Urban Transformations

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Food systems and rural-urban linkages in African secondary cities

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Abstract

Urban populations globally are expected to increase by approximately 2.5 billion by 2050. Much of this growth is taking place in African cities, where about 40% of Africans live in urban areas with populations of less than 250,000. In many of these cities, rapid urban growth has outpaced economic and social development, resulting in high levels of urban poverty and widespread food insecurity. As one response strategy, urban households may leverage their linkages with rural areas and other towns or cities to supplement their food consumption, for example through food remittances or food purchases from remote retailers. While this strategy has been found to occur among inhabitants of large cities where existing research on urban food systems and urban food linkages with other areas has focused, the dynamics in smaller cities are likely different. In this paper, we draw on data from 837 surveys collected in 2021 to investigate household food sourcing strategies across 14 urban areas in Zambia with populations less than 100,000. We find that rural-urban food linkages are dominated by grains while urban-urban food linkages are predominantly composed of higher value foods. Our data further suggest that urban area characteristics explain more of the variability in food sourcing behaviors than household level characteristics, and that urban food purchasing preferences in secondary urban areas are sensitive to the food retail landscape available to households. These relationships highlight the disparate role that rural and urban linkages play across cities of different sizes. They suggest a need for food-related policies to consider diverse urban food systems among smaller cities.

Highlights

- Households in African secondary urban areas have food linkages with rural areas and other urban areas
- Rural-urban food linkages are dominated by grains, while urban-urban food linkages comprise more higher value foods
- City-level characteristics explain more of the variability in food sourcing behaviors than household-level characteristics

Keywords: Rural-urban linkages, Urbanization, Food systems, Africa, Food linkages, Food sourcing

Policy and practice recommendations

- Secondary urban areas should be integrated into food systems planning in southern Africa
- Retail shops represent an important food outlet in secondary urban areas, but they remain understudied
- Future urban food security resilience efforts should focus on secondary urban areas which are spatially isolated from surrounding food sources.

Introduction and literature review

Urban populations represent approximately 55% of the total 7.7 billion people globally (United Nations 2018). Over the next 30 years, urban dwellers are expected to increase by 2.5 billion overall, and much of this growth will take place in developing regions (Mahtta et al. 2019). The most concentrated urban growth is projected to take place in Africa, where cities will host nearly 90% of the total increasing urban global population by 2050 (United Nations 2018). Much of this rapid urban growth is driven by high fertility rates and declining mortality rates, but a significant portion of African urbanization can also be attributed to rural-urban migration (Lerch 2017).

While primary and mega-cities continue to play a significant role in the urban landscape of countries around the world, much of the urbanization projected to take place in Africa will occur in cities and towns with populations of less than 500,000 people. These secondary urban areas currently represent 26.5% of the global population and more than 50% of the global urban population (Chai and Seto 2019; Buettner 2015). In Africa, two-fifths of people are already living in secondary urban areas with populations of less than 25,000 people (Zimmer et al. 2020). Despite the importance of these secondary and tertiary urban areas, much of the knowledge about urbanization processes and their implications for African food systems come from studies of large cities (McCall 1955; Fox 2012; Wolff et al. 2019).

One reason urban populations are growing is because of the perceived economic opportunities that rural-urban migrants seek (Duda et al. 2018; Mercandalli et al. 2019). Migration allows households to engage in non-agricultural livelihoods and secure permanent employment opportunities, as well as allowing other household members to benefit from education and other employment opportunities available in towns and cities. However, in many African cities, the rate of urban population growth has outpaced the ability of governments to provide basic services to urban residents, leading to "urbanization without growth" (Cohen 2004; Fay and Opal 2000). As a result, tens of millions of people across the region live in overcrowded, informal settlements with inadequate access to water, electricity, and sanitation (Cohen 2004). In many rapidly urbanizing African cities, these conditions exist alongside chronic underemployment and high poverty levels (Baker and Akin Aina 1995; McDonald 2000; de Bruijn et al. 2001; Falola and Salm 2004), resulting in widespread food and livelihood insecurity (United Nations 2018; Parnell et al. 2013). Developing safe and prosperous urban environments in Africa is now a pressing global challenge and a priority for meeting the United Nations

sustainable development goals of no poverty, zero hunger, clean water and sanitation, and sustainable cities and communities (Wu 2014; Seto and Ramankutty 2016; Giles-Corti et al. 2016).

Rapidly growing cities tend to have stressed food systems due to the pressure of increased demands for food from growing urban populations. A food system is defined as the set of activities and processes ranging from food production through to the consumption of food, which involves interactions between people and the environment that affect food security outcomes (Ericksen 2008). Whereas rural populations are net food producers, urban populations are net food consumers, typically purchasing most of the food that they consume. Although there is some evidence of urban households being engaged in food production, this is a relatively small amount, and there are considerable barriers to urban agriculture that limit the capacity of urban households to produce enough food to contribute meaningfully to their food budget (Davies et al. 2021). A high reliance on purchased food means that urban households are vulnerable to food price shocks, which is a particular concern for the urban poor who spend a significant portion of their income on food (McCordic and Frayne 2017).

Low-income urban households often use a range of coping strategies to ensure that they are food secure (Blekking et al. 2020). One coping mechanism that is often used by these households is to leverage the social and economic connections that they have with the rural areas from which they may have migrated (Onyango et al. 2021). These connections can allow households to access food through transfers or purchasing food while visiting other locations. These connections also allow household members to find employment in both rural and urban areas through seasonal agricultural work or opportunistic wage labor in cities (Smit 2016; Collinson et al. 2006). Other households live and work in urban centers but retain rural land where they produce food for their consumption (Andersson 2002; Foeken and Owuor 2008; Frayne 2005). Some urban households secure food linkages through kinship ties in rural areas, which help them to mitigate shocks to food access. Food linkages between rural and urban households are particularly crucial for alleviating food insecurity because it increases households' access to healthy, safe, and affordable food that is less susceptible to variability in price and accessibility (Frayne 2004; Frayne 2007; Nickanor et al. 2016; Owuor 2006). For example, Frayne (2010) found that across 11 large cities in southern Africa, 40% of households in low-income neighborhoods received some of their food from rural households. These were typically cereals, pulses, and vegetables, which form a substantial part of African diets. Other evidence from rural settings suggests that 40% of rural households send maize to family and friends in nearby towns or cities (Djurfeldt 2015). These rural food linkages received by urban households have been shown to play a significant role in promoting household food security, even more than urban households' engagement in agricultural production (Krüger 1998). Frayne (2004) found that urban households in Windhoek, Namibia with limited social connections to rural areas were the most vulnerable to hunger, whereas those with active and robust ties to rural households regularly received transfers of food that made a considerable contribution to their overall household food budget.

