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Research Supporting African MSMEs
To Provide Safe and Nutritious Food

Transformation of vegetable value chains in Nigeria: Spatial and seasonal lengthening & intensification

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About Research Supporting African MSMEs to Provide Safe and Nutrition Food (RSM2SNF)

The Research Supporting African MSMEs to Provide Safe and Nutritious Food (RSM2SNF) is funded by the Bill and Melinda Gates Foundation. RSM2SNF dives deep into the wholesale, logistics, processing, and retail segments of the value chains of several products, such as fish, tomato, and green leafy vegetables. The goal is to understand the midstream of these food value chains with a focus on Micro, Small and Medium Enterprises (MSMEs), and to inform policies and interventions to support MSMEs in providing safe and nutritious foods at affordable prices. This five-year project (2022–2026) is led by Michigan State University (MSU) working with partners in Nigeria and Tanzania.

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Abstract

The paper presents the results of a rapid reconnaissance done in 2022 of 150 nano, micro, and small firms and farms along the segments (input suppliers, farmers, wholesalers, logistics providers, and retailers) of the tomato and green leafy vegetable (GLV) value chains in the North and South of Nigeria. This study found that the tomato value chain has grown over time and features a substantial supply of tomatoes that has "lengthened geographically" from the North to a thousand kilometers to the South; even GLV, traditionally produced and sold in very short local supply chains, has in some parts of Nigeria lengthened to span several states. This spatial change has been facilitated by longer seasons where irrigation, especially of tomatoes, and the multiplication of tomato farming sites has resulted in steady output. A crucial segment in these value chains is wholesalers, who are primarily based in produce wholesale markets within cities and peri-urban areas. As these traders rely heavily on third party logistics services (3PLS), there is a clear need for more information on this understudied segment of the value chain, Additionally, while these vegetable value chains have grown quickly, becoming massive in volume and number of actors, each segment faces vulnerabilities to high costs and shocks such as of climate, gender inclusion, and environmental issues.

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AVC	Agrifood value chain
GLV	Green leafy vegetable
MSME	Micro, small, and medium enterprises
RSM2SNF	Research supporting African MSMEs to provide safe and nutritious food

1. Introduction

In this paper we analyze value chains of vegetables (tomatoes versus green leafy vegetables, GLV) in Nigeria. Tomatoes are among the three most important vegetables (onions, chilli peppers, and tomatoes) in the country in consumption terms (Parkhi et al., 2023). GLVs are also important, composed partly of indigenous greens and partly of non-indigenous greens such as spinach and cabbage.

Our analysis focuses on domestic value chains because vegetable imports and exports have tiny shares of consumption and output in Nigeria (and Sub-Saharan Africa, SSA, in general) (Figure 1). Macro data show rapid growth in domestic vegetable production in SSA and Nigeria over the past three decades. While FAOSTAT does not disaggregate vegetable production for GLV per se, it does provide data on tomatoes and products, other vegetables, and onions. Figure 2 shows the production values of aggregated vegetables, and tomatoes and products in millions of tons for both SSA and Nigeria from 1990 to 2020. Tomato tonnage in SSA jumped 5-fold (approximate 10/2) over those 3 decades, and in Nigeria, nearly 10-fold, from about 0.4m to 3.7m. Aggregate vegetables in SSA rose 3.1-fold, and in Nigeria, 3.4-fold.

The case of tomatoes is interesting and even spectacular. Tomato production in Nigeria grew 3 times faster than overall vegetables in Nigeria, a clear sign of a shift in the cuisine due to tomato's versatility in being incorporated into traditional dishes and the the diffusion of "rice jollof" based on tomato and onion). This growth is all the more surprising because tomatoes were introduced to SSA in the 1800s and tomatoes by 1990 were still a very minor crop in Nigeria, with 400,000 tons output (and 1,000 tons imported), representing just 42kg per person per year. By 2000, the output was already 1.3 million tons with 5,000 tons imported, so output represented 100kg per person per year. Only twenty years later (2020), output had grown almost threefold to 3.7 million tons a year, with 0.2 million tons of imports (down from 0.3m tons in 2010) with output per year per person at 170kg. In 2020, about 6.8 million tons of vegetables were produced in Nigeria (per FAOSTAT data), of which tomatoes were about 3.3 million (NAERLS & FMARD, 2020). This shows a rapid increase in tomato output overall (nearly 10-fold) and per person (4-fold) over a few decades.

We believe the paper makes three contributions to the SSA agricultural economics literature. First, the coverage of vegetables in that literature is small in comparison with vegetables importance in SSA food consumption. For instance, only 1% of the nearly 300 articles in AFJARE since its founding 15 years ago have been on vegetables. By contrast, Dolislager et al. (forthcoming) found, using LSMS data from 11 SSA countries that fruits and vegetables are 16% of urban, 15% of peri-urban, and 13% of rural food consumption (in value terms). These shares are more striking when compared with those of key cereals central to food debates. In Nigeria, vegetables and fruits are 13% of food consumption (11% vegetables, 2% fruit, a similar pattern to other SSA countries) (Parkhi et al. 2023). Compare that with the shares of the leading cereals (13% for rice and 7% for maize)..

