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This study was carried out by Wageningen Economic Research and was commissioned and subsidised by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature within the context of the 'Food and Water Security programme' research theme of the Knowledge Base (project number KB-35-104-008).

Wageningen Economic Research
Wageningen, August 2024

REPORT
2024-113

WAGENINGEN
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Talabi, J., Y. Dijkxhoorn, B. de Steenhuijsen Piters, 2024. *Contributing to food system outcomes in the onion value chain in Nigeria; The potential role of midstream traders to reduce post-harvest losses and enhance food safety.* Wageningen, Wageningen Economic Research, Report 2024-113. 44 pp.; 6 fig.; 5 tab.; 3 ref.

The Nigerian food system comprises various interconnected actors who are crucial for food production and distribution. Based on our findings, we recommend involving the midstream segment of the supply chain in food system transformation processes, including emphasising the profit potential from reducing losses, introducing incentive mechanisms aimed at midstream actors, and fostering collaborative knowledge sharing to enhance food system outcomes. Aligning incentives that boost the profit potential for midstream actors primarily encourages adoption, thereby contributing to positive changes within the food system.

Key words: onions, Nigeria, innovation, value chain, food system

This report can be downloaded for free at https://doi.org/10.18174/671021 or at www.wur.eu/economic-research (under Wageningen Economic Research publications).

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Wageningen Economic Research Report 2024-113 | Project code 2282900003

Cover photo: Jimi Talabi

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Summary

The Nigerian food system comprises various interconnected actors – including small-scale farmers and informal enterprises – that are crucial for food production and distribution. Although the informal economy significantly contributes to poverty reduction, employment generation, food security, and household resilience in the country, research on its underlying drivers and responses to socio-economic changes has remained limited to date.

This study focuses on the onion value chain in Nigeria, in which most participants operate informally. The key stakeholders include farmers, aggregators, dealers, wholesalers, retailers, and exporters, who work together to move onions from farms to consumers. The objectives of this study include examining internal and external factors influencing value chain actors, analysing incentives for adopting innovative practices, and recommending strategies to improve food system outcomes, particularly reducing post-harvest losses and waste and enhancing food safety. We interviewed 31 stakeholders involved in the onion sector.

Farmers, predominantly located in northern Nigeria, vary from those cultivating on a small scale and producing small volumes to others producing significant amounts. Seasonal variations can influence input costs, and labour requirements influence their operations.

The midstream phase of the onion value chain involves a network of stakeholders, including local agents, aggregators, dealers, wholesalers, and retailers, who play essential roles in linking farmers to consumers. Transportation infrastructure plays a critical role in maintaining the quality of onions during transit.

Enablers such as Local Government Authorities, non-governmental organisations (NGOs), and agricultural extension services provide support to stakeholders within the value chain, offering inputs, training, and advice to improve productivity and sustainability. Support services, from financial institutions to input providers, also contribute to the profitability of onion farming and trading.

All stakeholders in the onion supply chain acknowledge the profitability of the business, with returns varying depending on the season and market demand. Farmers employ strategies such as diversification, grading, and storage to maximise their profits. Traders utilise storage strategies, market intelligence, and capitalise on price fluctuations and disparities to generate substantial profits, especially during periods of market glut.

Value chain actors implement a variety of strategies, including risk management, innovation, and profit maximisation. This showcases the level of resilience within the industry, despite challenges such as inadequate infrastructure and limited support. For example, innovations including cornstalk huts for storage and jute bags for transportation have been highlighted as effective solutions to mitigate post-harvest losses.

Currently midstream actors in the onion value chain are not often involved in food system transformation. Based on our findings, we recommend involving the midstream segment of the supply chain in food system transformation processes, including emphasising the profit potential from reducing losses, introducing incentive mechanisms aimed at midstream actors, and fostering collaborative knowledge sharing to enhance food system outcomes. Aligning incentives that boost the profit potential for midstream actors primarily encourages adoption, thereby contributing to positive changes within the food system. Our study also shows that value chain stakeholders predominantly prioritise innovations aimed at achieving economic outcomes (e.g. reducing post-harvest losses), while giving less attention to other food system outcomes such as environmental sustainability and access to healthy and safe food.

1 Introduction

The Nigerian food system is made up of a complex web of interconnected actors, each playing a critical role in ensuring that food reaches consumers' plates. An important component of this system is formed by the many small-scale farmers and enterprises, operating in an informal economy. It is increasingly recognised by academia and policymakers that businesses operating in the informal economy play a key role in enhancing food system outcomes: by reducing poverty and generating employment, as well as contributing to food and nutrition security and the resilience of low-income households.

This study covers the onion value chain in Nigeria. Most players in the onion chain – such as farmers, traders, processors, retailers and labourers – operate in informal sectors of the economy. The informal economy is recognised as the counterpart of the formal economy (Mekonnen et al., 2022). Chen (2007) further defines the informal economy as comprising all forms of 'informal employment' – that is, employment without labour or social protection – both inside and outside informal enterprises, including self-employment in small unregistered enterprises and wage employment in unprotected jobs (Chen, 2007). This informal economy definition includes both informal businesses as well as informal workers that are part of informal businesses.

Studies into the informal economy have paid little attention to the underlying drivers behind the behaviours and dynamics of economic actors in the sector, or their responses to changing socio-economic conditions and incentives which all affect how food systems function. A novel analytical framework was developed by de Steenhuijsen Piters et al. (forthcoming) that provides insights into these dynamics. This study untangles these elements and analyses the role of farmers and the different value chain actors operating in the informal sector, and their contribution to selected food systems outcomes.

The study answers the following research questions: objectives:
- How does the onion value chain looks like, and what roles do key value chain actors play?
- What external drivers (such as policies, market requirements, and competition) affect the different value chain actors?
- What motives, actions, and strategies influencing different value chain actors?
- What incentives and disincentives influence the adoption of innovations and practices aimed at reducing post-harvest losses and waste, and enhancing food safety?
- What strategies can be recommended to enhance the contribution of different actors in reducing post-harvest losses and waste, and improving food safety within the food system?

This report is organised as follows. The framework used in the analysis is presented in Chapter 2. This is followed by a discussion of Nigeria's onion sector (Chapter 3) and a presentation of the results of the onion case study (Chapter 4). Chapter 5 ends with a reflection on the key findings.

2 Approach

To understand the behaviour of actors in the informal sector, in terms of their decisions and strategies, it is important to examine the factors that drive their actions. Each actor in the informal sector and its enterprise is a microeconomic unit driven by motives or objectives to improve income, manage risks and act based on necessity, opportunities, trust, reputation and reciprocity and other conditions including drivers external to the informal business or enterprise. These external drivers such as policies, market requirements and competition, translate to incentives and disincentives to the performance of the informal sector. These external drivers influence the decision-making of midstream actors in the informal sector. These motives and strategies are turned into value chain operations that affect food system outcomes. For example, the level to which news ways of packaging vegetables are taken up and reduce post-harvest losses is impacted by the motives of informal actors. One motive is perceived risk. For traders or agents, for example, the question is whether they will be able to recover the additional costs or time incurred in adopting new practices. The final decisions they make or strategies they implement then have an impact on the food system outcomes, for example on reducing food losses.

The approach or framework used in the analysis of the cases is presented in Figure 2.1, which is based on the paper by de Steenhuijsen et al. (forthcoming) with some modifications.

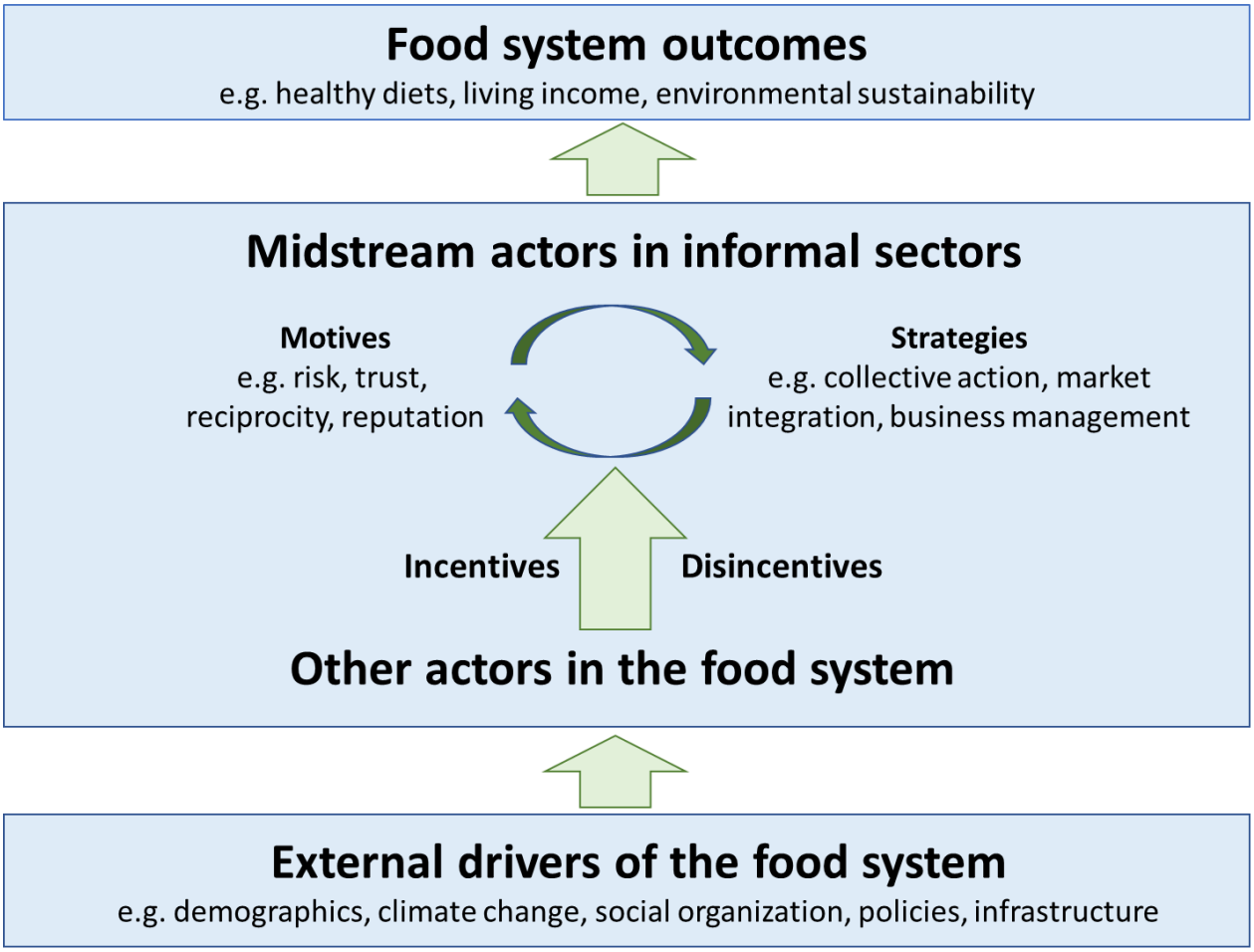

Figure 2.1 *Analytical framework for the case analysis*
Source: de Steenhuijsen Piters et al. (forthcoming).

In this study, a purposive sampling approach was employed to investigate onion supply chain stakeholders across Nigeria. For data collection, participants were deliberately chosen from the primary onion production centres in the rural northern Nigeria and the principal onion consumption centres in the more urbanised South West Nigeria. Specifically, four states and ten local government areas (equitably distributed as outlined in Table 2.1) were included in the study.

Table 2.1 *States and local government areas covered where onions are significantly produced and traded*

State	Local government area	
Oyo	I.	Akinyele LGA, Ibadan
Lagos	II.	Kosofe LGA
	III.	Ikorodu LGA
Kaduna	IV.	Ikara LGA
	V.	Makarfi LGA
	VI.	Zaria LGA
	VII.	Giwa LGA
Sokoto	VIII.	Kware LGA
	IX.	Wamako LGA
	X.	Sokoto North

After obtaining informed consent, each stakeholder was visited in the field to verify their consent and confirm their identity as stated in the informed consent document. All interviews were recorded in audio format for future reference. To ensure anonymity, unique identifiers were removed from the data at a later stage. Each interview session, lasting 60 minutes, involved a rigorous exploration of the subject matter. The specific actors interviewed are presented in Table 2.2.

Table 2.2 *Overview of onion value chain stakeholders and enablers interviewed in Nigeria*

State	North				South	
	Farmers	Aggregators	Dealers	Enablers	Traders	Retailers
Sokoto	3	3	3	3		
Kaduna	3	3	3	3		
Ibadan					2	
Lagos					2	3
Total	6	6	6	6	4	3
Grand Total			31			

The study involved 31 actors, consisting of 25 supply chain actors and 6 enablers. These stakeholders were purposefully selected and interviewed. The sampling process can be summarised as follows:

- In the north, 6 farmers were selected from Sokoto and Kaduna states (3 from each state), both of which are prominent onion-producing regions in Nigeria.
- Six aggregators (3 each from Sokoto and Kaduna states), 6 dealers (3 from each state), and 6 enablers (3 from each state) were also purposively chosen.
- In the Southern region, four wholesalers were selected from Lagos and Oyo states (two from each state). Additionally, three retailers were purposely chosen from Lagos State.

All the interviewed actors and stakeholders are male, highlighting the male-dominated nature of this value chain. Most of the actors fall within the middle-age bracket, while the retailers tend to be younger, typically between 25 and 40 years old. The years of experience in the business varied widely, with no clear pattern in the number of years spent. The fewest years in business among those interviewed was three years, while some have experience spanning over four decades.