Food linkages between rural and urban areas represent an important food sourcing strategy for low-income households in African cities (Crush and Caesar 2017), and

urban households with high levels of social capital are most likely to leverage linkages with households in rural regions (Glowacki-Dudka et al. 2013; Crespo et al. 2014). Food linkages between households located in different urban areas are also likely to be an important component of African urban food systems (Tacoli 2007), however, there are substantial knowledge gaps regarding urban-urban food linkages. Food sharing across urban households in secondary African cities is a phenomenon yet to be explored. Indeed, much of the existing literature on urban food linkages has focused on large cities, while less is known about the dynamics of food sharing in smaller urban areas (Mougeot 2005; Frayne 2007). Secondary urban areas possess unique food systems due to their proximal location to rural agricultural production and their developing urban infrastructure. Understanding how the dynamics of household food sourcing strategies vary across households and secondary urban areas enables the identification of households vulnerable to food insecurity. Developing this knowledge is especially important given the projected growth of secondary urban areas throughout the twenty-first century, which is likely to place continued stress on rural-urban food systems.

In this paper, we present analyses of rural and urban food sourcing strategies for 837 households across 14 secondary urban areas in Zambia. These secondary urban areas range from small market towns to large provincial towns, providing a transect of urban growth. We analyze food sourcing strategies as a function of different household- and city-scale characteristics at both the urban level and aggregated level across the 14 urban areas. Using this framework, we address the following questions: (1) What are the dynamics of food sourcing strategies used by households in secondary urban areas; (2) What household characteristics influence rural and urban food linkages; and (3) How does urban development influence rural and urban food sourcing strategies in Zambia?

Study-site, Data & Methods

Zambia is a landlocked country in southern Africa with a population of approximately 18 million.

Driven largely by high fertility rates, Zambia's population is estimated to be growing at a rate of 2.8% per annum, which translates to a doubling of the population almost every 25 years (World Bank 2021). 45% of Zambia's population is concentrated in urban areas, with 3.3 million people living in the capital city of Lusaka (World Bank 2018; 2021). Other, secondary urban areas are spread around the country, often situated along main transportation routes. More than half of Zambia's population lives in poverty and around 45% of Zambians are unable to meet their minimum calorie requirements (World Food Programme 2021), with 1.18 million people facing acute levels of food insecurity in 2021 (IPC 2021). Maize is the staple crop in Zambia and much of the population maintains a traditional diet, although there is increasing evidence of a "nutrition transition" towards processed foods that are high in fat, salt, and sugar, particularly in urban areas (Harris et al. 2019).

We partnered with the Zambia Agriculture Research Institute to conduct household surveys in 14 secondary urban areas across Zambia with populations ranging from around 500 in Pemba to over 60,000 in Choma (Landscan 2018) (Fig. 1). These urban areas span the Southern, Central, Eastern and Copperbelt provinces. Most of the urban areas in our sample, including Pemba, Batoka, Petauke, Nyimba, Chongwe,

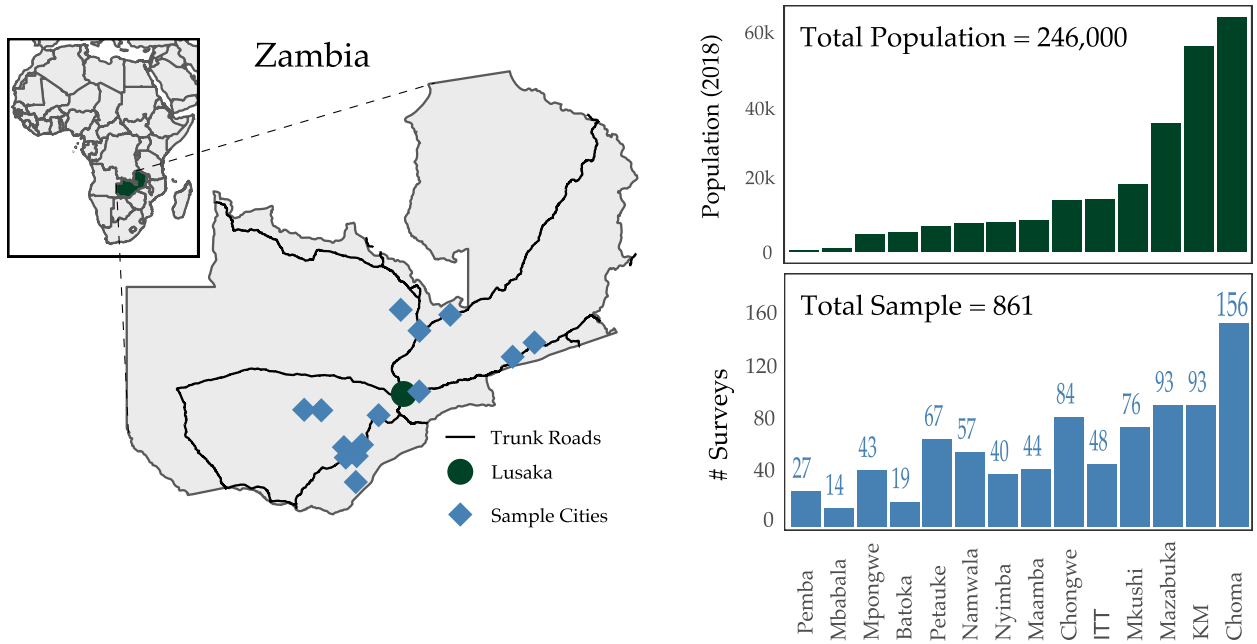

Fig. 1 A locations of the 14 cities in Zambia where surveys were conducted, capital city of Lusaka is noted for reference B Population estimates for each urban area based on Landscan (2018). C Number of completed household surveys in each urban area. ITT refers to Itezhi-Tezhi and KM refers to Kapiri Mposhi

Mazabuka, Kapiri Mposhi and Choma, are located along major paved trunk roads that connect to Lusaka. Four of the urban areas are more isolated from these trunk roads, namely Namwala, Itezhi-Tezhi, Maamba, and Mpongwe, as depicted in Fig. 1. We focused our data collection in low- and middle-income settlements within these secondary urban areas because we assumed that households located in these areas are more likely to face food insecurity and use coping strategies to meet their household food budget. The smaller urban areas in our sample did not have designated high-income residential neighborhoods in the manner of larger metropolitan cities, and so our sample in these smaller urban areas included their entire spatial extent. Moderate-sized urban areas (10,000+) exhibited some differences in household income across stratification of residential neighborhoods, but these constituted a small proportion of the total population. We present population estimates from gridded population datasets using the methodologies from Tuholske et al. (2019) and Zimmer et al. (2020). Visits to these towns confirmed their status as urban centers, with open-air markets, retail stores, and banking facilities. The number of households initially sampled in each urban area varied by total population, with larger samples selected in urban areas with larger populations (Fig. 1). The households in our sample had monthly incomes averaging 2750 K (approximately $160 USD), which is close to the national average of informal sector employees (2193 K or approximately $125 USD). The average income of our sample is around 40% less than the national average of 4393 K (approximately $250 USD).

