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# URBAN FOOD DESERTS IN NAIROBI AND MEXICO CITY

JEREMY WAGNER,[1] LUCY HINTON,[2] CAMERON MCCORDIC,[3] SAMUEL OWUOR,[4] GUENOLA CAPRON[5] AND SALOMÓN GONZALEZ ARELLANO[6]

SERIES EDITOR: JONATHAN CRUSH[7]

[1] Balsillie School of International Affairs, Waterloo, Ontario, Canada, jrwagner15@gmail.com
[2] Balsillie School of International Affairs, lhinton@balsillieschool.ca
[3] Balsillie School of International Affairs, cmccordic@balsillieschool.ca
[4] University of Nairobi, Nairobi, Kenya, samowuor@yahoo.com
[5] guenola.capron@gmail.com
[6] salomonglez@gmail.com
[7] Balsillie School of International Affairs, jcrush@balsillieschool.ca

## Abstract

Recent conceptualizations of "food deserts" have expanded from a sole focus on access to supermarkets, to food retail outlets, to all household food sources. Each iteration of the urban food desert concept has associated food sourcing behaviour in relation to household poverty, food insecurity, and dietary diversity characteristics. While the term continues to evolve, there has been little empirical evidence to test whether these associations hold in cities of the Global South. This discussion paper empirically tests the premises of three iterations of the urban food desert concept using household survey data collected in Nairobi, Kenya, and Mexico City, Mexico. While these associations are statistically significant and show the expected correlation direction between household food sourcing behaviour and food security, the relationships tend to be weak with limited spatial patterning. These findings indicate that the urban food desert concept developed in North American and UK cities may have limited relevance to explaining urban food insecurity in the Global South.

## Keywords

food deserts, food security, dietary diversity, Nairobi, Mexico City

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# Introduction

Since the 1990s, the "food desert" concept has been extensively used in cities in the Global North, most often in the United States, Canada, and the United Kingdom. It has not, however, been widely applied to cities in the Global South. While there are many potential reasons for this gap, the primary one is the way food security and malnutrition in the Global South are framed as rural issues and related to hunger and food scarcity (Crush and Riley 2017). In addition, food deserts have traditionally been related to the presence or absence of supermarkets, which do not yet have a commanding presence in urban food systems in many parts of the South. Researchers who use the food desert concept argue that differences in food access between households and neighbourhoods can best be understood through analysis of the structural and spatial dimensions of food environments. To date, this kind of analysis of the food desert concept has not been applied to cities in the Global South.

Food deserts are usually characterized as economically disadvantaged areas where there is relatively poor access to healthy and affordable food because of the absence of modern retail outlets (Beaumont et al 1995). Cities in the Global South contain many poor neighbourhoods where the prevalence of malnourishment and food insecurity is far more dramatic than in North America and the UK. The key question then is whether mainstream definitions of food deserts applied to the Global North can usefully be applied to the Global South's rapidly growing cities. If the concept can be reformulated to fit the realities of urban food systems in the Global South, it may prove to be a useful analytical tool on which urban food researchers and policy makers can capitalize (Crush and Battersby 2017). To test the applicability of the food desert concept in the Global South, this discussion paper uses household survey data collected in Nairobi and Mexico City by the Hungry Cities Partnership. The paper first provides a genealogical account of how the concept of food deserts has been defined and changed over time. The following sections evaluate the usefulness of the three different definitions to understanding food insecurity in Nairobi and Mexico City. Following an analysis and discussion of the results, the paper concludes by highlighting the research and policy implications.

# Food Desert Iterations

## Classic Food Deserts (mid 1990s-early 2000s)

The concept of the food desert grew out of a small body of evidence that suggested that food items were more difficult to access in deprived areas of cities (Wrigley 2002, Wrigley 2003). While policy interventions were undertaken by the UK government, there was a dearth of evidence on the causal factors creating food deserts. Originally, food-desert conceptions were based almost solely on distance to supermarkets. The further a neighbourhood was from a supermarket, the larger the food desert would be. An absence of supermarkets in a neighbourhood was attributed to redlining: a spatially discriminatory practice among retailers of not serving certain areas based on their demographic composition (D'Rozario and Williams 2005). These neighbourhoods were sometimes characterized as "too low-income" for retailers concerned with profitability. This first version of the food desert concept was tied to highly quantitative, easily calculable values like distances and/or food prices. However, without significant evidence to endorse the quantifiable variables being used, the food desert concept soon began to evolve.

## Food Deserts Plus (early 2000s-mid 2010s)

Food Deserts Plus represents a second iteration of the concept. There were two significant additions to the analysis of food deserts in this period. First, researchers recognized the multitude of factors operating in food-deprived areas and began adding them to the analysis. Exogenous factors included mobility, pricing, and different types of retail locations. There was also a recognition that individual food consumption behaviour impacted on how

people accessed different types of food (Beaulac et al 2009, Bridle-Fitzpatrick 2015). Second, and perhaps more fundamental, was the realization that supermarkets were not necessarily the best proxy measure for food access, and that this was an inadequate way to measure how marginalized populations were actually eating.

During this period, the inclusion of dietary diaries in research methodologies was popularized, with most studies underlining the need to grasp the "healthiness" of foods being accessed (Pearce et al 2008). This gave rise to additional concepts such as the "food oasis" (pockets of healthy food access) and the "food swamp" (an abundance of unhealthy food), complicating what had originally been seen as a simple spatial issue. Food deserts were becoming more complex conceptualizations, and analysis of patterns of fruit and vegetable consumption soon became as ubiquitous as supermarket analysis had once been.

### Food Deserts as Complexity (mid-2010s to the present)

Current conceptualizations of food deserts are characterized by recognition and acceptance of the complex nature of food accessibility in the city. Food deserts are no longer considered a simple spatial definition issue, to be analyzed through the addition of more variables. Instead, the food desert is seen as a complex, dynamic meshwork of social, economic, and political interactions (Horst 2016, Sadler 2016, Shannon 2016). Studies are increasingly taking into consideration the interrelated nature of income, mobility, transportation, time, seasonality, family structure, presence and types of retail location, dietary diversity, education, structural inequalities and so on. With this complexity in mind, Crush and Battersby (2017) redefine food deserts as "poor, often informal, urban neighbourhoods characterized by high food insecurity and low dietary diversity, with multiple market and non-market food sources but variable household access to food." As such, the concept has the potential to be a useful analytical tool in understanding the structural barriers leading to inequalities in food access. Despite the growing literature and changing definitions of urban food deserts, there is little empirical evidence to assess the relevance of the concept to cities of the Global South. This paper empirically assesses these three conceptualizations of urban food deserts in the context of Nairobi and Mexico City.

## Methodology

The research objectives and associated questions are summarized in Table 1.