3 The onion sector

3.1 Introduction

Nigeria holds a prominent position in the regional onion market. Onions, a staple food in Nigerian cuisine, are integral to the nation's food system. The onion supply chain in Nigeria is dynamic and organised into several distinct segments, involving various stakeholders and processes. Each segment presents opportunities for improvement in efficiency, quality, and sustainability. Various stakeholders, including external stakeholders, work together to address challenges and enhance the overall performance of the onion value chain, and by extension contribute to food system outcomes including reducing losses and improving food safety.

Understanding the organisational structure of the onion value chain provides insights into how onions move from the farm to consumers. In the rest of this chapter, we present an overview of the main production areas and detail the key value chain actors and their core activities.

3.2 Production areas

Onion cultivation in Nigeria is widespread, benefiting from the country's diverse climates. In total, an area of 596,000 ha of dry onions and shallots is being cultivated. This represents 88% of the total dried onion area in West Africa. An area of 14,000 ha of green onions and shallots is also produced in Nigeria, accounting for 31% of the total green onion production area in West Africa (Table 3.1).

Table 3.1 *Onion and shallot area cultivation (in ha) and production (in tonnes) in Nigeria, 2017-2022*

			2017	2018	2019	2020	2021	2022
Nigeria	Dry onions and shallots	Area harvested	502,800	549,890	568,225	589,610	595,850	596,146
		Production	1,346,100	1,416,960	1,464,280	1,517,270	1,534,430	1,554,965
	Green onions and shallots	Area harvested	14,091	14,235	14,097	14,141	14,157	14,132
		Production	233,831	233,681	244,743	244,444	240,956	243,381
West Africa (excluding Nigeria)	Dry onions and shallots	Area harvested	64,420	65,621	68,696	69,558	74,436	80,410
		Production	1,858,144	1,893,194	2,053,070	2,032,328	2,106,326	2,247,868
	Green onions and shallots	Area harvested	23,916	33,369	26,098	29,801	28,917	31,517
		Production	538,706	699,339	549,014	722,237	710,794	636,619

Source: FAOSTAT.org, visited June 2024.

Despite the widespread growing areas, the computed yields of both crops is much lower compared to the regional averages. For dried onions, Nigeria only produces 10% of the regional yield average (Table 3.2). It appears from the data that Nigeria has focused on increasing the land area for onion cultivation to boost overall production rather than improving yields by introducing improved production practices and making improved varieties available for farmers.

Table 3.2 *Onion and shallot yields (in tonnes per ha) in Nigeria, West Africa and worldwide 2017–2022*

		2017	2018	2019	2020	2021	2022
Dry onions and shallots	Nigeria	2.7	2.6	2.6	2.6	2.6	2.6
	West Africa (ex Nigeria)	28.8	28.9	29.9	29.2	28.3	28.0
	Global	18.9	19.0	19.4	19.3	18.7	18.5
Green onions and shallots	Nigeria	16.6	16.4	17.4	17.3	17.0	17.2
	West Africa (ex Nigeria)	22.5	21.0	21.0	24.2	24.6	20.2

Source: FAOSTAT.org visited June 2024.

The primary onion-producing states include Sokoto, Kano and Kaduna.

- Sokoto: Accounts for approximately 40% of Nigeria's total onion production.
- Kano: Accounts for approximately 40% of Nigeria's total onion production. The Dawanau market in Kano serves as the nucleus of the Nigerian onion trade, handling over 600,000 tonnes of onions annually.
- Kaduna: Kaduna, particularly the Zaria Region, contributes significantly to national production, yielding around 20% of total onion production. Modern farming techniques have increased yields, and the state produces over 400,000 tonnes annually.

Combined, these states cover the entire national onion production. The favourable climatic conditions in these regions, including well-distributed rainfall and fertile soils, result in an estimated annual onion production of over 2m tonnes.

Both smallholder farmers as well as larger commercial farms cultivate onions in Nigeria. Traditional farming methods are prevalent, but there's a growing trend towards adopting modern techniques. While harvesting methods vary, the use of manual labour is common. Onions are carefully pulled from the ground, and the tops are left to dry before bundling. Additional post-harvest handling includes curing and drying to enhance shelf life. This stage is crucial to minimise losses during storage and transportation.

3.3 Seasonality and pricing

The extreme fluctuations in onion supply and demand throughout the year play a crucial role in determining prices. The price of onions is lower during the peak production period – typically January to April when supply is abundant. Conversely, prices rise towards the last quarter of the year when demand surges but availability reduces. This is primarily because onions are not harvested during this period. Instead, the market supply consists mostly of stored onions. Consequently, the price depends on the volume released by the businesses that stored them, which in turn depends on their available stock. Market speculation further introduces price variation and instability, resulting in the possibility of three different prices per bag of onions in a single day.

3.4 The value chain map

Critical stakeholders in the onion value chain are farmers, aggregators, dealers, wholesalers, and retailers. See Figure 3.1 for a schematic representation of the sector.

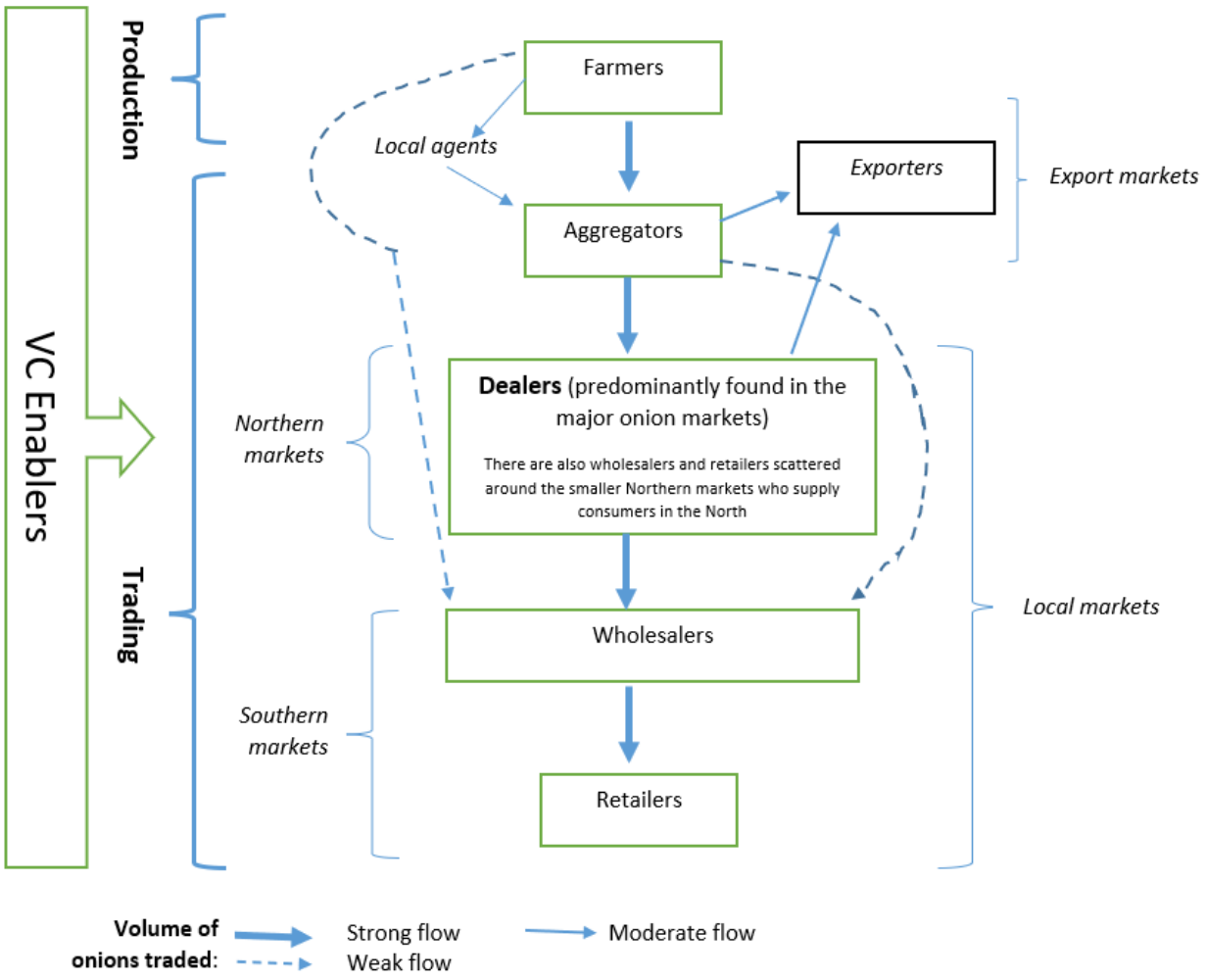

Figure 3.1 *A value chain map of the onion sector in Nigeria*
Source: Authors' own.

3.5 Farmers

Farmers who produce onions predominantly operate in the northern part of the country. Farmers demonstrate a diverse array of production methods, with many engaging in small-scale farming. These farmers harvest 20 to 40 bags per season, and with each bag weighing approximately 100 kg this implies a harvest of 200 to 400 kg. In contrast, medium-sized farmers produce as much as 150 bags per season (1,500 kg), and some larger farmers even produce 450 bags (4,500 kg) per season. Some farmers also engage in the production of onion seeds, which are sold to fellow farmers.

The volume of onion production and level of trade by other stakeholders in the supply chain is influenced by the season of production. Onion yields are consistently higher and superior during the dry season (November to May) compared to the wet season (May to October). The entire onion production cycle, from planting to harvesting, spans 70 to 90 days. Variations in yield are determined by factors such as the selection of onion

varieties, soil properties, fertiliser application, and extension services. However, the cost of inputs and labour requirements also imposes constraints on farmers' ability to expand their operations.

The varieties of onions produced by the farmers contribute to price differentials. The white onion variety commands the highest value and price, followed by the peach-coloured variety, while the red onion variety is the most common and generally less expensive.

Farmers can be categorised into two groups based on their season of production: dry season-only farmers and year-round farmers who cultivate onions during both dry and wet seasons.

Farmers can also be roughly categorised into two groups based on trading patterns: those who directly sell to aggregators or local agents at the farm gate, and those who take their produce to the local northern markets.

3.6 Midstream value chain actors

The trading phase within the onion supply chain is a dynamic process characterised by a web of interconnected activities involving various midstream actors. This phase serves as a crucial link, connecting onions from farmers to consumers. Key participants include local agents, aggregators, exporters, dealers, wholesalers, and retailers, collectively referred to as traders.

Aggregators, acting as intermediaries, purchase directly from farmers, in addition to engaging local sourcing agents and then distribute to dealers in northern markets who in turn supply/sell onions to major markets in the south of the country through wholesalers. Sometimes, some aggregators also sell directly to wholesalers in southern markets. The final link in the chain involves retailers selling units of onions to end consumers. There are also fringe activities where exporters buy from aggregators and dealers in northern markets and export to neighbouring countries.

3.6.1 Local agents

Rural local sourcing agents mostly work with aggregators and source onions from interior farming communities. They help aggregators to buy at the farm gate and take care of transportation to aggregating centres.

Onions are transported from rural areas to major markets using various modes of transportation, including trucks and sometimes donkeys. The transportation system plays a critical role in maintaining the quality of the onions during transit.

Figure 3.2 *Transportation of onions with a trailer holding approximately 300 bags (4,500 kg)*
Source: Authors' own.

3.6.2 Aggregators

Aggregators play a pivotal role in the supply chain, as they purchase onions from multiple farmers either directly and/or via local agents. The volume of onions traded by aggregators varies widely based on the scale of their operations. Some aggregators handle as much as 2m onion bags per season, while others trade only 1,500-1,800 bags per week (5-6 trailers). Additionally, some aggregators import onions from Niger when local supply is low. Depending on their scale, aggregators may also engage in exporting onions (e.g. to markets such as Benin, Burkina Faso, Cameroon, Ivory Coast, Ghana, and Niger), with some exporting up to 3,000 bags (10 trailers) per season.

3.6.3 Rural dealers

Dealers or brokers trade onions obtained from rural aggregators and farmers. They are located in rural areas close to onion markets and onion farming production areas. Their main customers are wholesalers who sell onions in many locations outside of the farming region particularly in the south. Dealers are often paid a commission for each transaction they conduct or based on the volume of onions sold on behalf of the farmers or aggregators. In other words, they do not technically take any financial risks because they do not own the onions. In the event of a loss, most, if not all, of the losses are incurred by the owner of the onions though it does affect their commissions as well. They also export to or sell to exporters who transport onions to neighbouring countries. Large-scale dealers can handle over 13,500 bags (45 trailers) per month during peak periods and 4,500 bags (15 trailers) during lean periods.

Major onion wholesale markets serve as central points for trading. The markets are often strategically located to facilitate distribution to various regions across the country:

- Sokoto markets
  The vegetable markets in Sokoto are a crucial network of markets scattered across the state. While Sokoto City serves as a major trading hub for onions, it is complemented by several satellite markets located in various towns and villages throughout the state. Collectively, these markets form an infrastructure that facilitates the trade and distribution of onions at both local and national levels. While the Sokoto City market handles larger volumes and serves as a focal point for inter-regional trade, smaller markets in rural areas play an equally vital role in connecting local producers to traders.
- Dawanau Market, Kano
  Dawanau, is another large onion market in West Africa. This market plays a pivotal role in the onion supply chain, serving as a central point for the aggregation, sorting, and distribution of onions across the country.

3.6.4 Wholesalers

Wholesalers serve as the link between a hub of onion production and other parts of the country. They mostly operate in the markets outside of onion production hubs. Those markets are scattered around the country, particularly in the south. All wholesalers pay charges per bag sold to the market authority or the owner of the space that they rent for conducting their business.

In the south, wholesalers sell varying volumes, with some selling up to 350 to 400 bags per week. During lean periods, these volumes may decrease to 45-70 bags per week. At this level of trading, the price of a bag of onions (100 kg) ranges from 7,000 to 14,000 Naira (USD 4.60 to USD 9.20) during the peak supply period (usually from January to May). Conversely, during the lean supply period (usually from October to December), a bag of onions could sell for as much as 100,000 to 120,000 Naira (USD 66 to USD 79).