Our initial engagement with the Zambian households in our sample occurred between May and August 2019, when we conducted an in-person survey of 2040 households. We subsequently conducted two follow-up phone call surveys with these households in February 2021 and September 2021, respectively. The February 2021 phone call survey had a smaller sample of 1041 households, but the sample size for each town was proportional to the original dataset. In September 2021, we collected the data used in this analysis, which is based on the same 1041 households from the February 2021 sample. Attrition between the two 2021 phone call surveys create our final dataset of 861 respondents, across all secondary urban areas. We report on 837 of these household surveys in this analysis. All surveys and data collection protocols were reviewed by the Institutional Review Board at our institution, which gave us approval to conduct human subjects-based research according to ethical research standards.

The sampling design that we used for the 2021 phone call surveys was inherited from our initial (2019) in-person survey in Zambia. This sampling design used a purposive approach to select secondary urban areas across Zambia that had a range of population sizes, although all urban areas in our sample had populations of less than 650,000. The larger twins in our sample are typically district, or provincial towns, which contain many government and municipal offices and services, making up much of the formal employment sector. Other, smaller towns are placed close to major agricultural regions where employment consists of regular employment in the CBD and informal employment of piecework and wage labor jobs. Prior to beginning our survey, we consulted with the municipal governments in each of the 14 urban areas to identify low- and middle-income neighborhoods. We then surveyed households throughout each residential area using a systematic random sampling approach.

The surveys were administered in local languages by 10 trained Zambian enumerators, with survey respondents comprising household heads over 18 years of age. The enumerators began the survey at a central starting point in each neighborhood that was established by a visual inspection of a satellite image, and then they selected households by skipping homes after every successful interview. The number of households skipped depended on the size of the neighborhood. For example, in a neighborhood with a population of 1000, enumerators would skip 10 households after each successful survey, while in a neighborhood with a population of 2000, they would skip 20 households between each successful survey. Our target sample size was between 15 and 30 households in each residential neighborhood. This systematic approach ensured a representative spatial distribution of households in each urban area.

The sample for the initial 2019 survey was proportionally representative to the population of each secondary urban area, and a proportional group of these households was contacted in each of the 2021 follow-up phone call surveys. In these follow-up surveys, households were randomly selected from each urban area until their proportional value was reached. Questions in all surveys focused on general household demographics, labor characteristics, and food security status. The survey questions that we analyze in this study aimed to understand household food sourcing strategies for food accessed in the respondent's own urban area, other urban areas, and rural areas. We asked each household about 8 food types, including cereals, pulses, vegetables, fruit, meat or fish, milk, sugar or oil, and processed goods. These 8 food types were selected based on the household dietary diversity score, which is a commonly used metric for measuring households' ability to access food (Kennedy et al. 2011). For each food type and sourcing location (i.e., this urban area, another urban area, and rural areas), we asked households where they purchased or received most of each food type, how often they sourced each food type from the specified location, how much of each food type they sourced from that location, and the reason why they sourced each food from that location. These questions were answered using likert scales, which helped to ensure consistent data quality and repeatability across households and urban areas, and to include food purchased and transferred.

We refer to these food sourcing preferences as food linkages throughout this analysis. These food linkages represent the presence of a food connection from either a rural or an urban area to the urban household surveyed. This includes food purchased at open-air markets, retail shops, or supermarkets in other urban areas. We present some summary statistics for each urban area in Table 1 below, which displays the different population, geographic and economic variables used in the analysis.

Methods of analysis

To examine relationships between urban areas, households, and their food sourcing strategies, we separate the dataset into clusters. First, we use characteristics of each secondary urban area to group similar urban areas together, depending on their population and proximity to key transportation links. Secondly, we use household level characteristics including income, employment formality, housing tenure status, and household size to group similar households together. This clustering process produced three different types of urban areas and two different types of households, which we describe in detail

Table 1 Summary statistics for households in each urban area. Population estimates variables come from LandScan

Town Name	Population Estimate (2008)	Population Estimate (2018)	FEWS Net Livelihood Zones [a]	Supermarket Presence	Mean Household Income (ZMW)	Mean Household Food Expenditure (ZMW)
Batoka	793	5341	ZM 08	No	4042	1993
Choma	36,512	64,085	ZM 09	Yes	3387	1242
Chongwe	1756	13,998	ZM 08	No	1268	721
Itezhi-Tezhi	1571	14,426	ZM 07	No	1758	819
Kapiri Mposhi	20,258	56,193	ZM 12	Yes	3295	1294
Maamba	608	8712	ZM 08	No	1693	734
Mazabuka	42,285	35,055	ZM 08	Yes	3409	1227
Mbabala	63	1076	ZM 09	No	2870	1051
Mkushi	2549	18,486	ZM 11	No	3385	1593
Mpongwe	123	4882	ZM 11	No	1466	812
Namwala	5263	7839	ZM 08	No	1883	734
Nyimba	366	8118	ZM 16	No	2869	1290
Pemba	326	467	ZM 08	No	2979	1037
Petauke	2564	7041	ZM 16	No	1810	961

[a] FEWS Net Zambia Livelihood Zones

- ZM 07 - Kafue Plain Maize, Cattle and Fishing
- ZM 08 - Commercial Rail Line Maize, Livestock and Cotton
- ZM 09 - Southern Plateau Cattle, Maize and Tobacco
- ZM 11 - Mkushi, Chisamba and Mpongwe Commercial Farming Block
- ZM 12 - Central Copperbelt Maize, Cassava, and Sweet Potato
- ZM 16 - Eastern Plateau Maize, Cotton and Groundnut

Table 2 Summary statistics for urban area clustering. The description provides a qualitative category we use to describe this cluster of urban areas throughout the analysis. Values represent mean with standard deviation in parentheses

Cluster	Description	Sample Size	Population	Supermarket	Distance to Lusaka (km)	Distance to nearest urban neighbor (km)	Distance to trunk road (km)	Urban area
1	Larger urban areas	322	51,778 (15,010)	Yes	202 km (77 km)	34 km (27 km)	0 km (0 km)	Mazabuka, Choma, Kapiri Mposhi
2	Smaller, more isolated urban areas	346	9929 (4767)	No	326 km (41 km)	70 km (17 km)	42 km (39 km)	Namwala, Nyimba, Petauke, Mpongwe, Itezhi-Tezhi, Mkushi, Maamba
3	Smaller, well connected urban areas	132	5221 (6240)	No	200 km (108 km)	25 km (13 km)	7 km (15 km)	Pemba, Chongwe, Batoka, Mbabala

below and present in Table 2. Finally, we join these clusters of urban areas and households together to produce 6 separate groups of respondents, comprising higher and lower income households across smaller, medium, and larger urban areas. We developed

the clusters following a logic that suggests meaningful differences in food sourcing strategies among the clusters.

