer shelf life and avoid contamination.					
Iii	There is speed in packaging/repackaging at the warehouse					
iv	There is a high cost of packaging material					
V	The warehouse charges a high cost to repack farmer's goods**.**					
B4	**APPLICATION OF TECHNOLOGY**	**SD [1]**	**D [2]**	**N [3]**	**A [4]**	**SA [5]**
I	I use technology to ease access to transport, immediately after harvest.					
Ii	The IPEP warehouse adopts technology to prolong the freshness of my produce during storage					
Iii	Technology is being used to enhance packaging/repackaging at the warehouse and to extend shelf life.					
Iv	There is technology to ease tracking and tracing of stored products at the warehouse					

NB: SD= strongly Disagree, D= Disagree, N=Neutral, A= Agree, SA= Strongly Agree

B5. What means of transport do you often use to carry your harvests to the warehouse?

Head porterage [ ] motorbike [ ] bicycle [ ] tricycle [ ] van/ truck [ ] Donkey cart [ ] other means (please specify)……

SECTION C: CHALLENGES OF LOGISTICS MANAGEMENT THAT AFFECT FOOD SECURITY

Many issues including those listed below may constrain the effective management of logistics in the agricultural sector. To ensure food security, a modern warehouse will be required to

coordinate storage, transport packaging etc logistics from a fulcrum point. From your experience using the IPEP **warehouse**, which factor is yet a drawback to the effective running of this warehouse? Please rank the issues below in order of importance.

NO	Challenges	1= most pressing to 12=extremely less pressing
a)	Poor storage condition	
b)	Inadequate storage space	
c)	High storage cost	
d)	Lack of transport	
e)	Poor road network	
f)	High transport cost	
g)	Farmers Lack sufficient education on the warehouse	
h)	slow **packaging** process at the warehouse	
i)	High cost of packaging material	
j)	**Lack of packaging materials**	
k)	Poor packaging materials	
l)	Ineffective administration	

SECTION D: EXTENT OF ATTAINING POST-HARVEST LOSSES SECURITY

1. Have you ever experienced postharvest loss (es)? Yes [ ] No [ ]
2. If No, kindly indicate how you are able to avoid post-harvest loss (es)
   ……
   ……
3. If Yes (to question 1), which factor(s) account(s) for the Loss (es)?
   No transport route(s) [ ] no access to transport [ ] lack of proper storage [ ] poor packaging [ ] other [ ] please specify…….
4. How often do you experience postharvest loss (es)?
   Every harvest season [ ] not every season [ ]
5. Do your losses remain the same, reduce or increase in each harvest season?
   Same [ ] reduce [ ] increase [ ] sometimes reduce/increase [ ]
   What is the pattern of your post-harvest losses experience?

6	**Although I lose some of my harvests…**	**SD [1]**	**D [2]**	**N [3]**	**A [4]**	**SA [5]**
I	At least I am able to escape post-harvest losses by 90%					

NB: SD= strongly Disagree, D= Disagree, N=Neutral, A= Agree, SA= Strongly Agree

7. Have you ever complained to your FBO on any issue regarding logistics like the IPEP warehousing, their packaging system and/or transport issues affecting your farming business? Yes [ ] No [ ]
8. If yes, what was it about?…….
9. If No to 7 but yes to question 1, why have you not made any complaints to your FBO?.....
10. Does your response "yes" at point 7 contribute to your post-harvest losses? Yes[ ]No[ ]
11. What step(s) has/have your FBO taken to help you address your concern(s)?.....
12. From your perspective how can logistics management be improved from the warehouse, if the district wants to cut farmers' losses by 90% of season produce? Kindly address it in relation to the:
    - IPEP Warehousing. What must be done to improve **warehousing at the warehouse?**

      ……
      ……
      ……
    - Packaging system at the warehouse. What must be done to improve packaging at the warehouse?

      ……
      ……
      ……
    - Transport issues. What must be done by the warehouse to improve transport access?

      ……

……

……

……

……

……

Thank you.