The data used to answer these questions is drawn from household surveys in two very different cities in the Global South: Nairobi, Kenya, and Mexico City, Mexico, in 2016. In Nairobi, the household sample was stratified by sub-district population, with sub-districts randomly selected from within all districts in Nairobi City County. Households were then selected by enumerator teams within each sub-district using systematic sampling, resulting in a final sample size of 1,424 households. In the household survey of Mexico City, enumeration areas were randomly selected across the entire metropolitan area. The total sample size was stratified using proportionate allocation across enumeration areas within socio-economic bands. Households were then selected by teams of enumerators using random systematic sampling. The total sample size for this survey was 1,210 households.

These city-wide surveys of Mexico City and Nairobi used the Hungry Cities Partnership (HCP) household survey instrument. This instrument measured household food security and food sourcing behaviour, together with measures of poverty and household demographic characteristics. This paper relies on the following measures from the survey instrument: the Household Food Insecure Access Prevalence (HFIAP) scale, the Household Dietary Diversity Score (HDDS), the Lived Poverty Index (LPI), household income quintiles, food price impact, and household food sources.

The HFIAP is an ordinal-level scale that measures the severity of household food insecurity in the

**TABLE 1: Research Design**

| Research objectives | Research questions |
|---|---|
| Objective 1: Test the original concept of food deserts | 1.1 Is there a spatial clustering of food insecure households? |
| | 1.2 Is there a relationship between household supermarket access and household food security? |
| | 1.3 Is there a relationship between household poverty and supermarket access? |
| Objective 2: Test the food deserts plus concept of food deserts | 2.1 Is there a relationship between household access to all food retail sources and household food security? |
| | 2.2 Is there a link between the type of food products purchased and the sources of those food products at the household level? |
| | 2.3 Is there a link between fruit and vegetable purchase/consumption and household food security? |
| | 2.4 Is the number of household food retail sources related to household food security? |
| Objective 3: Test the food deserts as complexity concept of food deserts | 3.1 Is there a relationship between access to all food sources (market and otherwise) and household income, household dietary diversity, and food access/food price challenges? |
| | 3.2 Is there a relationship between the number of household food sources and household food security? |
| | 3.3 Is there a spatial clustering of households with low dietary diversity? |

previous month (Coates et al 2007). The score is based on answers to nine Likert-scale questions on the frequency with which households experienced various food access challenges. The answers to these frequency-of-occurrence questions are aggregated using a scoring algorithm to classify households in four categories of food insecurity: Food Secure, Mildly Food Insecure, Moderately Food Insecure, and Severely Food Insecure. The HDDS is an ordinal-level scale representing the number of food groups consumed by any member of the household in the previous 24 hours (with a total of 12 possible food groups included in the scale) (Swindale and Bilinsky 2006). A higher score on the HDDS indicates greater dietary diversity. The LPI is an ordinal-level scale that measures lived poverty. The scale is made up of six Likert-scale questions measuring the frequency with which households went without electricity, clean water, medical care, cooking fuel, food, or a cash income in the previous year. The household LPI score is the average of these six sub-scale questions. A higher score on the LPI represents greater severity of lived poverty.

Household income quintiles were calculated by summing the amount of income earned by households in the last month across all household income sources (except for loans or credit). Total household income was then binned into five ranked and proportionately equal categories or quintiles. This calculation was done separately for each city. A higher score on the household income quintile scale represents higher household income.

The HCP household survey instrument included a question on food price impacts. Respondents were asked to indicate the frequency with which the household had gone without food due to rising food prices in the previous six months. The response was recorded using a Likert-scale indicating frequency of occurrence. The household food sources measured in the survey instrument show the source of food items accessed by the household in the previous month.

The data analysis uses frequency distributions, measures of central tendency, Pearson's chi-square test of independence, Fisher's exact test, Spearman's Rho correlation, and GIS analysis. Some of the assessments of the relationships between the variables use cross-tabulations. These cross-tabulations represent both measures of central tendency (averages) across the categories of other variables as well as frequency distributions. The frequency distributions are assessed using Pearson's chi-square test of independence. This test determines whether the distributed frequency of households across any two categorical variables is random. In the case where

the assumptions of this test are violated, the Fisher's exact test is used to test for the association between two categorical variables.

Spearman's Rho correlations determine the extent to which two ordinal or continuous-level variables are related. This correlation is sensitive to non-linear relationships but also assumes a monotonic relationship (continuously increasing or decreasing relationships). The Spearman's Rho correlation strength was assessed using the criteria of Prion and Haerling (2014), where <0.4 indicates a negligible or weak relationship, 0.4-0.6 indicates a moderate relationship, and >0.6 indicates a strong relationship.

The GIS analysis relied on scatterplots of longitude and latitude coordinates. These scatterplots reveal spatial clustering of the co-occurrence between variables for each surveyed household. Given the sensitivity of the data collected, measures were taken to mask the exact location of sampled households. All shapefiles were removed from the GIS analysis to limit the identification of households. This investigation also randomly jittered the location of these households using a normal distribution. This jittering masked the location of these households and helped reveal clustering by avoiding graphical collisions between households located close to one another.

## Testing Classic Food Deserts

The first question is whether there is a spatial clustering of food insecure households. There does not appear to be a strong spatial clustering of food insecure households in either Nairobi or Mexico City (Figures 1 and 2). Food secure and food insecure households were represented within the various neighbourhoods sampled within both cities.

The second question is whether there is a relationship between household supermarket access and household food security. The analysis shows a statistically significant but weak relationship in Nairobi between food security and household access to supermarkets in the previous year. These variables share a non-randomly distributed relationship according to a chi-square test of independence at an alpha of 0.05 ($x^2=132.596$, $p<.001$, $n=1382$) (Table 2). There was a negligible but statistically significant Spearman's Rho correlation of .193 ($n=1093$, $p<0.001$). In addition, 33% of those who accessed supermarkets were food secure, while only 21% were severely food insecure. Only 14% of those who did not access supermarkets were food secure, whereas 42% were severely food insecure.

There was a similarly significant but weak relationship between household supermarket access