At the city-level, larger urban areas typically have supermarkets, in addition to retail shops, restaurants, fast food outlets, open-air markets, and informal vendors (Battersby and Peyton 2014). Lower income households typically source most of their food from open-air markets (Hannah et al. 2022) or directly from farmers to benefit from cheaper prices, whereas wealthier households often frequent supermarkets which tend to sell food in larger quantities at higher prices (Neven et al. 2006). Smaller urban areas rarely have supermarkets and are more likely to have open-air markets or purchase directly from farmers. When considering household food sourcing strategies, the spatial location of secondary urban areas is also important to note. For example, Zimmer et al. (2020) found that the distance of secondary urban areas to major roads and other urban areas can impact their urbanization rate, which in turn may affect different aspects of the urban food system including the types of food retailers available. The degree of connectivity between urban households and other urban and rural locations has also been identified as an important factor for facilitating or hindering food sourcing strategies (Onyango et al. 2021). Hence, we propose that the spatial location of secondary urban areas in our study impacts the ability of households to access both urban and rural food sources. At the household level, families living in smaller urban areas are more likely to engage in urban or peri-urban agriculture than residents in larger cities due to lower housing densities (Dorosh and Thurlow 2013). Additionally, households living in these smaller urban areas are likely to have unique characteristics related to household income, household size, and employment formality that may influence their food sourcing strategies (Crush and McCordic 2017; Mohamed et al. 2016).

To create groupings of urban areas and households, we used a k-means clustering function that disaggregated the sample based on three groups of urban areas and two groups of household type.

We classify the secondary urban areas in our sample into three groups based on their population size and distance to major cities and trunk roads. The results of this clustering analysis are available in Table 2, where urban areas are split into three types. Type 1 urban areas are secondary urban areas with higher populations, ranging from 35,055 to 64,085. These locations all have a supermarket and are well connected to the capital city, Lusaka, as well as other urban areas surrounding them. Type 1 urban areas include Mazabuka, Choma and Kapiri Mposhi, which are all provincial or district towns, the largest in our sample. Type 2 secondary urban areas have much lower average populations, ranging from 7041 to 18,486. They do not contain supermarkets and are spatially isolated from trunk roads and other urban areas, including Lusaka. Type 3 urban areas have the lowest average population in our sample (all below 5000) and do not have supermarkets. However, these urban areas are located in close proximity to trunk roads, other urban areas, and Lusaka, situating them in a well-connected area. The summary statistics for each cluster are presented in Table 2.

We categorize households into two groups based on the following variables collected in our survey: total household monthly income, total household monthly expenditure, household size, percentage of the household employed informally, the length of time the respondents have lived in the urban area, and their settlement

formality. Part of our analysis segments urban households into categories of formality, using both the formality of the sub-urban area settlement they live in, and the formality of their employment. To calculate average household employment formality, we asked each household member whether they were self-employed, informally employed or regularly employed. We define formal employment as self-employment and regular employment, and informal employment as such. We create an average for each household based on the number of working-age household members. To determine whether a household was part of a formal or informal settlement, we initially asked respondents if their household was part of a formal or informal settlement. We compared these responses with other questions about house structure and tenure status, as well as responses for proximal households. To ensure data quality, we conducted a pretest and worked with local collaborators at the Zambian Agricultural Research Institute to ensure enumerators and respondents understood the question as intended. Further checks were made with satellite imagery to view clusters of formal and informal households spatially across each town. On average, these households are employed in the formal sector and have been living in formal settlements in the urban area for 16 years. The second grouping of households on average has lower incomes, larger household sizes, and higher rates of informal employment. These households have been living in the urban area for 22 years on average, often in informal settlements. We present the summary statistics for these groupings in Table 3. Since formality is not binary and exists on a scale, we refer to these household groupings as 'more formal households' and 'less formal households' to signify the formality level of each household in our sample.

We stratified our sample of secondary urban areas and household types into separate groups for small, medium, and large urban areas, and lower and higher income households. To link both urban area and household-level characteristics, we merged the clusters together to create 6 individual groups. These groups have a sample size ranging from 63 to 259 and their composition covers all combinations of higher and lower income in the range of secondary urban area sizes, as explained in Table 4. We use these groupings to assess the food sourcing strategies of different household types in different secondary urban areas. The first section of our results examines trends in food sourcing strategies for all households across the sample of secondary urban areas, and the second section breaks these down by household and urban area type.

Table 3 Mean values from household clustering. The description provides a qualitative category we use to describe this cluster of households throughout the analysis. Values represent mean with standard deviation in parentheses

Cluster	Description	Sample size	Total HH Monthly Income (ZK)	HH Monthly Food Expenditure (ZK)	HH size	% Of HH employed informally	Years in urban area	Percent of sample living in informal settlement
1	More formal household	300	4272 (3549)	1580 (1257)	4.6 (1.6)	19.0 (29.8)	16.5 (14.0)	20 (41)
2	Less formal household	500	1666 (1111)	852 (550)	5.0 (1.5)	92.8 (19.4)	22.0 (15.4)	40 (49)

Table 4 Formulation of 6 household groupings from urban clusters and household clusters

Cluster	Urban Cluster	Household (HH) Cluster	N (%)
1	larger urban area, well connected	less formal HH	150 (18.8%)
2	larger urban area, well connected	more formal HH	172 (21.5%)
3	Smaller, more isolated urban areas	less formal HH	87 (10.9%)
4	Smaller, more isolated urban areas	more formal HH	259 (32.4%)
5	Smaller, well connected urban areas	less formal HH	63 (7.9%)
6	Smaller, well connected urban areas	more formal HH	69 (8.6%)

Results

Rural-urban and urban-urban food linkages

We find that food linkages are present in every urban area in our sample, with over 40% of households using rural or urban food linkages, or a combination thereof, to supplement their food budget (Fig. 2). This includes food purchased at open-air markets, retail shops, or supermarkets in other urban areas. On average, 28% of households engaged in rural food linkages, whereas only 19% of households engaged in urban food linkages. In 8 of the 14 urban areas, food linkages from rural areas were more prevalent than food linkages from urban areas.

Our analyses show that the location of an urban area relative to other urban areas and main transportation routes affects household food linkages. Mpongwe and Namwala, for example, are relatively remote. In these urban areas, more than 50% of sampled households purchased or received food from rural areas. On the other hand, a greater proportion of households in Batoka, Nyimba, Chongwe, and Mkushi, which are located on major transport routes and are in close proximity to larger urban areas, received food from other urban areas. In addition, the urban areas with a higher percentage of households using rural - urban food linkages were not necessarily accompanied by higher percentages of households using urban - urban food linkages. In fact, only 7 of the 14 urban areas had households using both rural - urban and urban - urban food linkages. In general, we found considerable variation at the urban area level for both urban and rural food sourcing, suggesting that an understanding of the drivers of food linkages must consider local dynamics.

