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Domestic vegetable value chains in Nigeria and Tanzania: evidence from a Rapid Food System Assessment

[version 1]

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Abstract

Despite limited recognition, African domestic value chains (VCs) for vegetables have undergone a dynamic transformation in recent decades. Contrary to the prevailing narratives that portray these VCs as stagnant or hyper-local, we show a pattern of rapid growth, commercial intensification, and spatial expansion, driven primarily by domestic farms and small agribusiness firms. Here, we present our findings from the Rapid Food System Assessment (RFSA) in Nigeria and Tanzania. The RFSA covered 800 actors (all MSMEs (micro, small, and medium enterprises) in input and output VCs for tomatoes and green leafy vegetables. Findings: (1) While these VCs are traditionally seen as stagnant, we observed very rapid growth. (2) While these VCs are traditionally viewed as being spatially "short," we found long VCs for tomatoes and even medium and long VCs for some GLVs. (3) While vegetable farming in Africa is viewed mainly as rural home gardens and peri-urban plots, we found massive growth in small-scale commercial farming, facilitated by land rental markets, and generally using irrigation, fertilizer, pesticides, and hybrid seeds. (4) While the debate portrays off-farm MSMES (e.g. agro-dealers, wholesalers, and 3PLS MSMEs) as the "missing middle," instead we found they are a dynamic "Hidden Middle" playing a fundamental role in the VCs.

Keywords

vegetables value chain; transformation, midstream, farm intensification, wholesale

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1. Introduction

The international agribusiness management and development literature has extensively treated the dynamism and transformation of African horticultural export agribusiness and participation in international value chains (VC), such as Maertens *et al.* (2012), Van den Broeck and Maertens (2016), George (2022), and Jaffee and Morton (1995). In contrast, there has been much less treatment, and thus important gaps in the literature on domestic vegetable VCs in Africa. The gaps center on the growth and transformation of (1) micro small and medium enterprises (MSMEs) in midstream segments (wholesale, logistics, and processing) and upstream services (agro-dealers selling farm inputs) and (2) domestic VCs. We surmise that this was because of several reasons.

First, the gap in research on midstream MSMEs in African vegetable VCs is part of the general dearth of empirical research in Low- and Middle-Income Countries (LMICs) on output VC midstream MSMEs (Barrett *et al.*, 2022) and input-supplying agro-dealers (Dillon *et al.*, 2025).

Second, international debate appears to have cast African vegetable VCs as stagnant and constrained. The debate has emphasized the shortfall, relative to nutrition norms, in the consumption per capita of fruits and vegetables in Africa (e.g., Harris *et al.,* 2022), the costliness of these products to domestic consumers (e.g., Heady and Alderman, 2019; Masters *et al.*, 2018), and the assumption that domestic vegetable VCs are so constrained that they grow slowly and transform little and are instead dominated by fruit and vegetable imports (African Development Bank, 2016).

In contrast, emerging evidence shows dynamism in domestic VCs for vegetables and fruits in Africa. Analysis of FAOSTAT data shows rapid growth of vegetable output in Africa, and nearly all domestic consumption of vegetables comes from domestic production, rather than imports. Specifically, vegetable output has grown faster than population growth and grown faster than in Asia over the past several decades. Over 2010-2020, vegetable output has increased by 36% (versus 25% in Asia). Moreover, imports accounted for only 4% of consumption (versus 2% in Asia) (Reardon e*t al.*, 2024b).

When the domestic vegetable sector has been studied in Africa, the study categories are as follows, with each also presenting a gap in research.

First, many studies have been conducted on rural home production for home consumption. However, this focus neglects the emerging fact that most fruit and vegetable consumption is in African cities, and in both urban and rural Africa, most vegetable consumption is purchased from VCs and not consumed from home production. Dzanku *et al.* (2024) found that, for seven African countries[1] in rural areas, the purchase share of fruit and vegetable consumption was 74%.

Second, studies have tended to focus on African indigenous vegetables (such as okra and African eggplant), especially those produced in rural home gardens (e.g., Rybak *et al.*, 2018; Keding *et al.*, 2017; Eicher and Baker, 1982). Recent studies have investigated the supply of indigenous vegetables to cities (Alulu *et al.*, 2023; Senyolo *et al.* 2018 for South Africa).

In contrast, there have been far fewer studies on non-indigenous vegetables (e.g., tomatoes, onions, and cabbage). This dearth may be because the consumption of these was a tiny share of vegetable consumption in the 1980s and 1990s and grew very fast only in the past several decades, as we show below. However, the share of these vegetables now equals or exceeds the share of indigenous vegetables in the total vegetable consumption (e.g., Faye *et al.*, 2023 in Senegal; Parkhi *et al.,* 2023 in Nigeria; Sauer *et al.*, 2025 in Tanzania).

Third, there are two main types of VC studies in Africa.

a) Studies on emerging modern VCs of tomatoes for African supermarkets and intra-regional trade (e.g., Barrientos and Visser, 2013) and specialty vegetables for export to European supermarkets (e.g., Minten *et al.*, 2009 from Madagascar; Masakure and Henson, 2005 from Zimbabwe; Jaffee and Morton, 1995). While these studies are of interest in themselves, the share of African vegetable output exported is small: Figure 1 shows that it was 0.2% in Nigeria in 2022, and Figure 2 shows that it was 8% in Tanzania in tonnage terms. We used FAOSTAT data from 2022 for Sub-Saharan Africa (SSA) to calculate that exports form only 2.6% of vegetable output.

[1]Ghana, Nigeria as upper GDP/capita stratum, Tanzania, Uganda as middle, and Ethiopia, Malawi, Niger as lower stratum in relative terms.

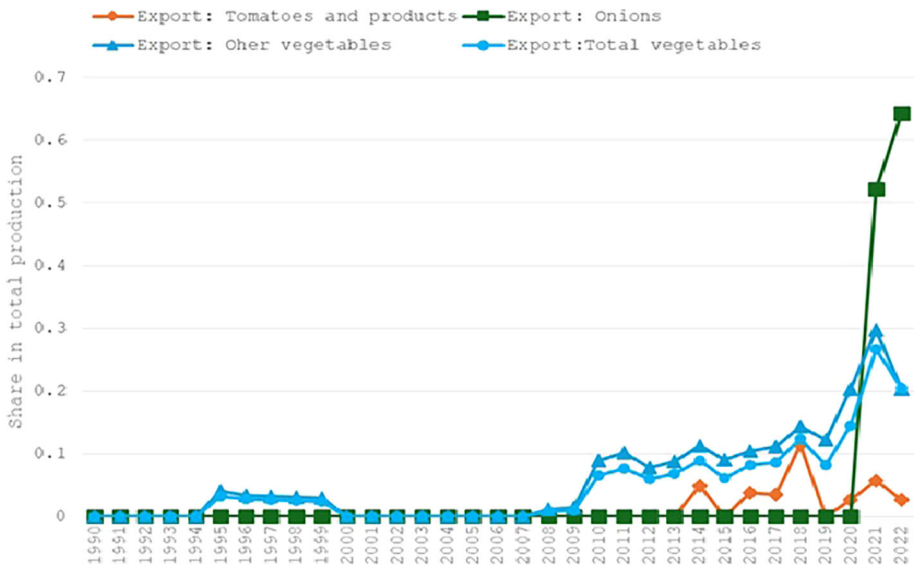


Figure 1. Percentage of exports in total output of tomatoes and products, onions, other vegetables and total vegetables for Nigeria, 1990 – 2022.

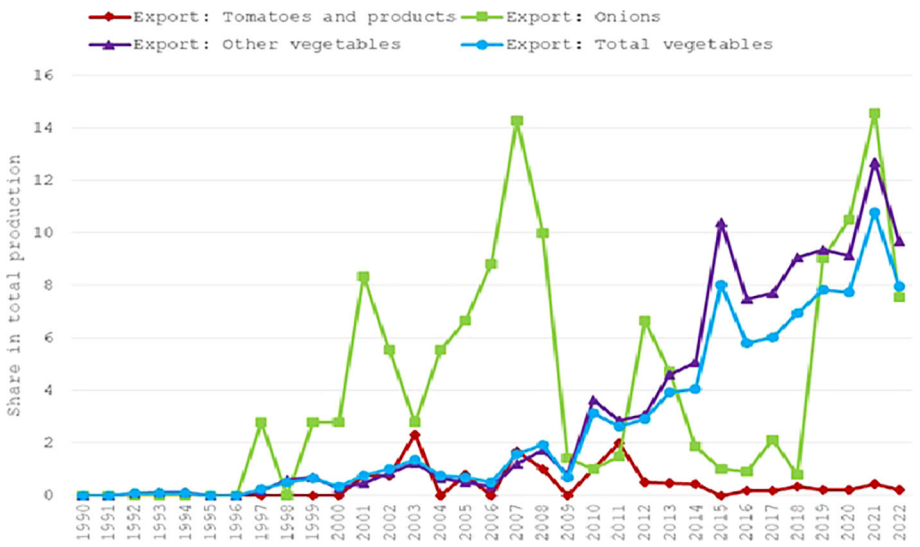


Figure 2. Percentage of exports in output of tomatoes and products, onions, other vegetables and total vegetables for Tanzania, 1990 – 2022.

b) Studies of peri-urban vegetable production in hyper-short supply chains from a green belt around cities to urban markets (e.g., Mbaye and Moustier, 2000; Weinberger and Pichop, 2009). These studies are of lasting importance, given that peri-urban vegetable production continues to play a role, especially in green leafy vegetables (GLVs). However, as the main type of domestic VC literature, they leave a gap with respect to the longer VCs within countries that are emerging from spontaneous clusters in particular zones of a country to send out VC "tendrils" all around the country (such as shown in Ethiopia by Minten *et al.*, 2020). This is also a major point of the findings we show below for Nigeria and Tanzania.

Fourth, perhaps because of the conventional wisdom that African domestic vegetable VCs are limited and stagnant, it appears that much of the literature has been on "what are the challenges and what should be done?" rather than investigating the rapid transformation that already occurs in VCs. The "challenges" literature is abundant, with stakeholder-workshop based papers such as Geoffrey *et al.* (2014) on tomatoes in Kenya eliciting challenges and

Plaisier *et al.* (2019) on tomatoes in Nigeria eliciting ideas for cocreated interventions such as for the reduction of post-harvest losses in tomato VCs. While these exercises are important, we believe that there has been a relative dearth in understanding the patterns and changes in what we have found to be a rapidly developing domestic sector in Africa.