Second, the coverage of domestic vegetable value chains in SSA agricultural economics has been small when compared to how important vegetable purchases (from value chains) are by SSA consumers in both urban and rural areas. For example, in Senegal (Faye et al. 2023), more than half the vegetable consumption is in urban areas, and in rural areas 76% is purchased; Smale et al. (2020) found in Mali 80% of rural vegetable consumption is purchased. Yet the great majority of articles focus only on vegetable farming; very few treat vegetable wholesale, logistics, processing, and retail let alone input suppliers to vegetable farms. The few studies that looked beyond the farm fall into two sets.

The first set are studies on vegetable exports to European supermarkets (e.g., Minten et al. 2009 from Madagascar, and Masakure and Henson, 2005 from Zimbabwe; Jaffee and Morton, 1995). The interest of these studies should however be placed in the context of Figure 1 that exports form only 2% of SSA vegetable output.

The second set of studies has focused on the supply chains (and farming) of indigenous vegetables such as local species of GLV, African eggplant, and okra (e.g., Rybak et al., 2018; Keding et al., 2017). Study of indigenous vegetable farming in SSA is longstanding, dating back at least to the farming systems literature in the 1970s (Eicher and Baker 1982). The literature started (and still mainly focuses on) home consumption from rural or urban gardens. It has also treated emerging supply of indigenous vegetables to cities (Alulu et al. 2023 for SSA in general; and Senyolo et al. 2018 for South Africa).

By contrast there has been far less attention to value chains of non-traditional vegetables (e.g., tomatoes) in SSA. The few exceptions study peri-urban irrigated agriculture in the 1980s and 1990s supplying cities (e.g., Mbaye and Moustier, 2000; Weinberger and Pichop, 2009). However, there is a relative lack of studies of longer supply chains of tomatoes and onions and other non-indigenous vegetables produced in clusters of small and medium commercial farms and then moved by medium to long value chains, which are composed of logistics providers and wholesalers, to cities, peri-urban, and rural areas around the country (such as noted for Senegal in Faye et al. (2023), for Zambia by Kabwe et al. (2023), and for Ethiopia by Minten et al. (2020)). This gap's importance is highlighted by three sets of emerging research: (1) Non-indigenous vegetables constitute the majority of vegetable consumption with local indigenous vegetables a minority (e.g., Faye et al. 2023 in Senegal; Parkhi et al., 2023 in Nigeria). (2) The majority of vegetable consumption is in African cities (pointing to the importance of rural-urban vegetable supply chains) and even most rural vegetable consumption is purchased (pointing to the role of rural-rural and even urban-rural vegetable supply chains where cities serve as entrepots for vegetable on-supply) (Dolislager et al. forthcoming). (3) Irrigated small/medium commercial vegetable farming zones far from cities (rather than the earlier literature on peri-urban irrigated perimeters) have developed in the past several decades and in various countries have become the main supply source of vegetables to cities (e.g., in Ethiopia, Minten et al. 2021, and Zambia, Kabwe et al. 2023) and even to rural areas (e.g., in Senegal, Faye et al. 2023).

Where domestic tomato value chains have been studied the focus has been on assessing:: (1) challenges based on stakeholder workshops (e.g., tomatoes in Kenya, Geoffrey et al. 2024); (2) emerging modern value chains of tomatoes for African supermarkets and intra-regional trade (e.g., Barrientos and Visser, 2013); and (3) the best design for interventions such as the reduction of post-harvest losses in tomato value chains in Nigeria (Plaisier et al. 2019).

To address the above gaps, we undertook a rapid reconnaissance of tomato and GLV value chains in Nigeria across three states, Kaduna in the North, and Oyo and Ebonyi in the South. The regions have different product foci.

On the one hand, the North tomato areas (represented here by Kaduna state, but also including Kano, Gombe, and Jigawa) and the Center (Plateau state) supply most of the tomatoes in Nigeria. Northern states have the most favorable conditions for growing tomatoes: hot and dry with sandy loam soils. Tomato farmers in these states have invested in irrigation over the past two decades (Adelodun & Choi, 2018). Certain areas in the generally more humid South also produce tomatoes, such as in Oyo (where the northern zone, a semi-arid area, is used for tomatoes). However, the South's production overall is much lower than in the North.

In contrast, GLVs are produced in all Nigerian states as they are important to local cuisine and play a significant role in local and intra-regional markets. The primary GLVs included in this study were those most consumed in Nigeria: Corchorus olitorus (ewedu), fluted pumpkin (ugu/ugwu), bitter leaf, water leaf, and Amaranthus spp (green), although there are many other GLV species produced and consumed. Amaranth is a very popular complement to Nigerian carbohydrate dishes such as pounded yam and fufu (Lawal et al. 2018). Their short production cycle (60-80 days) and variety of species allows them to be grown in most places, at least during the rainy season. However, their production is most widespread in the well-watered areas of the South (such as in our southern study states of Oyo and Ebonyi) and in "fadama" (low lying areas with temporary water standing from the rainy season) in the North (including in Kaduna). It appears that GLV farming is spreading or emerging in some areas; in our Oyo (South) sample of farmers, most had entered only in the past 2-7 years.