AN INTERVIEWER

IPEP WAREHOUSE

Akin to other segment of the study, this part is for academic purposes and is earmarked to contribute to a global understanding of challenges to logistics management practices for food security in Ghana*. The interview explores the strategies the government is adopting to improve logistics in the Agricultural food industry. Prospective respondents are assured of the confidentiality and anonymity of data being solicited.*

Duration for Interview: 1 hour

The IPEP warehousing seems a very promising initiative by the government:

1. How long have you worked in this warehouse?.....
2. Have you ever managed or worked in a warehouse before IPEP?.....
3. For how long was your experience?.....
4. If yes to point 2, what makes this IPEP warehouse different?.....

A) warehouse logistics management practices to ease food security:

Do you use any technology to fast-track the operation of this warehouse? If yes, which of these is in use? Software [ ] name it …….

Mobile phone [ ] CCTV cameras [ ] RFID [ ] other [ ] kindly specify …….

How does this technology work in relation to the management practices below?.....

- ✓ *Minimizing storage cost for farmers……*
- ✓ *Ensuring Longevity in food preservation……*
- ✓ *Easing Farmer access to their stored goods ……*
- ✓ *Easing access to the warehouse storage space……*

Briefly describe the cycle farmers go through with their harvest when they bring their surpluses for storage:……

……

……
…….

What do you do in managing the following practices?

- *Minimizing storage cost for farmers:*
  - How do you do this?……..
  - What challenges do you encounter?……
- *Ensuring Longevity in food preservation*
  - How do you ensure this currently ……
  - What is the challenge?……

- *Easing Farmer access to their stored goods*
  - How do you ensure this?……
  - What challenges do you encounter?……

- *Easing access to the warehouse storage space*

- How spacious is the warehouse for farmers? …….
- What challenge does it pose on you; managing farmers' surpluses?.....

B) Packaging management practices to ease food security:

- What kind of material do you often use for packaging in this warehouse? ……
- Do you use any technology **to** fast-track the **packaging process**? If yes, what is it and how does it work in connection with any of the practices below…….....

✓ *Ensuring packaging materials are safe for use:……..*
✓ *Minimizing the Cost of packaging materials for farmers:……..*
✓ *Ensuring speed in packaging……*
✓ *Ensuring packaging material availability……..*

What do you do in managing the following practices?

- *Ensuring packaging material availability:*
  - How do you ensure this ……..
  - What challenges do you encounter?……

- *Minimizing the Cost of repacking the farmer goods:*
  - How do you do this?……
  - What is the challenge?……

- *Ensuring speed in **repackaging:***
  - How do you do this?……
  - What challenges do you encounter?..……

- *Minimizing the Cost of packaging materials for farmers:*
  - How do you ensure this? …….
  - What challenges do you encounter?.....

C] Transport logistics management practices to ease food security:

i. Does the warehouse contribute to farmers' access to transport? Yes [ ] No [ ]
ii. If yes, what specific role does it play…….
iii. If no, why please? …….

Kindly proceed with [iii] if yes to [i]:

iv. What do you do in managing the following practices?

- *Easing access to Vehicle for farmers:*

- How do you handle this ……..
- What is the challenge …….

- *Minimizing the Cost of transport:*

- How do you handle this ……
- What challenges do you encounter?……

- *Vehicle Availability:*

- What do you do to ensure this?……
- What challenges do you encounter?……

- *Farmers' Access to Motorable Roads:*

- How is the road linking to farm areas in this district? Is it motorable? ……
- What challenge does it pose on your task to managing farmers' surpluses?.....

- Does the warehouse use any technology to help farmers transport issues? If yes, what is it and how does it work in relation to any of the practices below:

✓ *Easing access to Vehicle for farmers……:……*
✓ *Minimizing the Cost to Transport……*
✓ *Ensuring Vehicle Availability:……*
✓ *Farmers' Access to motorable Roads:……*

d) What other **innovative** efforts can the government put in place to improve management practices? On;

i. The warehousing

.....

.....

ii. **Packaging at the warehouse:**

.....

.....

iii. **Transport to farmers**……

.....

.....

v. Do farmers still record post-harvest losses since the operation of this warehouse? Yes [ ] No [ ] have No idea [ ].

vi. If yes, what is your view on the intensity of the losses compared to the Pre-IPEP period?.....

vii. Is it possible for this district to cut farmers' post-harvest losses to 90% of season produce, if all the above challenges are addressed? Yes [ ] No [ ]

viii. Do farmers have a role playing to enhance food security at this warehouse? Yes [ ]No [ ]

ix. If yes, what role must they play?.....

x. If No to [viii], kindly justify……

Thank you.