3.6.5 Retailers

Retailers purchase onions from wholesalers and sell them to consumers in urban markets, grocery stores, and street markets. The retail segment is diverse, ranging from small roadside vendors to established grocery chains and supermarkets. The largest market outside of the production hubs is located in Lagos. On average, retailers sell 3-7 bags per week during lean periods and 10-16 bags per week during peak periods. Also, retailers pay a fee to the market authority. A retailer mentioned paying a daily fee of 50 Naira (USD 0.03) to the market authority.

3.6.6 Exporters

A growing segment of the onion value chain involves exports. Large farmers and some aggregators and dealers also export their produce directly to neighbouring countries such as Cameroon, Côte d'Ivoire, and Ghana.

3.6.7 Value chain enablers

Various supporters and enablers are present in the onion value chain. This includes financial institutions, agricultural extension services, and input providers. Financial institutions provide credit to farmers, extension services offer advice on best practices, and input providers offer solutions for improved production.

Enablers in various categories play a crucial role in influencing the onion value chain. These include Local Government Authorities (LGAs), NGOs, institutions providing extension services such as the *National Agricultural Extension and Liaison Services* (NAERLS), civil society organisations (CSOs) such as the *National Onion Producers, Processors, and Marketers Association of Nigeria* (NOPPMAN) and the *All Farmers Association of Nigeria* (AFAN), and Departments of Agriculture, e.g. *Sokoto Agriculture and Rural Development Authority* (SARDA).

- The LGAs engage directly with vegetable farmers, forming collaborations with organisations like East-West Seeds and *AGRA*. These partnerships involve providing inputs such as fertilisers, chemicals, and seeds for demonstration plots. LGAs noted that cooperative societies can effectively influence the behaviour of value chain actors.
- NGOs also work closely with fruit and vegetable farmers, partnering with entities such as AGRA, *United Nations Development Programme* (UNDP), and the *International Institute for Tropical Agriculture* (IITA) to offer farm demonstrations, advice, and training for farmers. NGOs pointed out that pepper farmers can effectively influence onion farmers due to their complementary nature, and successful innovations for pepper farmers can influence onion farming as well.
- NAERLS provides extension services directly to fruit and vegetable farmers, assisting them in adopting innovations and technologies that can enhance their operations. NAERLS stressed the importance of external bodies building the capacity of value chain actors and identifying influential stakeholders among them who can inspire others with their progress.
- CSOs like AFAN focus on addressing specific challenges within the value chain, such as onion preservation and reducing post-harvest losses. It focuses on farmers and provides support to address these challenges. Additionally, AFAN collaborates with various other fruit and vegetable value chains, including those involved in carrot, pepper, and tomato production. AFAN identified the Sarkin Albasa (translated as King of Onions) in Sokoto State as the critical stakeholder for influencing behaviour, emphasising that they solely communicate with onion farmers through him.
- The Department of Agriculture in Sokoto, represented by SARDA, directly engages with all value chain actors, particularly fruit and vegetable farmers. SARDA emphasises the benefit to farmers of adopting improved seeds, the necessity of using licensed agrochemicals, and the implications of using contraband chemicals on soil quality.
- NOPPMAN works in collaboration with NGOs and traditional institutions to enhance practices in the value chain. Their efforts aim to secure recognition from the government for the informal onion supply chain as a significant contributor to food security in Nigeria. In addition, NOPPMAN has been instrumental to the success of the adoption of jute bags to improve storage, particularly in Sokoto in the last few years. NOPPMAN highlighted traditional rulers (Sarkin Albasa) and enablers as significant influencers in the supply chain.

3.6.8 Access to finance

An analysis of funding sources for various stakeholders in the onion supply chain reveals that onion farmers and traders are predominantly self-funded, often with support from family and friends. Farmers universally assert that their businesses are primarily self-financed, using earnings from previous seasons to fund operations for subsequent farming seasons. However, the majority also acknowledged that they sometimes access additional sources of funding. Some farmers secure loans and repay them with produce equivalent to the loan. Others obtain loans from microfinance banks, with one farmer mentioning a 400,000 Naira (USD 26) loan to be repaid after 6 months. Another farmer cites additional income from cultivating other crops, while one relies on a family relative who lends 1m Naira (USD 659) per season without interest, to be repaid after the farming season. Interestingly, another farmer stated that they invested their farm proceeds to purchase and fatten rams and cattle during the off-season, then selling them to finance the upcoming farming season.

All aggregators emphasise that their businesses are predominantly self-funded, but some mentioned supplementary income from other businesses. Aggregators also stated that they were able to access loans from microfinance banks when necessary. Most aggregators also save money by acquiring physical assets that can be sold to finance the business when needed. Dealers, too, largely rely on self-funding, with some turning to family and friends for extra financial support. Some dealers diversify into trading other crops during the onion off-season, while others have never sought loans.

Wholesalers in the south also primarily self-fund their onion businesses. Some wholesalers express disinterest in loans due to the interest attached, conflicting with their religious beliefs. However, one trader secures soft loans with interest from a business woman, as conventional banks are either unwilling to extend loans to informal businesses or have very stringent conditions. In his words:

> ‘Yes, as traders, we do need loans regularly, especially whenever we see business opportunity in onions and quickly want to seize it. I have a woman who gives me loan at an interest. I have approached formal institutions like banks before but they are not willing to lend me money and their requirements are too burdensome. The process of releasing the money too can be discouraging. Taking advantage of the opportunity in this trade is timely, if one misses it, that is all. Most opportunities come when the prices of onions start increasing, you can quickly buy, hoard it for a short period and make thousands of Naira per bag within a short period of time. For example, I did a transaction last month, and within three weeks, I made a profit I have never seen from the beginning of the year. That is the attribute of this business.’
> An onion wholesaler, Ibadan

Another wholesaler obtains loans from a microfinance bank using properties as collateral, while another relies on non-interest loans from relatives.

Onion retailing is similarly self-funded, with one retailer involved in tomato and pepper retailing reinvesting proceeds into onion retailing. Two retailers cited religious beliefs as a reason for not seeking loans, while two others highlighted their ability to obtain onions on credit from dealers and wholesalers, repaying after selling within 3-4 weeks.

3.7 Gender in the onion value chain

Almost every segment within the onion supply chain is male dominated, except for onion retailing as highlighted below.

In our study, farmers emphasised that the demanding nature of onion cultivation, coupled with cultural and religious factors that limit women’s engagement with outsiders, contribute to the male-dominated nature of this sector. While acknowledging the presence of a few women involved in small-scale onion farming for household consumption, or engaging in less strenuous activities such as handpicking, the overall consensus among farmers is that the primary bulk of onion farming is undertaken by men.

Aggregators and dealers also shared a unanimous view that onion aggregation and dealership businesses are also male dominated. They attributed this trend to cultural and religious beliefs as hindrances that prevent women from entering the aggregation business. Despite this, some dealers pointed out the significant number of women involved in retailing, particularly in the south of the country. Dealers further highlighted the existence of prominent women dealers in other countries such as Benin, Côte d’Ivoire, Niger, and Senegal.

Wholesalers echoed similar sentiments, stating that the labour-intensive and risky nature of onion trading contributes to its male-dominated status.

Onion retailing is often considered a less demanding physical activity, and is predominantly carried out by women. The consensus is that onion retailing is female dominated. It is noteworthy that male retailers dominate in some markets in the north, while female retailers dominate the overall onion retailing business, particularly in the south.

4 Results

4.1 Introduction

This chapter delves into the outcomes of our study, building upon the framework presented in Chapter 2. Here, we present the behaviour of actors within the informal sector, looking into detail at their decisions and strategies. Each entity within the onion value chains functions as a microeconomic unit driven by a myriad of motives, ranging from income augmentation to risk mitigation. As we unravel the intricacies of these motives, we shed light on the array *drivers* influencing their actions, from necessity to market dynamics and governmental policies (Section 4.2). By understanding these drivers, we are uncovering the different *incentives* (Section 4.3) and *disincentives* (Section 4.4) shaping the *innovations* within the informal onion sector, which impact food system outcomes (Section 4.5).

4.2 External drivers of the food system

4.2.1 Demographics

Nigeria, the most populous country in Africa, is experiencing significant demographic shifts that are influencing the consumption of onions. The country's population, currently exceeding 220m, is projected to continue growing rapidly. This burgeoning population is accompanied by increasing urbanisation, with more people moving from rural areas to cities. Urbanisation often leads to changes in dietary habits, with urban dwellers having better access to a variety of foods, including onions. As a staple ingredient in Nigerian cuisine, the demand for onions is rising, driven by both population growth and the changing food preferences of an urbanising society. Additionally, the expanding middle class is boosting the demand for more diverse and nutritious food options, further increasing onion consumption.

4.2.2 Climate change

Climate change poses significant challenges to onion farming in Nigeria, a country already vulnerable to environmental fluctuations. Changes in temperature, irregular rainfall patterns, and increased frequency of extreme weather events like droughts and floods are adversely affecting onion production. This increased the risks for farmers active in the sector.

Onions require specific climatic conditions to thrive, and the disruption of these conditions can lead to reduced yields and poorer quality produce. For instance, excessive rainfall can cause waterlogging and rot, while prolonged dry spells can hinder growth and development. The increasing unpredictability of weather patterns in Nigeria necessitates the adoption of resilient agricultural practices and technologies to sustain onion farming in the face of climate change. Farmers need to adapt by employing irrigation systems, using drought-resistant onion varieties, and improving soil management to mitigate the impact of climate change.

4.2.3 Social organisation and governance

Membership of organisation or network relevant to onion supply chain
Half of the interviewed farmers are members of an association. The reasons cited for joining include provision of valuable knowledge, innovations related to onion storage, quality inputs, new seed varieties, and the adoption of efficient bagging systems. However other farmers explained their non-membership as they felt associations were unnecessary, they hadn't received an invitation to join, or felt associations neglected farmers.

> 'There is an onion producers and marketers association here in Sokoto but to be frank I am not part of any organisation. The reason why I am not part of the organisation is that they are not involving us that are within the swamp (Fadama). They only restrict themselves within Sokoto metropolis. The organisation mostly selects onion marketers, additionally they did not invite farmers to come and be part of them despite the fact that we (farmers) are the influential partners in the value chain.'
> Onion farmer, Sokoto

Among the aggregators, all but one interviewed were members of an association, such as NOPPMAN. These associations conduct regular meetings to address collective challenges. Notably, one association asks a fee of 300 Naira (USD 0.20) per bag of onions sold in the market. The aggregator who did not belong to an organisation expressed concerns about the lack of support certain associations provided their members.

Similar patterns are observed among dealers, where more than 80% of the interviewed respondents belong to an association dedicated to advancing onion trading in the local environment. The associations help in regulating supply on daily basis and influencing selling prices. Other roles include settling rifts between members in the markets, providing social support for members outside of onion business (such as helping with the costs of social ceremonies), and representing members' interests in the market.

Among wholesalers, half of those interviewed are affiliated with an association. The wholesalers contribute revenue to the association which is utilised for daily operations and to support members in times of need. These members also engage in collective buying from the north and jointly discuss pricing. Wholesalers who are not affiliated with an association noted that membership is not compulsory. Wholesalers also mentioned that NOPPMAN plays a crucial role in disseminating new innovations, such as jute bags, within the onion value chain.

In contrast, most of interviewed retailers do not belong to an association. The retailer expressed interest in joining an association but highlighted the absence of an exclusive association for onion traders in the market.

> 'I am not a member of any organisation. We do not have an association specifically for onion trading. All we have to do as a retailer is get a space in the market through the market leaders and once this is done, I make a daily payment of 50 Naira (USD 0.03) daily to the market union leaders, that's all.'
> Onion retailer in Lagos

Conversely, a retailer belonging to an association acknowledged the support provided to members, emphasising that the association caters to various traders, including pepper and tomato traders. The association provides a number of services including overseeing market activities, ensuring orderliness, collect levies, organising meetings, coordinating with external bodies including government representatives, and ensuring sanitation at the market etc.

Barriers to entry for new players and payment of operation fees

Participants within the onion supply chain unanimously agreed that entering the business at any segment is relatively easy, with no significant barriers to entry. While the general consensus is that there are no insurmountable barriers to entry, stakeholders did state that a combination of experience, capital, and a commitment to learning the intricacies of the onion supply chain was essential for new entrants to succeed.

Farmers emphasised the importance of prospective entrants gaining experience before venturing into farming. They highlighted the need to secure land, establish a water source for irrigation, and secure adequate financing, given the capital-intensive nature of onion farming. Moreover, they stressed the necessity for newcomers to learn the technical aspects of onion cultivation.

Aggregators and dealers echo similar sentiments, emphasising the importance of having sufficient capital and a commitment to learning about the business, especially in terms of onion preservation to avoid losses due to spoilage. Knowledge about identifying good-quality produce and possessing ample storage capacity were also deemed to be essential. Joining an onion-based association was recommended by some, with a

cautionary note that the association might conduct due diligence and background checks on new entrants to ensure trustworthiness.

Wholesalers and retailers also stated that there are no significant barriers to entering their respective segments. Wholesalers suggest that gaining experience and accumulating sufficient capital is vital for success. Some also highlighted the importance of establishing relationships with trusted customers, particularly as retailers often operate on credit and repay after selling.

For retailers, joining an association was recommended. There was also a general agreement that capital is a crucial requirement for starting, although trustworthy retailers may receive credit from wholesalers and dealers.