The paper proceeds as follows. In Section 2 we describe the study sample and methodology for data collection and analysis. In Section 3 we present the findings. In Section 4 we conclude and present implications.

2. Data and Methods

To capture the heterogeneity of production zones and study short supply chains within states, medium supply chains between states, and long supply chains between regions, we selected a state (Kaduna) in the poorer and drier North region of Nigeria, where most of the tomatoes are produced and shipped around the country; and states in the higher income and more humid Southwest (Oyo) and Southeast (Ebonyi) that consume lots of tomatoes, produce some, and produce and consume lots of GLVs.

In all three states we studied firms in urban, peri-urban, and rural areas, and farms in rural areas. We studied actors in all segments of the value chains, including farm input suppliers, farmers, rural wholesalers, urban wholesalers, logistics firms such as truckers for long distance trade and small vehicles for short distances, and retailers.

We use data and qualitative insights from our "rapid reconnaissance" of actors in the above segments of tomato and GLV value chains in those states. In June and July of 2022, we interviewed individually 151 respondents, with around 50 per state in each of the three states), distributed over the products, value chain segments, and firm and farm size scale strata. (Table 3) The interviews included questions about the firm or farm's assets, input procurement, value added activities and services provided, and marketing method and patterns. We asked what they do now and a decade ago, and their reasons for their actions and choices, as well as the constraints they face.

For the size strata we use used the classification of the Nigerian National SME policy that specifies that nano enterprises employ 1-2 persons, micro, 3-9 persons, small, 10-49 persons, and medium, 50-199 persons. The great majority of the enterprises we sampled were nano, micro, and small scale; this probably reflects the size distribution in reality but we cannot verify that as there is no census of informal sector enterprises. We tried to find medium-scale firms and farms for these products could not as they appear to be scarce. Sampling from the three strata was done using the "snowball" technique as there are no official sampling frames due to lack of census data. Our limited sample and method of sampling mean that we cannot say whether our findings are statistically robust or necessarily representative. The findings are broadly indicative, suggestive of hypotheses to test with surveys, and provide direction for further field research.

3. Results

3.1. The existence of medium and long domestic value chains (VCs) especially for tomatoes but also growing for GLV – and the central role of wholesalers

The literature on domestic value chains of vegetables in SSA has emphasized short VCs, either peri-urban to urban, or intra-village or indeed "intra-household", i.e., subsistence garden plots by women supplying the household needs. By contrast, we find that long and medium length VCs have developed over several decades for tomatoes, and in the past 1-2 decades medium length VCs for GLVs. For both products there is a coexistence of short VCs. We define long as inter-regional (between North and South); medium as inter-state but intra-regional; and short as intra-state. Our findings on these spatial trends and patterns is as follows.

3.1.1. Long and medium VCs for fresh tomatoes

a) Consumption patterns suggest the emergence of long VCs in tomatoes

Parkhi et al. (2023) shows that around 80% of consumers in both the North and South consume fresh tomatoes (usually made into sauce at home). Annual per capita consumption of fresh tomatoes is 11kg in the South versus 7.7kg in the North. Given that the great majority of tomatoes in Nigeria are produced in the North and an overwhelming majority of fresh tomatoes comes from domestic supply chains, these consumption data and production geography are consistent with our rapid reconnaissance findings below that there are long VCs from North to South of tomatoes.

b) Inter-region wholesale has played a major role in developing long VCs in tomatoes

First, with tomatoes being grown both (mainly) in the North and (some) in the South, there are both short and medium VCs of tomatoes inside and among states in each region. We found that tomatoes are channeled from farming areas to produce wholesale markets (in rural towns but mainly in cities), thence to retailers. Urban wholesalers source tomatoes either directly from farmers (often collecting via third party logistics, 3PLS, discussed below), or from rural traders who assemble from farmers. In some cases, wholesalers source tomatoes from other urban wholesalers.

Second, wholesalers (and 3PLS) from the North and to a lesser extent the Center region, provide a large tomato supply to wholesale markets in the South. South wholesalers reported that they buy around 70% of their tomatoes from the North. These South wholesalers noted that they source from farmers and wholesalers in the North: (a) to supplement the very limited local supply in the South; (b) to buy tomatoes from the largely irrigated and/or differently timed season in the North (especially Kaduna) and Center (especially Plateau) after the South tomato farming season; (c) to buy Northern tomato varieties, especially the "Hausa variety" (Hausa is an ethnicity in the North) that South traders find tastier, fleshier, and less sour than South varieties.