Food linkages from rural areas were dominated by cereals in every urban area in our sample, with this food type representing almost half of all rural - urban food linkages (Fig. 3). This is likely because cereals are durable food products and so are ideal for transferring across longer distances. These food staples also store well and so can help to sustain household food security for a longer time-period than more perishable products such as fruits and vegetables. Nonetheless, we also found that there was also a high prevalence of vegetables and pulses transferred to urban areas from the rural regions where they are predominantly produced. In contrast, food linkages from other urban areas displayed much more variability in food types and, notably, had more linkages composed of higher-value foods such as meat, fish, and processed foods. These higher-value foods, in particular processed goods, are often only available for sale in urban areas, which may explain why they represent such a significant proportion of the food types sourced from other urban areas. Despite their diversity, these food linkages do not vary across urban

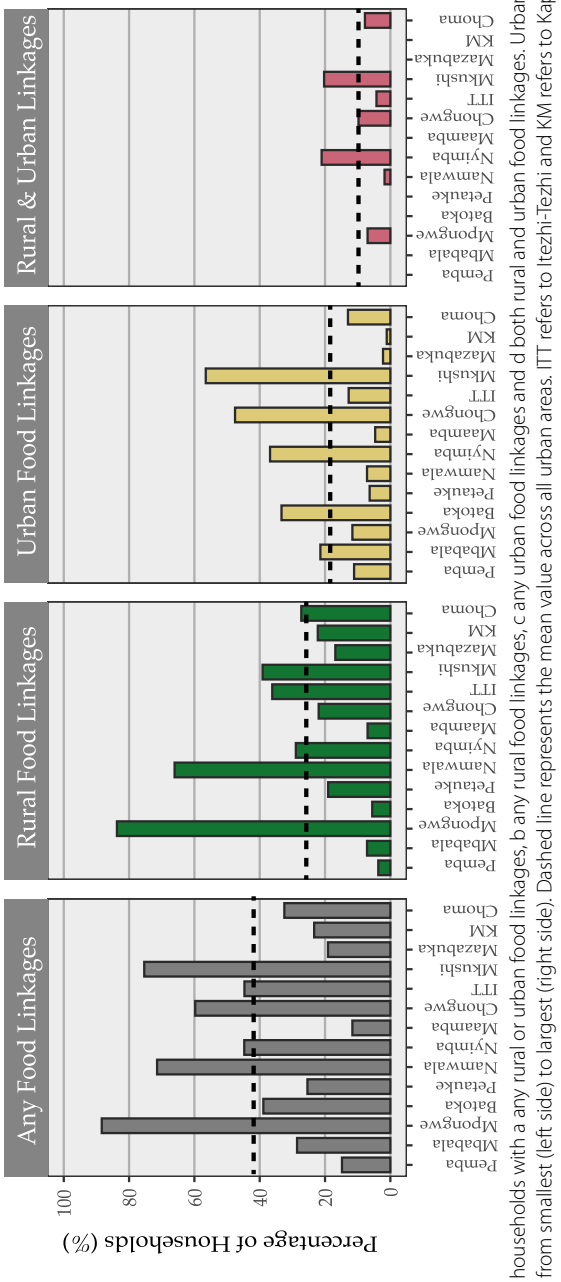

Fig. 2 Percentage of households with a any rural or urban food linkages, b any rural food linkages, c any urban food linkages and d both rural and urban food linkages. Urban areas are arranged in population size order from smallest (left side) to largest (right side). Dashed line represents the mean value across all urban areas. ITT refers to Itezhi-Tezhi and KM refers to Kapiri Mposhi

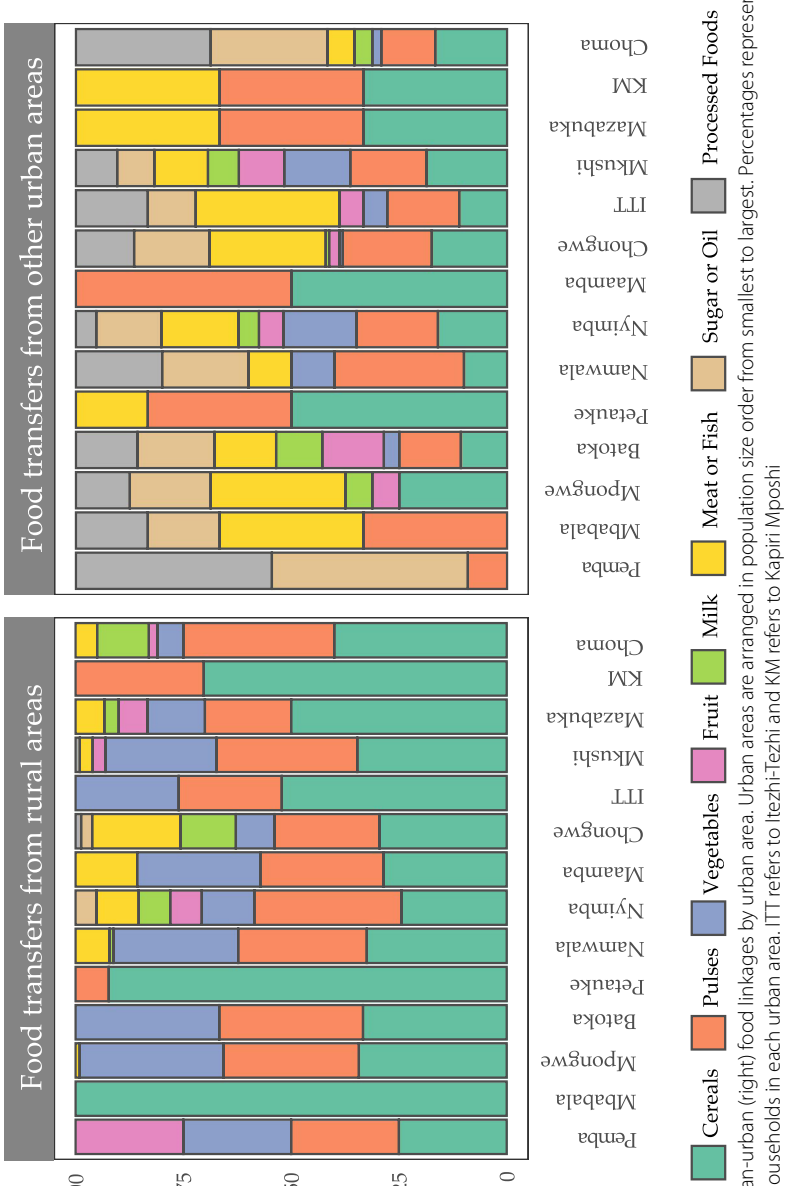

Fig. 3 Rural-urban (left) and urban-urban (right) food linkages by urban area. Urban areas are arranged in population size order from smallest to largest. Percentages represent the proportion of each food type received by the households in each urban area. ITT refers to Itezhi-Tezhi and KM refers to Kapiri Mposhi

areas, and as such suggest more complex food transfer dynamics across secondary urban areas.