**FIGURE 1: Spatial Distribution of Food Secure and Food Insecure Households in Nairobi**

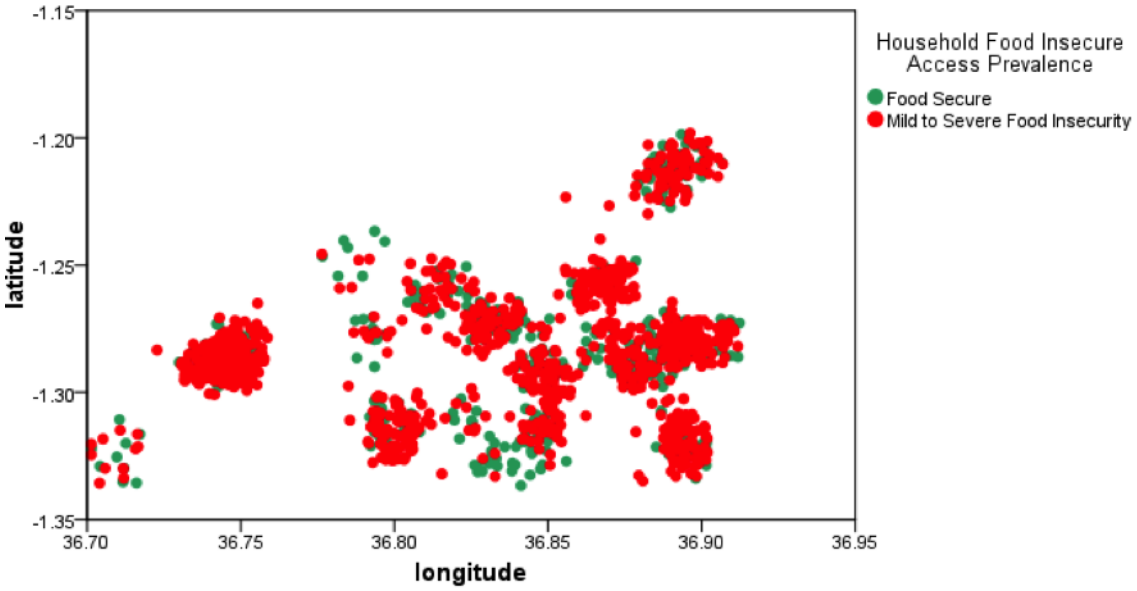
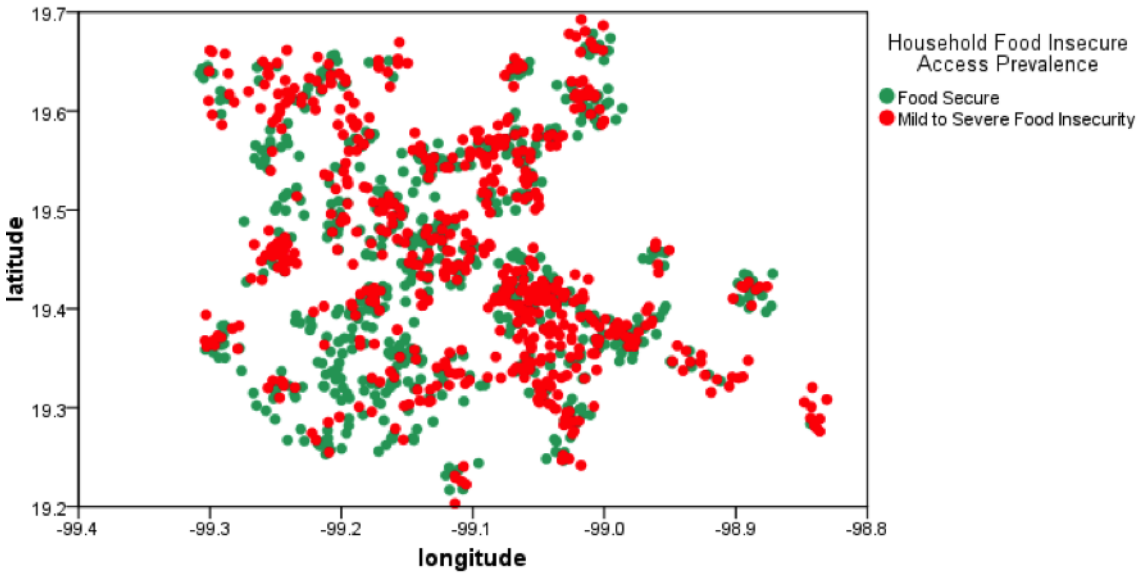


FIGURE 2: Spatial Distribution of Food Secure and Food Insecure Households in Mexico City




in the previous year and food security in Mexico City. Table 3 indicates that these variables share a non-randomly distributed relationship according to a chi-square test of independence at an alpha of 0.05 (x2= 74.933, p<.001, n=1200) and a statistically significant Spearman's Rho correlation of .138 (n=681, p=0.006). A majority (60%) of those who accessed supermarkets were food secure, while only 19% with access were severely food insecure. A total of 36% of households that did not access supermarkets were food secure, whereas 37% of those with no access were severely food insecure.

These observations also extend to regular (at least once per month) household supermarket access.

TABLE 2: HFIAP Scores and Supermarket Access in Previous Year in Nairobi

| Food security status | No access | | Access | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 43 | 14.4 | 366 | 33.2 |
| Mildly food insecure | 28 | 9.4 | 148 | 13.4 |
| Moderately food insecure | 103 | 34.4 | 360 | 32.7 |
| Severely food insecure | 125 | 41.8 | 228 | 20.7 |
| Total | 299 | 100 | 1,102 | 100 |

TABLE 3: HFIAP Scores and Supermarket Access in Previous Year in Mexico City

| Food security status | No access | | Access | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 186 | 36.0 | 409 | 59.9 |
| Mildly food insecure | 66 | 12.8 | 80 | 11.7 |
| Moderately food insecure | 76 | 14.7 | 62 | 9.1 |
| Severely food insecure | 189 | 36.6 | 132 | 19.3 |
| Total | 517 | 100 | 683 | 100 |

In Nairobi, regular supermarket access shared a non-randomly distributed relationship with household food security according to a chi-square test of independence at an alpha of 0.05 (x2= 132.596, p<.001, n=1,382) (Table 4). Over one-third (35%) of households with regular access to supermarkets were food secure, while only 18% of households were severely food insecure. Among the households that irregularly accessed supermarkets, 44% were severely food insecure, while only 14% were food secure.

Similarly, in Mexico City, there is not a significant difference in the relationship between household food security scores and regular versus irregular supermarket access. Table 5 indicates a non-randomly distributed relationship between household food security and regular supermarket access according to a chi-square test of independence at an alpha of 0.05 (x2= 66.660, p<.001, n=1,190). As many as 57% of households with regular access to supermarkets were food secure and only 21% were severely food insecure. Among the households that irregularly accessed supermarkets, 40% were severely food insecure while only 34% were food secure.

There does not appear to be a strong spatial relationship between household food security and regular household supermarket access in either Nairobi or Mexico City (Figures 3 and 4). Households with regular supermarket access were spread across the sampled households in the city. All levels of food security were represented among households with regular supermarket access.

In testing the classic food deserts concept, the third question is whether there is a relationship between household poverty and supermarket access in the two cities. The sampled households in Nairobi had a significant, but weaker, relationship between supermarket access and the LPI. Table 6 shows that households that accessed supermarkets shared a non-randomly distributed relationship with the LPI according to a Fisher's exact test of independence at an alpha of 0.05 (F=42.866, p<.001, n=1,351) and a negligible but statistically significant Spearman's Rho correlation of .074 (n=1,067, p=0.015) with LPI. Ninety-one percent of households that had shopped at a supermarket in the previous year had an LPI of 1.00 or less, compared with 78% households that had not.