Department of Entrepreneurial and Management Studies

Faculty of Management Sciences

Durban University of Technology

05/11/2022

The District Director of Agriculture

Department of Agriculture

Nadowli /Kaleo District Assembly.

Upper West Region

Dear Sir,

REQUEST FOR AUTHORIZATION TO CONDUCT ACADEMIC RESEARCH ON YOUR OUTFIT

Title**: The Influence of Logistics Management on Food Security in Ghana.**

1.0 Introduction

My name is Helena Mary Boakye. I am conducting a research project for my PhD in Management Sciences (Business Administration) at Durban University of Technology (DUT). Subject to approval by DUT ethics, my research on your outfit will be using structured interviewer-administered questionnaires, semi-structured interview schedules and informal discussions (where necessary) to know 'the ***management strategies government has put or is putting in place to ensure food security through the IPEP storage initiative***.

The study targets farmers of various Farmer Based Organizations in a quantitative section and IPEP warehouse Management in a qualitative segment that is under your department and among the districts in the chosen regions for this study as such requires your permission/cooperation in the conduct of the aforementioned.

I humbly seek your permission to be allowed access and direction to the various Farmer Based Organizations meeting venues and IPEP Warehouse facility, with authorization to engage the Farmers and *the Manager as well as senior staff in charge of routine running* of the facility to gather sufficient data. I will also need to observe your storage process after the engagement.

The research will not take too much of your time and can be conducted at a suitable time and date to be arranged. All I need is to seek a convenient time I should come over to execute this questionnaire, interview and observation.

2.0 Assurance

The participants in the course of the data gathering have the right to retract their information at any time.

Moreover, all data gathered and conclusions made from the questionnaires, interviews, informal discussions, and observations will be kept strictly confidential, and anonymity maintained. The data gathered from the research method will be published (where need be) to enable participants to have access on completion.

The Attaché involves a questionnaire, and an interview schedule spelling out the few questions/ content relevant to my discussion and giving you further details.

I have also provided you with consent forms being used in the research process as well as a copy of the approval document from my Institutional Research Ethics Committee (IREC).

I hereby plead for your timely cooperation to set a date that will be feasible to interact with my research team, to enable us to meet a time-bound date of ***three months*** from now.

3.0 Acceptance

Please tick **[**√**]** to confirm your understanding and willingness to being part of this study;

I confirm that I have read and understand the information provided for the above study [ ]

I understand that my department Farmers and the operation's manager as well as Senior staff is free to correct or withdraw information at any time during the discussions [ ]

I understand that any personal information collected during the study will be anonymous and remain confidential [ ]

I agree for the Farmer Based Organizations meeting venues and the operation's manager as well as senior staff facility to be used in this study [ ]

Please do not hesitate to contact, should you need further clarification: call me (Helena M. Boakye on (+233208121363), email: [masirieb@yahoo.com] or my supervisor; Prof. N.S. Matsiliza) on (+27726397410), email: [thandimatsi@yahoo.co.za].

Thank you for your time and consideration in this matter.

Yours Sincerely,

……

Helena Mary Boakye

[Researcher]

Gatekeeper/Receiver;

Date:

Sig:

Department of Entrepreneurial and Management Studies

Faculty of Management Sciences

Durban University of Technology

05/11/2022

The District Director of Agriculture

District Agricultural Office

Garu District Assembly.

Upper East Region

Dear Sir,

REQUEST FOR AUTHORIZATION TO CONDUCT AN ACADEMIA RESEARCH ON YOUR OUTFIT

Title**: The Influence of Logistics Management on Food Security in Ghana.**

1.0 Introduction

My name is Helena Mary Boakye. I am conducting a research project for my PhD in Management Sciences (Business Administration) at Durban University of Technology (DUT). Subject to approval by DUT ethics, my research on your outfit will be using semi-structured interviews and informal discussions (where necessary) to know '***management strategies government has put or is putting in place to ensure food security through the IPEP storage initiative***.

The study targets farmers in a quantitative section however; a qualitative segment that needs your co-operation is the aforementioned. Your division under the IPEP is among the nearest branches in the chosen regions for this study.