To ensure supply over seasons when sourcing from the North, South traders have two strategies: (a) provide advances (such as via bank transfers) to suppliers; (b) buy from an array of traders over time in cities in different states with staggered tomato seasons. North traders (per our interviews in Kaduna) send tomatoes to south wholesale markets. Payment used to be made by transporting cash, but the informants noted that this has shifted over the years to electronic money transfers.

Third, threshold investments for traders and 3PLS firms exceed those for GLVs. Tomato supply chains tend to be operated by larger traders (but still SMEs) and trucks while GLVs tend to be traded by small and micro firms and small trucks and three wheelers.

Fourth, wholesalers play crucial roles in operating long tomato supply chains. For example, in Ebonyi state (in the South), wholesalers aggregate tomatoes from around the country, especially from the states of Plateau, Benue, Enugu, and Cross River (with the latter also being a transit point for tomatoes from Cameroon). Further aggregation then takes place in the biggest wholesale market in the state, the Ebonyi State International market in the capital city. This wholesale market has tomato supplies year-round as supply comes in various "time windows" determined by the variety of tomato that is available. The Plateau State variety, also known as the 'UTC' or Jos tomato, has its season from November–April. The Benue State tomato season is May–September. The Enugu State (Nsukka) tomato variety season is April– September. The tomato variety from Cameroon, aggregated and sold in Cross River State (Ikom area), is grown all year but its sales in Ebonyi State are seasonal. Wholesalers in Ebonyi make regular trips to tomato source states 3-5 times a week. Some wholesalers doubled as retailers to sell the rest of their tomatoes; some reported providing credit to retailers who bought from them.

Fifth, wholesalers in the wholesale markets sort tomatoes by variety, geographic source, and quality and sell at differentiated prices. In the Ebonyi wholesale market for example, tomato retailers sort their products daily into 3-4 categories. These categories are based on the grades of firmness/deterioration.

c) Importance of 3PLS in long VCs of tomatoes

Third party logistics services (3PLS) have received little attention in agricultural economics research in SSA. This may be because policymakers and researchers have assumed wholesalers have their own trucks (Liverpool-Tasie et al. 2021). However, recent research, such as on urban maize wholesalers in Nigeria, has shown that 3PLS are important: Liverpool-Tasie et al. (2017) showed that only 4% of urban maize traders own trucks, and about 75% of the maize they trade is moved by 3PLS. Wholesalers pay a fee to a trucker.

Our interviews of tomato wholesalers found that 3PLS are important in the medium and long VCs. North and South wholesalers said they go to the cluster of truckers next to wholesale markets, or phone them on their cell phones, and arrange logistics with the 3PLS SME firms. Our interviews in Kaduna found that the smaller wholesalers are particularly reliant on 3PLS to send tomatoes to the South, while large wholesalers tend to have their own trucks.

It was commonly reported that wholesalers employ truckers with whom they have a long-standing relationship. The truckers are sometimes responsible for loading and unloading the product. As we were informed in Oyo, labor teams are regularly contracted by the wholesaler and sent along with the trucker. The Kaduna interviews revealed that 3PLS consisted of regular truckers as well as drivers of petrol tankers, where transport consists of baskets of tomatoes tied to the top of the tanker (though some petrol companies banned this practice in 2015). In some cases, the trucker also delivers cash payments to farmers or traders, although it appears that mobile money payments are replacing this. Given the soaring road banditry and kidnapping in Nigeria, the shift to mobile money is not surprising.

The fee is substantial for transport from North to South. Wholesalers in Oyo in the Southwest noted that in a season an average trader spends around 1200 USD to move 21,000 crates (around 420 tons at 20kg per crate) of tomatoes, scotch bonnet peppers, cayenne peppers, and red bell peppers. That is about 3 dollars (in

Naira) per ton. For comparison grain traders in the North reported paying about 12 dollars per ton in 2023 and 5 dollars in 2022) (Premium Times, Nigeria, 2023).
South traders (such as in Oyo) reported that they went to the tomato farms in their area to source directly. Thus, for tomatoes, it appears that short value chains are not yet using 3PLS nearly as much as long value chains.

3.1.2. GLV medium and short VCs and again the importance of wholesalers and 3PLS

Our rapid reconnaissance corroborated the importance of (short) peri-urban to urban GLV supply chains, but also revealed medium-length VCs traversing states in a given region. Despite the high perishability of GLVs, this lengthy transport is made possible by moving the product at night and early morning (usually just for a few hours however), covering the GLVs with a tarp while moving and at transit points, and restoring its humidity by splashing water on the leaves when they arrive at the market and are displayed for sale.
An example from our reconnaissance in Ebonyi state is as follows. The wholesale market of its capital (Abakaliki) is supplied by GLV farmers in Ebonyi and in neighboring Cross River state and Benue. The wholesalers who supply the Abakaliki market are mainly women in nano- and micro-scale firms. These wholesalers can be classed into two groups. (1) GLV wholesalers based mainly in Cross River state a few hours away: they aggregate vegetables from farms vegetable markets in the northern part of Cross River State. The GLV are then supplied to the Ebonyi State major market. These female traders act both as wholesalers and sometimes as 3PLS. They package the vegetables in bundles of about 100 bunches wrapped in soft bags or cloth. Then they pay the 3PLS to bring the product down to the major markets in Ebonyi State, where the products are delivered to the second group of wholesalers. (2) Wholesalers in the Ebonyi State major market: these traders buy the GLV from the first group, debulk the GLV, and sell them to retailers in the main market and other markets, and sometimes retail it themselves.
The 3PLS are mainly nano or micro enterprises with small vehicles. They cluster at the rural supply markets in Cross River, Plateau, and Benue States, and Nsukka (a town in Enugu State), and then make trips to the urban wholesale markets. The 3PLS load, transport, and off-load for the farmers or traders that dispatch the produce, charging by the unit delivered to the market. The 3PLS operators are mainly men; the respondents noted that this is because of the physically demanding nature of the loading and unloading of the heavy bags and baskets and safety issues associated with traveling.