**TABLE 4: HFIAP Scores and Regular Supermarket Access in Nairobi**

| Food security status | Regular access | | Irregular access | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 345 | 35.2 | 56 | 13.9 |
| Mildly food insecure | 143 | 14.6 | 31 | 7.7 |
| Moderately food insecure | 319 | 32.6 | 139 | 34.6 |
| Severely food insecure | 173 | 17.7 | 176 | 43.8 |
| Total | 980 | 100 | 402 | 100 |

**TABLE 5: HFIAP Scores and Regular Supermarket Access in Mexico City**

| Food security status | Regular access | | Irregular access | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 450 | 56.5 | 135 | 34.3 |
| Mildly food insecure | 101 | 12.7 | 45 | 11.4 |
| Moderately food insecure | 80 | 10.1 | 58 | 14.7 |
| Severely food insecure | 165 | 20.7 | 156 | 39.6 |
| Total | 796 | 100 | 394 | 100 |

FIGURE 3: Spatial Distribution of Food Security and Regular Supermarket Access in Nairobi

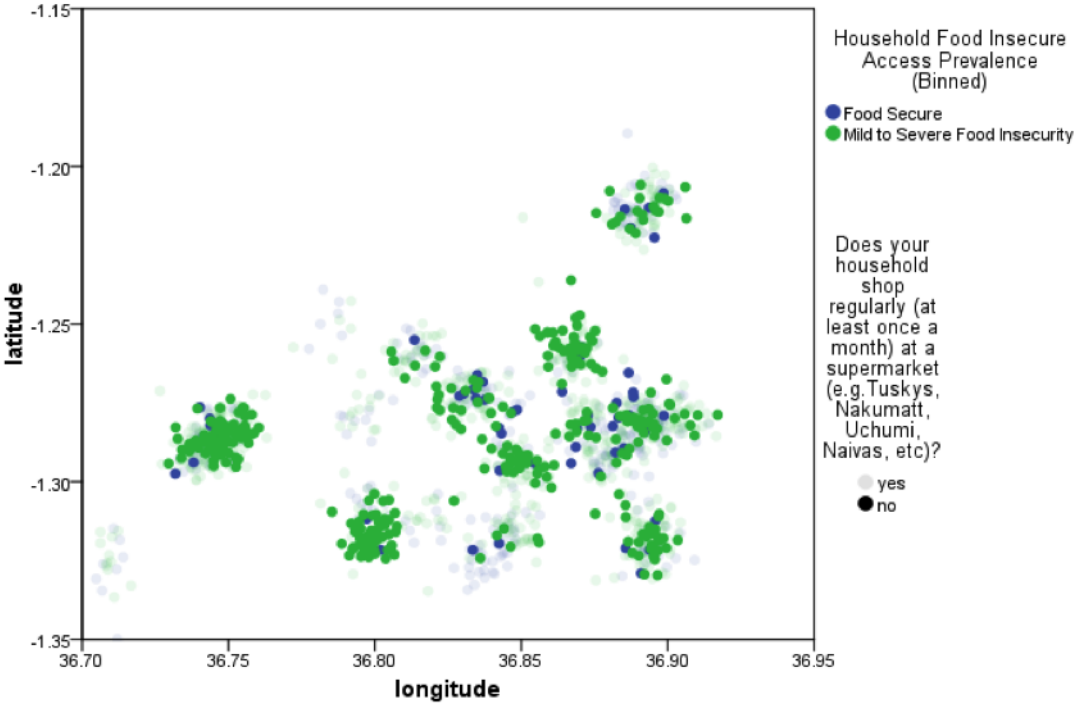



FIGURE 4: Spatial Distribution of Food Security and Regular Supermarket Access in Mexico City

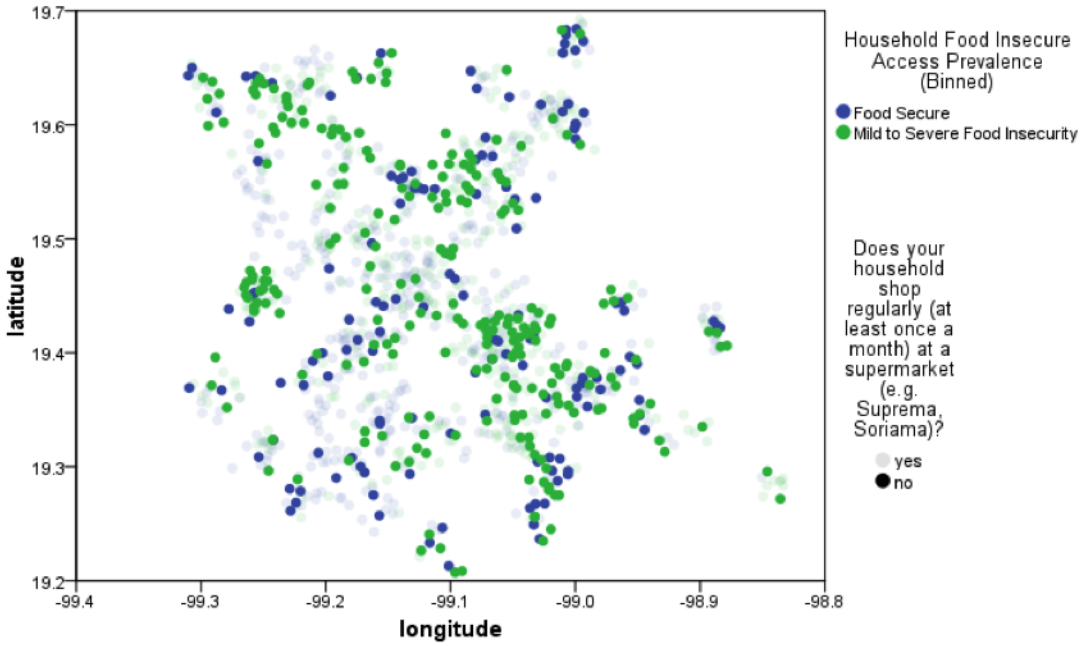



TABLE 6: Lived Poverty and Supermarket Access in Previous Year in Nairobi

| Lived poverty status | No access | | Access | |
|---|---|---|---|---|
| | n | % | n | % |
| <=1.00 | 215 | 77.6 | 978 | 91.1 |
| 1.01-2.00 | 52 | 18.8 | 93 | 8.7 |
| 2.01-3.00 | 9 | 3.2 | 3 | 0.3 |
| 3.01+ | 1 | 0.4 | 0 | 0.0 |
| Total | 277 | 100 | 1,074 | 100 |

The relationship was even weaker in Mexico City. As Table 7 shows, household supermarket access shared a non-randomly distributed relationship with the LPI according to a Fisher's exact test of independence at an alpha of 0.05 (F= 24.082, p<.001, n=1184). There was a negligible and statistically insignificant Spearman's Rho correlation of .009 (n=673, p=0.823) between supermarket access and the LPI.

The regularity of supermarket access does not appear to have a significantly different relationship with the LPI in Nairobi. The variables in Table 8 share a non-randomly distributed relationship according to a Fisher's exact test of independence at an alpha of 0.05 (F=50.427, p<.001, n=1,349). Some 92% of households with regular access to a supermarket had a score of 1.00 or less on the LPI, compared with 78% of those with irregular access.

Similarly, the regularity of supermarket access in Mexico City does not have a significantly different relationship with the LPI. These variables share a similar non-randomly distributed relationship according to a Fisher's exact test of independence at an alpha of 0.05 (F=14.53, p<.001, n=1,182) (Table 9). Some 95% of households with regular access to a supermarket score 1.00 or less on the LPI, compared with 90% with irregular access.

