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Enhancing Nutrition and Food Systems Resilience under the Stability-and-Peace Innovation Accelerator Program: The footprints of Koolboks cold storage solutions in Fragile and Conflict-Affected (FCA) settings of Northeast, Nigeria

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Background

The Stability-and-Peace Accelerator Programme is a global initiative of the CGIAR Fragility, Conflict and Migration Initiative, in collaboration with the WFP Innovation Accelerator and powered by the International Water Management Institute (IWMI). It is a monumental challenge that seeks innovative solutions to address the pressing issues over 1.5 billion people face in fragile and conflict-affected settings (FCAs), where food security and livelihoods are under unprecedented threats. The Programme's aim is to drive resilience, ensure food and nutrition security, enhance climate adaptability, and promote social cohesion and sustainability among communities battered by conflict and fragility.

Given the challenges faced in fragile settings, allowing for context-specific interventions that can effectively address issues like food insecurity, land degradation, and water scarcity is highly desirable. Accordingly, this program aims to identify and enable the scaling of high-impact, high-potential innovations that promote the resilience of Food, Land, and Water Systems (FLWS) in Fragile and Conflict-Affected (FCA) settings in migrant and host communities. To achieve this purpose, the program has sourced high-potential innovation with a local footprint, such as Koolboks solar-powered refrigeration technology and harnessed the immense technical expertise of CGIAR Centres to support the innovation in Nigeria.

The accelerator project actively promotes demand-driven dissemination of appropriate technologies/innovation and advises on how the private sector can play a crucial role in strengthening food markets, promoting healthy eating habits, and improving nutrition levels. This collaboration is key to achieving the Country Theme of Resilient Food Systems and Nutrition (Nigeria).

The selected innovator accelerator for Nigeria is Koolboks. This company is assessing the technical feasibility, business viability, and affordability of its solar-powered refrigeration units within new user groups in crisis-affected areas of Nigeria. Koolboks' aim to integrate IoT technology across all deployed units to monitor and analyse their performance and impact on customers, primarily food traders, holds significant promise. Each unit features a thermostat that can be adjusted for refrigeration or freezing purposes for highly perishable items, offering a potential solution to the food security challenges in Nigeria.

Food insecurity is a pressing issue in fragile and conflict-affected areas globally, with Nigeria's Northeast region, in particular, facing severe challenges due to the Boko Haram insurgency. While various stakeholders have made significant strides in ensuring food system resilience, particularly in Northeast Nigeria, effective food preservation, storage, and safe transportation remain critical concerns. Refrigeration systems, therefore, play a vital role in promoting food security across the globe, with the situation in Nigeria underscoring the urgency of this issue.

According to the International Institute of Refrigeration (IIR, 2019), even though 1,661 million tonnes of food products (representing 46% of food production) should have benefited from refrigeration, only 47% of this tonnage got refrigerated, resulting in losses costing about 13% of food production. These losses are even higher in developing countries due to lower refrigeration capacity. IIR (2019) further shows that refrigeration could have prevented 475 million tonnes of lost food, which could have fed about 950 million people annually. Food and Agriculture Organisation (FAO, 2018) provided an estimate showing that almost one-third of all global food is lost or wasted (Emadi & Rahmanian, 2020). The organisation suggests that it becomes critical to devise better methods of using and preserving food while focusing on reducing food losses and increasing productivity.

LITERATURE REVIEW

Food security

According to Idrisa et al. (2008), as cited in Ayomide et al. (2022), food security consistently has enough food and products to satisfy growing consumer demand while lowering production and price fluctuations. Food security is defined as a situation when everyone has physical and financial access to enough wholesome food for a constant, active, and healthy life. Producing enough food in sufficient numbers and quality to feed everyone is what is meant by food security (Oriola, 2009). Food security's four pillars are availability, access, utilisation, and stability. Depending on the kind of food, different amounts of food are lost or wasted (Parfitt et al., 2010). While non-perishable foods like cereals are expected to account for 15% of losses after harvest (Jagadeesan, 2011), 40% of roots and tubers are lost before they reach the market. Half of fruits and vegetables are lost (Njagi & Wainaina, 2018), and perishable foods lose one-third of their value before reaching final consumers (Kader, 2004). One of the main reasons for the high rates of food loss and waste in developing nations is deteriorating infrastructure, both in production and storage (Jagadeesan, 2011). Infrastructures like power, mechanised farming, storage facilities, and adequate transportation systems impact food security.

Food systems

Refrigeration is one of the methods for ensuring food systems achieve the core functions of getting food from producers through processors and distributors to consumers, especially in conflict-affected areas. According to Delgado, Murugani, and Tschukert (2021), food systems are “complex, interconnected and adaptive systems comprising of every person and every process involved in a set of activities ranging from production to consumption and disposal of food.” Furthermore, food systems comprise broader environmental, political, social, and economic settings in which these activities are embedded. They range from highly localised, rural, and traditional food systems to the global agro-industrial ones. Refrigeration enhances

food systems (Heard, 2020; Caroline & Kristina, 2022).). From energy consumption and greenhouse gas (GHG) emissions to consumer diets and producer behaviour, the worldwide integrated refrigerated supply chain, or the "cold chain," affects various sustainability outcomes (Heard, 2020).

Fragile and Conflict-Affected Region

One and a half billion people still live in fragile, conflict-affected areas. People in these countries are about twice as likely to be malnourished and to die during infancy as people in other developing countries (World Bank 2011). This outcome is often a direct consequence of conflict: conflict reduces food availability by destroying agricultural assets and infrastructure. Conflict also usually destroys physical infrastructure and increases the security risks of accessing food markets, thus increasing local food prices. This negative impact on food availability is accompanied by conflicts' detrimental impacts on household-level food security, particularly on key determinants of food insecurity such as nutrition, health, and education. Food systems are destroyed during conflict, and food insecurity remains a legacy of conflict" (Messer & Cohen 2006).