We found that households in secondary urban areas obtained food from other urban areas more frequently than from rural areas. On average, urban-urban food linkages occurred monthly or weekly, while rural-urban food linkages occurred once or twice a year. This frequency may reflect the types of food previously noted. The majority of households in our sample (70%) accessed food linkages from within 40 km of their households. Rural sources were on average slightly further away (> 40 km) than urban sources. Households primarily used motorized transportation to obtain food from other urban or rural areas, which highlights the importance of transportation infrastructure for enabling households to access diverse food sources.

Urban area and household characteristics that influence food sourcing strategies

The presence of food linkages is likely to be influenced by city-level qualities such as distance to major transportation routes and household-level attributes like income (Frayne 2010). In this section we analyze food sourcing strategies among our 6 clusters that reflect different household and urban-level characteristics (Table 4).

Figure 4 shows the percentage of urban households that receive food linkages from rural or other urban areas for each of the 6 groupings. We found that 31% of households in smaller, well connected urban areas leverage food sources from other urban areas (cluster 5 and 6), compared to 15% in smaller, more isolated urban areas (cluster 3 & 4). These well-connected urban areas are situated along regional transportation routes with more direct connections to neighboring towns and cities, possibly allowing households in these areas to benefit from diverse food retail options that may not be available in their own urban area. Urban areas that are more isolated have a greater proportion of households sourcing food from rural areas, possibly as a function of their proximity to rural agricultural production. In larger urban areas, fewer households (27.5%) source any food from outside their urban area compared with households in smaller urban areas, where 49% of households use any food linkages. Larger urban areas offer numerous food retail options, including supermarkets and retail shops, thereby reducing the need for households in these areas to source food from other locations. When households in these larger urban areas do receive food linkages, they are predominantly from rural areas.

Our findings suggest that the characteristics of secondary urban areas shape household food sourcing strategies more so than household-level characteristics. We found that on average, 44% of households in higher income groups receive some food linkages compared to 40% in lower income groups. There was some stratification of food sources received by households in smaller, more isolated urban areas, with a greater proportion of households in lower income groups receiving food linkages from other urban areas, and from both other urban and rural areas. This gap is proportionally larger in the biggest urban areas in our sample, with only 1% of households in the higher income categories receiving food from other urban areas. Higher income households in larger urban areas may be less price sensitive and therefore more able to purchase food within their urban area without seeking food in other towns and cities.

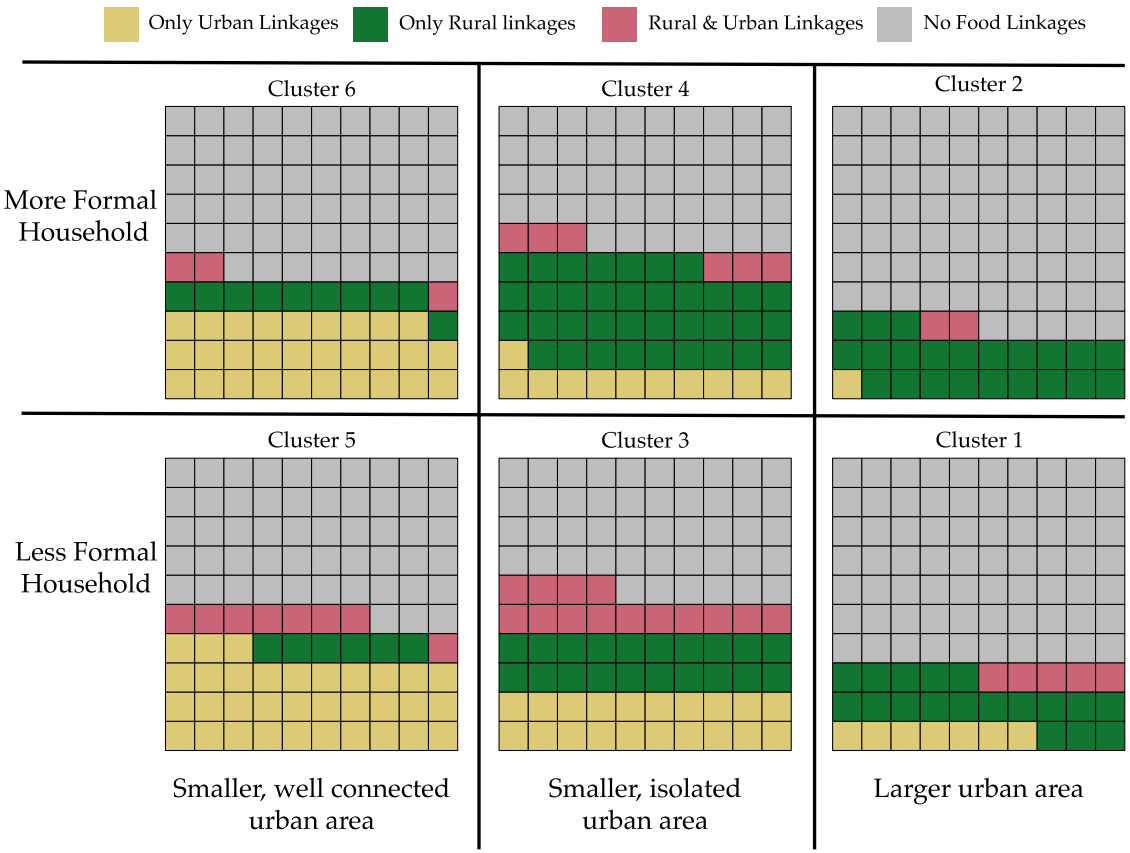

Fig. 4 Percentage of households with rural food linkages (green), urban food linkages (yellow) and both rural and urban food linkages (red). Panels represent cluster number, arranged according to urban area population (y-axis) and household income (x-axis). Each box contains 100 squares; each square represents 1%

The food purchasing preferences of households in our sample was largely skewed toward open-air markets, where 60% of households buy their food, 30% of households purchase food from retail shops, and only 6% from supermarkets. We again found that urban area characteristics play a more important role in determining household food purchasing habits than household characteristics. In smaller towns that are isolated from main transportation routes, more than 75% of households purchased their food from an open-air market. In small towns that are well connected, this number declines to 55%, with a greater share of households purchasing food from more formal retail shops, which often offer a greater selection of food products than open-air markets. Larger urban areas again stand out with more unique food purchasing patterns. In these urban areas, supermarket proliferation has shaped food purchasing, representing 18.5% of household food purchases across income groups. Interestingly, we find that a higher proportion of lower income households shop at supermarkets. Typically, supermarkets offer products at higher prices than retail shops and open-air markets and are frequented by those with higher incomes. However, supermarkets may be leveraged by lower income households who cannot travel to other urban areas to purchase higher value food types.