To summarize, in both Nairobi and Mexico City, there was a negligible correlation between the frequency of supermarket access and household food security status. Both cities also show a relationship between irregular access to supermarkets and household food insecurity. Spatially, both cities indicate a relationship between higher levels of lived poverty and food insecurity. In Figure 3, the central band mostly represents the central business district within Nairobi where food insecurity and lived poverty would be expected to be lower. The cities begin to differ in relation to regular access to supermarkets. In Nairobi, supermarket access is spatially aligned with food insecurity, especially in the far western and eastern parts of the city. In Mexico City, the spatial relationship between regular supermarket shopping and food security is loose at best.

**TABLE 7: Lived Poverty and Supermarket Access in Previous Year in Mexico City**

| Lived poverty status | No access | | Access | |
|---|---|---|---|---|
| | n | % | n | % |
| <=1.00 | 456 | 89.6 | 652 | 96.6 |
| 1.01-2.00 | 47 | 9.2 | 22 | 3.3 |
| 2.01-3.00 | 6 | 1.2 | 1 | 0.1 |
| Total | 509 | 100 | 675 | 100 |

**TABLE 8: Lived Poverty and Regularity of Supermarket Access in Nairobi**

| Lived poverty status | Regular access | | Irregular access | |
|---|---|---|---|---|
| | n | % | n | % |
| <=1.00 | 891 | 92.3 | 301 | 78.4 |
| 1.01-2.00 | 71 | 7.4 | 74 | 19.3 |
| 2.01-3.00 | 3 | 0.3 | 8 | 2.1 |
| 3.01+ | 0 | 0.0 | 1 | 0.3 |
| Total | 965 | 100 | 384 | 100 |

**TABLE 9: Lived Poverty and Regularity of Supermarket Access in Mexico City**

| Lived poverty status | Regular access | | Irregular access | |
|---|---|---|---|---|
| | n | % | n | % |
| <=1.00 | 755 | 95.4 | 350 | 89.5 |
| 1.01-2.00 | 33 | 4.2 | 37 | 9.5 |
| 2.01-3.00 | 3 | 0.4 | 4 | 1.0 |
| Total | 965 | 100 | 391 | 100 |

Differences also emerge when examining the relationship between household poverty and supermarket access. In Nairobi, there is a consistently weak but statistically significant correlation between household levels of poverty and accessing supermarkets more regularly, indicating that access to supermarkets may be a good indicator of better levels of lived poverty. In Mexico City, the relationship is inconclusive.

## Testing Food Deserts Plus

The first question is whether there is a relationship between household food security and access to different retail sources. This question assumes that household food security status can vary according to the types of household food source accessed. Table 10 demonstrates that households in Nairobi that accessed food from informal street sellers and vendors had a higher average HFIAS score than those that accessed from supermarkets (4.98 versus 6.46). Similarly, there were differences in average HFIAS scores across the food sources accessed by the households in Mexico City (Table 11). The highest HFIAS scores were observed among households that accessed food from convenience stores (4.95) and markets (3.34). Households that accessed food from supermarkets had a lower mean HFIAS score (2.32).

Second, is there a link between the type of food products purchased and the sources of those products at the household level? One potential reason underlying the distribution of HFIAS scores by food source may have to do with the types of food accessed at these sources. Supermarkets were the most common place to buy many food items in Nairobi, followed by kiosks, small shops, and street sellers. Items most commonly purchased at supermarkets included maize meal, brown bread, rice, pasta, tinned food, frozen meat, sour milk, tea/coffee, sugar, cooking oil, snacks, and sweets. Fresh foods, on the other hand, are seldom purchased at supermarkets. Items such as fruit and vegetables were commonly purchased at small shops, kiosks, and street traders. Fresh fish, cooked fish, and pies/samosas were most often purchased from street sellers. Fresh and whole foods are therefore most

**TABLE 10: Average HFIAS Scores by Household Food Sources in Previous Year in Nairobi**

| Food sources | N | Mean HFIAS |
|---|---|---|
| Informal street seller/vendors | 631 | 6.46 |
| Kiosks/corner store | 961 | 5.91 |
| Other shops including grocer and butcher | 1,144 | 5.83 |
| City council/county market | 715 | 5.48 |
| Supermarket | 1,096 | 4.98 |
| Restaurant | 306 | 3.44 |
| Online market shopping | 12 | 2.83 |
| Fast-food outlets | 199 | 1.98 |
| Note: Multiple-response question | | |

**TABLE 11: Average HFIAS Scores by Household Food Sources in Previous Year in Mexico City**

| Food sources | N | Mean HFIAS |
|---|---|---|
| Convenience stores | 43 | 4.95 |
| Markets | 1,031 | 3.34 |
| Small shops | 816 | 3.10 |
| Street seller/vendor | 195 | 2.82 |
| Supermarket | 681 | 2.32 |
| Online market shopping | 12 | 1.92 |
| Restaurant | 82 | 0.83 |
| Fast-food outlets | 54 | 0.26 |

often purchased at smaller scale retail types, while more processed foods and foods high in sugar and fat are most often purchased at supermarkets.

In Mexico City, many of the food items recorded in the survey instrument were bought from supermarkets and seemed to be supplemented by markets and small shops. One exception was eggs, with 64% buying them from small shops, 30% from markets, and 26% from supermarkets. Another exception is tamales, quesadillas, and tacos, which were purchased primarily from street sellers and then markets. Fresh fish and chicken were primarily purchased at markets, whereas frozen fish and chicken were primarily purchased at supermarkets. Fresh fruit and fresh cooked vegetables were bought more often from markets than supermarkets. Mexican staples such as tortillas were purchased at specialized stores, whereas rice was bought more or less equally from markets and supermarkets. Bread was mostly bought in supermarkets, with only a small percentage in markets. Finally, most cooking oil was purchased in supermarkets.

The third question is whether there is a link between fruit and vegetable purchase/consumption and household food security. In Nairobi, there seems to be a relationship between food security and fruit and vegetable consumption in the previous 24 hours (Table 12). This relationship is not as strong as that previously observed between food security and supermarket access, but it is present nevertheless. These variables share a non-randomly distributed relationship according to a chi-square test of independence at an alpha of 0.05 ($x^2=6.504$, $p<.001$, $n=1,402$).

Similarly, there seems to be a relationship between fruit and vegetable consumption in the previous 24 hours and food security in Mexico City (Table 13). The variables shared a non-randomly distributed relationship with household food security status according to a chi-square test of independence at an alpha of 0.05 ($x^2=20.740$, $p<.001$, $n=1,201$). Again, this relationship is not as strong as it is between food security and supermarket access.