I humbly seek your permission to be allowed access to your facility, with authorization to carry the interviews and informal discussions with *the manager in charge of routine running* of the facility. I will also need to observe your storage process after the interview.

The research will not take too much of your time and can be conducted at a suitable time and date to be arranged. All I need is to seek a convenient time I should come over to execute this interview and observation.

2.0 Assurance

The interviewee in the course of the interview has the right to retract their information at any time.

Moreover, all data gathered and conclusions made from the interviews, informal discussions, observations will be kept strictly confidential, and anonymity maintained. The data gathered from the research method will be published (where need be) to enable participants have access on completion.

The Attaché involves an interview schedule spelling out the few questions/ content relevant to my discussion and gives you fore, details.

I have also provided you with consent forms being used in the research process as well as a copy of the approval document from my Institutional Research Ethics Committee (IREC).

I hereby plead for your timely co-operation to set a date that will be feasible to interact with my research team, to enable us meet a time bound date of ***three months*** from now.

3.0 Acceptance

Please tick **[√]** to confirm your understanding and willingness to being part of this study;

I confirm that I have read and understand the information provided for the above study [ ]

I understand that my outfit and the operation's manager is free to correct or withdraw information at any time during the discussions [ ]

I understand that any personal information collected during the study will be anonymous and remain confidential [ ]

I agree for our facility and the operation's manager to take part in this study [ ]

Please do not hesitate to contact, should you need further clarification: call me (Helena M. Boakye on (+233208121363), email: [masirieb@yahoo.com] or my supervisor; Prof. N.S. Matsiliza) on (+27726397410), email: [thandimatsi@yahoo.co.za].

Thank you for your time and consideration in this matter.

Yours Sincerely,

……

Helena Mary Boakye

[Researcher]

Gatekeeper/Receiver;

Date:

Sig:

APPENDIX 2

		Year			Total
		1-5 years	above 10 years	above 10 year	
Info12	Insufficient harvest	18	22	12	52
	have my own storage	6	12	6	24
	lack of knowledge	4 (100%)	0	0	4
Total		28	34	18	80

Table 1 Reason for stopping storage with IPEP * Years farmed Cross tabulation

		Education		Total
		Below Senior High	Above Senior High not Tertiary	
Age	18-25	4 (1%)	0	4
	26-33	17(5%)	5(19%)	22
	34-41	218(61%)	0	218
	42-49	0	5(19%)	5
	50 above	118(33%)	17(62%)	135
Total		357(100%)	27(100%)	384

Table2 Age * Education Cross tabulation

		Bags						Total
		1-10	11-20	21-30	31-40	41-50	51-60	
Age	18-25	0	0	1	0	0	1	2
	26-33	11	1	1	1	1	0	15

	34-41	67(27%)	49(20%)	6(2%)	9(4%)	6828%)	47(19%)	246(100%)
	42-49	5	0	0	0	0	0	5
	50 above	110(95%)	1(0.9%)	1(0.09%)	2(2%)	1(0.9%)	1(0.9%)	116(100%)
Total		193	51	9	12	70	49	384

Table 3 Age * Bags Cross tabulation

		Acres		Total
		2.5	Above 5	
Age	18-25	0	2	2
	26-33	12	3	15
	34-41	116 (47%)	130(53%)	246
	42-49	5	0	5
	50 and above	111(96%)	5(4%)	116
Total		244	140	384

Table 4; Age * Acres Cross tabulation

		Acres		Total
		2.5	Above 5	
District	Garu	107 (58%)	85(44%)	192(100%)
	Nadowli Kaleo	137(71%)	55(29%)	192(100%)
Total		244	140	384