Role of Refrigeration in Food Security

In a society where refrigeration is available, buying, retailing, and behavioural decisions are conceivable that would not otherwise be possible. The modifications made possible by the cold chain have a positive (such as longer product shelf life), negative (such as higher energy costs for refrigeration), and unknown (such as the quantity of food waste) influence on the food system's environmental impact. The food system's geographical scope is further altered by creating a cold chain, which makes it possible to move from regional to global supply chains. The cold chain causes several infrastructural changes, including modifications to retailing formats and cold transportation and storage.

Optimising the performance of refrigerated systems, decreasing food waste through spoilage, and improving supply chain efficiency. Temperature monitoring and technical refrigerated system optimisation account for much of the cold chain literature (Garnett, 2013). Efficiency is crucial, and it has been projected that technological advancements such as appropriate refrigerated equipment selection, operation, and maintenance might result in energy savings of 20–50% in the current cold chain (Garnett, 2007).

Literature has shown that refrigeration systems play a key role in safe food transportation/refrigerated transportation, increasing product value via more efficient refrigerated transportation techniques (Vigneault et al., 2009). The intricacy of the global food transportation system has been demonstrated in the literature, highlighting the critical role that technology plays in the efficient movement of perishable food items.

Power Outage and Food Insecurity in Nigeria

Imagine running a business such as frozen foods without a constant electricity supply. Businesses power their fridges with generator sets, exorbitantly inflating the prices of their products while at the same time facing the challenge of fewer operational hours due to high fuel costs (Adaghesan,2024, January 1). While households lament substantially high and almost unbearable bills, businesses are running at losses because, with the extremely high pump

price of diesel and fuel, individual generating power to sustain enterprises is no longer sustainable (Adaghesan,2024, January 1). The worst hit in this category is frozen food sellers. Their businesses depend on steady light. Inadequate electricity supply means they must generate power to keep businesses going. But this also bloats overhead costs and snowballs into inflated frozen food prices. So common people can hardly afford frozen fish, meat and other diaries.

However, frozen food sellers, always left with large volumes of unsold cartons of fish, chicken, and turkey, now resort to frying them as constant light to preserve them appears elusive. Although dairy products are priced better when fully frozen, it has been established that frozen food sellers have to pay N1,000 daily to preserve unsold goods in cold rooms in places like Lagos and many in Nigeria. The inconsistent power supply has compelled the cold room owners to double the preservation bill to N2,000, owing to the high cost of diesel. This significant increase in preservation costs is a heavy burden on the already struggling frozen food sellers.

This implies that access to essential proteins has become a luxury out of reach for most households while also threatening small businesses critical to local food systems. This is due to the high costs of frozen food associated with using expensive generator-diesel-powered cold chain facilities in food insecure and conflict-violent areas, such as Northeast Nigeria, where electricity is very unstable. In addition to limiting the availability of reasonably priced, nutritious food, frozen food vendors are forced out of business by financial losses, so they have to resort to less desirable methods of food preservation, which also puts the safety of their products at risk.

Koolboks Solar-Powered Refrigeration Solutions in Food Security

The selected innovator accelerator for Nigeria is Koolboks, a company assessing the technical feasibility, business viability, and affordability of its solar-powered refrigeration units within new user groups in crisis-affected areas of Nigeria. Koolboks' aim to integrate IoT technology across all deployed units to monitor and analyse their performance and impact on customers, primarily food traders, holds significant promise. Each unit features a thermostat that can be adjusted for refrigeration or freezing purposes for highly perishable items, offering a potential solution to the food security challenges in Nigeria.

Methodology

Population and Sample of the Study

The population of this study comprises all the businesses in the cold chain in the sample local government areas in Adamawa and Borno states. The population was estimated at 1,720. Based on the population a 10% proportion of the population was used as the sample of the businesses included in the study. This provides a total sample of 172 collected from the field for analysis.

Data

This study employs primary data collected through a structured questionnaire to capture the research objective. The data was collected using research assistants and the Kobocollect mobile application. Data was collected on 172 businesses in Adamawa and Borno states regarding their

perceptions of cold chain businesses facilitating nutrition and food system resilience in fragile and conflict-affected areas.

Method of Analysis

This study employs a descriptive data analysis method that aligns with the research objective. The descriptive analysis includes tables and charts to present the information collected from the respondents.

Result and Discussion

DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

The survey explores the demographic characteristics of the respondents by collecting data on their gender, age and educational background.

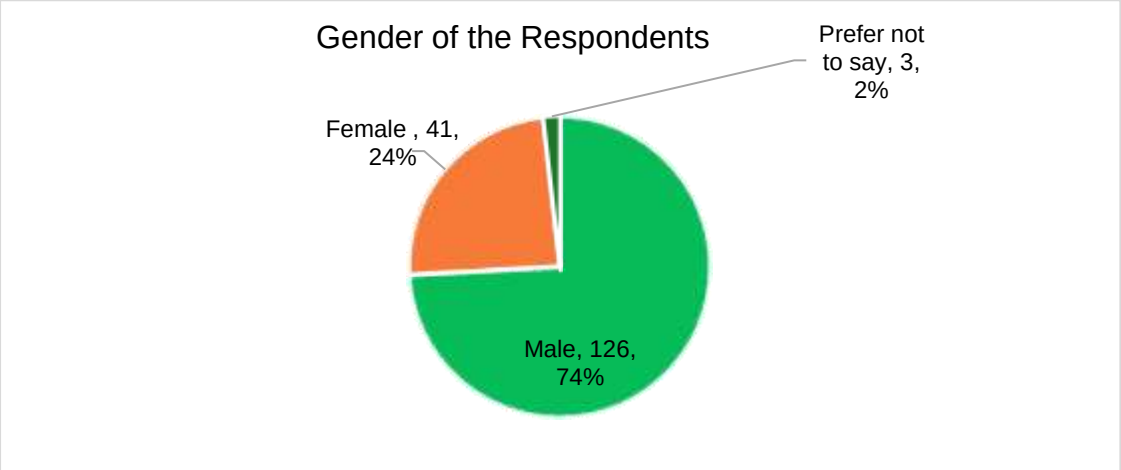

Figure 1: Gender Distribution of the Respondents
Source: Field Survey, November, 2024.