Local retail shops are an important source of food for households in all urban areas and income categories from our sample. In smaller and larger urban areas that are well connected, retail shops represent a sizable portion of food purchases (37% on average across the two urban areas and two household types) potentially highlighting the lack of formal retail outlets in isolated secondary urban centers. Connectivity to transportation routes is essential for formal food retail outlets, allowing timely replenishment of perishable goods. Across income groups, we see a greater proportion of households in lower income categories shopping at retail shops over open-air markets. Retail shops often have a permanent structure in which they can store and sell produce, allowing traders to store products overnight, allowing them to maintain stock and sell produce in smaller units, at lower prices, potentially more suitable for low-income households. Additionally, retail shops are commonly situated close to mills, allowing lower income households without access to transportation the opportunity to purchase and mill their grains without incurring additional costs (Fig. 5).

Discussion

Our analysis highlights the different ways in which urban households in Zambia leverage their linkages with rural areas, and with other towns or cities, to supplement their food consumption. We found that both rural - urban and urban - urban food linkages were common across households in secondary Zambian urban areas, which mirrors the findings in Crush and Caesar's (2017) study of food linkages in larger cities in Zimbabwe and Namibia. Research in other secondary urban centers has found that rural food linkages to urban households ranged from 20% of households (in Mzuzu, Malawi) to 69.2% of households (in Dschang, Cameroon) (Riley and Chilanga 2018; Nickanor and Kazembe 2019; Legwegoh et al. 2020). Across all urban areas in our study, 27.5% of households sourced food from rural areas and 19% of households sourced food from other urban areas. We found that rural - urban food linkages are dominated by grains, while urban - urban food linkages comprise more higher value foods. For example, households procured meat, fish, and processed goods from other urban areas on a more frequent basis

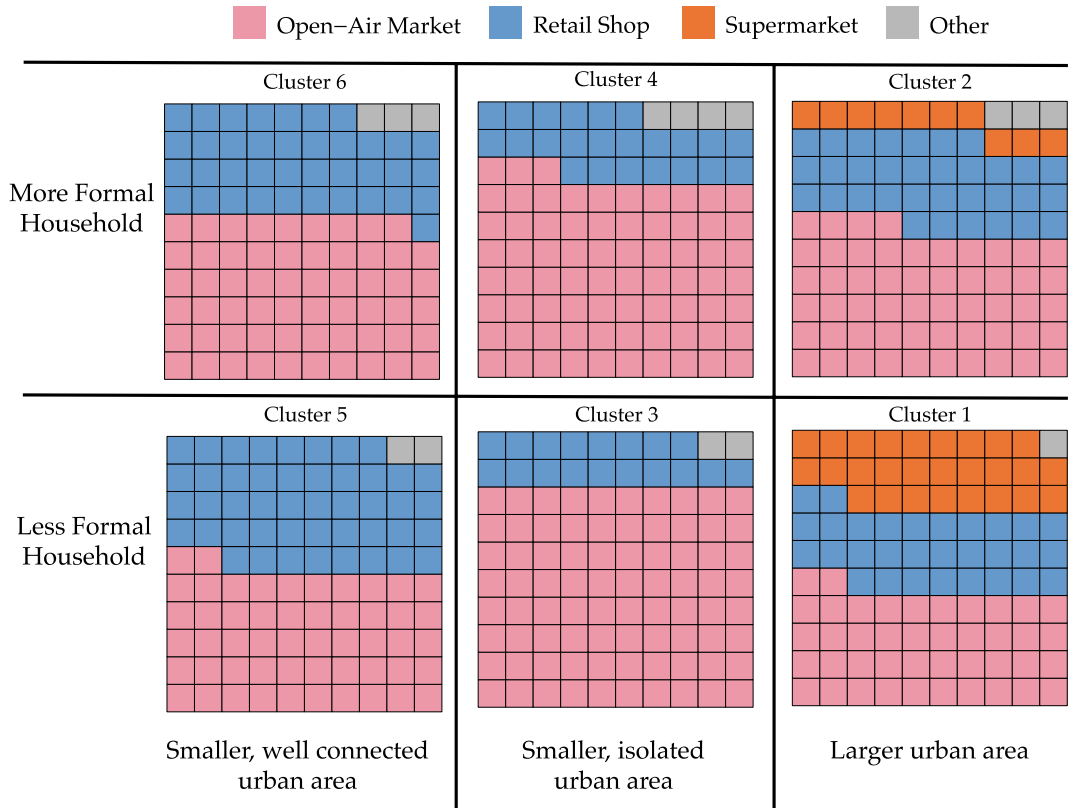

Fig. 5 Food sourcing strategies by cluster. These plots represent food sourced from within the household's own urban area. Segments indicate the percentage of food sourced at this location by cluster, where one box equals 1%. Individual plots represent the cluster number, with the y axis representing clusters with larger urban populations and the x axis representing higher household income

than from rural areas. Households with moderate to high incomes are increasingly consuming meat and processed foods which are available from retail shops and supermarkets (Battersby and Peyton 2014; Ruel et al. 2008). Food sourced from these retailers form much of the urban - urban food linkages present in our data. As urban areas grow and consumer preferences change, retail shops and supermarkets will continue to develop, thereby making calorically dense food types more readily available. As such, a 'nutrition transition' from traditional to westernized diets with foods higher in saturated fats and sugar may begin proliferating in secondary urban centers (Crush et al. 2011; Steyn and Mchiza 2014).

Increasing urban development and food retail diversification also leads to urban areas experiencing a transition from being net-receivers of urban food linkages to net-providers supplying proximal smaller urban areas. Although there is some evidence of decelerating trends in urban growth (Potts 2005; Potts 2009; Zimmer et al. 2020), we nonetheless notice an increase in population for all the urban areas included in our sample (Table 1). Any substantial increase in the number of urban residents, as well as the spatial distribution of additional urban residents, will place added pressures on urban food systems, particularly in secondary urban areas where local governments often lack resources and capacity. While households need to access food regardless of where they live, households located in smaller urban areas far from major transportation routes and agricultural production regions may have fewer options for accessing food and may therefore be more vulnerable to disruptions in the food system than households located in larger, less isolated urban areas. For instance, we found that urban residents in Mazabuka, Kapiri Mposhi, and Choma, the three largest towns in our sample, all have supermarkets and a smaller proportion of households located in these towns acquire food from other urban areas. On the other hand, residents in smaller urban areas leverage their proximal location to larger towns to source various types of food that are perhaps not as readily available in their own urban areas, including highly processed foods.

Overall, we found that urban households sourced food from other urban areas on a weekly or monthly basis, compared to less frequent seasonal or annual visits to rural areas to acquire food. These findings add a secondary cities perspective to Frayne's (2010) study of larger cities in southern Africa, which found that urban households tended to receive urban-urban food linkages much more frequently than rural-urban food linkages. One explanation for these trends likely relates to the perishability of food sourced in urban areas, where they are generally processed, are easier to store and have much longer shelf life.