Fifth, most studies on vegetable VCs in Africa have focused on single countries or just one zone or district. There have been very few country-comparative studies, with the exception of Isoto *et al.* (2025), who undertook a rural reconnaissance of 266 enterprises and farms across segments of tomato, onion, African basil, and African eggplant leaf VCs in Benin and Ethiopia.

To address these gaps, we analyzed the transformation of domestic VCs of tomatoes versus green leafy vegetables (GLVs) in Nigeria and Tanzania in three zones in each country. We treat upstream change (among farms and input suppliers, called "agro-dealers" in the countries) and in the midstream segments of wholesale and logistics. To inform the analysis, we undertook an assessment commonly called "Rapid Food System Appraisal" (RFSA) or rapid reconnaissance study (Koomen *et al.*, 2024). We conducted in-depth interviews in the two countries, and 800 lengthy one-on-one interviews involved qualitative current and retrospective discussions as well as quantitative indicators. The interviews included farmers, agro-dealers, wholesalers, transporters (third-party logistics, or 3PLS), and retailers.

Contrary to what we observed in those countries as common perceptions or "conventional wisdom" (CW) about these VCs, we found surprising, rapid transformation, both upstream and midstream, and striking parallelism in the changes in these two countries in West and East Africa. To our surprise, we found that the results of the field study often sharply contrasted with the initial statements of stakeholder meetings with the government and researchers (before we started the individual interviews) about VC length (with the CW that vegetable VCs are short), midstream segment development (with the CW that the services are missing or stagnant), and farming intensification (with the CW that farmers are not yet intensifying).

In contrast to the CWs, the RFSA of tomatoes and GLV value chains in both Nigeria and Tanzania showed the following trends: (1) farming intensification; (2) the formation of spontaneous clusters with the proliferation of small-scale growers; (3) lengthening of value chains for tomatoes and surprisingly also for GLVs; and (4) rapid development of midstream services, such as logistics and wholesaling, and upstream, such as agro-dealers. This study recounts these findings and their implications for policy makers and researchers.

The remainder of this paper is organized as follows. In Section 2, we present the macro context of the vegetable sector evolution in the two countries. Section 3 describes the study sample and methodology for data collection and analysis. In Sections 4 (upstream), 5 (tomato midstream), and 6 (GLV midstream), we present the following findings: (1) vegetable farming proliferation, clustering, and intensification, and (2) VC lengthening and midstream development. Section 7 concludes and presents implications, as well as an agenda for further research on vegetable agribusiness VCs in Africa.

2. Macro background: rapid growth in production and consumption of vegetables in Nigeria and Tanzania

We examined the trends in Nigeria and Tanzania using macro data from FAOSTAT. The latter does not disaggregate vegetable production for GLV per se, but it provides data on tomatoes and products, other vegetables, and onions, and hence for total vegetables.

Income growth and urbanization are two important drivers of vegetable VCs. On the one hand, per World Bank data, in constant dollars, Tanzanian income per capita increased 5-fold, and Nigeria's income increased 3.6-fold from 1990 to 2022.[2] Bennett's law predicts that, with increasing income, there is an increasing consumption of vegetables and other non-staples. Moreover, the Tanzanian urban population grew 4.5-fold and went from 19% to 35% of the population from 1990 to 2021. The urban share of national FV consumption reached 60% by 2017. Nigerian urban population grew from 29 million to 120 million from 1990 to 2022, 4.1-fold; as a share of the national population, the urban population rose from 30 to 54%. These rapid urbanizations set the stage for rapid growth in rural-urban vegetable VC.

One can see the enormity of urban (and overall national) domestic vegetables using tomato calculations as an example. In Nigeria, 120 million urban persons consumed nearly 1.5 million tons of fresh tomatoes per year, or 4000 tons every day had to move through tomato VCs from rural to urban areas. The urban fresh domestic tomato market is approximately

[2]https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=NG

450 million dollars. The total Nigerian tomato market (urban plus rural) is nearly 1 billion dollars per year. Nearly all that volume is moved by VCs from rural to urban and rural to urban to rural areas.[3]

Second, total vegetable output grew quickly in both countries from 1990 to 2022. Figure 3 shows that in Nigeria, the output (in tons) of total vegetables rose 3.4-fold, and Figure 4 shows that the growth of total vegetable output per capita was 1.5-fold.

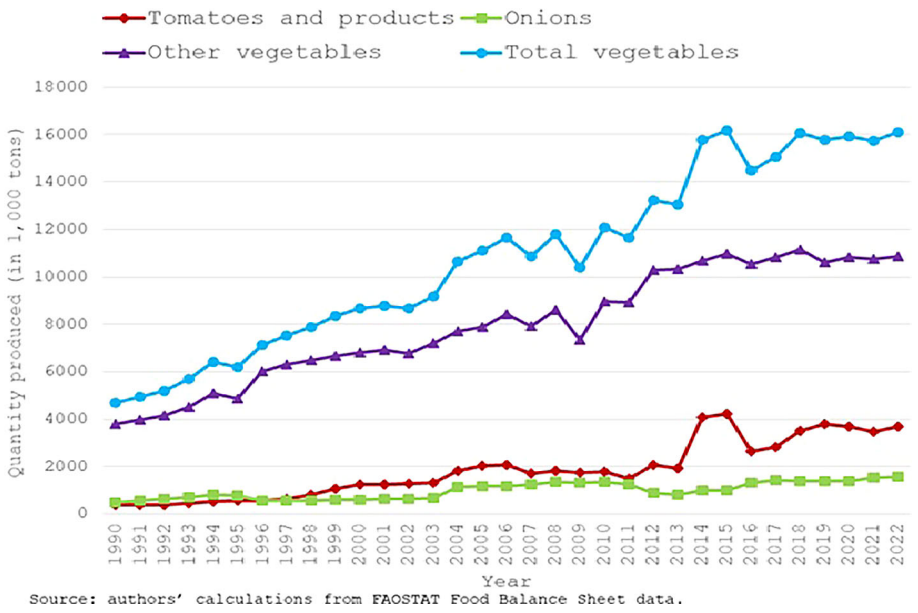


Figure 3. Output of total vegetables, tomatoes and products, onions, and other vegetables in Nigeria, 1990 – 2022.

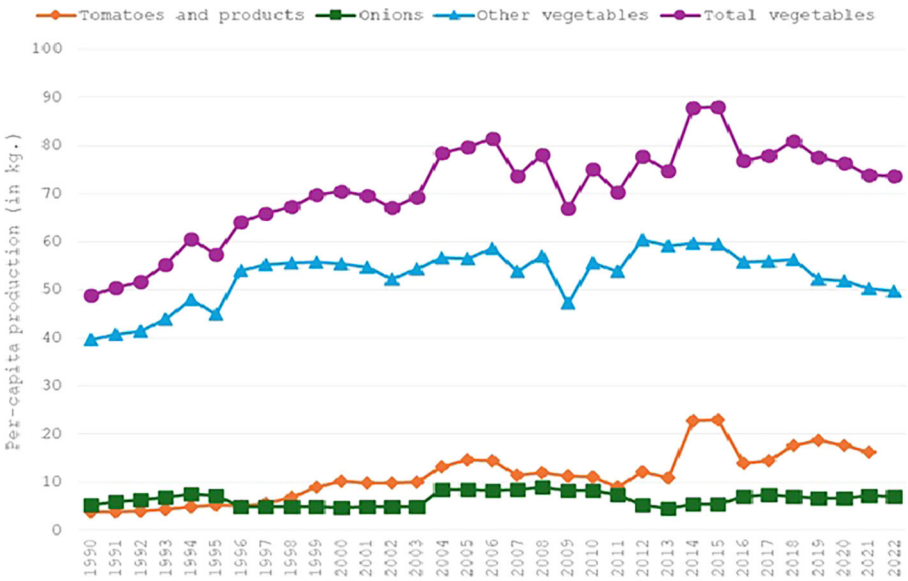


Figure 4. Per-capita output of total vegetables, tomatoes and products, onions, and other vegetables by Nigeria, 1990 – 2022.

[3]The calculations were as follows. In 2019 (per LSMS data, Parkhi *et al.* 2023), the average urban person consumed 12.25 kg of fresh tomatoes per year; 120 million urban persons thus consumed nearly 1.5 million tons of fresh tomatoes per year. Fresh tomatoes in 2019 cost 110 naira per kg, hence 110,000 N per ton; at 360 N/dollar end 2019, that makes 305 dollars/ton. The 1.5 million-ton-urban market of tomatoes equals around 450 million dollars. The overall Nigerian tomato market (urban plus rural) is nearly 1 billion dollars per year.