The reconnaissance interviews noted that in the past five years, GLV wholesalers (nearly all small-scale) grouped into an association to "coordinate" with one another for two ends: (1) to assure adequate supply to the wholesale market; (2) to limit deliveries to the market of GLV to avoid gluts and bolster the price, especially of the highly demanded fluted pumpkin leaves
In contrast to the high level of activity at the GLV market in Ebonyi, in Oyo state in the Southwest, we found that a number of GLV farmers, especially women, also acted as wholesalers who sold the GLVs from their own farms and occasionally GLVs from other farmers. Many wholesalers in Oyo sold more than one kind of vegetable, potentially reflecting the need for product diversity for traders operating outside larger markets.

3.1.3. Farming and input segment of tomato and GLV VCs

a) Emergence of irrigation especially of tomatoes in the North and South and in GLV in the North

Our respondents from all three states noted that there has been an increase over time in irrigation on tomato plots that facilitated an increase in output and longer production seasons in the dry North and Center states. The development of irrigation in the North for tomatoes (and rice) consisted in the 1970s and 1980s of large-scale irrigation schemes by the Federal River Basin Development Authorities. These schemes ran into a host of problems (Adams 1991). The emphasis shifted to small-scale irrigation in the 1990s on. To our knowledge there has been no empirical study of diffusion of small-scale irrigation for tomatoes in Nigeria. Studies of irrigation have tended to focus on small samples of farms and on assessing the effects of irrigation versus rainfed farming.

The South informants noted that most GLVs are merely rainfed. This is not a problem in the very humid areas of the South (Oyo and Ebonyi) where rainfall is plentiful and even excessive so that the threat is flood not drought. But even in those humid areas, there is seasonality and so there is relative dearth in the drier seasons; it is then that some limited intra-region trade and the very limited irrigated GLV areas tend to shore up the supply. However, that irrigation appears to be limited. This reflects in the sharp seasonality of output and income from GLVs. For example, GLVs, such as fluted pumpkin leaves, supply the Ebonyi capital market and are mainly grown in the Izzi and Ezza local government areas. These locations are in upland, less-swampy regions where GLVs are grown using rainfed cultivation only which causes their supply to be fairly sharply seasonal.

The North informants noted that GLV farming and tomato farming are irrigated. Medium and large tomato farmers grow year-round with irrigation, while small farms grow tomatoes and GLV under irrigation only during the dry season in the same fields which had a rainy season crop like rice or maize. The irrigation is fed by pumps, pipes, and buckets to move the water from streams and rivers to fields. Nano and micro farmers often borrow or rent irrigation equipment from medium farmers and cooperatives.

Our informants noted that there has been an increase in the use of fertilizer and pesticides, especially for tomato production. There has been some emerging use of chemicals on GLVs, along with hired labor for weeding and staking on commercial GLV farms such as in Cross River State. But the informants told us that the great majority of GLVs are grown without chemicals, as most of these are indigenous varieties and adapted to the local environment and are relatively resilient to local pests and diseases. Nevertheless, the Ebonyi reconnaissance noted that agrochemical suppliers' volumes increased over the past decade, reflecting the adoption of herbicides and other pesticides by farmers. This may be a parallel development to that noted by Haggblade et al. (2017) among female sorghum farmers in Mali who use herbicides to save weeding labor costs.

Our informants emphasized the role of agro-dealers in input supply to horticulture farms. In Oyo state, informants noted that agro-dealers supply pesticides (insecticides, fungicides, nematicides, rodenticides, and herbicides), fertilizers (granular fertilizers such as urea, Indorama NPK, calcium nitrate, potassium nitrate, and liquid fertilizers), vegetable seeds, and seedlings (the latter often produced by the dealers). They are "one stop shops" for a range of items.

Moreover, informants in Ebonyi and Oyo emphasized that retailers and wholesalers of farm inputs came to farm areas and informed and advertized and in some cases provided inputs on credit. We say "some cases" because we cannot claim with this small sample to know how widespread this practice was. The informants did not even mention government extension agents as sources of information, but rather dwelt on the private extension of input companies (including distributing flyers and samples as well as doing input demonstrations), as was the case in Ebonyi State. Further, the informants noted that input dealers face import challenges such as exchange rate fluctuations and the Russian-Ukraine war's effect on fertilizer access.