The final question in this section is whether the number of household food retail sources patronized is related to household food security. In Nairobi, there was a negligible but statistically significant Spearman's Rho correlation of -.140 ($n=1,401$, $p<0.001$) between the number of retail food sources accessed in the previous year and household food security status. The sign on this correlation suggests that a higher number of food retail sources is associated with greater household food security, although the correlation effect size is minimal. There also does not appear to be a clear spatial relationship between these variables. Figure 5 indicates

**TABLE 12: HFIAP Scores by Household Fruit and Vegetable Consumption in Nairobi**

| Food security status | None consumed | | Fruit/vegetables consumed | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 33 | 21.6 | 377 | 30.2 |
| Mildly food insecure | 17 | 11.1 | 159 | 12.7 |
| Moderately food insecure | 56 | 36.6 | 407 | 32.6 |
| Severely food insecure | 47 | 30.7 | 306 | 24.5 |
| Total | 153 | 100 | 1,249 | 100 |

**TABLE 13: HFIAP Scores by Household Fruit and Vegetable Consumption in Mexico City**

| Food security status | None consumed | | Fruit/vegetables consumed | |
|---|---|---|---|---|
| | n | % | n | % |
| Food secure | 75 | 36.2 | 520 | 52.3 |
| Mildly food insecure | 25 | 12.1 | 121 | 12.2 |
| Moderately food insecure | 31 | 15.0 | 107 | 10.8 |
| Severely food insecure | 76 | 36.7 | 246 | 24.7 |
| Total | 207 | 100 | 994 | 100 |

that many of the households had several food retail sources, but this behaviour was common across household food security categories and across the city.

In Mexico City, there was also a negligible but statistically significant Spearman's Rho correlation of -.127 (n=1,200, p<0.001) between the number of food retail sources accessed in the previous year and household food security status. Figure 6 also fails to demonstrate a spatial relationship between food security and the number of food retail sources. As in the Nairobi survey, it appears it was common among the Mexico City households to have multiple food retail sources, and this behaviour was not strongly linked to food security status or to a discernible spatial pattern.

To summarize, there does appear to be a relationship between household access to food retail types and household food security in both cities. In Nairobi, households accessing street sellers and

**FIGURE 5: Spatial Distribution of Number of Food Retail Sources Accessed and Food Security Status in Nairobi**

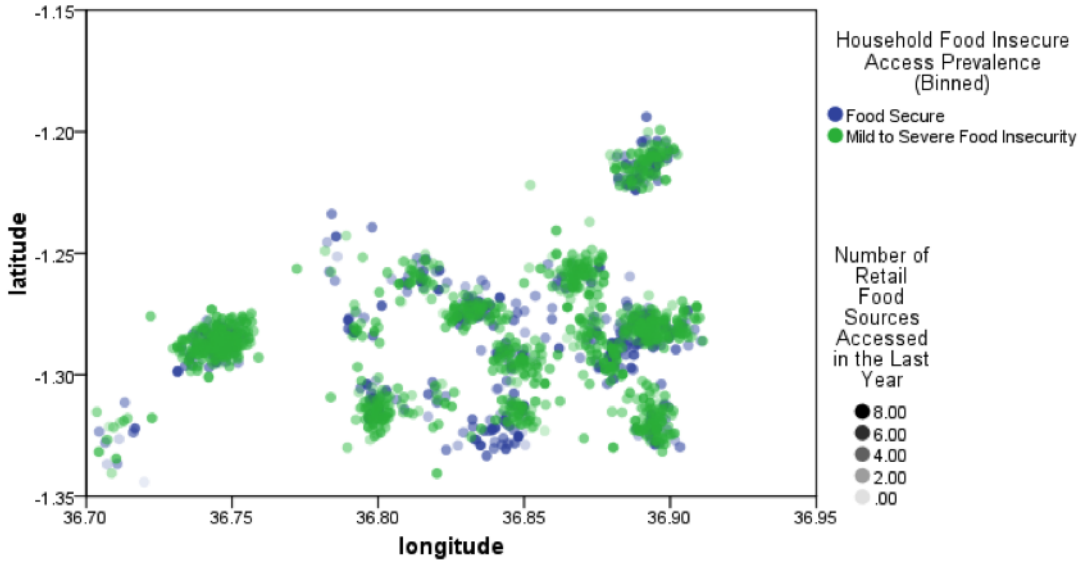
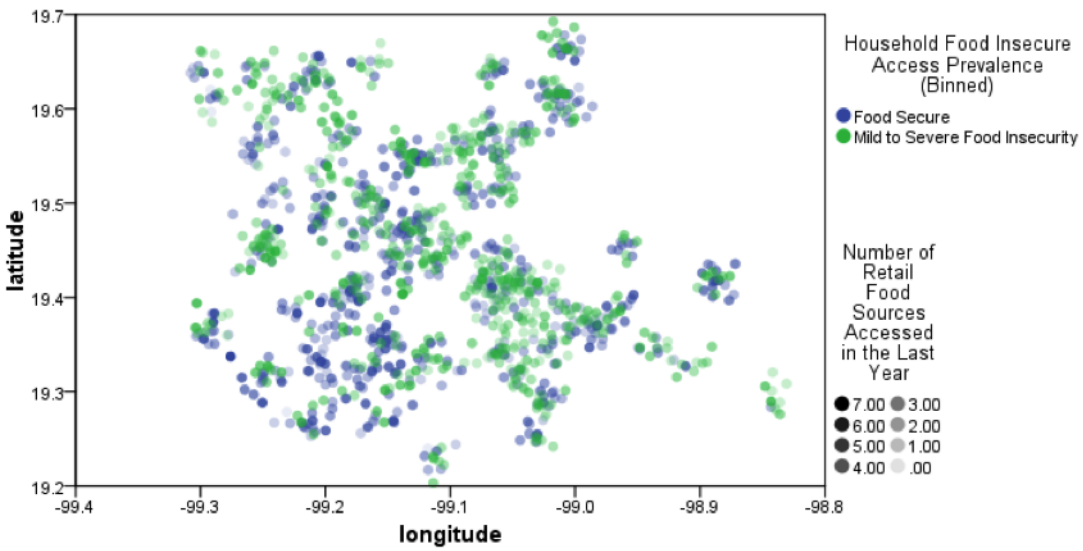



**FIGURE 6: Spatial Distribution of Number of Food Retail Sources Accessed and Food Security Status in Mexico City**



vendors are more likely to be food insecure than those accessing fast-food outlets, online market shopping, or restaurants. Households accessing supermarkets are moderately more food secure than those accessing street vendors. In Mexico City, the strongest relationship is between high levels of food security and visiting restaurants or fast-food outlets. Whereas in Nairobi, the most food insecure households accessed food through street sellers and markets, Mexico City households had more variety in food sources.

In both Nairobi and Mexico City, there seems to be a link between the types of food products purchased and the sources of those food products. In Nairobi, supermarkets appear to be the most common place to buy many food items. Fresh or cooked vegetables, however, are most often purchased from markets and fresh meats are bought at butcheries. In Mexico City, most items are bought at supermarkets, followed by formal and informal markets. Fresh fruit and fresh cooked vegetables are bought mostly from markets, and fresh meat is bought from these sources or butchers.