The gender distribution of respondents shows that most business owners are male, accounting for 74.12% of the total. Female business owners represent 24.12%, while a small proportion, 1.76%, chose not to disclose their gender. This data underscores a gender disparity in business ownership in the region, suggesting potential avenues for promoting inclusivity and support for female entrepreneurs.

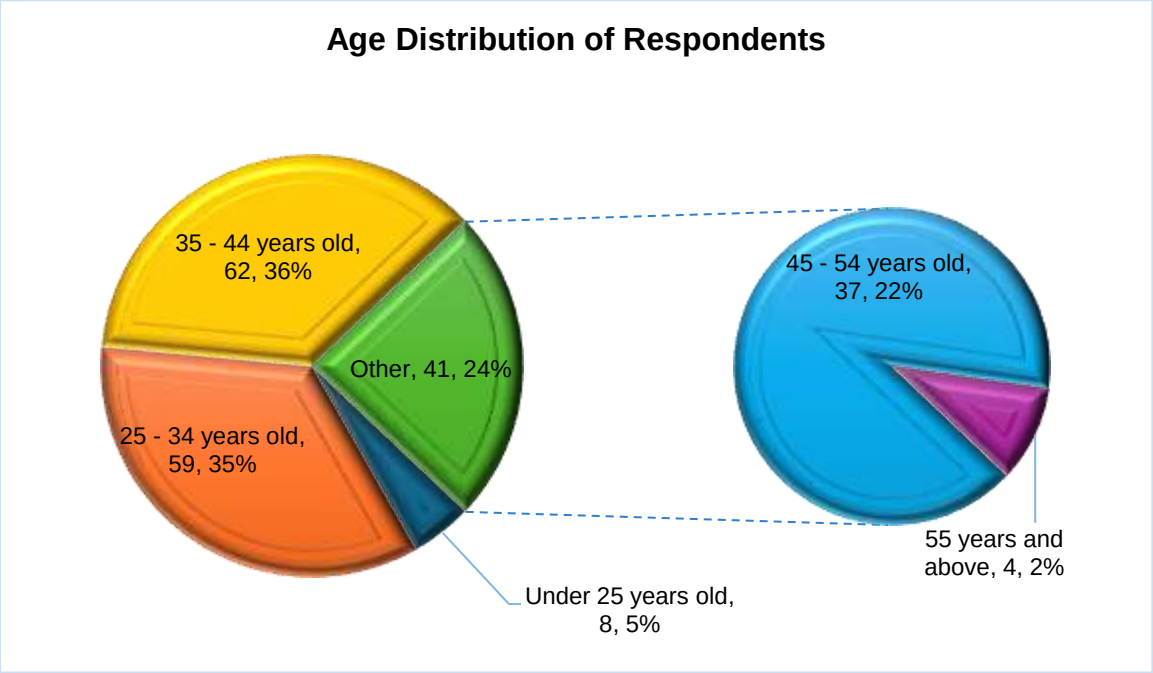

Figure 2: Age Distribution of the Respondents
Source: Field Survey, November, 2024.

The respondents' age distribution shows that most business owners were between 25 and 44 years old, with the 35-44 age group comprising the largest segment (36.47%), followed closely by the 25-34 age group (34.71%). A smaller proportion of the respondents fall within the 45-54 age bracket (21.76%), while those aged 55 and above account for only 2.35%. Additionally, 4.71% of respondents are under the age of 25. These figures highlight that the primary demographic engaging in refrigeration-related businesses in the Northeast conflict-affected region is relatively young, providing a greater potential market opportunity for Koolboks solar-powered refrigeration solution.