Table 5 District * Acres cross tabulation

Case	Text	Coder	Date	Variable
AGTF				
Case #4	Timely harvest, ¶Proper drying ¶Adviced to go for hermetic	Admin	9/25/2023	DOCUMENT
CSBH				
Case #1	…phone call to supplier	Admin	9/29/2023	DOCUMENT
Case #2	call on supplier before harvest	Admin	9/29/2023	DOCUMENT
Case #3	phone calls supplier	Admin	9/25/2023	DOCUMENT
Case #4	contact supplier before harvest	Admin	9/24/2023	DOCUMENT
ECBM				
Case #1	farmer can call or text us anytime in the working hours and days to access their stored	Admin	9/28/2023	DOCUMENT
Case #2	facility is managed by more than one committed officers, we communicate by phones	Admin	9/25/2023	DOCUMENT
Case #4	Facility is managed two. we communicate via phone calls	Admin	9/25/2023	DOCUMENT
Case #3	Facility is managed by more than one officers. always either or both are available. We communicate by phones	Admin	9/25/2023	DOCUMENT
FHAR				
Case #4	yes [ ]¶ Comply to education we offer and that of extension agents	Admin	9/24/2023	DOCUMENT
Case #3	comply to advice from us and the extension agents	Admin	9/24/2023	DOCUMENT
Case #2	to advice of we managers and the extension officers	Admin	9/24/2023	DOCUMENT
Case #1	comply to advice of the officers	Admin	9/28/2023	DOCUMENT
FS				

Case #1	Yes [///]	Admin	9/28/2023	DOCUMENT
Case #2	Yes [//	Admin	9/24/2023	DOCUMENT
Case #3	Yes [///]	Admin	9/29/2023	DOCUMENT
Case #4	for this district to cut her post-harvest losses to 10% of season produce, if all the above challenges are solved? Yes [///] No [ ]. Even more than that because we give them enough education	Admin	9/24/2023	DOCUMENT
FUM				
Case #4	…we fumigate the place	Admin	9/25/2023	DOCUMENT
Case #3	we fumigate the place	Admin	9/25/2023	DOCUMENT
HB				
Case #3	Hermetic bag	Admin	9/24/2023	DOCUMENT
Case #2	Hermetic bag	Admin	9/24/2023	DOCUMENT
Case #4	Hermetic bag	Admin	9/24/2023	DOCUMENT
Case #1	hermetic bag	Admin	9/28/2023	DOCUMENT
ITP				
Case #1	regulate the cost of hermetic bags, packaging and repacking machine to aid and fast tract packaging if farmer don't do it well	Admin	9/28/2023	DOCUMENT
Case #2	Reduce the cost of hermetic bags or govt to take charge of supply, packaging and repacking machine to aid and fast tract packaging if farmer don't do it well	Admin	9/24/2023	DOCUMENT
Case #4	Subsidize the cost of hermetic bags or govt to take charge of supply of another ideal bag	Admin	9/29/2023	DOCUMENT
Case #3	Subsidize the cost of hermetic bags or govt to take charge of supply, packaging and repacking machine to aid and fast tract packaging if farmer don't do it well	Admin	9/24/2023	DOCUMENT
ITT				

Case #1	supply Tricycles to the facility	Admin	9/28/2023	DOCUMENT
Case #4	supply Tricycles to the facility	Admin	9/24/2023	DOCUMENT
Case #2	supply Tricycles to the facility	Admin	9/24/2023	DOCUMENT
Case #3	supply Tricycles to the facility	Admin	9/24/2023	DOCUMENT
ITW				
Case #3	Unit load formation equipment	Admin	9/25/2023	DOCUMENT
Case #2	Unit load formation equipment, transport equipment, storage equipment, access equipment, display screen equipment to maintain ideal condition at the facility	Admin	9/24/2023	DOCUMENT
Case #1	Unit load formation equipment, transport equipment, storage equipment, access equipment, display screen equipment to maintain ideal condition at the facility	Admin	9/28/2023	DOCUMENT
Case #4	lot of things are getting damaged here, so I believe we need cctv camera to aid monitoring, dryer, electricity is needed at the facility	Admin	9/24/2023	DOCUMENT
No contribution				
Case #1	No [ ]	Admin	9/28/2023	DOCUMENT
Case #2	No [//]	Admin	9/26/2023	DOCUMENT
Case #3	No [//]	Admin	9/26/2023	DOCUMENT
Case #4	No [//]	Admin	9/26/2023	DOCUMENT
PCS				
Case #3	Mobile phone [//]	Admin	9/24/2023	DOCUMENT
Case #4	Sms	Admin	9/24/2023	DOCUMENT
Case #2	Mobile phone	Admin	9/24/2023	DOCUMENT
Case #2	Sms	Admin	9/24/2023	DOCUMENT
Case #1	Mobile phone [//]	Admin	9/29/2023	DOCUMENT