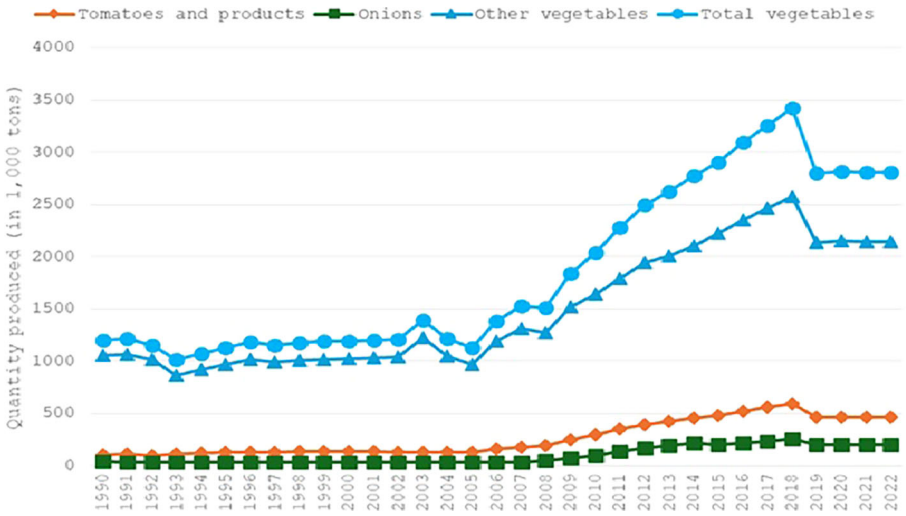
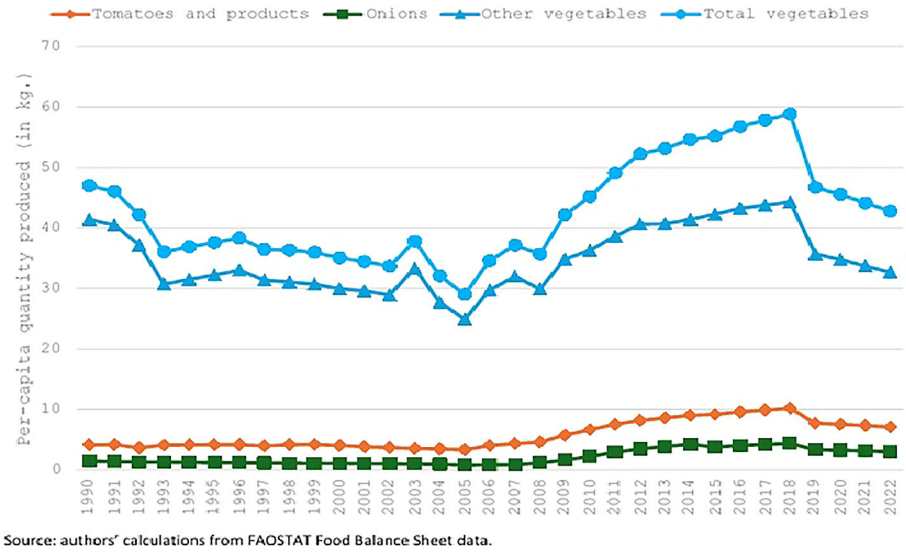


Figure 5. Output of total vegetables, tomatoes and products, onions, and other vegetables by Tanzania, 1990 – 2022.



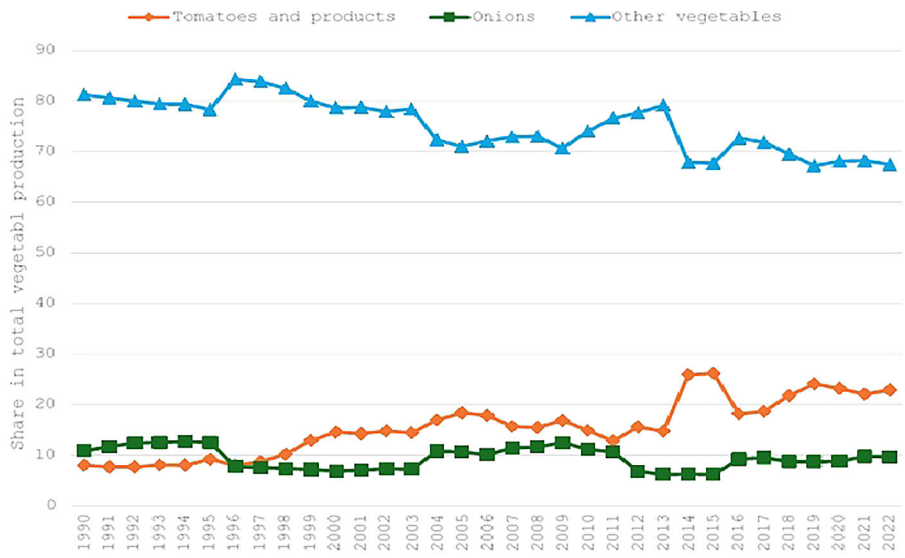
Source: authors' calculations from FAOSTAT Food Balance Sheet data.

Figure 6. Per-capita production of total vegetables, tomatoes and products, onions, and other vegetables by Tanzania, 1990 – 2022.

In Tanzania, in Figure 5, the growth in the total was 2.9-fold to 2018 (although with a decline for several years after that), and per capita, per Figure 6, was 1.3-fold through 2019 (and then a decline back to 1990 levels by 2022).

Third, the vegetable economy in both countries is overwhelmingly domestic. We noted that only 0.2% of Nigerian vegetable output was exported, and in Tanzania, it was 8%. for all vegetables, except for a blip in 2021/2022 when the share of onion output jumped to 0.6%, which is still quite minor. Figure 9 shows that in Tanzania, the export share went from near 0% to 8% of the total vegetable output over the period, with growth due to exports of onions and other vegetables (but not of tomatoes). Only 2.6% of African vegetable output was exported.

Similarly, vegetable imports form a very small share of vegetable consumption in both countries. Figure 5 shows that the import share of total vegetables in Nigeria hovered around 1-2% from to 1990-2022. GLVs are not imported. Tomato product imports went from 0 in the 1990s to 20% of tomato consumption in the early 2010s, but then plummeted to just 5% by 2022 (after a trend of import substitution in processed tomatoes). Figure 10 shows that imports accounted for less than 1% of total vegetable consumption in Tanzania over the whole period; these imports tended to be nearly only tomatoes, but even of those, the share imported bounced around 1-2% over the whole period. We calculated the share of imports in consumption by disappearance (imports divided by output less exports plus imports) in SSA in 2022; the share was only 8%.



Source: authors' calculations from FAOSTAT Food Balance Sheet data.

Figure 7. Percentage of total vegetable production of tomatoes and products, onions, and other vegetables for Nigeria, 1990 – 2022.

Fourth, tomatoes have been rising rapidly in vegetable consumption from very minor to very important levels over the past three decades. Figure 7 shows that, for Nigeria, the share of tomatoes in total vegetable production in tons rose from 8% in 1990 to 23% in 2022. (Note that this share is below the value share of all tomato products in consumption because of the important role of (predominately) imported processed tomatoes in Nigeria.) Figure 3 shows that tomato output grew 10-fold in the three decades (and 3.1-fold per capita) - growing 3 times faster than overall vegetables in Nigeria (which increased 3.4-fold), a clear sign of a shift in the cuisine due to tomato's versatility in being incorporated into traditional dishes (stews and sauces) and the diffusion of "rice jollof" based on tomato and onion.

This growth is even more surprising because tomatoes were introduced to SSA in the 1800s, and as of 1990, tomatoes were still a very minor crop in Nigeria, with 375,000 tons of output (and 1,000 tons imported), representing just 4 kg per person per year. By 2000, the output was already 1.3 million tons, with 5,000 tons imported, so the output represented 10 kg 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 13 kg. 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).

Figure 8 shows that, for Tanzania, the share of tomatoes and products in the total tonnage of vegetables rose from 9% in 1990 to 17% in 2022.[4] Tomato output increased 4.4-fold over the past three decades.

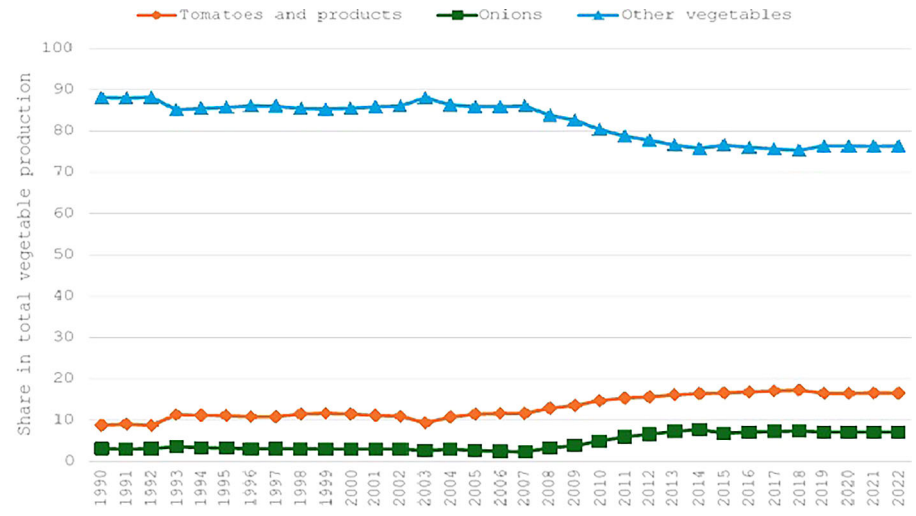
3. Meso and micro level view: RFSA context, sample, method, and data

3.1 Choice of study products

We studied tomatoes and GLVs because they are the two leading categories of vegetable consumption in Nigeria and Tanzania (Parkhi *et al.*, 2023; Sauer *et al.*, 2025). GLVs include a mix of indigenous crops, such as bitterleaf, and non-indigenous crops, such as cabbage. Tomatoes are a non-indigenous vegetable in Nigeria and Tanzania and are consumed only in small per capita volumes, even as recently as 1990, as noted above, but are now important.

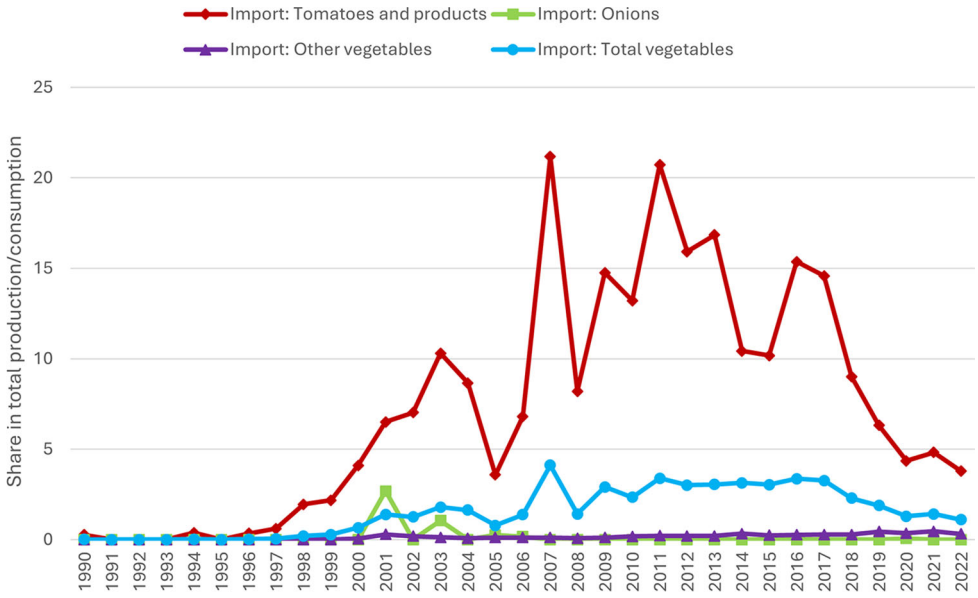
We focused on fresh GLVs because nearly all GLV output is wholesaled and retailed fresh per our RFSA in both the countries. We studied fresh tomato VCs for two reasons. First, our focus is on domestic VCs rather than trade, and all imported tomatoes are processed. However, the domestic component of processing is either small (as in Tanzania, more than 95% of tomato consumption is from purchases of fresh tomatoes per Sauer *et al.*, 2025) or mainly imported (as in

[4]This is close to but below the 21% share of fruits and vegetables in value terms shown for tomatoes in Tanzania in Sauer *et al.* (2025); this is likely due to the higher value of tomatoes than other major vegetables and possibly due to the usual minor discrepancies between macro data and micro survey data.