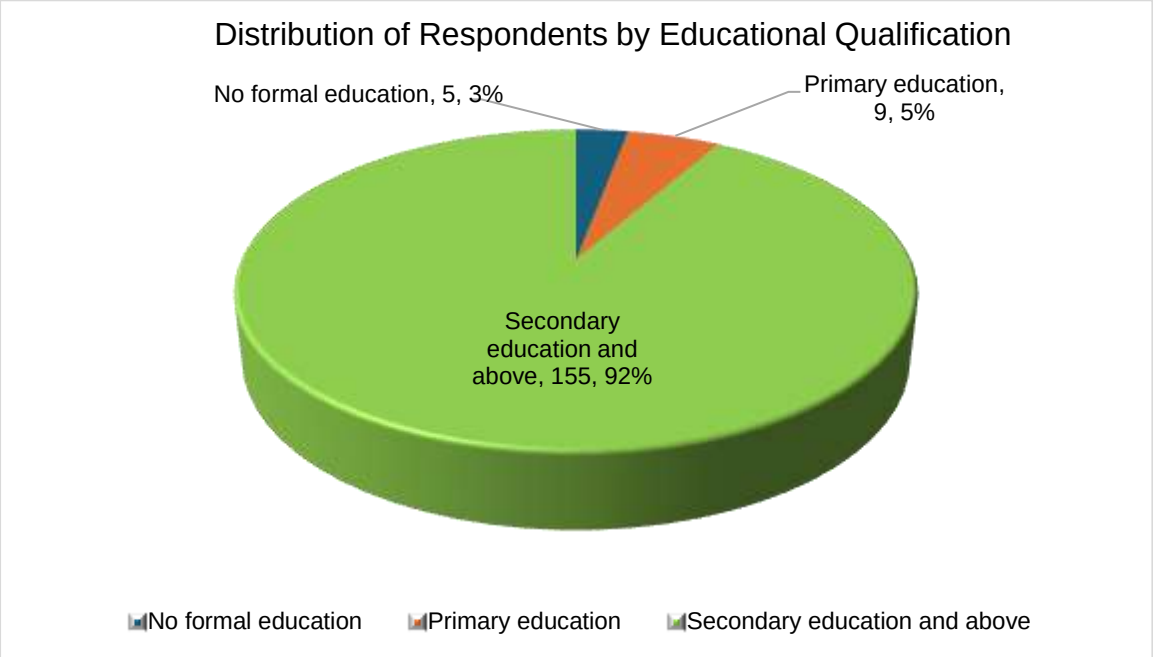

Figure 3: Educational Background of the Respondents
Source: Field Survey, November, 2024.

The survey shows that the majority of the respondents have attained at least secondary education, as indicated by 91.72% of the surveyed business owners, and this shows a high level of formal education among the respondents. Only a small number of people, 5.33%, completed just primary education. Additionally, 2.96% reported needing formal education. The business owners' strong education likely drives their openness to new ideas like Koolboks refrigeration solution. This strong educational background also shows that the respondents can read and understand instructions for applications and use of Koolboks refrigeration solutions, thereby facilitating the effective utilisation of the product.

CHARACTERISTICS OF THE RESPONDENTS' BUSINESSES

This section provides an overview of the businesses operated by the respondents, focusing on key attributes such as their location, type, years of operation, primary use of refrigeration, power supply sources, and related expenditures. Understanding these characteristics offers critical insights into the surveyed businesses' operational contexts, challenges, and opportunities. These details also form the basis for assessing the potential to adopt innovative solutions, such as Koolboks solar-powered refrigeration solution, in supporting and improving business efficiency and food security in conflict-affected regions such as Northeast Nigeria.

BUSINESS LOCATIONS OF THE RESPONDENTS

A business's location is crucial in this assessment, and the study ensured adequate geographical coverage across Adamawa and southern Borno.

Table 1.1: Business Locations of the Respondents

Business Location	Frequency	Percent
Ganye – Adamawa State	28	16.28
Girei – Adamawa State	15	8.72
Yola North – Adamawa State	25	14.53
Yola South – Adamawa State	34	19.77
Mubi North – Adamawa State	30	17.44
Biu – Borno State	20	11.63
Kwaya Kusar – Borno State	20	11.63
Total	172	100.00

Source: Field survey, November 2024.

The survey covered a diverse geographical spread of businesses within the Adamawa and Borno States. Among the respondents, the highest concentration of businesses is located in Yola South, Adamawa State, accounting for 19.77%. This is followed by Mubi North (17.44%) and Ganye (16.28%), both in Adamawa State. Other notable locations include Yola North (14.53%) and Biu (11.63%) in Borno State, with an equal representation from Kwaya Kusar, Borno State (11.63%). The least represented location is Girei, Adamawa State, at 8.72%. This distribution illustrates the regional focus of the study and highlights key areas where businesses operate, emphasising the strategic importance of these locations for implementing innovative solutions like Koolboks refrigeration.

Table 1.2: Business Location by Urbanisation

Type of Area	Frequency	Percentage
Urban	82	48.24
Semi-urban	61	35.88
Rural	27	15.88
Total	170	100.00

Source: Field Survey, November, 2024.

The survey data indicates that the respondents' businesses are distributed across urban, semi-urban, and rural areas, with nearly half (48.24%) operating in urban areas. Semi-urban areas account for 35.88% of businesses, while rural areas represent 15.88%. The urban concentration aligns with key hubs like Yola South (19.77%), Yola North (14.53%), and Mubi North (17.44%) in Adamawa State, which are recognised for their urban and semi-urban characteristics. Similarly, areas like Biu and Kwaya Kusar in Borno State reflect a mix of semi-urban and rural business environments, as do Ganye and Girei in Adamawa State.

This distribution underscores the significance of addressing urban and semi-urban businesses' unique needs while also considering the accessibility and feasibility of Koolboks refrigeration for rural-based businesses.

BUSINESS REGISTRATION STATUS

The registration status of the businesses is very important to the present assessment because it ensures that businesses are identified as registered or not registered to guide the Koolboks team's decision-making.

Table 2: Business registration status

Business Registration Status	Frequency	Percentage
Registered with the Corporate Affairs Commission (CAC)	29	17.16
Registered with the Local Government Authority	70	41.42
Registered with SMEDAN	7	4.14
Unregistered	63	37.28
Total	169	100.00

Source: Filed Survey, November, 2024.

The result in Table 2 highlights the registration status of businesses operated by the respondents. Among the surveyed businesses, 41.42% are registered with the Local Government Authority, representing the largest group. Those registered with the Corporate Affairs Commission (CAC) account for 17.16%, while 4.14% are registered with the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). However, a significant proportion, 37.28%, remain unregistered. This data underscores the varying levels of formalisation among businesses and may have implications for accessing support, financing, and other benefits tied to formal registration.

OWNERSHIP STRUCTURE OF RESPONDENTS' BUSINESSES

Businesses are generally divided into different ownership structures, and this survey considers the existing ownership structures of the respondents' businesses.