In both Nairobi and Mexico City, there seems to be a relationship between fruit and vegetable consumption and food security. This relationship in both cities is not as strong as it is between food security and supermarket access. Lastly, there was a negligible relationship between the number of food retail sources accessed by households and household food security status in Nairobi, and no statistically significant relationship in Mexico City. There is no obvious spatial pattern in either city because many households access large numbers of food retail sources.

## Testing Food Deserts as Complexity

First, is there a relationship between access to all food sources (market and otherwise) and household income, household dietary diversity, food access/food price challenges? Table 14 indicates that there was a positive statistically significant relationship between the number of food sources a household accesses and both household income and household dietary diversity in Nairobi. A higher number of food sources was related to improved household food security, dietary diversity, reduced food price impact, and higher household income. While these correlations were statistically significant, their effect sizes were small, indicating a weak relationship between the number of household food sources and each variable. The strongest relationship was observed between household dietary diversity and the number of food sources accessed in the last year, although this relationship is weak (Rho=.209).

A similar set of correlations is observed in Mexico City. Table 15 demonstrates a weak to negligible relationship between household dietary diversity and the number of food sources. A higher number of food sources was related to improved household food security, dietary diversity, reduced food price impact, and higher household income. However, the correlation effect sizes were small, indicating a weak correlation relationship. The strongest relationship observed was between household income and the number of household food sources (Rho=.305), although this relationship is still weak.

The second question is whether there is a relationship between the number of household food sources and household food security. In Nairobi, there does not appear to be a clear spatial relationship between the two. Across the city, households with higher numbers of accessed food sources were found across all food security categories. Furthermore, this relationship did not appear to be isolated to certain sampled areas of the city.

As in Nairobi, there does not appear to be a clear spatial relationship between the number of food sources accessed in the previous year and household food security status in Mexico City. Across the city, households with higher numbers of accessed food sources were also categorized across all food security categories. Also, this relationship was not isolated to certain sampled areas of the city. Instead, across the city, households demonstrated a diversity of food security scores and a varied number of food sources.

**TABLE 14: Correlation of HFIAP, HDDS, Food Price Impact, and Household Income with the Number of Household Food Sources in the Past Year in Nairobi**

| | Number of food sources | | |
|---|---|---|---|
| | Rho | P-value | n |
| HFIAP | -.096** | <0.001 | 1,401 |
| HDDS | .209** | <0.001 | 1,413 |
| Food price impact | -.093** | <0.001 | 1,396 |
| Household income quintiles | .186** | <0.001 | 830 |
| *P-value<0.05<br>**P-value<0.01 | | | |

**TABLE 15: Correlation of HFIAP, HDDS, Food Price Impact, and Household Income with the Number of Household Food Sources in the Past Year in Mexico City**

| | Number of food sources | | |
|---|---|---|---|
| | Rho | P-value | n |
| HFIAP | -.113** | <0.001 | 1,200 |
| HDDS | .282** | <0.001 | 1,209 |
| Food price impact | -.137** | <0.001 | 1,204 |
| Household income quintiles | .305** | <0.001 | 825 |
| *P-value<0.05<br>**P-value<0.01 | | | |

**FIGURE 7: Spatial Distribution of the Number of Food Sources Accessed and Food Security Status in Nairobi**

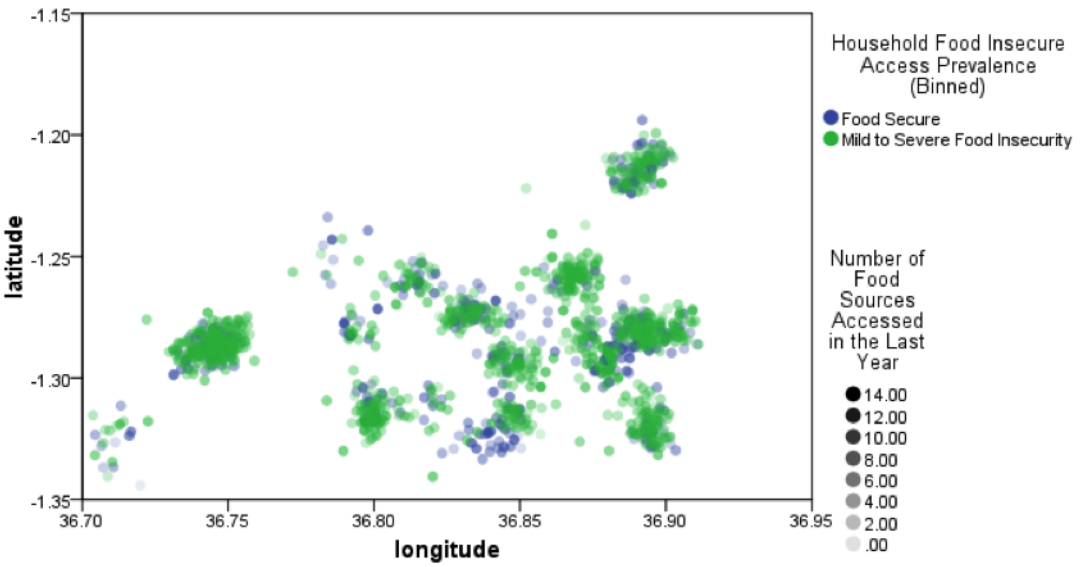
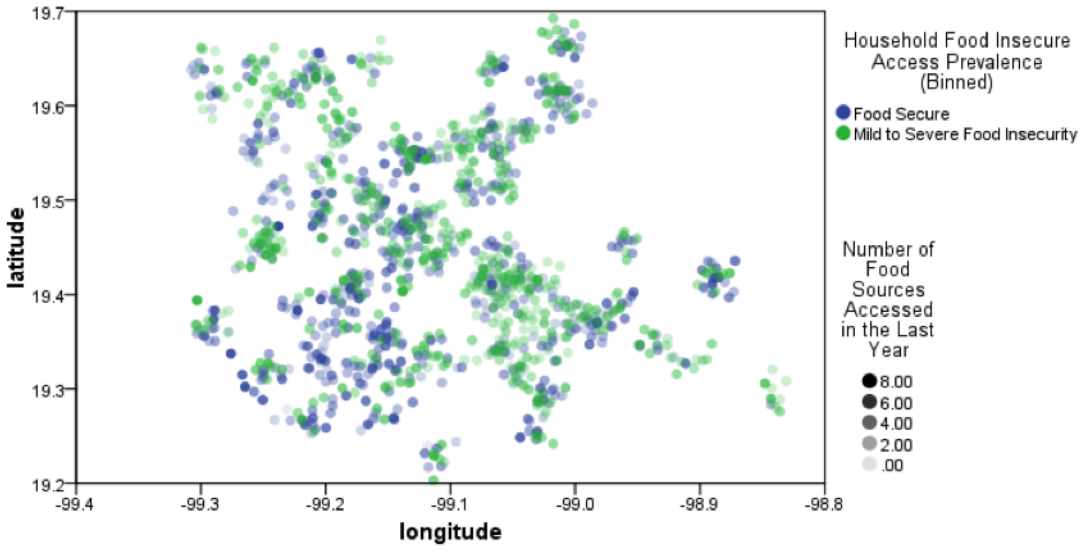


**FIGURE 8: Spatial Distribution of the Number of Food Sources Accessed and Food Security Status in Mexico City**




The last question is whether there is a spatial clustering of dietary diverse households. In Nairobi, there does not appear to be a clear spatial pattern between households with high dietary diversity (6.00+) and low dietary diversity (<=5.00). Households with low dietary diversity scores were found across the city.