For farmers seeking to be recognised by the government for potential benefits such as fertiliser and seed distribution, prior registration with the LGA is mandatory. However, individual farmers cannot register independently; registration is only allowed through groups. Forming a Farmers' Cooperative Association (FCA) requires a larger membership than a small farmers' group and carries more influence and advantages. To register, a group must pay a fee ranging from 7,000 to 8,000 Naira (USD 4.60 to USD 5.27) per registration. The group must also propose a name and submit a list of members, with the member count not falling below 10-15 individuals. Furthermore, LGAs state that 5-10 registered groups can collaborate to form a farmers' cooperative association (FCA).

NGOs also emphasise the absence of barriers for new entrants and indicate their role in guiding potential farmers associations through the registration procedures to gain recognition and access support.

NAERLS underscores the absence of barriers for individual farmers. New entrants can join any registered association of farmers at any time provided they meet established criteria. One of the criteria is that a new farmer for example must be introduced by a registered member and approaching association leaders for endorsement is key. Everyone including the enablers acknowledge that there is no barrier for new entrance.

NOPPMAN reinforced the importance of new entrants registering with NOPPMAN, asserting that such registration enables trading in onions nationwide and offers benefits such as information sharing and linkages with other players. However, NOPPMAN does impose a registration fee of 2,000 Naira (USD 1.30), along with a 2,000 Naira (USD 1.30) fee for an ID card.

While fees are not generally seen as a barrier to participating in the value chain, they are a form of discouragement. Our study revealed discrepancies in operational levies among onion supply chain actors, with aggregators, dealers, and wholesalers bearing higher costs compared to farmers and retailers. Farmers uniformly reported no fees for cultivating the land in form of taxes for production activities. Those leasing land typically pay annual rent fees to the landowner, with one farmer stating that he pays 20,000 and 50,000 Naira (USD 13 and USD 33) on two farms he rents. Farmers transporting onions to the market also mentioned State officials imposing charges of 7,500 Naira (USD 4.94) and 15,000 Naira (USD 9.90) for every 100 and 200 bags, respectively during offloading at the markets. Farmers associations do pay renewal of registration fee on annual basis to the government.

Aggregators highlighted various charges they incur, paying fees to State and LGAs. For example, charges are levied at different locations along transportation routes by law enforcement agents and at destination markets by LGA agents. Examples include charges to LGAs for each trailer, with rates of 10,000 Naira (USD 7) for a trailer of onion (300 bags) or 100 Naira (USD 0.06) per bag. Some aggregators pay weekly fees to LGAs for the space they are using in the market, while others also contribute to market associations.

Among the dealers, five out of six acknowledged paying operational charges. These fees varied, with one dealer paying monthly dues to an association, and another contributing 100 Naira (US$0.06) weekly to the LGA. In addition, they pay 5,000-10,000 Naira (USD 3.34-USD 7) per truck based on the distance of onion transportation. Wholesalers highlighted fees associated with rental of the space used for rental, truck entry to the market paid by the truck driver but integrated in price charged for transportation, and per-bag charges to onion associations and market authorities. For instance, one wholesaler paid 2,000 Naira

(USD 1.33) per bag of onion to the owner of the selling space, 250 Naira (USD 0.16) per bag to market authorities, and additional fees for every truck entering the market. Retailers also reported daily operational fees paid to market authorities, with charges ranging from 50 to 100 Naira (USD 0.03-USD 0.06) per day. Dealers involved in exporting onions incur significant expenses, including 250,000-300,000 Naira (USD 167-200) at the border, along with payments of 10,000 Naira (USD 7) to state officials, 2,000 Naira (USD 1.30) for LGAs, and 1,000 Naira (USD 0.65) for the market associations.

Regarding support received from government or other external bodies, most interviewed onion value chain actors reported never having received any subsidies or services. Four farmers confirmed they had never received subsidies, although some mentioned interactions with UNDP extension officers who provided advice on planting methods. A farmer noted receiving discounts from fertiliser companies, constituting a form of support. Another farmer highlighted past subsidies from the former governor of the state, covering fertilisers, pesticides, seeds, and irrigation pumps at half the market price.

Aggregators and dealers uniformly expressed never having received subsidies, services, or support from the government or any NGOs However, one aggregator described a cooperative effort to buy inputs in bulk, securing discounts from input supply companies. Another aggregator voiced concerns about government neglect, stating that taxes were not utilised for the benefit of value chain actors. Similarly, the interviewed wholesalers and retailers had not received prior support. One wholesaler acknowledged government support to farmers but said that support was not available for traders, while another wholesaler expressed scepticism about benefiting from government support due to their lack of formal registration and concerns about political influences and corruption. Only one retailer mentioned receiving support from their market association.

Registration of businesses

None of the interviewed stakeholders are directly registered with the government, underscoring the informal nature of the onion supply chain. This indicates a prevalent absence of direct government registration across the supply chain, with stakeholders often associating themselves with specific organisations or unions instead. For example, interviewed midstream actors were affiliated with organisations like NOPPMAN, which itself is registered with the government, the Sokoto Union of Onion Farmers, or the Onion Farmers and Marketers Association.

One farmer expressed scepticism about registration, citing a lack of tangible support from the government.

> 'My business is not officially registered because this farming is my personal business and since I don't belong to any group, this business is just to make ends meet. The government does not do anything for us so why register it with the government.'
> Onion farmer – Kaduna

Another farmer highlighted a lack of perceived benefits from registration, recounting experiences where registration efforts yielded no discernible outcomes.

Two aggregators were registered with local associations for onion aggregators. One aggregator attempted government registration unsuccessfully, while another cited literacy challenges as a hindrance, and yet another stated that they had plans for collective registration as an aggregator union under the government.

While none of the dealers were directly registered under the government, four out of six belonged to associations like NOPPMAN. Two wholesalers were not affiliated with any organisations (government or NGOs), while the remaining two were registered with the market authorities and NOPPMAN. Every market has an overall leadership structure complemented by smaller groups focused on specific products. Traders handling these specific products are often registered by these groups.

The traders underscored the importance of NOPPMAN in their trading activities, particularly in adopting innovations such as e-marketing. Among the retailers, two were registered with market authorities, while one lacked any form of registration.

Enablers interviewed generally agreed that a significant portion of the industry's participants are unregistered, despite acknowledging the existence of cooperative groups where many value chain actors are registered. According to NAERLS, the ratio of registered to unregistered actors is approximately 50:50. Though, even for those bodies that have government registration, members only loosely belong to the organisations and can't be directly accounted for by the government. NAERLS highlights that those involved in primary production and trading are predominantly unregistered, whereas processors are mostly registered. They emphasise, however, that they work with both registered cooperative members and those without registration.

SARDA, operating under the Department of Agriculture, also recognises that most participants in the value chain are unregistered. They are actively raising awareness and encouraging them to form groups and register to access government and World Bank support. AFAN as a CSO concurs, stating that they are vigorously urging individuals to register to avail themselves of insurance packages in case of disasters. NOPPMAN similarly notes that a significant number of actors and groups are unregistered and is actively promoting registration under NOPPMAN, as the organisation itself is registered under the Federal Ministry of Industry, Trade and Investment, Federal Ministry of Agriculture and Rural Development, as well as the Export Promotion Council. NOPPMAN emphasises its national presence, operating in all 36 states of the country and Abuja (the Federal Capital Territory (FCT)). Additionally, they have a website for members' registration and they provide ID cards for their members. However, members do not become formalised by registration. They will still operate informally but this kind of registration provides a leverage and possible access to some benefits e.g. loan, credits, inputs etc.

Power and influence of key value chain actors

In the Nigerian onion supply chain, aggregators and dealers emerge as the most critical actors influencing prices, while wholesalers also have some influence at the local market level. The impact of aggregators, dealers and wholesalers on pricing is facilitated through activities such as price speculation and collaborative meetings at niche or local level to determine the price and marketing arrangements. They can facilitate or hinder the scaling of any innovation across the onion supply chain.

Aggregators compete with other aggregators vigorously for premium onions from farmers by offering price incentives, and provision of fertilisers, seeds etc. to farmers during production seasons to ensure access to the farmers' produce. Dealers within and outside markets also vigorously compete for sales by offering price incentives to buyers, sell on credit to attract more sales, and discount for bulk purchases. In some instances, wholesalers and dealers also encroach on the territory traditionally occupied by aggregators, directly purchasing from farmers to maximise profits.

The effects of these price incentives and variations are particularly evident at markets close to consumers. This is commonly observed at the downstream end of the supply chain, where wholesalers and retailers attract customers by offering price incentives. LGAs highlighted that all actors, including transporters, have roles to play though the degree of their roles differ. They stated that farmers are most important and influential when it comes to the adoption of production technologies, while traders play a crucial role in the adoption of storage technologies.

NGOs felt that farmers were the most important group, as post-harvest loss reduction and food safety begin on the farm, and farmers determine the quality of produce reaching the market. NAERLS identified buyers – aggregators, dealers and wholesalers – a s the most influential actors, given their economic power to influence the market.

AFAN pointed out that aggregators are the most crucial value chain actors for improving food safety and reducing post-harvest losses, acting as the link between farmers and traders. Cornstalk rental service providers were also recognised for their importance, as they built cornstalk storage facilities for other value chain actors. SARDA identified producers and marketers as the most important, emphasising that quality begins at the farm. In addition, farmers and aggregators, involved in storing onions, are receptive to innovations aimed at reducing post-harvest losses. NOPPMAN identified farmers, storage rental service providers, and aggregators as the most important actors in reducing post-harvest losses and improving food safety.

4.2.4 Policies

The Local Government Areas (LGAs), the national government, and the Department of Agriculture in Nigeria play crucial roles in addressing issues related to onion consumption, climate change, and infrastructure. The LGAs are responsible for local agricultural policies and support to farmers, helping them adapt to the demographic shifts and urbanisation trends that are increasing onion demand. The national government, on the other hand, is focused on creating and implementing broader policies that address climate change impacts on agriculture, including onion farming. This involves investing in research and development of resilient agricultural practices and technologies. The Department of Agriculture is key in improving agricultural infrastructure, such as transportation networks and storage facilities, to enhance the efficiency of the onion supply chain. Interviewed stakeholders argued that there is as a lack of government support through enabling policies, regulatory hurdles, infrastructural deficits, and financial constraints. LGAs highlighted that government policies on the informal sector create difficulties for value chain actors in accessing finance. NGOs also noted that government policies are not encouraging and hinder innovations and pointed out factors such as insecurity, a lack of capital for investment, and the absence of government subsidies for inputs as challenges affecting the adoption of innovations.

4.2.5 Infrastructure

The state of infrastructure in Nigeria plays an important role in the trade of onions, impacting both local markets and regional exports. Efficient transportation networks, including roads, and storage facilities, are essential for the timely and safe delivery of onions from farms to markets. However, Nigeria's infrastructure is often inadequate, with many rural areas lacking good roads and reliable storage options. This can lead to significant post-harvest losses, as onions are perishable and sensitive to poor handling and delays. SARDA mentioned the importance of Sarkin Albasa, aggregators, and storage rental facility providers as key infrastructure for the sector.

4.3 Motivations, strategies and sensitivity to incentives

4.3.1 Risks, challenges or constraints associated with being in the informal sector

Each value chain segment within the onion supply chain faces distinct challenges and risks, although some general constraints are shared across all segments. Across all major actor categories in the onion supply chain, actors consistently identified price instability, lack of access to credit facilities, and the absence of government registration resulting in exclusion from government support and programs as the biggest challenges and risks associated with operating in the informal sector.

Some specific value chain segment challenges are noted:

For *farmers*, challenges encompass the lack of government recognition, resulting in exclusion from support and training initiatives as the government has no means of reaching them. Additional hurdles include insufficient capital and an inability to access capital from a formal entity which prevents them from expanding operations, pest and disease outbreaks driving up production costs, accessing insurance coverage to protect them against natural disasters and substantial losses during glut periods due to wastage and low sales prices.

> 'There are a lot of disadvantages from my view being in this sector. We have limited access to financial support especially from lending institutes. If your friend or relative cannot support your farming then your business is at risk of collapse.'
> Onion farmer from Sokoto

Aggregators encounter major challenges include insufficient capital for business operations, excessive and unstructured government taxation, limited or non-existent structured access to international markets (underlined by challenges with customs at the border), heightened perishability concerns during the wet season, a lack of trust among value chain actors, subpar produce quality from farmers as there are no

institutionalised standards, and a lack of unity among aggregators. Notable risks include the absence of legal protection, lack of insurance coverage, sales during surplus periods leading to losses, and fluctuating onion supply.

Dealers struggle with challenges such as inadequate capital, price instability, intense competition among dealers, limited access to credit facilities, excessive taxation, restricted growth opportunities, and exclusion from government programmes.

> 'As the business is not regulated, it has free entrance to anybody making competition very stiff, prices fluctuate unpredictably and sometimes lead to very low sales, especially during the glut season as supply itself is not controlled. Another challenge is access to funds. The business requires sufficient funding during the lean season as the prices of onions skyrockets.'
> Onion dealer from Kaduna

Wholesalers face issues like defaulting customers as there is no formal written agreement of transaction, and this can lead to debt. Transaction irregularities stemming from the sectors' informal nature and occasional business closures also contribute to wholesalers losing money. Tribal conflicts and violence in the south region, mistrust in agents and aggregators, price volatility, occasional low sales, wastage due to the perishable nature of onions, lack of government registration, occasional accidents involving transport vehicles with no insurance, and rising transport costs and other inflationary pressures are also challenges that wholesalers reported.

> 'Every business has its own risk. Failed transaction/debt is a major risk in this business. Sometimes we sell to customers on credit and the customers do not end up paying back the money due to unplanned circumstances. Maybe the customers die; since there is no formal written agreement between us or formal documentation, there is no way to recover the money from the diseased family. Accident or vehicular breakdown [is another challenge]. Transporting onions from the north to the south [poses] a lot of risk due to the poor state of the road, [and other] unforeseen circumstances which could lead to massive losses for the owners of the good on-board.'
> Onion wholesaler from Ibadan

Retailers struggle with challenges and risks including onion perishability (resulting in wastage and losses), a lack of insurance, transportation logistics problems, inflation, price instability, insufficient knowledge of appropriate storage methods, and poor-quality onions sourced from traders as there is no regulated and uniform standardisation.