Source: authors' calculations from FAOSTAT Food Balance Sheet data.

Figure 8. Percentage of total vegetable production of tomatoes and products, onions, and other vegetables by Tanzania, 1990 – 2022.



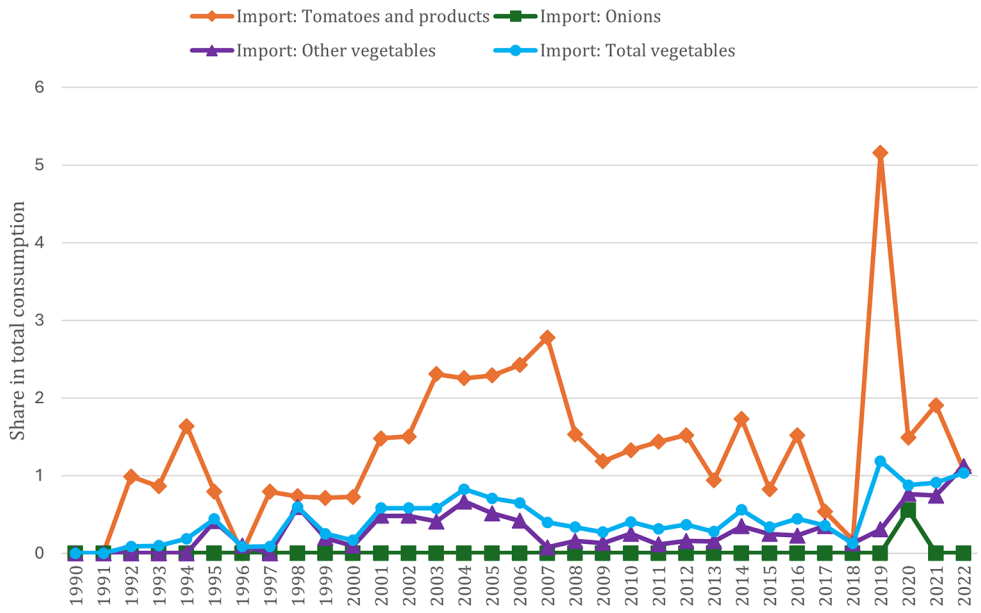
Source: authors' calculations from FAOSTAT Food Balance Sheet data.

Figure 9. Percentage of imports in consumption of tomatoes and products, onions, other vegetables and total vegetables for Nigeria, 1990 – 2022. Source: Authors' calculations from FAOSTAT Food Balance Sheet data.

Nigeria, where although tomato paste and fresh tomatoes are both significantly consumed, tomato paste is mainly imported from China and Italy).[5] The RFSA discussed below also found that farmers do not process their tomatoes, but there is some processing of tomatoes in Nigeria, particularly sun-drying.

We expect the market and production systems for tomatoes and GLVs to be different. Tomatoes are annual crops that are perishable (usually lasting 5-7 days at ambient temperatures in the shade, although several varieties allow a shelf life of

[5]Note that over the decade of the 2010s, in the South region of Nigeria (where processed tomato consumption is the highest partly as a way of compensating for any constraints to supply of fresh tomatoes from the North), per capita annual consumption of tomato paste declined significantly from 23kg to about 8kg (Parkhi *et al.*, 2023).



Source: authors' calculations from FAOSTAT Food Balance Sheet data.

Figure 10. Percentage of imports in consumption of tomatoes and products, onions, other vegetables and total vegetables for Tanzania, 1990 – 2022. Source: Authors' calculations from FAOSTAT Food Balance Sheet data.

several weeks) but are less perishable than GLVs (which last a day or two in the shade). Because tomatoes are more durable and are usually grown in specific zones under the right conditions, in many countries they tend to be trucked medium to long distances, at least as fresh tomatoes. In contrast, unless GLV are frozen or dried (not a common form in Africa), they tend to be trucked or biked short to medium distances, although we also find that some travel longer distances over several states. We show that these patterns hold for Nigeria and Tanzania.

3.2 Choice of study countries and zones

3.2.1 Study countries

We study Nigeria and Tanzania because they are large consumers (as national markets) of vegetables and are large countries, so there is variation over and distance between production zones, and thus potential heterogeneity within each country. We also examined the potential heterogeneity between countries by comparing West and East Africa. The populations of Nigeria (SSA's most populous country) and Tanzania are about 300 million people, nearly equal to the US or three-quarters of the population of the EU.

3.2.2 Nigeria study areas

In Nigeria, we studied three states: Kaduna in the North, Oyo in the Southwest, and Ebonyi in the Southeast. These are the main tomato-producing areas in the Northwest, Southwest and Southeast geopolitical zones of Nigeria (NAERLS and FMARD, 2022). The North tomato areas (represented here by Kaduna state, but also include Kano, Gombe, Sokoto, and Jigawa) and the Center (Plateau state) supply most of the tomatoes in Nigeria. The northern states have the most favorable conditions for growing tomatoes: hot and dry with sandy loam soils (Adelodun & Choi, 2018). Certain areas in the generally more humid south also produce tomatoes, such as Oyo's northern area and the Ebonyi-North agricultural zone. However, the overall tomato production in the south was much lower than that in the north.

In contrast, GLVs are produced in all Nigerian states as they can be grown wherever water is available. Various GLVs are popular complements to Nigerian carbohydrate dishes such as pounded yams and fufu (Lawal *et al.*, 2018). Their short production cycle (60-80 days) and diversity of species allows them to grow 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) Babalola *et al.* (2025).

3.2.3 Tanzania study areas

In Tanzania, we also focused on three regions: (1) Morogoro in the center, 3-4 hours from Dar es Salaam; Morogoro is a key tomato production zone and an area that has seen a rapid increase in river-based irrigation; (2) Mwanza in the North (a key tomato consumption zone but also a production zone watered by the lake and the water table near it); and (3) Dar es Salaam (the commercial capital region and largest city in Tanzania) in the east; it is a key tomato consumption zone (consuming 20% of the tomatoes in Tanzania per Sauer *et al.*, 2025) but also a production zone watered by rivers.

3.3 RFSA samples and methods applied in the two countries

In both countries, 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 ("agro-dealers"), farmers, rural wholesalers, urban wholesalers, third-party logistics (3PLS) firms (such as truckers for long-distance trade and small vehicles for short distances), and retailers. We used quantitative and qualitative insights from our RFSA of actors in the above segments of tomato and GLV value chains in the states/provinces studied. The interviews included questions about the firm's or farm's assets, input procurement, value-added activities and services provided, and marketing methods and patterns. We asked what they do now and a decade ago, their reasons for their actions and choices, and the constraints they faced.

In Nigeria, in June and July of 2022, for the RFSA, we individually interviewed 522 respondents, 319 in the tomato VC and 203 in the GLVs VC, distributed over VC segments, and firm and farm size scale strata, as shown in Table 1. In Tanzania, in August and September 2023, we interviewed 276 respondents: 134 in the tomato VC and 142 in the GLVs VC; the sample is shown in Table 2.

For the size strata, we used the classification of the governments of the study countries. In Nigeria, the National SME policy specifies that the nano scale comprises 1-2 permanent workers, micro, 3-9, small, 10-49, and medium, 50-199. The Tanzanian government specifies (Government of Tanzania, 2003) that the nanoscale has no non-family employees; micro, 1-4 employees; small, 5-49; medium, 50-99; and large has 100 or more.

The great majority of the enterprises we sampled were nano-, micro-, and small-scale. This probably reflects the actual size distribution, but we cannot verify that because there is no census of informal sector enterprises. We tried to find medium-scale firms and farms for these products but could not, as medium firms appear to be rare in these VCs. Sampling from the three strata was done using the "snowball" technique as there are no official sampling frames due to lack of census data.

In each of the ~800 interviews carried out with the VC actors, the interviewer had a question guide and engaged in roughly 1 to 1.5 hours of discussion with three quarters dedicated to understanding how the farm/enterprise was started and developed over time, how it procures its inputs and markets its outputs, and what processes and technologies it uses. In the last quarter of the interview, we asked about the challenges faced and their view of the development of their segment in the local area over time.

As the sample per segment, product, and country is small, we do not attempt to statistically test the results but instead discuss the broad patterns and note the interpretations and over-time trends that were indicated by informants in the interviews.

4. Farm segment transformation

4.1 Surge of entrants into commercial vegetable production

There has been a surge of recent entrants into growing vegetables; the majority have been new farmers rather than cereals farmers that added or shifted to vegetable production. For example, in Nigeria, the majority of the GLV farmers in our study sample from southwest Nigeria (Oyo state) were recent entrants into the business (between 2-7 years). Very few of them were long-term farmers. In Tanzania, many tomato growers started recently; for example, in Mwanza, 40% of the farms have been there for a decade, 40% for less than a decade, and only 15% had been engaged in tomato farming for more than 20 years.