Similarly, there does not appear to be a clear spatial pattern between households with high dietary diversity (6.00+) and low dietary diversity (<=5.00) in Mexico City. Households with low dietary diversity scores were found in all sampled neighbourhoods across the city, although there was a greater concentration of low HDDS households in the southern half of the city (Figure 10).

**FIGURE 9: Spatial Distribution of HDDS in Nairobi**

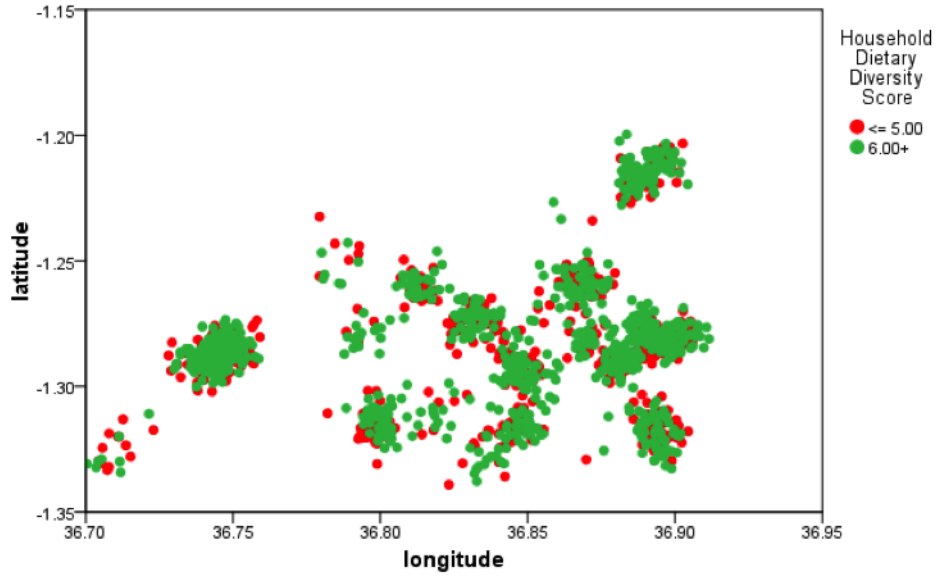
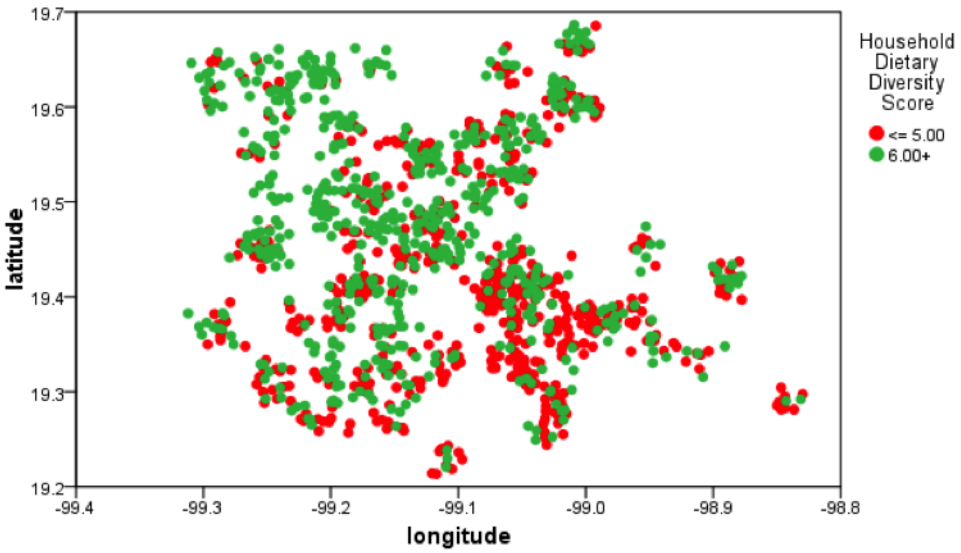


FIGURE 10: Spatial Distribution of HDDS in Mexico City




While there were statistically significant correlations observed in both cities between the total number of household food sources accessed in the last year and household food security, dietary diversity, reduced food price impact, and higher household income, these correlation coefficients tend to be weak. There also did not appear to be a clear spatial pattern in the distribution of this phenomenon across the two cities. Sampled households in both cities demonstrated a diversity of food security scores along with a varied number of food sources accessed. Spatial patterns of household dietary diversity are also weak in both cities.

## Conclusion

This paper provides an analysis of the concept of food deserts in Nairobi and Mexico City. To do this, the analysis used three definitions of food deserts taken from the evolution of food deserts literature, defined here as Original Food Deserts, Food Deserts Plus, and Food Deserts as Complexity. A number of tests were developed to determine the utility of each definition in the specific city contexts. The results indicate that, while these associations are statistically significant and show the expected correlation direction between household food sourcing behaviour and food security, the relationships tend to be weak with limited spatial patterning. When assessing the relative utility of the three food desert concepts in the contexts of Nairobi and Mexico City, they appear to be equally inapplicable. These findings indicate that the urban food desert concept may have limited relevance to explaining urban food insecurity in two very different cities in the Global South.

Important limitations accompany the findings from this investigation. First, the GIS analyses presented in this paper are designed to test the basic use of urban food deserts as a means of spatially mapping food insecurity in cities. Given this focus, there may be a spatial relationship between the investigation variables that was not assessed by this investigation. Further research will be needed to assess this limitation. Second, this investigation should not be interpreted as an analysis of any causal relationships between food sourcing and food security. The methods test the predictive relationship between food source access and food security assumed by the three urban food desert definitions. The paper therefore assesses whether food insecurity can be inferred based on limited household access to specific food sources. Additional research will be needed to assess any causal interpretations of urban food deserts. Lastly, investigating food deserts through an understanding of their complexity requires the inclusion of factors such as mobility,

transportation, time, education, structural inequalities, and neighbourhood policy environments, which have not been explored in this study.

Given that research on food deserts in the Global South has not yet systematically explored the structural drivers of food insecurity that operate outside the home, future studies should expand to neighbourhood and city-wide scales. This paper and future studies in the field are relevant to Sustainable Development Goal (SDG) 2 to end hunger, as well as Goal 11 to make cities and human settlements inclusive, safe, resilient, and sustainable. Urban food insecurity dynamics in the South are changing and becoming increasingly problematic. There is little chance of reversing this growth without the development and implementation of sound, evidence-based, neighbourhood and city-wide food security strategies that contribute to the achievement of the SDGs. Future research should systematically explore their dynamics to inform policy addressing food insecurity in cities of the South.

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