Interviewed *LGA* representatives pointed out that the primary challenge in dealing with the informal sector is their resistance to change. They expressed that this resistance extends to a reluctance to pay any levies and a disinterest in becoming part of any cooperative or government-recognised body. NGOs identified a lack of education, resistance to change, and a general reluctance to join cooperatives as the main challenges when working with the informal sector. NAERLS echoed similar sentiments, highlighting that the informal sector lacks coordination, often working as individuals rather than as a group. AFAN noted that farmers may sometimes request money before adopting new practices but also emphasised an opportunity – they are willing to adopt innovations that can reduce losses and increase yields. In other words, farmers are more interested in immediate (short-term) rather than long-term benefits of an innovation.

SARDA acknowledged resistance to change but also stated that the informal sector is more likely to adopt innovations if they have previously proven beneficial. NOPPMAN cited a challenge in the misinterpretation of information by the informal sector. However, they mentioned that once trust is established, these actors are more receptive to accepting innovations.

4.3.2 Trust: relationships among value chain actors

In the area of influence, across the entire onion value chain, value chain actors stress the importance of collective influence rather than individual impact on both the onion and the broader fruit and vegetable value chains. While stakeholders in the onion value chain mostly exhibit mutual relationships via intra/inter trading, there is also some rivalry. For example, all interviewed farmers emphasised that their relationships with aggregators and dealers were built on mutual trust and respect. Some farmers stated that aggregators occasionally provided new seed varieties based on consumer preferences and, in return, farmers also offer advice on optimal methods for onion preservation.

Aggregators engage agents to purchase from farmers in different locations, especially in rural areas. Aggregators and agents maintain positive relationships with farmers and transporters. They also provide credit facilities to farmers for purchasing inputs and fertilisers, to be repaid with onions after the harvest. The activities of aggregators also exert a collective influence on other value chains, such as tomato and pepper businesses. General meetings are occasionally held with other value chain actors in the horticulture sectors to address common issues. Some aggregators mentioned influencing cabbage and carrot value chain actors through joint transportation and information sharing. They also note that onion scarcity affects tomato and pepper prices due to the interdependence of these markets.

Dealers ensure the consistent quality of products and collaborate well with other value chain actors. They buy from aggregators during the dry season and from nearby farmers during the wet season. They noted that price determination is a collective effort rather than an individual decision.

Dealers also acknowledge competition between onion and tomato value chains, especially during the peak season for transporters.

Wholesalers typically purchase from the north and sell in the south. Their activities also influence the availability, price, and types of onions in the market. Retailers highlight their positive relationships with wholesalers and other value chain actors.

4.3.3 Reciprocity

Transactions within the value chain are rooted in reciprocal exchanges, facilitating access to scarce resources such as land and capital. Farmers, traders, and other stakeholders engage in networks of mutual dependency, where obligations are forged through past favours and assistance. This reliance on reciprocity enables informal traders to navigate challenges in accessing essential inputs and services, which are often scarce or unavailable through formal channels. For instance, interviewed onion traders indicate that they leverage reciprocal relationships to secure credit facilities or delayed payments, ensuring the uninterrupted flow of goods and sustaining their operations within the informal market. Thus, reciprocity emerges as a strategic tactic employed by actors in the onion sector.

4.3.4 Motivations for running business in the informal sector and its implications for food system outcomes

The primary motivations for participating in the onion supply chain are income generation and profit maximisation. In addition, actors in the onion supply chain pointed to the flexibility of the supply chain and the absence of administrative burdens associated with formal sectors as other motivating factors.

> ‘The primary motivation is to make money to take care of my wards. The business itself belongs to the informal sector, thereby making everything unregulated. For example, I just decided to take up this space to sell my goods, no registration, no consultation with anyone etc. That is most likely not acceptable in formal business. My business contributes to food and nutritional security no doubt but of course that is distant thinking. I am here to make money.’
> Onion dealer, Kaduna

Aside from the primary motivation of making money, secondary motivations were also identified. Farmers mentioned a desire to create and strengthen a family business (often inherited), job security, and the aspiration to enhance food availability and security. Aggregators and dealers cited motivations beyond profit, including the goal of ensuring year-round food availability and nutritional security, fostering amicable relationships with other value chain actors, and receiving support from family, friends, and customers. Wholesalers emphasised employment creation and contributions to food and nutritional security as secondary motivating factors. Retailers, on the other hand, emphasised daily high sales from customers and using the business as a source of sustenance.

> 'What motivates me are many. It creates employment for me and others that work for me. It has reasonable profitability. Last month, I wedded and bought a new car from the proceeds of this business.'
> Onion wholesaler, Ibadan

From the perspective of the value chain enablers – opinions on what motivated the onion actors ensued. LGAs stated that the principal motive of value chain actors is to improve their standards of living. NGOs expressed that their principal motives are to make a profit, create employment for themselves and others, and contribute to food security. NAERLS mentioned that the primary motive is to make money from the business, with the secondary motive being to support food security and create a sustainable food system. AFAN indicated that their motive is to make money and reduce post-harvest losses. SARDA stated that their primary motive is to make a profit, while NOPPMAN highlighted an increase in returns on investment as their primary motive.

Contributions of the onions business to value chain actors' livelihoods can be read in the following testimonies.

> 'The business is profitable with good interest. I make more profit in the dry season and have more customers at the same time. It is a good business because the proceeds from the business helps me in meeting my basic family need.'
> Onion farmer, Kaduna

> 'The business is profitable and good business. Had it been there is no profit we could have left this business since. From this business I take care of my family. I pay my children school fees from the profit that I am making.'
> Onion aggregator, Kaduna

> 'Based upon years of experience I testify this business as a profitable one. I have built houses, I own vehicles and I help others all with the profit I have generated.'
> Onion dealer, Sokoto

> 'The connection I'm making with different people, the places I have visited gave me kind of courage that I need to do more expanding the business. [The] onion sector has provided people with employment without education. It is a sector that feeds millions of smallholder farmers [who have] never been to school. The business is flexible and autonomous.'
> Onion dealer, Sokoto

4.3.5 Income: profitability of the business

All interviewed stakeholders in the onion supply chain (including farmers, aggregators, dealers, wholesalers, and retailers), unanimously acknowledged the profitability of onion farming and trading. However, they emphasised that profitability is intricately tied to the season of production, with the lowest returns occurring during the peak season and the highest during the lean period. Farmers specifically highlighted increased profitability during the dry season, particularly when the product is scarce and retail prices are high. This heightened profitability serves as an incentive, attracting more individuals to engage in onion farming and trading. The interplay of demand and supply trends also significantly impacts profitability, with a noticeable surge in onion prices in recent years. Farmers employ various strategies to enhance profitability, including diversifying onion species by cultivating more profitable varieties which command a premium price. Additionally, farmers classify onions into large, medium, and small sizes, selling them at different prices to maximise profit. Storing onions from the peak period for sale during the lean period, when onions become scarce, is another practiced strategy. A bag of onions, which might fetch 15,000 (USD 9.90) to 20,000 Naira (USD 13) during the peak period, can command prices as high as 100,000 Naira (USD 66) during the lean period.

> 'Onion is a very good business. I started decades back. Through the profit I got, I have grown from producing 15 bags to 300 bags. Had I not made profits, I would not achieve that. If I invested 1.5m Naira (USD 990) in a season to grow and store, later when the market demand is high I used to make over 7m Naira (USD 4,620) return on investment.'
> Onion farmer from Sokoto

Aggregators also report substantial improvements in their standard of living attributed to trading in onions. Notably, a specific aggregator could generate up to 1m Naira (USD 659) from a trailer of onions, containing about 300 bags. Dealers could experience notable profits of 30,000 Naira (USD 20) per bag during periods of scarcity.

4.3.6 Strategies for coping with business risks

Stakeholders across all segments of the onion supply chain acknowledged playing diverse roles and providing various services to mitigate post-harvest losses. The predominant driving force for their actions is the protection of their investments, underscoring a profit-driven motivation.

Many strategies are employed within the supply chain to address the unpredictable risks associated with the onion business to ensure the sustainability of these businesses. Onion farmers identified several business risks and corresponding coping strategies to manage these challenges. Risks included a lack of water for irrigation during the dry season, which they address by installing solar-powered boreholes or purchasing pumping machines. Farmers also faced challenges from unfavourable weather conditions for which they sought advice from weather forecasters to navigate this challenge during planting and harvesting. Other risks involved their inability to repay loans, which farmers resolved by providing onions equivalent to the loan value to creditors.

> 'The loan I used to collect from my brother after I shared to other farmers, there would be a time when we are hit by low harvest or poor pricing that I cannot meet up to pay back the loan. The strategy is to give him to hold the onion base on agreement for some times until the market price appreciates.'
> Onion farmer, Sokoto

Pest infestations required the application of pesticides, while surplus harvests leading to poor prices and poor-quality harvests were managed by having multiple farms, ensuring that a specific problem would not impact all farms simultaneously. Most farmers also reported cultivating other crops (such as tomatoes, maize, potatoes, millet, and rice), although onions remained their major crop – a characteristic feature of smallholder farmers. The percentage contribution of onion farming to the household income of farmers ranged from 70 to 90%. Other farmers engaged in non-farming activities, such as selling motorcycles and collecting herbs, to supplement their income from onion farming.

'The business has little risk such as pest infestation, unfavourable weather condition, fluctuating sales of onion among others. The best strategy I used is to have more than one farm so that if one farm fails, I can depend on the proceed from the other one.'
Onion farmer, Kaduna

Other risk mitigation measures to deal with post-harvest losses by farmers include building cornstalks huts (a local storage facility called *rudu* in the local language) to store onions to ensure adequate ventilation during storage, stopping irrigation a week before harvesting to reduce the moisture content of the onions, routine checks to remove spoiled onions and prevent cross-contamination in storage, utilisation of quality seeds, and careful application of pesticides and fertilisers. Notably, farmers exercise caution in the use of inorganic fertilisers when planning for storage. They believe that over-application of fertilisers hastens the rotting of onions.

Figure 4.1 *Cornstalk hut used for storage of onions*
Source: Authors' own.

Aggregators and dealers face challenges such as a lack of capital and access to credit facilities, which they resolved by obtaining soft loans from associations or relatives. Strategies to deal with poor-quality onions from farmers involves supporting farmers with technical advice on suitable seeds before the planting season. Price instability is another challenge mentioned by most midstream actors and is managed through continuous market intelligence. This enables aggregators and dealers to speculate by stocking extra onions. Wastage due to inadequate infrastructure and storage facilities is mitigated by receiving onions in batches and the use of effective local storage facilities. Customs-related issues at the border were managed through relationship building.

> ‘The risk is price fluctuation and unpredictability in the future supply/demand. The strategy I used is proper market intelligence. Once I noted from ear say that price will increase, I will stock more than the usual onions. Sometimes, it does not work as planned.’
> Onion dealer, Kaduna

> ‘We see our forefathers constructing a hut like structure where they make a bed of cornstalk inside, placing a cover at the top, the cover is removed during the day and closed at night. This structure was used for the past two decades. We are now using rudu – a cornstalk structure for storing of onion. It is made up of cornstalk, rice straw and sticks. It is [thought to be a] better storage facility by all actors within the value chain than the old storage used by our fathers. Another invention is the jute bag which we are now using to transport onions to distant markets.’
> Onion aggregator, Sokoto

Defaulting customers were managed by asking customers to make partial payments in advance, and an increase in onion prices leading to a higher capital requirement is addressed through careful financial planning.

> ‘During market glut we are experiencing loss. You may buy from farmers at 10,000 Naira (USD 7) and when you reach the market the price may dropped to 7,000 Naira (USD 4.60) or below, and don’t forget you have to pay the transporter and labour for offload. However within same day another market price may appreciate above that. One can communicate and take it to other markets. In that glut period the onion would exceed our storage capacity, therefore we strives hard to look for where to take it in order to reduce the stress of losses. Sometimes we sold at lower price depending on the quantity, while the remaining we stored for longer periods to compensate the lost and give us back more profit than during the glut.’
> Onion aggregator, Sokoto

Aggregators also engage in trading other commodities such as palm oil, pepper, beans, rice, and guinea corn during the onion offseason. The percentage contribution of onions to their household income ranged from 30 to 100%. Five out of six aggregators identified onion trading as their primary business, with contributions to household income ranging from 60 to 100%. However, one aggregator derived only about 30% of their income from onion farming.

Dealers also emphasised the importance of other mitigation methods, including ensuring proper ventilation, regular inspections to remove spoiled onions and prevent cross-contamination, using only jute bags for transport, instructing and educating other value chain actors on proper onion handling, collectively storing onions in market-constructed storage units, and counselling farmers against premature harvesting until onions are sufficiently dry.

> ‘The new innovation is the way we build our storage now. Initially, [we] spread our onions directly on the floor which aids spoilage, but now we usually use cornstalk beds in preserving the onion compared to just pouring it on the floor. The cornstalk bed helps in making the onions look very clean and you don’t see black patches on the onion.’
> Onion dealer – Kaduna

Wholesalers adopted coping strategies to address the risk of spoilage, including ensuring adequate ventilation for onions in jute bags and dividing the contents of jute bags into baskets to further aid ventilation. To further underscore the importance of avoiding onion wastage, wholesalers utilise pricing as a tool to prevent losses by adjusting prices based on onion volume, that is, by selling at reduced prices in order to drive sales

To manage surplus onions during the glut, wholesalers rented warehouses for temporary storage. Collaborative efforts, such as collectively hiring vehicles (i.e. a wholesaler not having all his goods in a single vehicle), helped spread the risk in case of vehicle accidents. Calculated purchasing decisions were also made in response to fluctuations in onion supply chain prices. All interviewed wholesalers solely focused on selling

onions, representing the group with the lowest level of income diversification. However, one wholesaler expressed plans to diversify in the future.