3.2 Challenges attendant on VC lengthening and intensification.

Challenges have occurred alongside and to a certain extent been caused by the trends in VC lengthening and farming intensification we observed above. We discuss below these challenges as revealed by the respondents in the rapid reconnaissance.

3.2.1 Challenges of the midstream of medium and long value chains

First, as tomato value chains stretch from North to South, they traverse zones of conflict and are exposed to banditry and corruption of (extorsion by) road officials. This is perhaps the sharpest complaint of the value chain participants, who also noted that this raises costs which are passed along to retailers and consumers.

Second, the length of the value chains makes vehicle maintenance and fuel major costs and creates substantial delays and thus also spoilage. These are exacerbated by the poor state of the roads for long stretches and the frequent scarcities and cost spikes of fuel, and by vehicle breakdowns from the poor roads and low-quality vehicles. These challenges were noted by wholesalers in all the three states studied. The Kaduna logistics informants noted that there is often a lot of traffic congestion on the long drive south and some spectacular backups like traffic jams lasting seven days. Tomato cargoes are spoiled and sometimes fully destroyed by sitting in the heat during these delays.

Third, climate shocks, in particular flooding and road washouts, made worse by insufficient public investment in culverts and dams to control water over and near roads, add to travel uncertainty and costs. Heat and humidity, lack of proper storage facilities, and poor handling practices create spoilage and food safety problems in tomatoes and GLVs on long trips and among retailers.

Fourth, as long value chains require relatively large loads shipped to make the long trips profitable, there is often a need to store the produce, especially tomatoes, for a few days at the markets. We found that there were few storage facilities (ambient or cool) for either the wholesalers or retailers in the markets studied. This lack of storage space paired with sharp seasonality and produce being delivered in gluts often results in very low prices. Tomatoes are usually bagged or crated in farm areas and then moved long distances to markets by 3PLS. At the market, wholesalers generally sell them in baskets packed tightly thus speeding spoilage. In the South some wholesalers have started using plastic crates introduced by the crate companies; the crates have better air circulation and cause less pressure on tomatoes, but cost more than baskets and are to date hard to access.

Fifth, we found that there is very little freezing of vegetables. But there is large and rising demand for tomato paste as more convenient and easier to store than fresh tomatoes. Most tomato paste is mainly supplied by imports, and partly supplied by North processors in clusters of small firms and farms. Respondents noted that it is hard to get processing equipment and electricity. In the North processors said it is hard to get tomatoes from farmers who prefer to sell to the better paying fresh market. In the South informants noted the same issues of input and equipment costs and added that local tomato supply is erratic.

Some small retailers' custom supply "fresh cuts" of GLVs custom-done for restaurants. Informants noted that these firms often neglect to wash the leaves or their hands thus creating a potential food safety problem.

Another food safety (and deterioration) problem in retail is leaving unsold tomatoes uncovered in baskets or on mats in open spaces, exposed to flies, rodents, and bacteria. Tomatoes with cuts are often left exposed and handled with bare unwashed hands

3.2.2 Challenges of intensifying farming

First, heat, drought, and floods have intensified with climate change and favor the spread of plant disease and constrain multi-season tomato production in areas reliant on irrigation in the North and in semi-arid parts of the South, and through flooding in GLV areas such as Ebonyi. As respondents noted, these issues are exacerbated by inadequate small-scale irrigation in tomato and GLV areas.

The long-term environment of humid areas constrains tomato production, for example in Ebonyi state where thrips and white fly infestations are common and controlling them with pesticides is costly. In hot semiarid areas in the North,tomato farmers noted inadequate availability of heat tolerant tomato varieties. In North and South, for tomatoes and GLVs, farmers noted that rainfall in the past several years has become more erratic.

Second, farmers noted that they face other diverse risks. Oyo farmers informed us that they face theft and insecurity. Farmers in Oyo and Kaduna noted they face challenges of getting well-functioning tractors from government centers and private companies, and that they pay high prices for inputs. Fertilizer retailers/wholesalers in Kaduna have to source fertilizer from the South of Nigeria which adds cost. Farmers in Kaduna in the North also noted rising costs for renting land.

Third, tomato farmers in the North have been besieged by tomato leaf mining moths (tuta absoluta) which undermines yields and even kill the whole crop (Hortidaily, 2023). The National Horticultural Research Institute (https://nihort.gov.ng) developed an integrated pest management (IPM) program to address the pest, but our informants noted the diffusion of skills for farmers to implement it have been inadequate

3.2.3 Patterns and potential challenges of inclusivity in the value chains

Our respondents noted that there is a gender division of labor. Generally, women are much more involved in the GLV value chain (as growers, wholesalers, and retailers) than in the tomato value chain. This appears to be for several reasons.

First, GLVs have traditionally (until recently) nearly only been home produced in gardens tended by women for use as condiments in sauces, and thus men were traditionally little involved in GLV production.