Case #3	Sms	Admin	9/24/2023	DOCUMENT
Case #4	Mobile phone [//]	Admin	9/24/2023	DOCUMENT
Case #1	Sms	Admin	9/29/2023	DOCUMENT
POS				
Case #1	farmers unable to present to the warehouse buy the hermetic bag and does similar storage in their homes.	Admin	9/28/2023	DOCUMENT
Case #2	some also buy the zero fly bags for home storage	Admin	9/29/2023	DOCUMENT
PRR				
Case #2	fairly reduced	Admin	9/24/2023	DOCUMENT
Case #1	fairly reduced	Admin	9/28/2023	DOCUMENT
Case #3	fairly reduced	Admin	9/24/2023	DOCUMENT
Case #4	it has reduced	Admin	9/24/2023	DOCUMENT
PSE				
Case #2	Yes [///]	Admin	9/24/2023	DOCUMENT
Case #3	Yes [///]	Admin	9/24/2023	DOCUMENT
Case #1	Yes [///]	Admin	9/28/2023	DOCUMENT
RHBPSD				
Case #2	recommend the use of hermetic bag and advice proper sun drying	Admin	9/25/2023	DOCUMENT
Case #3	recommend the use of hermetic bag and advice proper sun drying	Admin	9/25/2023	DOCUMENT
Case #1	recommends the use of hermetic bag and proper sun drying	Admin	9/28/2023	DOCUMENT
Case #4	we advise a thorough drying before presenting for storage.¶ recommend the use of hermetic bag	Admin	9/25/2023	DOCUMENT
WEMS				

Case #4	Ensure there’s serenity here by spraying	Admin	9/29/2023	DOCUMENT

Table 6: qualitative code retrieval chat from the QDA Miner lite

ABBREVIATIONS/ ACRONYMS

RHBPSD-recommends usage of hermetic bag and proper drying

ECBM – Managers of the warehouse communicate via phone calls

PoS – proximity of storage

CSBH – contact supplier before harvest

WEMs – fumigation done at the warehouse

PSE –PHL still experienced

PRR- PHL relatively reduced

FS (food security)- possible to cut PHL to 10%

FHAR – farmers have a role playing

AGTF – Advice given to farmers

HB – Hermetic bag

Pcs = phone call & Sms

Fum = Fumigation

ITT – innovation by government on transport

ITP – Innovation to better the packaging logistics

ITW – Inventions to improve the IPEP warehouse

Case 1- operations manager, Nadowli Kaleo

Case 2 –Senior staff, Nadowli

Case 3 – Garu operations Manger

Case 4 –senior staff, Garu

Demographic Variables	Variable Definition	Human/Head Porterage N=180 (47%)		Tricycle N=148 (39%)	
		n	%	n	%
Gender	Male	18	10	46	31
	Female	162	90	102	69
Age	Age of respondent (years)				
	18-25	1	1	0	0
	26-33	14	14	1	1
	34-41	69	38	134	90
	42-49	5	3	0	
	50 above	91	51	13	9
Education	Below SHS	160	89	144	97
	Above SHS < Tertiary	20	11	4	3
Grain	type of grain planted				
	Maize	61	34	49	33
	Millet	69	38	41	28
	Rice	50	28	58	39
Acre	Farm acreage cultivated				
	2-5acres	134	74	75	51
	above 5acres	46	26	73	49
District/ region	District and region of respondents				
	Garu [upper east)	54	30	108	73
	Nadowli (upper west)	126	70	40	27
years of experience	years of expertise in grain farming				
	1-5yrs	19	11	28	19
	6-10yrs	33	18	70	47
	above 10yrs	128	71	50	34
The warehouse usage	whether the respondent uses the warehouse				
	Yes	151	84	102	69

	No number of bags harvested in a season	29	16	46	31
Bags	1-10bags	124	69	43	29
	11-20bags	10	6	31	21
	21-30	4	2	4	3
	31-40	4	2	5	3
	41-50	24	13	38	26
	51-60	14	8	27	18

Table 7: Descriptive Statistics on respondents' demography

Source: Authors Field Survey, 2023