Table 3: Ownership Structure of the Businesses

Ownership Structure	Freq.	Percent
Cooperative Society	1	0.59
Limited Liability Company	19	11.24
Partnership	42	24.85
Sole Proprietorship	107	63.31
Total	169	100.00

Source: Field Survey, November, 2024.

The ownership structure of the respondents' businesses reveals a significant prevalence of sole proprietorships, representing 63.31% of the surveyed enterprises. Partnerships account for 24.85%, indicating a moderate level of collaborative ownership. Limited liability companies make up 11.24%, reflecting a smaller proportion of formalised business entities. Cooperative societies are the least common structure, with only 0.59% of businesses falling under this category.

YEARS OF BUSINESS OPERATION

The survey explores the business experience of the target businesses by examining their years of operation, which is also essential in determining the extent of the respondents' business experiences.

Table 4: Years of Business Operation

Years of Business Operation	Frequency	Percentage
Less than 1 year	7	4.17
1-3 years	71	42.26
4-6 years	50	29.76
7-10 years	26	15.48
More than 10 years	14	8.33
Total	168	100.00

Source: Field Survey, November, 2024.

The data on the years of business operation reveals that a significant proportion of businesses are relatively young. Most respondents (42.26%) have operated their businesses for 1-3 years, indicating a recent surge in entrepreneurial activities, possibly driven by opportunities or necessity in this conflict-affected region.

Businesses with 4-6 years of experience represent 29.76% of the respondents, reflecting a growing segment of slightly more established enterprises. Meanwhile, 15.48% have been operational for 7-10 years, suggesting a notable level of resilience and stability among these entities. A smaller group of businesses (8.33%) have over a decade of experience, highlighting a long-term presence in the market. In comparison, only 4.17% of respondents are newcomers with less than a year of operation.

This distribution illustrates the different stages of business maturity, showcasing both business owners' entrepreneurial potential and resilience in navigating challenges, such as inconsistent energy supply, in fragile and conflict-affected regions.

Nature of Business of Respondents

The survey results in Table 5 show that a significant portion of respondents (46.47%) are engaged in cold room or storage businesses, reflecting the critical role these establishments play in preserving and distributing perishable goods. Supermarkets account for 18.82% of the businesses, while grocery stores (14.71%) and restaurants (14.12%) constitute notable respondents' shares.

Smaller segments include food vendors (4.71%), bars (0.59%), and wine shops (0.59%). These figures highlight the diversity of business types relying on refrigeration infrastructure. Cold room/storage facilities form the backbone of this ecosystem, followed by supermarkets and smaller retail outlets.

Table 5: Nature of Business Operation

Business Nature	Frequency	Percentage
Cold Room/Storage	79	46.47
Supermarket	32	18.82
Grocery Store	25	14.71
Restaurant	24	14.12
Food Vendor	8	4.71
Bar	1	0.59
Wine Shop	1	0.59
Total	170	100.00

Source: Field Survey, November 2024.

The prevalence of cold room businesses indicates a strong demand for efficient refrigeration solutions, such as Koolboks, to enhance operational efficiency and reduce energy costs across various business scales.

USE OF REFRIGERATION BY THE BUSINESSES

The survey data shown in Table 6 indicates diverse refrigeration uses among respondents, highlighting the varying needs of their businesses. The largest share of respondents (34.52%) use refrigeration primarily for storing and chilling beverages, reflecting the region's widespread demand for chilled drinks. A slightly smaller group (31.55%) relies on refrigeration to preserve perishables, showcasing the importance of maintaining food quality and reducing spoilage in the conflict that affected Northeast Nigeria.

Ice block production is also a significant use, accounting for 30.95% of respondents, emphasising its utility in commercial and household cooling needs, especially in areas with inconsistent power supply. Smaller proportions of respondents use refrigeration solutions for combined purposes, such as beverages, perishables, and ice block production (0.60%) or for beverages and ice block storage (0.60%). Similarly, 0.60% of respondents exclusively focus on storing cold soft drinks.

Table 6: Use of Refrigeration Solutions

Usage of Refrigeration Solutions	Frequency	Percentage
Beverages and Ice Block	3	0.60
Beverages, Perishable and Ice Block	1	0.60
Cold soft drinks	1	0.60
Ice block production	52	30.95
Storing beverages	58	34.52
Storing perishables	53	31.55
Total	168	100.00

Source: Field Survey, November, 2024. This survey was conducted to understand the current state of refrigeration solutions in Northeast Nigeria and to identify potential market opportunities for Koolboks refrigeration solutions.

The result in Table 6 underlines the critical role of refrigeration in supporting various business activities, from beverage sales to food preservation and ice production, particularly in fragile and conflict-affected regions. However, the awareness gap about refrigeration solutions like Koolboks in these areas is significant, indicating the need for more education and promotion.

PRIMARY CUSTOMERS

Table 7 illustrates the primary customers of the surveyed businesses. Over half of the respondents (56.21%) cater primarily to individual households, emphasising a strong focus on retail consumers. This data is significant as it indicates a large potential customer base for Koolboks refrigeration solutions. Small businesses comprise 30.18% of the customer base, reflecting a notable engagement with local enterprises. A smaller proportion (13.02%) serves large corporations, while a minimal number (0.59%) reported simultaneously serving small businesses and individuals.

Table 7: Primary customers of the Businesses

Primary Customer	Freq.	Per cent
Individual households	95	56.21
Large corporations	22	13.02
Small Business and Individual	1	0.59
Small businesses	51	30.18
Total	169	100.00

Source: Field Survey, November, 2024.