Second, GLV farming requires relatively little investment as it is often only in the rainy season and on very small plots; it has not in general involved outlays on irrigation or fertilizer or pesticides. It is harvested little by little and so there is little outlay on hired labor. These low cash requirements match women's relative lack of cash.
Third, by contrast, tomato farming typically involves investment in irrigation for water control in the rainy season and for off-season production. Tomato farming in the North and South involves substantial expenditure on fertilizer and pesticides as well as stakes, string, and hired labor. Thus, there are higher "threshold investments" to enter tomato farming which appear to prevent many women from being more involved in tomato farming.
Fourth, long-distance 3PLS and wholesale of tomatoes from North to South are dominated by men and involve substantial outlays for fuel, labor, and vehicle purchase and maintenance. In contrast, short and medium-length GLV value chains such as in Ebonyi, are more commonly dominated by female nano enterprises. Our informants noted that this is due to lower returns (disinteresting men) and lower entry barriers (enabling women). Some respondents also said that there are local social mores discouraging women to undertake activities that require them to travel far and be exposed to road crime and harassment.
These gender correlations are themselves related to the rough relation we found between the length of the supply chain and firm scale: nano and micro scale firms dominate local and medium distance wholesale and logistics, while small firms (we found no medium scale firms using the official definitions of scale) dominate longer distance value chains. This appears to be a typical pattern seen in other countries (e.g., such as the former Zaire, Kyle and Minten, 1999).

4. Conclusions and policy implications

1. This paper showed the Nigerian tomato value chain has grown over time and has "lengthened spatially" from the North to a thousand kilometers to the South. Even GLV, traditionally produced and sold in very short local supply chains, has in some parts of Nigeria lengthened to span several states. This spatial change has been facilitated by longer seasons where irrigation, especially of tomatoes, and the multiplication of tomato farming sites has resulted in steady output.
2. We found that a crucial segment in these value chains is wholesalers, who are primarily based in produce wholesale markets within cities and peri-urban areas. As these traders rely heavily on third party logistics services (3PLS), there is a clear need for more information on this understudied segment of the value chain,
3. Moreover, while these vegetable value chains have grown quickly, becoming massive in volume and number of actors, each segment faces vulnerabilities to high costs and shocks such as of climate, gender inclusion, food safety, and environmental issues.
4. The emerging policy implications center on the need for government investment in the basic infrastructure underpinning these value chains – including wholesale markets, storage facilities, roads and good transport policies, electricity grids, and governance. Likewise, investment in soft infrastructure, in particular a reduction of road officials' corruption, food safety education, and women's capital building would also aid in the efficiency and inclusiveness of the value chains.

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Tables and Figures:

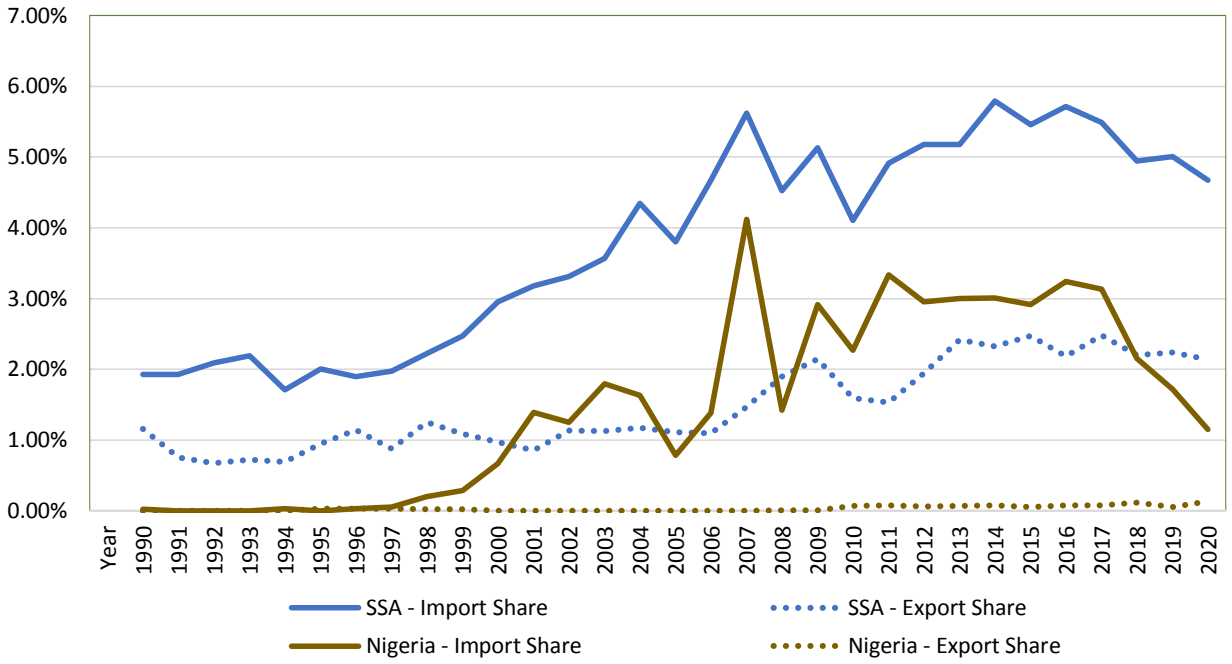

Figure 1: Import share in Consumption by Disappearance and export share in output of Aggregated Vegetables in Sub-Saharan Africa (SSA) and Nigeria from 1990-2020 (calculated from FAOSTAT, Food Balance Sheets data, September 2023)