> 'To cope with the risk of glut, I make calculated purchases and also make prior contact with the buyers to get their [provisional] orders before making orders from the north. To cope with the risk of wastage, once the onions arrive and we notice anything unusual, we unbag them and put them in the basket for ventilation. Also, when arranging those ones in jute bags, we do it in separate columns with space in-between to aid ventilation. We also cover the bags with nylon overnight to prevent dew.'
> Onion wholesaler, Ibadan

Retailers address the risk of spoilage by sorting and selling onions likely to spoil at reduced prices.

Their strategies include spreading onions on a plain floor inside a building for ventilation, and avoiding sack bags in favour of jute bags for transport. Staying informed about prices in the onion supply chain is important so they conduct market studies so they can make informed decisions on the quantity of onions to purchase. They primarily engage in onion trading, with two-thirds selling only onions. One retailer, whose primary trade item is onions, also traded pepper and tomatoes.

Except for one farmer who emphasised individual risk mitigation efforts, most farmers acknowledged the importance of collaborative measures to address risks. For example, they actively engage with other stakeholders in the supply chain to collectively find solutions to shared challenges. Collaborative efforts extend to jointly exploring alternative water sources, such as digging wells, to mitigate water scarcity issues. Farmers also come together to meet with traditional rulers and market organisations, fostering a collaborative approach to addressing common concerns, and they actively share critical market information among themselves.

Aggregators similarly highlighted their collaborative initiatives to mitigate risks. They play a role in recommending suitable seeds to farmers and participate with other value chain actors in joint meetings with LGAs to collectively address issues affecting the entire supply chain. Notably, aggregators cited instances of cooperation with other fruit and vegetable stakeholders, during transportation challenges, where vehicles carrying onions might be given priority due to the perishable nature of the product, even when faced with traffic. A significant portion of dealers acknowledged collaborating with farmers to identify water sources for irrigation and, at times, facilitate part-payment arrangements for long-time customers who are wholesalers. Even those dealers who emphasised individual risk mitigation practices acknowledged sharing market information with friends in the business. Wholesalers expressed a strong commitment to collaborative efforts to mitigate risks, particularly through joint initiatives like vehicle hiring and warehouse renting. Most retailers also affirmed their involvement in collaborative practices, particularly in the joint transport of onions to reduce overall transportation costs.

4.4 Incentives and disincentives for the adoption of innovations

In this segment, we provide a summary of the various factors that encourage or discourage the adoption of innovations. The onion supply chain is continually evolving, demanding diverse strategies to navigate challenges, mitigate risks, and capitalise on opportunities forcing actors across every stage of the onion value chain to be flexible to adopting change. The adoption of innovations is one way stakeholders in the value chain can strengthen their resilience, with major innovations in demand centring around storage and transportation of onions.

4.4.1 Potential disincentives for the adoption of innovations

Factors contributing to the non-adoption of innovations include resistance to change, labour and capital requirements, and the awareness level among stakeholders. Other factors include the belief that existing technologies and practices are adequate, financial constraints, and a lack of capacity-building initiatives for innovation.

Farmers expressed constraints to adopt innovations such as water availability, uncertainty about the effectiveness of innovations, high costs, and a lack of technological know-how, ease of operation, and the availability of raw materials as negative influences on adoption. Many also pointed towards some resistance due to contentment with traditional practices, the high cost of improved seeds, and competition for raw materials for cornstalk hut construction.

Aggregators highlight negative influences on adoption, including a lack of funds for warehouse construction, labour-intensive, seasonal construction of cornstalk facilities, technical knowledge gaps, and a lack of government support and the cost and unavailability of jute bags. However, they acknowledged the positive influence of the effectiveness of innovations on adoption.

Dealers acknowledged limiting factors such as illiteracy, labour requirements, a lack of capital required to fund new innovations, and limited sources and availability of materials. They also identified challenges such as a lack of government support through enabling policies, regulatory hurdles, infrastructural deficits, and financial constraints.

At the retailing level, challenges to innovation included financial constraints, resistance from value chain actors to change, and a lack of expertise or skill sets to adopt innovations.

LGAs highlighted that government policies on the informal sector create difficulties for value chain actors in accessing finance. They also noted that some value chain actors exhibit poor attention during training or demonstrations, leading to inadequate retention and subsequent low adoption of innovations. Additionally, the lack of basic education is identified as a significant factor affecting the success of innovations.

NGOs also noted that government policies are not encouraging and hinder innovations and pointed out factors such as insecurity, a lack of capital for investment, and the absence of government subsidies for inputs as challenges affecting the adoption of innovations.

NAERLS identified a lack of access to finance as a factor hindering innovation, along with issues such as inadequate government policies and transparency in distributing support to value chain actors due to multifaceted corruption. NAERLS also echoed concerns about the unavailability of quality inputs, particularly fertilisers.

AFAN mentioned challenges including a lack of adequate knowledge and skills, absence of enabling policies, and a lack of proper follow-up after an innovation has been introduced. Also highlighted was challenges related to the procurement costs of innovations like compressed natural gas (CNG) and solar pumps.

SARDA pointed out that while resistance to change persists, other obstacles such as lack of access to finance, lack of awareness, inadequate training, a shortage of facilities for storage and transport, as well as discouraging policies – such as multiple informal and formal taxation – hinder innovations.

NOPPMAN identified challenges including the unavailability of quality inputs like seeds and fertilisers, the high cost of solar pumps, graders and sorters, a lack of access to knowledge and technologies, as well as a deficiency in basic education and skills, and the absence of red net bags in the market. Red net bags are commonly used in the onion sector since they allow for good air circulation, which is crucial for onions as it helps prevent moisture buildup and reduces the risk of mold and spoilage. In addition these bags are durable and can hold a significant weight, ensuring that the onions are well-protected during transportation and storage.

4.4.2 Potential incentives for innovations

The primary factors influencing the adoption of innovations across the onion supply chain are affordability, the availability of materials for innovations, their effectiveness, and their acceptability by various value chain actors. However, there are also numerous incentives that could encourage value chain actors to participate in or adopt innovations. These include government support, capacity building and strengthening, and the potential of the innovation to increase profitability.

Farmers highlighted affordability and the potential for marginal profit as key incentives for innovation adoption or participation. They expressed a desire for increased capital, access to farm inputs, pumping machines and solar boreholes, and quality seeds as additional motivators for innovation. Innovations that reduce labour, minimise post-harvest losses, and encompass modern storage and irrigation techniques were deemed appealing. Farmers emphasised the need for training and government support in subsidising input costs and constructing storage facilities.

> 'First, the effectiveness of the innovation, the financial benefits it brings and the low cost of adoption.'
> Onion dealer, Kaduna

Aggregators expressed a readiness to embrace innovations if they are durable, effective, and superior to existing methods. They identified government assistance in building modern warehouses, financial support, and the availability of extension officers for training as crucial incentives. They also emphasised that innovations should be simple, cost-effective, and capable of storing onions for extended periods, preferably more than 10 months. The potential for growth and development within the supply chain, coupled with support for farmers, is also highlighted as an encouraging factor.

Dealers emphasised that they adopt innovations to expand their customer base, and cited incentives such as government support for basic amenities, training, and capacity building. They stressed that innovations should lead to additional profits, reduce post-harvest losses, and be both effective and cost-efficient.

Wholesalers expressed a willingness to adopt innovations and emphasised the importance of innovations that were effective, increased sales and profit, reduced post-harvest losses, and were affordable and readily available. They suggested that champions of these innovations should identify critical stakeholders, particularly aggregators, who can influence others within the supply chain.

Retailers stated their contentment with existing practices but recognised the need for innovations to reduce waste at the wholesale level, thereby improving the quality of onions. They highlighted the potential for additional market opportunities, increased profits, and overall business development as key motivators for adopting innovations.

Enablers note that the drive for value chain actors to innovate and/or adopt innovation hinges on an increase in profitability and return on investment. LGAs emphasised that value chain players would be encouraged to innovate if it was easier for them to access inputs such as seeds, fertilisers, and chemicals. They further recommended that the government should make these inputs more readily available in rural areas. NGOs highlighted that value chain actors would be motivated to innovate if the innovation proves effective and increases profitability. NAERLS suggested that value chain players would be greatly encouraged to innovate through access to soft loans and additional support, including the provision of inputs, subsidies, and training. AFAN stressed that capacity building and the inclusion of value chain actors in government programs and support would serve as encouragement for them to innovate. SARDA mentioned that value chain players would be more likely to adopt innovations if it efficiently reduces costs, increases profitability, and minimises post-harvest losses. NOPPMAN stated that value chain actors would innovate if capacity building is provided, awareness is increased and such innovation should address a cogent problem like post-harvest losses.

Enablers also unanimously emphasised the crucial role of demonstrations in encouraging innovation within the informal onion supply chain. LGAs emphasised that farmers are more likely to innovate when they witness it firsthand and underscored the importance of contacting community leaders to organise farmers to attend. NGOs also stressed the significance of extension services in fostering innovation adoption. They

detailed their approach of having staff stationed in each of the 10 wards in the local government, guiding farmers on innovations, monitoring progress, and offering solutions to challenges. NAERLS highlighted one of its mandates to encourage farmers to adopt new technologies through demonstrations. They provided examples, such as the adoption of good agricultural practices, with farmers witnessing the tangible benefits. AFAN collaborates with community leaders to organise demonstrations featuring selected farmers who then serve as ambassadors for the innovations showcased. SARDA supports the informal sector by actively demonstrating innovations and supplements these efforts with informative flyers containing images of the showcased innovations. NOPPMAN emphasised the necessity of establishing trust and then facilitating a comparison and contrast between existing practices and new innovations to encourage adoption within the informal sector.

4.4.3 Successful innovations introduced along the onion supply chain

We observed a low level of adoption of innovations across the onion supply chain. However, certain innovations, such as the usage of jute bags for transporting onions and the implementation of cornstalk hut for onion storage, have been widely adopted.

Innovations adopted by farmers have primarily focused on pre-harvest practices. These innovations encompass adjustments in watering intervals, pesticides application techniques, use of cows for ploughing, and the adoption of hybrid and improved seeds for planting. Notable post-harvest innovations include the use of jute bags and the construction of cornstalk huts for onion storage, with some value chain actors asserting that cornstalk huts can store onions for 5 to 7 months. As such, the cornstalk hut has significantly reduced post-harvest losses by improving air circulation and ensuring that onions do not come into direct contact with the ground. The huts have enhanced the shelf life of onions, enabling storage for up to six months.

Aggregators identified a lack of innovations in the supply chain, with comparisons drawn to the pepper supply chain where solar dryers have been introduced. Nevertheless, several aggregators highlighted innovations in the bagging system, incorporating Pakistan bags, jute bags, and polythene (sack) bags. A particular preference was given to the use of jute bags for mid- and long-distance transportation of onions, and the use of net bags for cross-border transportation due to longer transit times. Other innovations detailed included cornstalk huts, mud silos, and mud huts for onion storage, along with adjustments in warehouse design to facilitate adequate ventilation. Additionally, an aggregator has transitioned to using vehicles for onion transport, replacing donkeys that were utilised in the past.

Dealers also reported adopting innovations, including adjustments in warehouse design, the use of cornstalk beds, and the adoption of jute bags and polythene bags. Tarpaulins for spreading onions, as well as the use of baskets and plastic crates for onions, were also mentioned as innovative practices. Wholesalers emphasised the adoption of jute bags which were popularised by NOPPMAN, though some still prefer sack bags due to their fuller appearance. The adoption of jute bags is noted to be location-specific, with onions from Sokoto typically stored in jute bags and those from Bornu often in sack bags. Drip irrigation is also highlighted as an innovation used by some farmers by a trader. At the retailing level, jute bags were identified as the most significant innovation by retailers, although some mentioned that innovations in the supply chain are more relevant to farmers.

According to LGAs, a significant innovation introduced by the East-West Seeds Company involves changes in planting spacing in onions, increasing it from less than 20 cm to a range of 20-30 cm. Another innovation is the practice of spreading onions on tarpaulins rather than on bare floors during trading at the markets. NGOs highlighted various innovations in the sector, including the adoption of improved seeds and advancements in farming methods such as irrigation, fertilisation, and harvesting. AFAN identified innovations that contribute to cost savings and reduce post-harvest losses, such as the use of CNG pumps, solar pumps, cultural practice like cornstalk structures and red mesh/net bags for storage. SARDA mentioned innovations in nursery establishment techniques, packaging, storage, and transportation of onions. NOPPMAN highlighted innovations including improved seeds for farmers, solar pumps, sorters, graders, red net bags, and cornstalk structures.

4.4.4 Factors affecting the adoption of cornstalk structures and jute bags

Key factors highlighted by onion supply chain stakeholders contributing to the success of these innovations include their effectiveness in solving the problem of wastage and reducing post-harvest losses, affordability, and the potential to increase profitability. Farmers specifically noted that these innovations, such as cornstalk huts, have successfully reduced post-harvest losses, proving to be effective solutions that enhance ventilation and decrease losses, ultimately increasing profits. For instance, cornstalk huts were emphasised for their ability to absorb moisture from onions, providing increased ventilation and contributing to reduced losses. The ease of sourcing and local availability of the materials needed for cornstalk beds is also noted as a success factor, however the non-recyclable nature of cornstalk storage necessitates the construction of new ones every season, which leads to high competition for limited local materials and labour, which was a challenge noted by many in the supply chain. In addition, the cost of an empty jute bag not being competitive compare to sack bag discourages its use particularly during the peak period when price of a bag of onion is not more than 12,000 Naira.