These RFSA findings are corroborated by the Government of Tanzania (2021), which shows that 9.5% of Tanzania farms grew fruits or vegetables in 2008; just 12 years later (2020), the share doubled to 21%. The fastest shift occurred among small-scale farmers, from 8% to 20% of farms. For medium-scale farms, the shift ranged from 24% to 38%, and for large farms, it ranged from 16% to 26%. Overall, the area under fruits and vegetables jumped by 130%, adding 240,000 hectares in that decade. Half of this increase in area was a jump in the area under the tomatoes. In contrast, cereal area expanded by only 27%.

Table 1. **RFSA sample of firms and farms per VC segment by state and scale in Nigeria.**

		North (Kaduna)				Southwest (Oyo)				Southeast (Ebonyi)			
	Overall	**Nano**	**Micro**	**Small**	**Total**	**Nano**	**Micro**	**Small**	**Total**	**Nano**	**Micro**	**Small**	**Total**
Tomato													
Input Suppliers	**3**	0	0	0	**0**	0	0	0	**0**	0	3	0	**3**
Farmers	**74**	6	14	23	**43**	0	15	0	**15**	0	16	0	**16**
Wholesalers	**96**	11	12	47	**70**	0	14	3	**14**	12	0	0	**12**
Third-Party Logistics	**41**	8	13	14	**35**	4	2	3	**6**	0	0	0	**0**
Processors	**49**	5	0	21	**26**	4	19	5	**23**	0	0	0	**0**
Retailers	**47**	9	6	6	**21**	1	1	0	**2**	20	4	0	**24**
One-Stop Shops	**9**	0	0	0	**0**	0	0	0	**0**	5	4	0	**9**
Total	**319**	**39**	**45**	**111**	**195**	**9**	**51**	**11**	**60**	**37**	**27**	**0**	**64**
GLVs													
Input Suppliers	**9**	0	0	0	**0**	0	6	0	**6**	0	3	0	**3**
Farmers	**65**	11	20	4	**35**	0	19	0	**19**	0	3	8	**11**
Wholesalers	**52**	12	12	2	**26**	1	3	0	**4**	12	10	0	**22**
Third-Party Logistics	**12**	2	2	0	**4**	2	0	0	**2**	4	2	0	**6**
Processors	**5**	0	0	0	**0**	0	0	0	**0**	5	0	0	**5**
Retailers	**51**	3	8	2	**13**	7	0	0	**7**	26	5	0	**31**
One-Stop Shops	**9**	0	0	0	**0**	0	0	0	**0**	5	4	0	**9**
Total	**203**	**28**	**42**	**8**	**78**	**10**	**28**	**0**	**38**	**52**	**27**	**8**	**87**

Table 2. **Tanzania: RFSA sample of firms and farms in each supply chain segment by region/zone and scale.**

		Overall	Mwanza					Morogoro					Dar es Salaam				
	Segment		**Nano**	**Micro**	**Small**	**Med.**	**Total**	**Nano**	**Micro**	**Small**	**Med.**	**Total**	**Nano**	**Micro**	**Small**	**Med.**	**Total**
Tomato	Input suppliers	**14**	0	3	3	0	**6**	1	1	0	0	**2**	2	3	1	0	**6**
	Farmers	**35**	7	4	2	0	**13**	8	8	1	0	**17**	4	0	1	0	**5**
	Wholesalers	**26**	1	4	2	0	**7**	4	1	0	0	**5**	1	9	3	1	**14**
	Transporters	**22**	0	6	2	0	**8**	1	4	0	0	**5**	7	2	0	0	**9**
	Retailers	**37**	7	1	0	0	**8**	12	2	0	0	**14**	11	3	1	0	**15**
	Total	**134**	15	18	9	0	**42**	26	16	1	0	**43**	25	17	6	1	**49**
GLV	Input suppliers	**17**	1	1	0	0	**2**	2	7	0	0	**9**	1	3	1	1	**6**
	Farmers	**44**	11	5	1	0	**17**	3	9	3	0	**15**	1	4	1	6	**12**
	Wholesalers	**18**	4	2	1	0	**7**	2	2	1	0	**5**	0	5	1	0	**6**
	Transporters	**15**	4	2	1	0	**7**	4	0	0	0	**4**	1	2	1	0	**4**
	Retailers	**48**	12	3	0	0	**15**	9	6	0	0	**15**	6	7	5	0	**18**
	Total	**142**	32	13	3	0	**48**	20	24	4	0	**48**	9	21	9	7	**46**

4.2 The surge manifested in formation of spontaneous clusters

First, tomato farms are proliferating in spontaneous clusters, primarily in hot and dry areas that have easy access to highways and rivers or groundwater. In Nigeria, these areas are primarily found in North Nigeria, such as in our study state Kaduna. These areas were formerly locations for government irrigation schemes for rice and tomatoes that gave way in the 1990s to individual farm irrigation (see below). In South Nigeria, clusters of tomato growers are much smaller and tend to be in areas similar to Kaduna, such as in the northern part of Oyo State.

In Tanzania, the RFSA found that tomato farms are in clusters in rural and peri-urban areas, such as in Dumila and Mlali in Morogoro in the center of Tanzania, 3.5 hours from Dar es Salaam. The number of farms has increased significantly over the past decade (corroborating the census and FAO data for tomato output growth). The clusters are spontaneous, that is, not set up by the government, NGOs, or large company projects. They emerge in areas with easy access to water and to highways.

Second, commercial GLV farms are also proliferating in spontaneous clusters near rivers and lakes, or in areas with high water tables and near highways. In Nigeria, GLV commercial clusters are in peri-urban and urban areas, or rural areas near towns. In Ebonyi (southeastern Nigeria), the GLV clusters we studied were in the Izzi and Ezza LGAs close (within 10-30 km) to the capital city, Abakaliki. The clusters produce high-value but labor- and water-demanding fluted pumpkin leaves, as well as lower-value commodity greens such as waterleaf and bitterleaf. The city market is also supplied by farmers of fluted pumpkin GLV from a well-watered GLV cluster 100 km from Abakaliki, in the Cross River State (Ogoja area). The latter competes with the above LGAs, which are more seasonally water constrained than Ogoja. Cross-river farmers produce deep-green soft-leaf-fluted pumpkins during the rainy season using rain-fed agriculture.

In Tanzania, commercial GLV farming clusters are in areas similar to those in Nigeria: the clusters are near rural towns, such as Dumila near Morogoro and along lakes (as in Mwanza), and in urban areas (such as in well-watered areas inside the city of Morogoro). They are formed by local “grass roots’ individual entry into areas where production is favored by water and marketing by roads.

Third, MSMEs in the off-farm segments of the VCs co-locate with GLV and tomato farmers in villages or nearby towns. These segments include agro-dealers upstream, traders, third-party logistics firms, and sometimes, processors, mid-stream. They are in “symbiosis” with the farmers: the clustered farmers depend on them, and they depend on the farmers.

4.3 Commercial small-scale farmers dominate vegetable production

First, in the leading tomato zones, there is a mix of small and medium commercialized farms, such as in Kaduna in northern Nigeria and Morogoro in central Tanzania. Smaller farmers tend to grow grains in the rainy season and irrigate tomatoes in the off-season. Medium farmers tend to grow tomatoes in both seasons, with supplemental irrigation in the rainy season and irrigation in the dry season.

The RFSA showed that in Tanzania, the tomato farm size distribution differs across zones because of land markets and water access. Morogoro has “bigger” small tomato farms (than Mwanza or Dar es Salaam area) because of abundant water and proximity to highways. Most tomato farms in Morogoro are 1 ha, and some are 2-3 ha. Some of the individual farms include a group of farmers farming a larger small farm (such as a 4 ha farm) with several owners, such as teachers in the town. This appeared to be common in Dumila and Mlali in Morogoro.

Second, in less advanced tomato zones, there are mainly micro or small farmers. In Mwanza in the South of Tanzania, the RFSA found that 90% of the tomato farms operated less than 1 acre. This is partly due to constraints on the irrigation water available along the lake near Mwanza. This is also true in Dar es Salaam, where tomato farms are small because there is less land available near water sources and water constraints.

Third, in the more advanced GLV areas and in higher-value GLVs, there are also some medium farms (smaller than in the tomato sector, but relatively large among GLV farms). An example is the commercial fluted pumpkin leaf cluster supplying the capital city of Ebonyi in Nigeria, featuring relatively large farms (but still small to medium farms) with irrigation. In Tanzania, in the more commercial and intensive Morogoro area, GLV farms are relatively large and irrigated but are still classified as small farms with approximately 2 acres.

Fourth, in less advanced GLV areas and in “easy entry” low investment GLVs such as waterleaf, bitterleaf, and amaranth) farms are tiny (less than 1 acre) and tend to be only rainfed or hand-watered and operate seasonally. Examples include low-value GLV clusters on the periphery of the Ebonyi capital, and in Tanzania, around the lake in Mwanza, and along the river in Dar es Salaam.

The size distribution differs across regions because of land rental markets and water access. In Tanzania, Morogoro has larger small farms because of abundant water in areas near highways (as seen in the cluster of farms in Dumila), with paddy farmers renting land to GLV growers. In contrast, in Mwanza and Dar es Salaam, there are smaller farms because of less land available near the water sources and water constraints.

Fifth, commercial farmers (including the micro and small farmers that were near the totality of these clusters) of GLVs were mainly male. This is despite GLV gardening traditionally being a "woman's task" (to supply ingredients for household consumption). Men are more prevalent in commercial GLV production because land rental and input outlays are threshold investments that appeared to be more feasible for men than for women. However, the RFSA found that some women grew commercially but as their main employment.

4.4 Surge of farm entry enabled by widespread farmland rental

First, farmland rental markets have played a key role in the surge in tomato farming. In Tanzania, many tomato growers in all three regions rent their land. They rent from: (1) long-term landowners in Dumila/Morogoro and (2) paddy farming landowners in Dumila/Morogoro and lakeside farmers in Mwanza. In Nigeria, we found that 35% of tomato plots are rented-in (25% in Kaduna and 45% in Oyo; hence, the rental rate is much higher in the south).