NUMBER OF PEOPLE EMPLOYED BY THE BUSINESS

The survey data for the number of employees working for the respondents' businesses reveals that most companies are small-scale enterprises with limited employment capacity. Specifically, 70.66% of the surveyed businesses employ between 1 and 5 people, indicating their micro or small-scale nature. Businesses with 6-10 employees make up 26.35%, suggesting a moderate level of operational capacity. However, only a small fraction, 2.99%, employ between 11 and 20 people, reflecting the medium-sized businesses within the sample.

Table 8: Number of People Employed by the Business

Number of Business Employees	Frequency	Percentage
1-5	118	70.66
6-10	44	26.35
11-20	5	2.99
Total	167	100.00

Source: Field Survey, November, 2024.

The distribution of employment capacity of the businesses highlights the predominance of micro and small enterprises in the study area, which aligns with typical characteristics of businesses in fragile or conflict-affected areas such as Northeast Nigeria.

PRIMARY SOURCE OF POWER SUPPLY FOR BUSINESS OPERATION

The survey data on the primary power supply sources for business operations highlights the dependency on conventional and alternative energy sources in the surveyed areas. Most respondents (54.71%) rely on the national grid as their primary power source, underscoring its significance despite potential inconsistencies in supply.

Generators, often used as an alternative or backup solution, are the primary power source for 38.82% of the respondents, reflecting the challenges of unreliable electricity from the national grid. A small fraction (0.59%) of respondents combine the national grid and generators, likely as a strategy to mitigate power outages.

Notably, only 2.35% of respondents utilise solar power, indicating limited adoption of renewable energy solutions in conflict-affected areas despite their potential to offer a sustainable and cost-effective alternative in areas with unreliable electricity.

Table 9: Primary Source of Power Supply for Business Operation

Primary Source of Power Supply	Frequency	Percentage
National Grid (Electricity)	93	54.71
Generator	66	38.82
National grid and generator	7	0.59
Solar Power	4	2.35
Total	170	100.00

Source: Field Survey, November 2024.

The result in Table 9 demonstrates a heavy reliance on traditional energy sources, emphasising the need for more accessible and sustainable power solutions, such as solar-powered refrigeration systems like Koolboks, particularly in northeast Nigeria, a conflict-affected and energy-deficient region.

MONTHLY EXPENDITURE ON POWER SUPPLY FOR BUSINESS OPERATION

This survey also explores the respondents' monthly expenditures on power supply. It provides information revealing significant cost implications for businesses in the surveyed conflict-affected areas of the Northeast.

Table 10: Monthly Expenditure on Power Supply for Business Operation

Monthly Expenditure on Power Supply (₦)	Frequency	Percentage
Less than 5,000	40	23.53
5,000-10,000	58	34.12
10,001-20,000	39	22.94
20,001-50,000	21	12.35
Above 50,000	12	7.06
Total	170	100.00

Source: Field Survey, November 2024.

A substantial proportion of the respondents (34.12%) spend between ₦5,000 and ₦10,000 monthly on power, followed closely by 23.53% who incur costs below ₦5,000. These lower expenditure brackets indicate smaller-scale operations or reliance on unreliable power sources like the national grid. Approximately 22.94% of respondents report spending ₦10,001 to ₦20,000 monthly, reflecting businesses with moderately higher energy demands.

Meanwhile, 12.35% of businesses fall into the ₦20,001 to ₦50,000 expenditure range, and a smaller group (7.06%) incurs costs exceeding ₦50,000, likely representing larger-scale operations or those heavily reliant on expensive alternatives like generators.

This breakdown highlights the financial burden of power supply on business operations. It demonstrates the potential appeal of more cost-efficient and sustainable solutions, such as solar-powered refrigeration like Koolboks, to reduce energy costs and enhance operational efficiency.

CHALLENGES WITH CURRENT/EXISTING REFRIGERATION SYSTEM

The survey explores the challenges faced by the respondents with their current refrigeration system in an attempt to understand how modern solar-powered refrigeration, Koolboks, can be immensely significant in addressing these challenges.

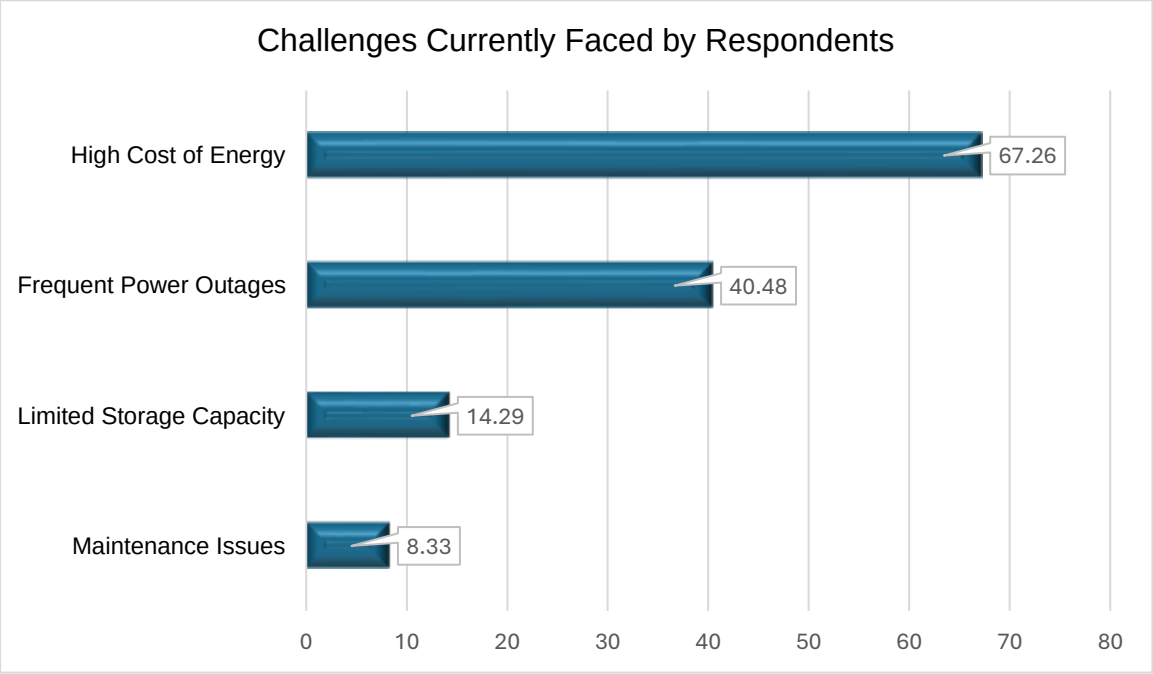

Figure 5: Percentage of Responses on Challenges Facing Respondents' Businesses
Source: Field Survey, November 2024.