We find that urban area characteristics are important determinants of household food sourcing behaviors, with households in secondary urban areas being sensitive to the food retail landscape available. For example, in smaller, isolated urban areas, retail shops tend to be less viable due to factors such as limited access to wholesalers, hence household food purchases at retail shops are understandably more limited. We find that many households in these urban areas shop instead at open-air markets. Conversely, in larger, more well-connected urban areas where the food retail environment is more diverse and retail shops are likely to prosper, households tend to purchase more food at these locations. The connectivity of an urban area to its urban neighbors and major transportation routes are also salient urban-level variables shaping household food purchasing patterns.

As previously mentioned, households in smaller, more isolated urban areas rely strongly on rural food sources and receive very little food from other urban areas compared to households in larger towns, where connections to transportation infrastructure are stronger. These well-connected households frequently receive food from both rural and other urban areas, as well as purchasing food at open-air markets, retail shops and, in larger towns, supermarkets. Without strong transportation links, the frequency of food replenishment at retail shops and markets is likely to be much slower, as we see in some of the smaller, more isolated urban areas in our sample. Weak connections to transportation routes also affect food supply chains, thereby limiting the ability of modern food retail to diversify and flourish in smaller urban areas, and reducing the degree to which households can access food from other urban areas. In contrast to isolated urban areas, the urban areas in our sample that are located along major transportation corridors and in close proximity to urban neighbors display more robust food linkages. Future projections of urban growth suggest that urban areas in all locations will continue to grow (United Nations 2018), driving changes in rural-urban food systems. However, in isolated secondary urban areas, these changes will likely be more drastic, with households less likely to benefit from the improved food access that occurs with urban growth and infrastructure development.

When compared to urban-level features, we find that household-level characteristics play a limited role in determining household food sourcing strategies in secondary urban areas. However, some differences between household types are evident in our results. Firstly, we find that in general, lower-income households purchase food at retail shops and supermarkets more frequently than higher-income households. Retail shop vendors tend to sell food in smaller quantities and at lower prices than supermarkets, making food more affordable for lower income households who often have to buy small amounts of food daily, rather than in bulk quantities that might last for the week or month (cite). In addition, retail shops may be more physically accessible to lower income households as they are often located in or near urban residential areas, reducing the need for households to pay additional fees to transport food home.

Secondly, we found that lower-income households source food from other urban areas more often than higher income households. This may be linked to a limited availability of preferred food types at local retailers, although is more likely an outcome of price sensitivity whereby lower income households compare prices among retailers in their own and other urban areas in order to find the most affordable options. Urban households may also face other challenges in addition to income levels that affect their food sourcing strategies. For example, food price shocks (e.g., driven by climate variability) and household-scale economic shocks (e.g., caused by job losses or unexpected expenses such as medical bills) may affect the ability of households to purchase food, causing them to use alternative coping strategies such as engaging in urban agriculture or food sharing among neighbors (Smart et al. 2015). In addition, we recognize that although urban population growth is driving increasing demand for food by creating more net-consumers, this is not the only cause of increased poverty and food system vulnerability in secondary urban areas. For instance, global conflicts, health pandemics, and national-scale policy changes may also affect food security, livelihoods, and wellbeing at the household scale (Martin-Shields and Stojetz 2019). Moreover, actors and institutions

from across the food system, including national, regional, and municipal governments; food producers and agricultural cooperatives; non-governmental and community-based organizations; market committees; and private sector actors such as supermarkets, all play a key role in shaping urban food system governance such that urban households have equitable access to safe, healthy, nutritious, and affordable food.

Our findings suggest that the spatial location and connectivity of secondary urban areas to transportation routes and other urban areas, as well as the viability of urban food retail opportunities within urban areas, are likely to shape food purchasing habits more than household income. These results contrast with Crush and McCordic (2017), who found that household income largely dictates food purchases. However, their study was conducted in Maputo, Mozambique, which is a large, primary city with a robust food retail structure that may enable households to diversify their food purchasing patterns more easily if their income increases. In secondary cities, households are limited to the food retail options available to them.

As urban areas develop, the urban food retail landscape will diversify, providing more stratification across different household types. However, the ability of urban households to leverage these retail opportunities depends on the approach taken by governments toward urban planning and development. The creation of employment opportunities, the location of food retailers in proximity to low-income urban areas, and the improvement of urban transportation networks are examples of possible strategies that could improve household access to food. However, there are likely to be disparities in the capacity of governments in different sized urban areas to plan for and adapt to food systems transformations. Local governments in smaller urban areas are typically under-resourced, meaning that low-income households have to find ways to cope with food insecurity independently of government interventions. Rural - urban and urban -urban food linkages may therefore prove to be particularly critical for ensuring the food security of low-income households in secondary urban areas into the future. Coupled together, these responses show levels of substitutability that allow urban households to source food from different locations, leveraging more affordable options to satisfy their overall household food budget.

Conclusion

African secondary urban areas are projected to grow substantially in the future. To date, much of the urban growth in Africa has occurred without concurrent development of services and infrastructure to facilitate sustainable urban livelihoods. As a result, many urban households are food insecure, and adopt a range of coping strategies to ensure access to food. These may include diversifying their food sourcing strategies and relying on food linkages, whereby households travel to other urban or rural areas to purchase or receive food. Our study has demonstrated the diversity of food sourcing strategies and food linkages used by households in secondary urban areas across Zambia. We find that across all urban areas, 27.5% of households sourced food from rural areas and 19% of households sourced food from other urban areas. Rural food sources are typically cereal-based, and urban food linkages reflect the nutrition transition present in African urban diets, with meat, fish and processed foods being sourced more regularly. We explored how these food sources change across different sizes of urban areas and types of

households and find that the size of the urban area is more important in shaping household food sourcing strategies than income type. We find that households in isolated urban areas have the least diversity in urban food sourcing strategies, and receive the most food from rural areas, highlighting them as vulnerable to food availability shocks. We present results from a unique dataset covering 14 secondary urban areas in Zambia and add rural and urban food linkages to the discussion of African urban food systems. Future projections for urban growth in Africa suggest secondary urban centers will continue to grow, making the understanding of food systems in Africa critically important.

Authors' contributions

Conceptualization – AZ, ZG, JD, NJ, AC, TE. Methodology - AZ, ZG, JD, NJ, AC, TE. Software – AZ. Formal Analysis – AZ, ZG. Investigation – AC, AZ, ZG. Writing - AZ, ZG, JD, NJ, AC, TE. Visualization – AZ. Supervision – TE. The author(s) read and approved the final manuscript.

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Availability of data and materials

Household survey data includes personal identifiers and spatial coordinates that underly the analysis. Due to human subjects protocols these data cannot be made publicly available in raw form.
Urban area population data is open access, and available from https://landscan.ornl.gov.
Road vector data used to calculate distance between urban areas is open access, and available from https://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1.

Declarations

Competing interests

Not applicable.

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