Second, land rental markets spurred commercial GLV farming, especially in leading clusters. In Tanzania, most GLV farmers in Morogoro and Mwanza rent, whereas in Dar es Salaam owning the farmland is still dominant. For example, in one production area in Morogoro (Dumila), 15 of the 16 GLV farmers interviewed rented their land; only one owned it. Informants noted that some growers started by renting and later owned the land.

Third, GLV farmland rentals originate from a surprising array of sources. In Tanzania, the RFSA identified: (1) collectively owned "schemes" in areas designated as GLV near water sources (Dar/Ilala); (2) government and religious institutions in Dar es Salaam; (3) schools and religious institutions in Pwani near Dar es Salaam); and (4) farmland owners such as paddy farmers in Dumila/Morogoro and lakeside farmers in Mwanza.

Fourth, farmland rental costs are rising under demand pressure from the surge of entrants, first in the leading clusters and then in the other zones. For GLVs in Tanzania, land rental costs (per hectare per unit time) differ within and between zones. Where land access is constrained (e.g., in the city of Morogoro and along the lake in Mwanza), land and water are costly and difficult to access. Where land access is less constrained (e.g., in Dumila (town/village near Morogoro city)), where many paddy farmers rent out land, land, and water costs are lower. However, entry into these areas has been rapid, so the land market is tightening.

Fifth, some farms are also expanding. In Morogoro, some grew from two to five plots (urban Morogoro) and one to more hectares (Dumila). Some acquired land by buying or renting from other farmers in their clusters who dropped out or rented-out some of their plots. Some acquired additional land in other clusters where the land rental cost was lower (including newer areas).

4.5 Surge of farm entry enabled by irrigation investment & water access

First, the diffusion of individual farm irrigation has been important for the spread of tomato farming. In Nigeria, respondents from all three states noted that there has been an increase in irrigation that facilitated an increase in output and longer production seasons in the dry north and central states. The development of irrigation for tomatoes and rice in the north occurred in the 1970s and the 1980s in large-scale irrigation schemes by the Federal River Basin Development Authorities. These schemes run into a host of problems (Adams, 1991). Emphasis shifted to small-scale irrigation in the 1990s.

Water access has been crucial for tomato diffusion in Tanzania. All tomato clusters were near lakes (Mwanza) or rivers (other zones). This mirrors the findings of Minten *et al.* (2020) on vegetable farm clusters in Ethiopia. These water-rich areas were either already the basis of irrigated farming (such as paddy farming in Dumila) or part of the geography of urban settlements that then supported water-using horticulture (all other zones) as urban demand grew and induced commercial tomato clusters.

Second, tomato irrigation practices and seasonality differed according to farm size, controlling for the zone. In Nigeria, medium-sized tomato farmers grow year-round with irrigation. Small farms grow tomatoes under irrigation only during the dry season in the same fields, which have a rainy season crop, such as rice or maize. Irrigation is fed by pumps, pipes, and buckets to move water from streams and rivers to fields. There is evidence of nano- and micro-farmers borrowing or renting irrigation equipment from medium-sized farmers and cooperatives. Competition for access to water pumps is increasing. There is a general constraint on water access in the dry season: farmers increasingly have to dig wells.

In Tanzania, there is uneven diffusion among tomato farmers of pump irrigation (as a shift from traditional bucket use). In Morogoro, tomato farmers tended to start with buckets and then many shifted to pumps/pipes to irrigate from rivers. They also shifted tomato cultivation from one to two seasons and from a small scale to a larger area as they irrigated more. Irrigation investments appear to be self-financed investments based on reinvesting in retained earnings from tomato farming. In contrast, in Mwanza, there is much less pump irrigation; 60% still use buckets to obtain water from the lake. They reported that a pump is expensive, and that only farmers using a pump have easy access to water from the water table near the lake and have invested in a borehole.

Second, there is some GLV irrigation in drier areas and small/medium commercial growers in humid areas. Microfarms are typically only rainfed in secondary zones. In Nigeria, in wet areas in the south (Oyo and Ebonyi), rainfall is plentiful in the rainy season, when there is even a constant threat of flooding. However, even in humid areas, water is scarce in the off-season and there is some irrigation in areas with higher-value GLV production, such as for fluted pumpkin production in the Cross River state. There are various categories of farmers: (1) farmers practicing rain-fed agriculture; they engage in rainy-season cultivation and the supply of fluted pumpkin. These groups are located in upland, less swampy areas of the state (Izzi and Ezza local government areas). They practiced intercropping of the GLV with other major crops such as yam, cassava, and pepper; (2) farmers practicing dry season cultivation of GLV by riverbanks around Ikwo and Afikpo local government areas; and (3) farmers practicing irrigated farming on smaller patches of land year-round.

In Tanzania, access to water is crucial for the diffusion of GLV farming. All the GLV zones we studied (and, it appears, all the GLV clusters in Tanzania as a hypothesis) are near lakes (like Mwanza, with low water tables around them) and rivers (other study zones).

Third, there has been an uneven diffusion of pump irrigation among GLV farmers. In Tanzania, small-scale GLV farmers tend to begin with buckets. Those unable to afford (or without) the incentive to obtain a pump only stayed with buckets. The shift to pumps was earliest and fastest in Morogoro where the larger "small farmers" bought or rented imported Chinese pumps. In contrast, in Dar es Salaam (Ilala), tiny farms only use buckets, whereas in Pwani (near Dar es Salaam), there is incipient pump use.

In Morogoro, we found that pump investments were financed mainly by retained earnings from vegetable farming, or sometimes from outside income. However, credit is not an important driver. The RFSA found that many farmers rent pumps from others at a cost similar to that of their land rental outlay for one season. The respondents noted that, relative to local incomes, the start-up costs (for water pumps and land rental) are high, but after starting, the returns are high. We performed rough calculations with the RFSA responses and found that GLV production earns roughly two or three times the gross returns per hectare as paddy and much more per day than farm workers earn.

4.6 Farming intensification with external inputs (hybrid seed, fertilizer, pesticide, herbicide)

The RFSA found a trend of farming intensification with tomato hybrid seeds, irrigation uptake, and chemical fertilizer and pesticide use in the production areas, especially in the tomato clusters and the leading GLV clusters.

4.6.1 Hybrid seed use

Regardless of the scale, tomato growers have shifted over the past decade to hybrid tomato seeds. Rapid diffusion was reported to have been encouraged by: (1) agro-dealers supported by seed companies sending representatives to the villages, (2) extension agents, and (3) farmer-to-farmer contacts.

RFSA did not reveal diffusion of hybrid GLV seeds. This may be partly because most indigenous species such as waterleaves or bitterleaves do not yet have much varietal R&D and hybrid seed commercialization. It may also be because a main GLV, amaranth, is itself non-indigenous to Africa (it is indigenous to North America and was introduced into Africa; Adegbola *et al.* 2020) and some of the introductions were hybrids but may not be locally recognized as such in Africa.

4.6.2 Fertilizer and pesticide use

First, informants in the two countries noted that there has been a widespread increase in the use of chemicals for tomato production. Chemical use is widespread for tomato production in Nigeria. The RFSA indicated that 5% of the tomato farmers used them (97% in Kaduna and 70% in Oyo). In Tanzania, among tomato farmers, pesticide use has spread over the past decade, from 30% to 55% of farmers. More than half the growers used herbicides. This did not change over the lives of the studied enterprises.

Mwanza and Dar es Salaam respondents reported using more than the recommended doses because they believed the recommended rates were not enough to control pests. They increased the dosage over time because growing intensively and densely with a climate of heat and humidity have combined to bring more disease and pests, and they report that pesticides "lose their potency" so they have to apply more. Respondents noted that the price of these inputs has been increasing along with the costs of irrigation pipes and tractor services. At the same time, the tomato prices were erratic and seasonal. However, the farmers appeared to be making profits as they were re-investing, and newcomers were spilling into the sector.

Second, fertilizer and manure use is ubiquitous (and has been in the past decade) regardless of the tomato farm scale. Some have reported increasing use because of "tired soils" from intensive cultivation. Fertilizers are mainly sourced from agro-dealers and some from government-subsidized supply. Mwanza respondents noted a sharp jump in fertilizer prices over the decade and that small farms used below the minimum purchase volume needed to be able to access subsidized fertilizer, so they buy from agro-dealers in small amounts. Morogoro respondents noted that government-subsidized fertilizer is on offer to 1-2 times per year. They have to register and then the association informs them, but they often do not get it and thus mainly buy it from agro-dealers.

Third, there has also been an increase in pesticides and fertilizer in GLV, but compared to tomatoes, the diffusion has been limited to lead clusters and "larger" small farmers. For example, in Nigeria, there has been some emerging use of chemicals on GLVs, along with hired labor for weeding and staking on commercial GLV farms, such as the fluted pumpkin leaf farms in the Cross River State. However, the informants told us that the majority of GLVs are grown without chemicals, as most of these are indigenous varieties that are adapted to the local environment and are relatively resilient to local pests and diseases.

4.6.3 Tractor use

The pattern of diffusion of tractor use is similar to that for chemicals; uptake is mainly in the lead clusters and among the "larger" small farmers. In Tanzania, most farmers use hand hoes and hired labor to prepare the land during the rainy season. However, in Morogoro, a substantial share of farmers use tractors during the dry season. As expected from smaller farms, there is far less tractor use in Mwanza and Dar es Salaam. Only about a third of GLV farmers use tractors, while the rest prepare land by hand. Tractor use is positively correlated with farm size.

4.7 The diffusion and growth of agro-dealers

First, agro-dealers are based in vegetable wholesale markets and farming communities (the farm clusters). The agro-dealers have been proliferating. This trend mirrors the increase in the use of inputs noted above. The agro-dealers sold inputs to both tomato and GLV farmers.

In Nigeria, the Ebonyi RFSA noted that agrochemical suppliers' volumes have increased over the past decade, reflecting the adoption of pesticides and herbicides.[6] They noted that this was not the case about 15 years ago, and that the increased adoption was related to increased awareness and improved knowledge of agrochemicals, as well as the marketing activities of company sales representatives in rural locations. In Tanzania, for example, in Mwanza, agro-dealers are proliferating, matching the rise in chemical use on tomato farms: our RFSA found that nearly 70% of the surveyed enterprises were established in 2023. Half of the surveyed agro-dealers were micro scale, and half were small enterprises.