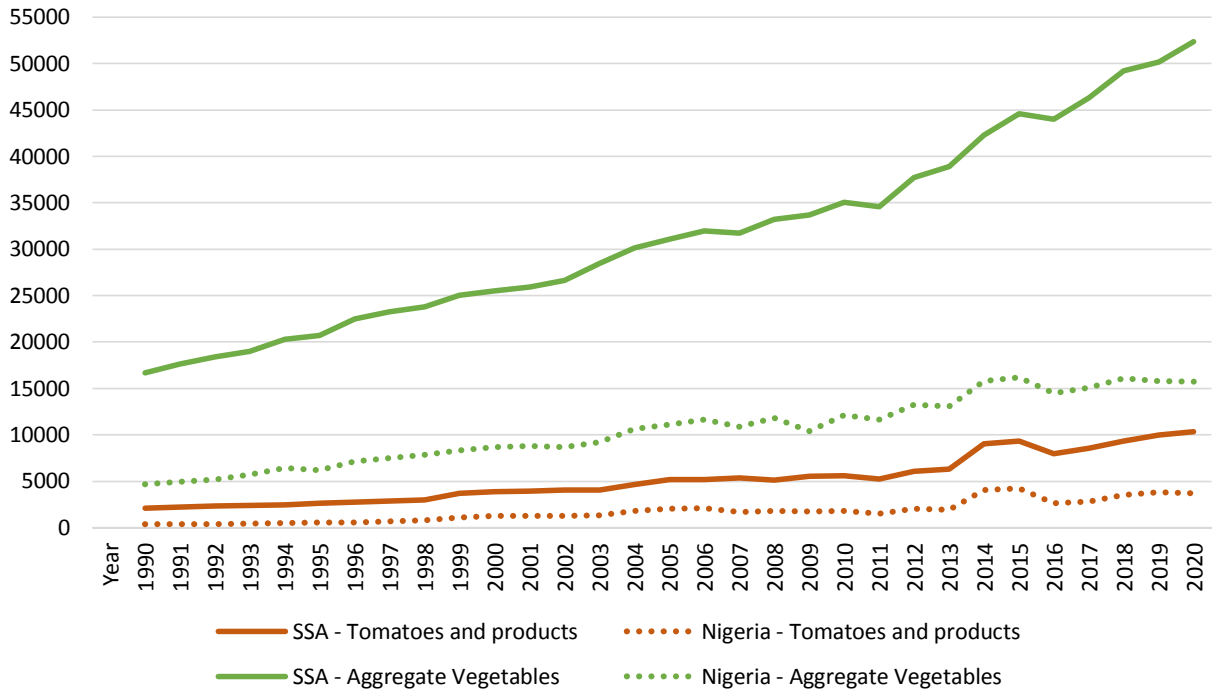

Figure 2: Production Quantity of Tomatoes and Aggregated Vegetables in Sub-Saharan Africa and Nigeria from 1990-2020 (FAOSTAT, 2023)

Table 1: Rapid Reconnaissance Sample of firms and farms in each supply chain segment by state and scale

		North (Kaduna)				Southwest (Oyo)				Southeast (Ebonyi)			
	N	Nano	Micro	Small	Total	Nano	Micro	Small	Total	Nano	Micro	Small	Total
Tomato	Input Suppliers	0	0	0	0	0	0	0	0	0	3	0	3
	Farmers	6	14	23	43	0	15	0	15	0	16	0	16
	Wholesalers	11	12	47	70	0	14	3	14	12	0	0	12
	Third-Party Logistics	8	13	14	35	4	2	3	6	0	0	0	0
	Processors	5	0	21	26	4	19	5	23	0	0	0	0
	Retailers	9	6	6	21	1	1	0	2	20	4	0	24
	One-Stop Shops	0	0	0	0	0	0	0	0	5	4	0	9
GLV	Input Suppliers	0	0	0	0	0	6	0	6	0	3	0	3
	Farmers	11	20	4	35	0	19	0	19	0	3	8	11
	Wholesalers	12	12	2	26	1	3	0	4	12	10	0	22
	Third-Party Logistics	2	2	0	4	2	0	0	2	4	2	0	6
	Processors	0	0	0	0	0	0	0	0	5	0	0	5
	Retailers	3	8	2	13	7	0	0	7	26	5	0	31
	One-Stop Shops	0	0	0	0	0	0	0	0	5	4	0	9