Among highlighted the unavailability of Pakistan (net) bags in the market, the higher cost and limited availability of jute bags compared to polythene or sack bags, and the need for cornstalk construction to be carried out annually.

Dealers and wholesalers also raised concerns about the cost and non-availability of jute bags as a significant limiting factor to their adoption. Other obstacles highlighted by wholesalers include the necessity of using additional coverings with jute bags, the unacceptability of net bags as a standard unit of measurement, and the location-specific adoption of jute bags – for instance, they are widely accepted in Sokoto but not in Jigawa and Borno.

4.5 How innovations are contributing to food system outcomes

It is interesting to note that the two innovations acknowledged to be the most impactful by value chain actors (cornstalk huts and jute bags), were both locally innovated and conceived. Our study indicates that value chain stakeholders predominantly prioritise innovations aimed at achieving economic outcomes within the food system, while giving comparatively less attention to environmental sustainability and access to healthy and safe food.

> ‘Rudu or cornstalk structure has materials from rice straw that suck milky sap from injured bulbs [and] air circulates from beneath making it dry all the time. This makes the onion dry very well making it stay longer. This structure is the lasting solution to onion [value chain] actors. It has proved to be very effective.’
> Onion farmer, Sokoto

> ‘The use of and spreading onions on the rice straw and sand on the floor, we still later noticed damp penetration. Onion from the top will look good, not knowing the one under has been rotten. This idea was since then abandoned after we realised using rudu.’
> Onion farmer, Sokoto

Jute bags, employed for long-distance transportation of onions, help to preserve onion quality by encouraging ventilation and providing protection against external impacts during handling. The jute bags have been shown to reduce waste compared to the use of polythene bags (sack bags). For shorter journeys, from the farm to nearby markets, some farmers have stated that they have begun to create holes in sack bags to improve ventilation (see Figure 4.2A). Traders also stated that baskets had helped to reduce post-harvest losses at wholesale and retail levels, while net bags were considered superior in minimising wastage compares to jute bag during a long-distance travel, especially cross-border transactions.

'Actors across the chain accept [the jute bag] as a unit of measurement. It also creates a business opportunity. There are merchants who have taken it upon themselves to make the bags available at the production and trading hubs in the north. They can buy from manufacturing company [in the south] at 600 Naira (USD 0.40) and sell at 1,400 Naira (USD 0.95) in the north. They also scout for the used bags from retailers who have taken them into different markets in the south, buy the bags from them, aggregate and send them to the north.'
Wholesaler, Ibadan

Figure 4.2 *Some of the packaging materials used: A: Polythene bags (sack bags), with holes created to improve ventilation; B: Jute bag; C: Net bag*
Source: Authors' own.

Other innovations that have improved the production and quality of onions at production level include the use of cattle for ploughing, which is a quicker and more accessible alternative to manual hoeing. Farmers can easily hire a cattle owner who specialises in ploughing, as it is less costly than using a tractor and more readily available. Weekly irrigation practices were recognised for reducing the rotting of onion seedlings. AFAN noted that CNG irrigation pumps simplified irrigation processes and reduced production costs, while solar irrigation pumps, being climate-friendly, significantly lowered production costs by eliminating the need for fuel. NGOs also noted that the adoption of improved (hybrid) seeds with disease resistance had resulted in higher yields and improved product quality. Overall, both NAERLS and AFAN mentioned that the adoption of good agronomic practices had increased farmers' productivity, reduced chemical usage, improved shelf-life, decreased post-harvest losses and boosted their income, leading to improved livelihood status.

The use of vehicles to transport onions – which are capable of handling 500 bags per day compared to donkeys which could only manage 100 bags per day – have also expedited the delivery of onions to markets. Adjustments in warehouse design such as improved ventilation have also reduced post-harvest losses for aggregators and dealers, and traders noted that spreading onions on tarpaulins attracted new customers, enhanced the overall appearance of onions, and contributed to increased sales. According to LGAs, the impact of past innovations such as the net bags has been significant in reducing post-harvest losses, enhancing product quality, extending the shelf life of onions, and preserving their freshness.

4.5.1 Post-harvest losses are acknowledged by all stakeholders in the sector

Post-harvest losses are a significant challenge, acknowledged by all stakeholders in the onion supply chain. There is unanimous agreement that such losses lead to a considerable reduction in income derived from onion farming and trading. Farmers express the belief that post-harvest losses could reach alarming levels of 80-95% if essential measures, such as adoption of appropriate bagging systems and storage methods were not implemented.

'Post-harvest loss poses significant losses in onion production. If care is not taken a farmer may lose up to 80% of total production. Bagging and storage system are our major issues; if not handled very well would lead to post-harvest loss despite improve seed and improve management.'
Onion farmer, Sokoto

Farmers recognise the seasonal differences, noting that dry season onions generally have a longer shelf life compared to wet season onions. Dry season onions have lower moisture content because water supply can be controlled, with irrigation typically stopped a week or more before harvest. In contrast, wet season onions, with their high moisture content, are more perishable due to unpredictable rainfall that cannot be regulated.

Despite their awareness of these factors, farmers perceive themselves as facing relatively low risk of post-harvest losses because they sell their produce almost immediately after harvest to aggregators and dealers. However, they emphasise the challenge of glut periods, which force them to sell their onions quickly at reduced prices rather than storing them, especially during the wet season. Farmers believe the government could mitigate this issue by constructing more storage facilities.

While acknowledging post-harvest losses as a major concern, aggregators and wholesalers emphasise the mitigating potential of proper storage practices. Aggregators highlight the considerable price disparity between good-quality and spoiled onions in the market, underscoring the importance of adequate ventilation, appropriate storage methods, and good agricultural practices in minimising these losses. In addition, dealers also note that factors such as onion variety, type, and duration of storage are critical in reducing losses. Dealers further assert that post-harvest losses contribute to onion scarcity, thereby influencing market prices. Additionally, dealers and wholesalers stress the significance of meticulous handling and management during transportation, especially for exports that may span up to nine days in transit. Retailers recommended improvements in transportation logistics as a crucial step toward reducing post-harvest losses in the onion supply chain.

4.5.2 Food safety is recognised by most value chain actors

Most stakeholders in the onion supply chain recognise the significance of food safety within the sector, although there is a variance in their understanding of the issue. For example, some farmers were able to detail practices they believe contribute to food safety, such as discontinuing chemical applications of spray 2-3 weeks before harvest, and ensuring the cleanliness of onions by separating bulbs from sand debris. Cornstalk storage (preventing direct contact with the ground and reducing contamination with dust, dirt, and other environmental contaminants), the removal of spoiled or rotten onions to prevent cross-contamination, cleaning all bulbs after harvesting, discarding damaged onions and following guidelines from extension agents on food safety were also highlighted as important food safety measures. However, a few farmers observed that food safety is not universally prioritised, citing instances of indiscriminate herbicide purchases and the use of rat poison to deter rats from storage facilities.

Aggregators unanimously regarded food safety as important, though some considered it less critical in the onion supply chain compared to other fruit and vegetable supply chains. The emphasis was placed on maintaining a clean environment, achieved by elevating onions off the ground, thoroughly cleaning storage areas before use, and abstaining from chemical use before storing onions. Some aggregators highlighted the impact of farming practices on food safety, and indicated that excessive urea fertiliser could lead to rapid rotting and therefore reduce shelf-life. Other measures include installing nets in warehouses to deter rodents, cleaning and sorting onions before packaging, cleaning warehouses before and after use, storing only good onions and promptly selling others, and advising farmers to minimise the over-application of chemicals.

Dealers also stressed the importance of food safety, even though some did not view it as a major issue. They underscored the necessity of a clean environment to prevent infections, the importance of rat-proof storage facilities to prevent contamination related to diseases like Lassa fever, and the avoidance of chemical use during storage.

Wholesalers generally did not perceive food safety as a significant issue, asserting that they have adequate measures in place at their markets. Their measures include maintaining cleanliness, avoiding chemical use for onion storage, and not placing bags directly on the ground. However, some wholesalers recognised food safety concerns associated with pesticide use at the farm level.

Retailers also acknowledged the importance of food safety. At the *retailing* level they highlighted the maintenance of a clean environment to ensure food safety, and mentioned other measures including the avoidance of chemical use, prevention of rodent infestation, separation of spoiled onions from good ones, use of baskets that allow for ventilation, and adoption hygienic practices.

4.5.3 The contribution of the informal sector to food system outcomes

All the enablers acknowledged that the informal sector was a critical partner in improving food system outcomes, mainly targeting economic gains. But also food safety and reducing post-harvest losses have been mentioned as important aspects. LGAs mentioned that with adequate training, the informal sector could significantly reduce post-harvest losses and enhance food safety, and stated that cooperatives were best placed to help stakeholders adopt innovation, increase productivity, and enhance livelihoods. Specific strategies outlined included training and capacity building through demonstrations, and they stated that innovations like stalking and trellising were gradually being adopted because of demonstrations. LGAs highlighted how farmers were motivated to continue producing food during the COVID-19 disruption.

While NGOs believe that a lack of critical skills within the informal sector is a major cause of post-harvest losses and lack of food safety, they did highlight the contribution of the sector in ensuring continuous and year-round availability of food in the market, directly boosting their financial capacity and reducing poverty levels. NGOs also highlighted the importance of providing demonstrations for selected farmers, who then transfer the knowledge to others, i.e. using earlier successful adopters as innovation ambassadors.

NAERLS highlighted a direct correlation between poverty and the level of innovation adoption. Their experience indicates that adopters generally experience improved livelihoods and food and nutritional security, and reduced poverty levels compared to non-adopters. To increase innovation uptake, NAERLS therefore stated that the informal sector needs capacity building and support to become effective partners in reducing post-harvest losses and improving food safety. NAERLS also emphasised the importance of demonstrations and strengthening links across the value chain, in particular mentioning how some aggregators support farmers with inputs and are then repaid with onions.

AFAN underscored the contribution of the informal sector to the nation’s economy by creating jobs and offering services like logistics. They emphasised that the sector also contributes to government revenue, both through direct and indirect tax payments. AFAN noted that the informal sector did generally demonstrate a commitment to adopting innovations, such as when facilities to reduce post-harvest losses (such as storage systems) are introduced to them. AFAN also discussed the need to further strengthen strategies that improved interactions between aggregators and local and rural stakeholders such as traditional rulers.

SARDA stated that the informal sector was a leading source of employment, played a crucial role in poverty reduction, and ensured the availability and affordability of food, particularly for vulnerable and impoverished people. To further support the informal system to reduce post-harvest losses, SARDA stated that it was essential to reach out to traditional rulers, and other local actors through their traditional leadership structures, as they were influential figures whom all actors listened to.

NOPPMAN described the informal sector as the backbone of the economy by contributing to government revenue through tax payments and alleviating poverty through job creation, and considered the sector to be a strategic partner in strengthening the food system as they originate most local innovations aimed at reducing post-harvest losses. To further boost innovation uptake, NOPPMAN called for regular meetings to boost interaction between members, and for the introduction of innovations.

4.5.4 Examples of an innovations that have not been successful

Some farmers mentioned examples of unsuccessful innovations, including the introduction of a wooden structure for onion storage by Sokoto extension officers. The tall hut-like structure, which was covered by iron nets on all four sides was very light but allowed the rain to penetrate it, and using a tarpaulin for coverage then created unfavourable conditions for onions, causing temperatures inside to increase and the onions to rot. According to staff from the Sokoto Agricultural Development Project (SADP), the abandoned onion house storage was introduced by the National Special Program for Food Security (NSPFS) in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the market council.

Aggregators shared other instances of unsuccessful innovations, such as a net bag from Senegal that damaged the onions, a mud house lacking proper ventilation and structural support for the roof, a wooden storage structure that was too small and susceptible to water splash and limited in capacity, and a government-built structure in Sokoto state aiming to store a large number of onions that ultimately failed and has since been demolished.

Dealers also highlighted a storage unit made of wood and iron nets, which proved vulnerable to wind and rain due to its lightweight construction (see Figure 4.3). They noted that using tarpaulins to cover the structure, intended to prevent rain, led to heat generation and rotting of onions. Dealers and traders also mentioned net bags from Senegal, raising their doubts about its success given its smaller size compared to established units of measurement like jute and polythene bags.

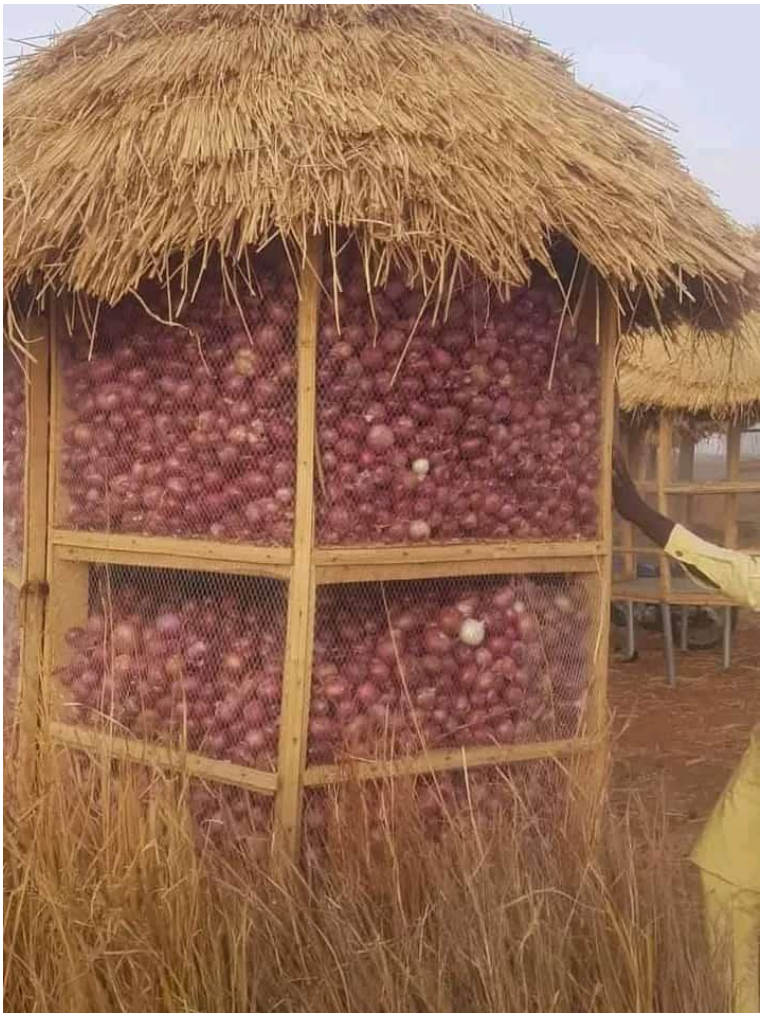

Figure 4.3 *Storage units*
Source: Authors' own.