The survey reveals the most pressing challenges facing businesses in the cool chain industry in the conflict-affected Northeast region. Figure 5 shows that the majority of the respondents, representing 67.26%, expressed concern about the high cost of energy making, signifying the severity of this problem in the study areas. The challenge closely followed is the frequent power outages, as indicated by 40.48% of the respondents. This reflects the country's current unstable and unreliable power supply, particularly in the conflict-affected northeast region of Nigeria. Furthermore, a small proportion of the respondents, representing 14.29% and 8.33%, indicated limited storage capacity and maintenance issues, respectively, as the challenges facing their businesses.

This finding highlights the significance of introducing more reliable refrigeration solutions to help address the existing challenges facing businesses in the cool chain industry in the study areas. Hence, Koolboks solar-powered refrigeration solutions can take advantage of these challenges by providing a reliable alternative that will ensure food preservation, storage, and transportation and enhance food security in the conflict-affected areas of Northeast Nigeria.

PERCEPTIONS ABOUT KOOLBOKS BY THE RESPONDENTS

This section explores the respondents' perceptions of Koolboks and their awareness, interest, perceived benefits, barriers, and financial readiness related to Koolboks solar-powered refrigeration solution.

Table 11: Awareness About Koolboks Refrigeration Solution among the Respondents

Response	Frequency	Percentage
Yes	55	32.54
No	114	67.46
Total	169	100.00

Source: Field Survey, November, 2024.

The respondents were asked whether they knew of the Koolboks solar-powered refrigeration solutions. The survey reveals that of the 169 respondents who answered the question on awareness, 55, representing 32.54%, were aware of the Koolboks solar-powered refrigeration solution. This percentage can be considered big, knowing that the product is new in Northeast Nigeria. However, the majority (114) of the respondents, representing 67.46%, reported no awareness of the Koolboks solar-powered refrigeration solution. This huge awareness gap highlights the need for targeted promotion and educational efforts to enhance product awareness among cool chain businesses in Northeast Nigeria.

INTEREST/WILLINGNESS TO SWITCH TO KOOLBOKS SOLAR POWERED REFRIGERATION SOLUTIONS

Table 12 shows respondents' interest in switching to a more energy-efficient refrigeration solution like the Koolboks.

Table 12: Interest in switching to Koolboks Solar-Powered Refrigeration Solutions

Degree of interest in switching to Koolboks	Frequency	Percentage
Very interested	120	71.43
Somewhat interested	44	26.19
Neutral	3	1.79
Not interested	1	0.60
Total	168	100.00

Source: Field Survey, November 2024.

The survey reveals that the majority of the respondents (120) out of 168, representing 71.43% of respondents, indicated strong interest in switching to Koolboks solar-powered refrigeration solutions as indicated by “very interested”. An additional 26.16% of the respondents indicated being “somewhat interested”, signifying moderate enthusiasm to switch. Interestingly, only a small percentage were neutral (1.79%) or not interested (0.60%) in switching to Koolboks. This high level of interest indicated by the respondents highlights the willingness of the businesses in the conflict-affected northeast region to opt for Koolboks, an energy-efficient and sustainable refrigeration solution suitable for food storage, preservation and transportation.

BENEFITS EXPECTED FROM POTENTIAL USERS OF KOOLBOKS

The respondents were given the options to indicate the likely benefits they would expect from the new and modern Koolboks solar-powered refrigeration solutions. Their responses are shown in Table 13.

Table 13: Benefits Expected from Potential Users of Koolboks

Perceived Benefits Expected from Potential Users of Koolboks	Frequency	Per cent
Backup power for consistent cooling	118	70.24
Lower energy consumption	29	17.26
Lower maintenance costs	8	4.76
Cost savings in the long term	8	4.76
Environmentally friendly	4	2.38
All of the benefits	1	0.60
Total	168	100.00

Source: Field Survey, November 2024.

The survey data in Table 13 reveals the primary benefits the respondents in northeast Nigeria expect from the Koolboks solar-powered refrigeration solution. The majority (70.24%) of the respondents expressed that a backup power supply for consistently cooling their products is the most significant benefit they expect from the new refrigeration solution. This explains the need for businesses to have more reliable and consistent cooling systems, especially in areas with erratic power supply. In addition, 17.26% of the respondents indicated lower energy consumption as the expected benefit from the Koolboks. Lower maintenance costs, long-term cost savings, and environmental friendliness were considered by 8% and 4% of the respondents, respectively, as the benefits expected from the Koolboks solar power. In comparison, 0.60% acknowledged the combination of all these benefits. This survey data suggests that the perceived reliability and energy efficiency of Koolboks are the most compelling features for potential users, aligning with the needs of businesses in fragile and conflict-affected areas where power supply challenges are prevalent.

POTENTIAL USERS' WILLINGNESS TO MAKE MONTHLY INSTALMENT PAYMENT FOR KOOLBOKS

The respondents were asked to indicate the monthly payment they would be willing to make for the Koolboks refrigeration solutions. Their responses are presented in Table 14.