Second, agro-dealers supply a wide range of inputs to farmers – a "one stop shop." In Oyo State, RFSA informants noted that agro-dealers supply pesticides (insecticides, fungicides, nematicides, rodenticides, and herbicides), fertilizers (granular fertilizers such as urea, NPK, calcium nitrate, potassium nitrate, and liquid fertilizers), vegetable seeds, and tomato seedlings (the latter are often produced by the dealers).

Third, agro-dealers provide "private extension" to the farmers, informing them with flyers, demonstrations, and advertisements. The informants did not mention government extension agents as their sources of information.

Fourth, the scale of input suppliers is mostly micro. It should be noted that input suppliers are usually trained agronomists. They engage in other services, including raising seedlings and advising others. Fertilizer and chemical sales occur in the

[6]The latter 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.

rainy season/cropping season, from the onset of the rain to the end of the cropping season, while seed sales occur before planting.

5. Growth and transformation of the midstream segments of the tomato VC

5.1 Spatial lengthening of tomato VCs in Nigeria and Tanzania

As noted in the introduction, the literature on domestic value chains of vegetables in SSA has emphasized the preponderance of spatially short VCs, from peri-urban to urban. In contrast, our RFSAs in Nigeria and Tanzania show that long- and medium-length VCs have developed over several decades for tomatoes, and in the past 1-2 decades, short-medium length VCs have developed for some (such as cabbage) GLVs. For both products, there was a coexistence of short VCs with rapidly growing medium and long VCs. We define long as inter-regional (such as between the North and South in Nigeria), medium as inter-state but intra-regional, and short as intra-state. Our findings on these spatial trends and patterns are as follows:

In Nigeria, our RFSA found spatially long VCs from North to South of tomatoes. This finding is logically underpinned by two factors. On the one hand, tomato consumption is ubiquitous; Parkhi *et al.* (2023) showed that around 80% of consumers in both the North and the South consume fresh tomatoes (usually made into sauce at home). The annual per capita consumption of fresh tomatoes is 11 kg in the South versus 7.7 kg in the north. However, tomato production is spatially concentrated in a few zones; the majority of tomatoes in Nigeria are produced in the north.

Traders (often via 3PLS, as discussed below) from the northern and central regions 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 to: (a) supplement the very limited local supply in the South; (b) 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) 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.

In Tanzania, this situation is similar. Tomatoes are consumed all over the country, but their production is mainly concentrated in three zones: the ones we study. Wholesalers go (or send 3PLS) to and from these zones to sell in wholesale markets or directly to retailers around the country in medium and long VCs, for the most part.

5.2 Rapid development of tomato wholesale markets, vegetable traders, and third-party logistics MSMEs with the lengthening of tomato VCs

5.2.1 Spread of tomato wholesale markets as nodes along VCs and within-cities

First, there has been a rapid proliferation of tomato wholesale markets and wholesalers in both Nigeria and Tanzania over the past several decades.

For example, in Tanzania, the tomato output increased from 36,000 tons to 464,000 tons from 1990 to 2022. Today, wholesale markets handle nearly half a million tons of tomatoes per year, or approximately 1300 tons per day. To put that in perspective, note that a "10-ton truck" (the most common transport vehicle for long distances) holds about 5 tons of tomatoes, implying that every day, 260 of those trucks load and offload in three or four dozen wholesale markets around that country. This is an enormous volume to pack, load, off-load, and sell each day with accompanying logistics. Each market is a large food industry platform.

To procure and market that huge volume (and its massive increase over time), there was a tripling of tomato wholesale markets over three decades, according to findings of a wholesale market survey of 31 tomato markets across 8 cities (with a total population of 6.5 million in 2012, the last census) in 2022. Six of the 8 cities are mainly "consumption cities" and 2 are "production cities" in the main tomato production zones; the wholesale markets in the latter are conduits to a much larger area than the cities they are located in.

This proliferation of markets usually featured, per city, the establishment in the 1970s-1990s of an official central wholesale market for produce. Over the decades, produce markets spread out from the city center along main roads in the diffusion of private informal markets. There was a gradual conversion of the latter into municipality-managed or supported markets, taxed, and serviced with infrastructure and policing. The markets evolved from seasonal to year-round, as irrigation of tomatoes allowed continuous suppliers (Reardon *et al.*, 2024a).

5.2.2 Tomato traders

Urban wholesalers source tomatoes either directly from farmers (often collected via third-party logistics, 3PLS, discussed below), or from rural traders who assemble from farmers. In some cases, wholesalers source tomatoes from urban wholesalers.

In Tanzania, the wholesale market survey noted above (Reardon *et al.* 2024a) found a doubling of wholesalers in the average tomato wholesale market over the past 10 years. This rapid increase in wholesalers was corroborated by our RFSA results. The respondents noted a large increase in the number of tomato wholesalers over time from the establishment period from 1990s to the present. This correlated with the spread of tomato farming in Morogoro and Mwanza, and with an increase in the consumption of tomatoes in Dar es Salaam and other regions.

RFSA informants in Tanzania reported various paths people have taken to become traders: (1) some were farmers then wholesale, (2) some started as retailers, (3) some had non-farm enterprises, (4) some had just graduated from school, and (5) some were unemployed. The share of men is approximately 60% and women, 40%. Women tend to be semi-wholesalers, buying from wholesalers and selling to retailers. Many traders (especially females) are wholesalers and retailers (depending on the volume desired by the customer). Moreover, in the high season, when tomatoes in the production areas are abundant, some retailers also sometimes become wholesalers.

The RFSA in Tanzania and Nigeria found that urban wholesalers clustered in wholesale markets, while rural traders were based in towns or villages in production areas. They tended to operate in both high and low seasons throughout the year (but with the highest profit rate in the low season).

Wholesalers play a crucial role in the operation of long tomato supply chains. In Nigeria, 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 largest 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 to April, and is perceived by many to be a preferred option. The Benue State tomato season is May to September. The Enugu State (Nsukka) tomato variety season is from April to September. The tomato variety from Cameroon, aggregated and sold in the Cross River State (Ikom area), is grown all year, but its sales in the Ebonyi State are seasonal. Wholesalers in Ebonyi make regular trips to tomato source states to 3-5 times per week.

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 and (b) buy from an array of traders in cities in different states with staggered tomato seasons. North traders (according to our interviews in Kaduna) send tomatoes to the South wholesale markets. Payment used to be made by transporting cash, but informants noted that this has shifted over the years to electronic money transfers.

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

Finally, wholesalers in both Nigeria and Tanzania make extensive use of third-party logistics MSMEs, including to "disintermediates", buying directly from farmers. This is further explored below. In Nigeria, while some relatively large tomato wholesalers own vehicles for transportation (e.g., J5 Ford, Trailer, Boxer) that they use to transport tomatoes from the north to the south, smaller wholesalers and farmers often hire "driver plus truck" 3PLS, or liaise with bigger wholesalers to transport their tomatoes in the larger wholesaler truck, or liaise with other smaller wholesalers to hire a 3PLS truck together. However, South traders (such as in Oyo) reported that when they went to the tomato farms in their area, they directly sourced and transported the tomatoes themselves. Thus, for tomatoes, it appears that short value chains may not use 3PLS as much as long value chains.

In Tanzania, RFSA findings showed that Morogoro and Mwanza (mainly production zones) traders buy direct from farmers, using 3PLS to fetch the tomatoes - hence "disintermediating" by eliminating or reducing their reliance on rural traders; such as found by Reardon *et al.* (2012) in India. They also buy goods from distant traders. Dar es Salaam traders buy from production zone traders and local farmers because there is a large local market, as Dar is one of the main tomato consumption zones (with some production for the local market).

The RFSA noted that in the high season, where there is a lot of supply, wholesalers (or rural traders working on their behalf) just buy from their "regular" (repeat transactions) farmers; and farmers are keen to sell or face losses so there is "easy access" In the low season, there is more competition for the small supply available, and traders use both the spot market and buy from their regular farmers. In Mwanza and Dar, traders also buy from other traders coming with tomatoes from other zones such as Morogoro.

As in Nigeria, in Tanzania, the RFSA revealed a large increase in wholesalers' use of 3PLS over the decade. Wholesalers own vehicles or hire 3PLS, but most traders use 3PLS in all the zones. Motorcycle and tricycle 3PLS operators go to farms to pick up tomatoes. Some farmers transport their own tomatoes, but 3PLS hired by farmers is now more common. Traders either ask farmers to arrange 3PLS or themselves to deliver the tomatoes to the trader, or the traders arrange 3PLS to go to the farm to pick up tomatoes.

5.2.3 Rapid development of 3PLS MSMEs in the tomato VC

Third-party logistics services (3PLS) have received little attention in agribusiness and supply chain research in SSA but are critical for the operation of VCs. This neglect may occur because policymakers and researchers have assumed that 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 is important to VCs in general and wholesalers in particular: only 4% of urban maize traders own trucks, and about 75% of the maize they trade is moved by 3PLS (Liverpool-Tasie *et al.*, 2021). Wholesalers typically pay a fee to truckers to move their products from farms to markets and/or customers. The results of our RFSA for both tomato and GLV VCs mirror the maize VC finding of the 3PLS importance.

In Tanzania, Reardon *et al*. (2024a) showed wholesale market survey results indicating the rapid development of 3PLS based in or near the tomato markets, including medium and small trucks for medium- and three-wheelers, and motorcycles for local pickups and deliveries of tomatoes.

Our RFSA corroborated these results, showing that there has been a significant growth in the number of transporters and some growth in the size of vehicles over the past decade. This mirrored the growth in volume moved in tomato VC.

Tanzania tomato 3PLS has a mix of scales and modes adapted to the local situation. For example, in Mwanza, there is a mix of: (1) large trucks, small trucks, tricycles, motorbikes, bicycles, and wheelbarrows; and (2) small boats on Lake Victoria (<3 tons of cargo, 5-person crew). Vehicle size is linked to transport function: (1) small vehicles (tricycles, bicycles, motorcycles) collect tomatoes from rural and remote areas; (2) motorcycles and trucks travel longer distances (from Morogoro fanning out over the country); and (3) in Mwanza, some reported shifting from a smaller to a larger vehicle, a small to a larger boat, but more boats entering has meant less cargo per boat (hence more transport competition). Most MSMEs are male-owned and nanoscale, and a quarter of them are small-scale. In Mwanza, 75% operate in peri-urban areas or towns, mostly within markets, and 25% in rural areas. Some vehicles are owned, and some are rented (joining a common theme in this paper of emerging equipment and land rental markets). In Mwanza, two-thirds of the 3PLS MSME own and one-third rent their vehicles.