5 Conclusions

5.1 Incentives and disincentives that drive food system innovation

In embracing innovation and fostering transformation in the food system, participants in the supply chain consider various motivating factors, both positive and negative, as they assess incentives and disincentives. This leads to diverse outcomes along the supply chain, ultimately generating dynamic changes within the food system.

One of the predominant challenges faced by many actors in the onion supply chain is effective post-harvest management. Onions are particularly prone to wastage, often attributed to inadequate management practices within the supply chain. Over the years, stakeholders have implemented various strategies to mitigate this risk, aiming to ensure profitability. These measures include storage methods after harvest, transportation procedures, and handling at marketplaces.

Cornstalk huts and jute bags have gained widespread recognition. These innovations, originating locally, have significantly contributed to addressing post-harvest challenges.

During the production and aggregation phases, stakeholders developed a local and productive means to store onions after harvest until more favourable market conditions arise. This cornstalk storage, a traditional method sometimes referred to as a local onion silo, comes in various sizes capable of accommodating different bag quantities. It is entirely locally initiated and remains the most effective available storage methods. The cornstalk and bamboo structure, which is portable and elevated by 6 to 7 sticks, enables onions to last for over five months, contingent on the onion variety and farmer's management practices.

Considered superior to other bags, the jute bag is the most widely adopted among supply chain actors. Its soft texture, in contrast to polyethylene sacks, and interwoven spaces promotes proper air circulation. Composed of plant biomass, the bag allows free air spaces that aids in preserving onions during long-distance journeys. While highly useful during transportation and temporary storage in markets before sales, it does not completely prevent water penetration.

In the interviews conducted, certain motivating and discouraging factors influencing the behavioural shifts of participants in the onion value were noted. Overall, the collective change in behaviour revolved around participants aiming to maximise profits and safeguard their investments (Table 5.1). In the table, we distinguish between internal and external incentives. Internal incentives refer to motivations that originate from within an individual or organisation. On the other hand, external incentives come from external sources, such as other individuals, organisations, or stakeholders.

Our study also shows that value chain stakeholders primarily adopt innovation related to economic food system outcomes, with less consideration given to other food system environmental sustainability or access to healthy and safe food.

Table 5.1 *Summary of incentives and disincentives per actor*

Actor	Incentives	Disincentives
Farmers	**> internal** • Longer shelf life, high quality product, increase marginal profit **> external** • Aggregator providing price incentives, inputs and cash support during production season • NGOs and government providing extension services, inputs and GAP training	• Cost of adopting improved seeds and complimentary good agronomic practices with little or no external support. • Inability of farmers to engage in storage due to limited infrastructure and a lack of finance to create new facilities. • Use of cornstalk huts for storage require reconstruction every season and competition for construction materials (within onion value chain actors and even other value chain actors) could be stiff during the peak season. • Cost of constructing cornstalk structures, including labour cost could be high and unaffordable. • Lack of technical knowledge and limited capacity to innovate. • Farmers being forced to sell by aggregators using price incentives and indebtedness as tools. • Adoption of jute bags are not encouraged and mandated to start from the farmgate as farmers are allowed to use any or no bagging systems, contributing to food loss in the chain. Aggregators do not pay farmers based on adoption of preservation and good handling innovations hence discouraging farmers to have a shift in behaviour. • Lack of adequate record keeping and formalisation of transactions within or between segments' actors.
Aggregators	**> internal** • Longer shelf life, potential for price speculation and appreciation towards lean • Season aiding profit maximisation High disparity in selling prices between different grades of onions Adoption of jute bags as a unit of measurement and transportation of onions due to acceptability and adoption across the chain **> external** • Farmers loyalty to aggregators to aid stable produce flow to them • Dealers and wholesalers are trusted to deal with recognised aggregators rather than directly with farmers	• Unavailability of both new and used jute bags during peak season. • The high cost of a jute bag discourages its use during the peak season. • The construction or rental cost of cornstalk structures and concrete storage units can be very high, therefore requiring high levels of capital. • The unacceptability of a net bag as a visual unit of measurement of onions in local markets and its unavailability discourages its adoption. • Lack of technical and knowledge capacity to innovate effective systems. • Encroachment by other actors in the chain of territory exclusively the reserve for aggregators (i.e. dealers, wholesalers). • Few or no government or external support compared to what is offered to farmers. • High chances of losing invested capital from supply of substandard onions, and dealing with unscrupulous agents and farmers. • Lack of adequate record keeping and formalisation of transactions within or between segments' actors.
Dealers (or brokers)	**> internal** • High quality aiding high profitability • Potential for price speculation • Maximisation of gap in price fluctuation • 7 **> external** • Regulated market entrance requirement for new actors to preserve competitiveness of existing dealers • Functioning market structure and regulation by market authority and government • Poor or no market standardisation. • Structured market leadership • Little or no risk taken by dealers (commission based) hence no motivation to improve the present system	• They can sell different quality onions at different prices as a lack of uniformity in standards discourages uniformity in prices. • Lack of technical and knowledge capacity to innovate effective systems. • High price fluctuation increases risks and rewards. • Unregulated and stiff competition between dealers in the same markets. • Unchecked and unscrupulous practices in the markets, and competition for the same customers using pricing and other tools. • Existing sales systems that encourage offloading of stock also discourages storage innovation and promotes trading of poor grade onions. • Excessive focus on farm level interventions at the expense of other segments of the chain. • There is a lack of motivation to innovate and embrace new ideas, with satisfaction derived from maintaining the current status quo. • Lack of adequate record keeping and formalisation of transactions within or between segments' actors. Dealers are paid on commission based so they are not incentives to maintain quality.

Actor	Incentives	Disincentives
Wholesalers	**> internal** • Longer shelf life, high quality produce, high profit margin **> external** • Willingness of dealers and aggregators to sell on credit • Business transactions occur even when the two actors have not seen each other before • Ease of handling and setting up logistics between the north and south • Little or no need for wholesalers to travel to the north to buy produce • Association influence on business structure	• Unavailability of both new and used jute bags during the peak season. • The high cost of a jute bag discourages its use during the peak season. • Limited storage space and associated costs. • Lack of technical and knowledge capacity to innovate effective systems. • Poor or no innovation introduction to this segment. • Excessive focus on farm level interventions at the expense of other segments of the chain. • Unchecked and unscrupulous practices in the markets and competition for the same customers using pricing and other tools. • High chance of losing invested capital from supply of substandard onions and dealing with unscrupulous agents and farmers. • Lack of adequate record keeping and formalisation of transactions within or between segments' actors.
Retailers	**> internal** • Higher volume of onions traded would mean greater profits **> external** • Access to credit facility from wholesalers • Freedom in price determination • Attraction of higher prices for selected graded onions supposedly bought as sub-standard • Customers willingness to pay more for quality products	• New technology/innovation does not add/create value for these actors. • Lack of influence over public logistic/transportation which could improve handlings. • Lack of technical and knowledge capacity to innovate effective systems. • Lack of adequate record keeping and formalisation of transactions within or between segments' actors.

5.2 Key strategies

To maintain competitiveness, each actor within the informal sector employs diverse strategies aimed at risk management, innovation facilitation, and exerting influence over product availability. The efficacy of these strategies, influenced by both internal and external factors, underscores the resilience observed within the onion value chain.

Diversification of production risks through mixed cropping practices, such as intercropping onions with tomatoes, cabbage, peppers, and other crops, is a common strategy employed by farmers. Additionally, the implementation of localised storage solutions during surplus periods contributes to enhanced income for farmers.

Key influencers within the supply chain, notably midstream actors such as aggregators, dealers, and wholesalers, employ price manipulation tactics to optimise procurement timing, quantities, and storage methods, all geared towards maximising individual profits. This assertion is substantiated by interviews conducted with these stakeholders. Profit maximisation serves as the primary driving force behind supply chain innovations and adaptations, with ancillary objectives including the sustenance of family enterprises and bolstering of food security.

The inherent risks associated with the informal sector, particularly within the onion industry, are rooted in inadequate infrastructure for post-harvest loss management which are insufficient governmental infrastructure management, insufficient knowledge of proper storage practices, limited credit access, taxation challenges, substandard storage and transportation measures, transparency issues, and barriers to international market access.

Collaborative efforts among supply chain actors, including bulk purchases, shared storage and transportation, utilisation of social capital for market intelligence, and establishment of informal market leadership structures, serve to mitigate some of these risks. Noteworthy among these efforts is the provision of support to farmers by onion aggregators, ensuring a stable supply through financial aid, provision of

inputs, and advisory services. These strategies have yielded positive outcomes, notably in reducing post-harvest losses and enhancing onion availability for urban consumers, thereby directly impacting food system outcomes.

5.3 Recommended pathways for midstream actors to contribute to food system outcomes

Midstream actors play a pivotal role by ensuring a consistent supply of onions from farmers to consumers, and also by providing essential support to farmers through financial assistance and input access.

By applying the framework as developed by de Steenhuijsen Piters et al. (forthcoming), we were able to address appropriate incentives and disincentives for different actors in the value chain, particularly dealers, aggregators and wholesalers. Based on the analysis, we have identified three key pathways to enhance the contribution of these actors within the informal sector to achieving food system outcomes:

- Innovative post-harvest solutions: Highlight the potential for profit maximisation through the adoption of innovative post-harvest solutions. Emphasise how reducing post-harvest losses can lead to increased profitability for dealers and wholesalers by reducing losses and maximising the saleable yield of onions. Showcase successful case studies or pilot projects where dealers and wholesalers have implemented efficient storage and transportation practices to improve product quality and extend shelf life, resulting in higher market prices and enhanced profitability.
- Introduce appropriate incentive mechanisms: Introduce incentive mechanisms to motivate and reward value chain actors for their involvement in adopting and promoting innovative practices. This could include providing financial incentives, recognition awards, or access to preferential market channels for actors that demonstrate exemplary performance in areas such as reducing post-harvest losses or improving transportation efficiency. By aligning incentives with desired outcomes, stakeholders can encourage the widespread adoption of innovative pathways and foster a culture of continuous improvement within the value chain.
- Collaborative knowledge sharing and capacity building: The role of knowledge sharing and capacity building in enabling dealers and wholesalers to identify and capitalise on new business opportunities needs to be demonstrated. Highlight how access to market intelligence, technical expertise, and training programs can enhance their ability to anticipate market trends and optimise profitability. Illustrate examples of successful value chain partnerships and collaborative initiatives where dealers and wholesalers have leveraged shared resources with other value chain actors and have gained expertise to overcome common challenges and achieve their mutual business objectives.

By addressing the appropriate incentives and disincentives for midstream actors, a conducive environment can be created for their active participation and collaboration in pathways aimed at enhancing food system outcomes. By aligning these pathways with the profit-maximisation motive of direct value chain actors (e.g. midstream actors) but also value chain enablers can more efficiently leverage market forces to drive positive changes within the value chain that ultimately contribute to achieving broader food system outcomes such as reducing food waste.

5.4 Reflections on the applied framework

Overall, conducting a case study on the Nigerian onion value chain using the Steenhuijsen Piters et al (forthcoming) framework provided valuable insights into the functioning of the informal sector and its role within the wider food system. This section provides some pertinent reflections on the framework's application:

- Clarity in understanding *drivers*: The framework provided a structured approach to understand the various internal and external drivers influencing decision-making within the onion value chain. It helped identify and categorise motives, incentives, and disincentives that shape the behaviour of actors at different stages of the value chain.
- Insights into the strategic *decision-making processes*: By using the framework, we gained insights into the decision-making processes of onion farmers, traders, processors, and other stakeholders. This understanding allowed us to assess how different factors, such as income generation, risk management and market dynamics, influenced their actions and strategies.
- Identification of key *challenges and opportunities*: Applying the framework highlighted key challenges faced by actors within the onion value chain, such as post-harvest losses, market access issues, and competition. It also revealed potential opportunities for improving efficiency, enhancing value addition, and increasing the competitiveness of the onion sector.
- *Contextual* understanding: The framework facilitated a contextual understanding of the onion value chain within the specific socio-economic and geographical context of Nigeria. It enabled the exploration of how factors like government policies, infrastructure limitations, and cultural norms impact the behaviour of actors and the functioning of the value chain.
- *Policy* implications: The insights generated from applying the framework will inform policy interventions aimed at supporting the onion value chain and promoting inclusive growth in the horticulture sector and the broader food system. By understanding the motivations and constraints of informal sector actors, policymakers can design more targeted and effective interventions to address their needs and challenges, and support food system transformation.

Through the onion case study, we observed how the framework captured the complexities of actors operating in the informal onion sector and its interaction with broader economic and social factors. This validation should be repeated in other sectors. Reflecting on the application of the framework to the case study would likely highlight its value in providing a systematic and comprehensive analysis of the onion value chain in Nigeria. The insights of this case study offer valuable insights for future research, policy development, and future interventions aimed at enhancing the performance and sustainability of the informal sector.

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REPORT 2024-113

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