Table 14: Amount of money willing to pay instalmentally for Koolboks every month

The amount of money willing to pay instalmentally for Koolboks every month (₦)	Frequency	Per cent
20,000 - 50,000	77	46.11
51,000- 100,000	65	38.92
101,000- 1500,000	17	10.18
151,000-200,000	3	1.80
201,000-300,000	3	1.80
More than 300,000	2	1.20
Total	167	100.00

Source: Field Survey, November 2024.

Most respondents (46.11%) expressed willingness to pay between ₦20,000 and ₦50,000 monthly, indicating significant interest in more affordable payment options. Another substantial percentage (38.92%) showed readiness to pay between ₦51,000 and ₦100,000, which reflects moderate affordability among this group. However, smaller percentages of respondents indicated higher levels of payment willingness from ₦101,000 to ₦150,000 (10.18%), ₦151,000 to ₦200,000 (1.80%), and ₦201,000 to ₦300,000 (1.80%). Only 1.20% of the respondents were willing to pay more than ₦300,000 monthly instalments. These findings highlight the importance of offering flexible payment plans, particularly within the lower monthly instalment brackets, to increase the accessibility of Koolbok solutions for a broader customer base in conflict-affected areas.

TIMEFRAME WITHIN WHICH RESPONDENTS ARE WILLING TO SWITCH TO KOOLBOKS REFRIGERATION

The survey also determined how soon businesses would switch to Koolboks solar-powered refrigeration solution.

Table 15: The timeframe within which respondents are willing to switch to Koolboks refrigeration depending on the availability of funds or financing

Response	Frequency	Percentage
Immediately	89	52.98
Within 6 months	53	31.55
Within a year	26	15.48
Total	168	100.00

Source: Field Survey, November 2024.

The survey reveals that 52.98% of respondents would switch to Koolboks refrigeration immediately if funds or financing were available. Additionally, 31.55% are prepared to switch within six months, while 15.48% would do so within a year. These results highlight a strong and urgent interest in adopting Koolboks refrigeration solutions, emphasising the importance of providing timely financial support or flexible payment options to facilitate this transition among the businesses in the Northeast conflict-affected region.

BARRIERS THAT MIGHT PREVENT POTENTIAL USERS FROM OPTING FOR KOOLBOKS

The survey probed into possible barriers to access to Koolboks by identifying key perceived barriers that could deter potential users from adopting Koolboks refrigeration solutions.

Table 16: Perceived Barriers that Might prevent Potential Users from opting for Koolboks

Perceived barriers that might prevent potential users from opting for Koolboks	Frequency	Percentage
Lack of financing options	109	64.88
High upfront cost	31	18.45

Insufficient information about benefits	5	2.98
Uncertainty about reliability	22	13.10
Storage capacity	1	0.60
Total	168	100.00

Source: Field Survey, November 2024.

The most significant barrier, cited by 64.88% of respondents, is the lack of financing options. This is followed by concerns over the likely high upfront cost (18.45%) and uncertainty about the product's reliability (13.10%). A smaller percentage of respondents (2.98%) indicated insufficient information about the benefits as a potential barrier, while 0.60% expressed concerns about the storage capacity of the Koolboks refrigeration solution. These findings demonstrate the need for flexible financing solutions, comprehensive product education, and assurances of reliability to address customer concerns effectively.

FINANCIAL READINESS OF THE RESPONDENTS TO PURCHASE KOOLBOKS

Assessing the respondents' financial readiness is crucial in determining their financial capability to buy the modern solar-powered refrigeration solution, Koolboks.

Table 17: Sufficient funds or credit availability by Respondents to purchase Koolboks

Sufficient funds or credit availability Respondents to purchase Koolboks	Frequency	Percentage
Partially, but it may need financing	109	64.50
Yes, sufficient funds are available	51	30.18
No, do not have sufficient funds	9	5.33
Total	169	100.00

Source: Field Survey, November 2024.

The survey also explores respondents' financial readiness to purchase Koolboks refrigeration solutions. A majority (64.50%) of the respondents indicated that they have partial funds but would require financing to complete the purchase, while 30.18% reported having sufficient funds available. However, 5.33% stated that they need more financial resources. This finding highlights the critical role of financing options in enabling broader access to Koolboks refrigeration solutions among potential users in the Northeast conflict-affected region of Nigeria.

CONCLUSION AND RECOMMENDATION

This report provides essential baseline information about the potential users of Koolboks solar-powered refrigeration solutions in the conflict-affected areas of Northeast Nigeria, focusing on Adamawa and Borno States. The participants in the survey comprised 172 businesses across seven local government areas from the two selected states. While over 70% of the sample businesses were owned by males, there was significant female participation in the cool chain business in the study areas, as indicated by over 20% of respondents. The majority of the business owners expressed concern over the current power supply relating to power supply relating to high cost and frequent power outages, among others.

The survey reveals that about 71% of the sampled businesses were interested and willing to switch to Koolboks solar refrigeration solutions as a backup for consistently cooling their products. Cumulatively, about 84% expressed willingness to make monthly instalment payments from ₦20,000 to ₦100,000 for the Koolboks to own the refrigeration equipment, and 52.98% expressing willingness to switch immediately, with 30.18 indicating their financial readiness to do so.

However, 18.45% of the respondents expressed concern over perceived high upfront costs/deposits. In comparison, 64.88% indicated a need for more financial opportunities as a factor that might prevent them from switching to solar-powered Koolboks refrigeration solutions.

The assessment results show that the Koolboks team needs to educate and raise awareness in this new environment, as most respondents must learn of the Koolboks or their existence.

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