In Nigeria, our interviews with tomato wholesalers revealed that 3PLS is important for 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 pickup and delivery. Our interviews in Kaduna found that smaller wholesalers are particularly reliant on 3PLS to send tomatoes to the south, while large wholesalers tend to have their own trucks.

It has been commonly reported that wholesalers employ transporters with whom they have long-standing relationships. Transporters are sometimes responsible for the loading and unloading of products. As mentioned 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 fuel tankers, where transport consisted of baskets of tomatoes tied to the top of the tanker (although some fuel companies banned this practice in 2015). This is usually done when they are going for loading, that is when the fuel tank is empty. Instead of traveling empty, the tomato baskets were arranged in two layers and tied with a strong rope.

Wholesalers in Oyo in the Southwest noted that in a season, an average trader spends around 1200 USD moving 21,000 crates (around 420 tons at 20 kg per crate) of tomatoes, scotch bonnet peppers, cayenne peppers, and red bell peppers. This is about three 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).

5.3 Challenges of the midstream of medium and long tomato VCs

As long as tomato VCs have emerged and developed in Nigeria and Tanzania, and farmers, traders, and logistics MSMEs have entered them in large numbers, the benefits to the participants in terms of income and growing markets, and to consumers in terms of availability of tomatoes in both production and consumption zones is evident. However, the challenges of long VCs that actors face and policymakers can address.

First, stretching from North to South, they traverse zones of conflict and are exposed to banditry and corruption by road officials. This is perhaps the sharpest complaint of the value chain participants, who also noted that this raises the costs that are passed on to retailers and consumers.

Second, the length of the VCs makes vehicle maintenance and fuel major costs and creates substantial delays, and thus spoilage. These are exacerbated by the poor state of the roads for long stretches, the frequent scarcity and cost spikes of fuel, and vehicle breakdowns from poor roads and low-quality vehicles. These challenges were noted by wholesalers in all 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, such as traffic jams lasting seven days. Tomato cargo is spoiled and sometimes fully destroyed by heating during these delays.

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

Fourth, as long value chains require relatively large loads shipped to make long trips profitable, there is often a need to store the produce, especially tomatoes, for a few days in the market. We found that there were few storage facilities (ambient or cool) for wholesalers or retailers in the markets studied. This lack of storage space, paired with sharp seasonality and production being delivered in gluts, often results in low prices. One innovation noted by traders (sometimes via arrangement with transporters) is the logistics around the quantities and times of offloading tomatoes in markets. This coordination prevents the collapse of tomato prices, but also involves the use of vehicles for the short-term storage of tomatoes.

6. Transformation midstream of GLV VCs

6.1 GLV VCs tend to be short or medium length in both countries but long VCs are emerging in some regions

The main GLVs, such as amaranth, are grown and consumed in nearly all zones in both countries, at least in the rainy season. We found that the predominant length of a GLV VCs was short, from the rural area around a town, or within a state or province.

However, we also found examples of emerging medium-length and even long-length VCs (inter-state from contiguous states or provinces for medium, but even longer in some cases). In Nigeria, we found evidence of long (over a number of states) GLV value chains due to the transportation infrastructure and strategies (such as moving products overnight). An example discussed below is that of the fluted pumpkin leaf production cluster in the Cross River State supplying the capital of Ebonyi in Nigeria, 100-200 km distant.

In Nigeria, our RFSA 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 in the morning (usually for a few hours) to minimize exposure to heat. The transporters cover the GLVs with a tarp while in transit, and restore the humidity of the leaves by splashing (not always clean) water on them when they arrive at the market.

6.2 GLV wholesalers are proliferating rapidly and disintermediating locally

In Tanzania, the RFSA revealed that there has been a significant increase in the number of GLV wholesalers over time. They tend to cluster in wholesale markets. They operate in both the high and low seasons. Several traders have reported large increases in their volumes over time. The general picture is trading profitability (manifested in its drawing in entrants) despite traders facing various challenges.

Second, GLV traders buy directly from farmers in the Morogoro area and via brokers/agents for those farther away. Nearly all GLV trade is cash, and few traders use digital payments to farmers. Fourth, the traders buy with criteria of quality traits: fresh, size, green, no blemished, not over-matured, and some traders said they also ask whether farmers

report a safe period observed (pesticide). Wholesalers noted that customers want fresh GLV (at most one day) and that GLV not sold after one day are normally sold to livestock/chicken farmers. However, there is no quality differentiation (in sorting or differentiated payment for grades) at the point of purchase from farmers, as they just buy what farmers have that is fresh and ready to sell immediately.

6.3 Third party logistics is key for GLV wholesalers in both Nigeria and Tanzania

The RFSA revealed that GLVs wholesalers in both countries rely mainly on 3PLS for transportation, with variations in the types and scales of 3PLS that fit the context. For example, in the Ebonyi state (Nigeria), the wholesale markets in its capital (Abakaliki) are supplied by GLV farmers in Ebonyi and in the neighboring Cross River and Benue states. The wholesalers who supply the Abakaliki market are mainly women in nano- and microscale firms. The wholesalers can be classified into two groups.

a) GLV wholesalers based mainly in Cross River State a few hours away: they aggregate vegetables from farms and vegetable markets in the northern part of Cross River State. The GLV is then supplied to the major market in Ebonyi State. Female traders act as wholesalers and sometimes as 3PLS firms. They package vegetables in bundles of approximately 100 bunches wrapped in soft bags or cloths. They then pay 3PLS firms to bring the product down to the major markets in Ebonyi State, where the products are delivered to the second group of wholesalers.

b) Wholesalers in the Ebonyi State major market: These traders buy the GLV from the first group, debulk it, sell it to retailers in the main market and other markets, and sometimes retail it themselves.

3PLS MSMEs dealing in Ebonyi GLVs operate in all the major supply routes for tomatoes and GLV produced from the Cross River, Plateau, and Benue States, as well as from Nsukka. They provide the services of loading, transporting, and offloading products from supplier markets to designated markets. Men dominate these services. The 3PLS are mainly nano- or micro-enterprises with small vehicles. They cluster at the rural supply markets in the Cross River, Plateau, and Benue States, and Nsukka (a town in Enugu State), and then make trips to urban wholesale markets.

In contrast to the high level of activity in the GLV market in Ebonyi, in the Oyo state in the southwest, we found that a number of GLV farmers, especially women, also acted as wholesalers who sold GLVs from their own farms and occasionally from other farmers.

In Tanzania, the RFSA noted that there has been rapid growth in the number of transporters and transport clients over time, with the number of motorcycles growing rapidly in the past to 2-3 years. Most were male and operated at the nanoscale. The owners have often built up from just hand-carrying/walking, bicycles, and tricycle/motorcycles. Most people own vehicles or rent them. Moreover, transporters sometimes double as wholesalers do. The clients were wholesalers and farmers. Most operate over short distances locally within their regions.

Second, some GLV traders have their own vehicles, but many use the 3PLS operators of bicycles, motorcycles, or motorized three-wheelers. 3PLS firms use trucks mainly to ship GLV to more distant markets such as Dar es Salaam; for example, in Dumila, traders buy Chinese cabbage in bulk and transport it to Dar es Salaam using hired 3PLS (buying from collection points in Dumila).

7. Conclusions, research agenda, and policy implications

This study showed that Nigerian and Tanzanian tomato value chains have grown over time and have “lengthened spatially” from spontaneous clusters of farmers to cities and rural areas all over the two study countries. Even GLVs, traditionally produced and sold in very short local supply chains, have in some parts of Nigeria and Tanzania lengthened to span several states/provinces. This spatial change has been facilitated by improved infrastructure and longer seasons where irrigation, especially of tomatoes, and the multiplication of tomato-farming sites has resulted in steady output.

We found that a crucial segment in these value chains are wholesalers, who are primarily based on 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 under-studied segment of the value chain.

The emerging development policy research implications of this study are as follows. First, Agrifood research in Africa and to a certain extent in Asia has underemphasized vegetables, yet they are important as a share of consumption and as important elements of a nutritious diet. Second, the literature and debate, in general African literature as well as in our two study countries, have underemphasized non-traditional vegetables, such as tomatoes, yet they are important among

vegetables in both production and consumption. Third, these vegetable value chains have important off-farm segments such as agro-dealers, wholesalers, and 3PLS, which are underemphasized. They constitute important shares of total value-added, affect farm profitability, and move the majority of vegetables consumed from medium to long distances to feed consumers. They are also an important source of employment and livelihoods for Africans. Additional research to better understand the behavior and constraints of millions of micro-, small-, and medium-scale enterprises (MSMEs) along horticulture value chains is essential to understand the vegetable economy and inform policies, as discussed below.

The emerging sustainable food system development policy implications of this work are not only for Nigeria and Tanzania, but also for other African and Asian countries where smallholder farming and MSMEs predominate in vegetable value chains. The most important implication is the need for government investment in the basic infrastructure underpinning these value chains, including wholesale markets, irrigation system interfaces, storage facilities, roads and good transport policies, electricity grids, and governance. Likewise, investment in soft infrastructure, including extension/information services, training for mechanics to service the vast 3PLS sector was found to be crucial. Finance for vehicle purchases and repairs, reduction of road officials' corruption, R&D in vegetable seeds, food safety education, and women's capital building would also aid in the efficiency and inclusiveness of the value chains.

Ethical approval and consent statement

All studies in this project involving humans were approved by Michigan State University Institutional Review Board and were conducted in accordance with the local legislation and institutional requirements. This project has the Michigan State University IRB Study ID: STUDY 00007403 and was determined exempt Category: Exempt 2ii. The participants provided their written informed consent to participate in this study.

Data availability statement

Data will be made available on request.

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