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Faye, Ndeye Fatou; Fall, Talla; Reardon, Thomas; Theriault, Veronique; Ngom, Yacine et al

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Ndeye Fatou Faye
Institut Sénégalais de Recherches Agricoles, Dakar, Senegal
Talla Fall
International Food Policy Research Institute, Dakar, Senegal
Thomas Reardon
Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, Michigan, USA and International Food Policy Research Institute, Washington, District of Columbia, USA
Veronique Theriault
Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, Michigan, USA
Yacine Ngom
United States Agency for International Development Feed the Future Policy Systems Services, Dakar, Senegal
Mamadou Bobo Barry
Institut Sénégalais de Recherches Agricoles, Dakar, Senegal, and
Mouhamed Rassoul Sy
Wageningen University & Research, Wageningen, The Netherlands

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Abstract

Purpose – This paper analyzes the consumption of fruits and vegetables (FV) in Senegal by: (1) urban and rural areas; (2) FV types (African-indigenous vs non-indigenous); (3) sources of FV (imports, purchases and own-production).

Design/methodology/approach – The authors undertake descriptive and regression analyses on consumption of FV sourced from purchases, own-production and gifts. The data come from primary surveys in 2017/2018 of 6,328 rural and urban households in Senegal.

Findings – The analysis showed that FV are important in urban and rural food consumption. A stunning 76% of rural FV consumption is from purchases, showing the importance of FV supply chains even into and among

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rural areas. Only 12% of national FV consumption is from imports. Most FV consumption in rural and urban areas is now of non-indigenous FV; African-indigenous FV have a minor share.
Research limitations/implications – A limitation of this paper is that it uses a cross-sectional dataset.
Originality/value – There are few national survey-based studies of FV consumption in Africa. This is the first to disaggregate FV consumption between primary versus secondary cities and rural towns, and rural areas close to and far from cities, in such detail regarding types and sources of FV as outlined in the findings. The regressions contribute by including determinants beyond income, including gender, employment, spatiality and education.

Keywords Senegal, Fruits, Vegetables, Consumption
Paper type Research paper

1. Introduction

Fruits and vegetables (FV) have become a major theme of food security discussions in low- and middle-income countries (LMICs) because they are crucial to nutrition and there are widespread concerns that they are under-consumed. Yet, there is a dearth of systematic survey-based research in LMICs on FV consumption (Harris *et al.*, 2022). The present paper contributes to addressing this gap with a study of FV consumption by rural and urban households in Senegal.

There have been just a few studies of FV consumption using nationally representative survey data in Sub-Saharan Africa (SSA) in the past two decades. They showed that FV consumption as a share of overall food consumption has become substantial. Smale *et al.* (2020) found 13% in rural and 20% in urban areas in Mali; Ayieko *et al.* (2005) found 26% in Nairobi. Ruel *et al.* (2005) found 14.1% for rural and urban together in Mozambique, 11.9% in Tanzania, 9.8% in Kenya and 11.3% in Ghana. Amfo *et al.* (2019) found 34% for urban Ghana. These African shares are roughly similar to those found in South and Southeast Asia (Reardon *et al.*, 2014). There is also evidence that FV consumption in SSA is growing and doing so at rates faster than cereals consumption. For example, FAOSTAT data show that from 1990 to 2018, national consumption by disappearance (output plus imports less exports) of cereals increased 2.6-fold, while FV consumption increased 4.4-fold.

There have been several strands of literature on FV consumption in SSA. The first strand focused on rural own-production and consumption of FV. This started from the farming systems literature that emerged in the 1970s (Eicher and Baker, 1982). Our review of the literature in the past several decades suggests that most studies on rural SSA consumption of FV continue to focus on home-production in homestead gardens, featuring home production in the dry season in wet patches and riverbeds (Rybak *et al.*, 2018; Keding *et al.*, 2017). Moreover, these rural studies have often focused on "traditional African vegetables" such as okra and African eggplant and local leaves and have tended to not examine the penetration of non-traditional vegetables such as potatoes, tomatoes and carrots or fruits in general.

Few SSA studies of rural FV consumption have examined purchases as a source of FV. This gap may come from what we perceive as a widespread assumption that the great majority of rural consumption of FV comes from home production and not purchases; Sibhatu and Qaim (2018) observe this assumption in general in the rural food consumption literature in SSA.

The second strand has focused on peri-urban horticulture as a source of urban FV consumption. Examples include Moustier and David (1996) and Mbaye and Moustier (2000). These studies focused on production and distribution systems but also often contained general analysis of shares of FV in urban consumption. The above studies found that urban FV consumption centered on leafy greens and local tomatoes from irrigated perimeters 20–50 km around the cities and onions mainly from imports.

The third strand has focused on imports of FV. Moustier and David (1996) noted that already in the 1990s, a few key vegetables like onions had a high share of imports as a share of urban onion consumption. While concerns were expressed about imports in the 1980 and 1990s, few survey studies calculated the share of imports in total urban or rural FV consumption. A rare exception is Flouriot (1985) which found that 90% of Zaire urban FV

consumption was domestic and 10% imported (mainly potatoes, onions, citrus, apples and processed tomatoes. However, imports of food concern African governments (African Development Bank, 2016), and FV are included in this concern, such as by the Senegalese government (Government of Senegal, 2014).

There are important gaps in knowledge left by the above strands of literature. First, with a few exceptions (Smale *et al.*, 2020 for Mali), there has not been a systematic analysis for rural FV consumption of the share of purchases versus home-production in SSA. Second, studies have not differentiated peri-urban rural areas from more hinterland areas. Third, urban FV consumption literature in SSA has to date dwelt mainly on primary cities like Dakar and not on secondary and tertiary cities and towns. But in the past several decades the non-primary urban areas have developed rapidly and now are the majority of urban population in Africa (Christiaensen and Todo, 2014). Fourth, we have not found any study more recent than the 1980s analyzing the import share in urban and rural FV consumption or testing the hypothesis that domestic sources dominate FV purchases. Fifth, most FV consumption studies have not disaggregated FV into products beyond the categories of vegetables and fruit. The few national studies of FV consumption have largely treated FV as an undifferentiated whole; rural consumption studies have tended to focus on traditional African FV while urban studies have focused on non-traditional leafy vegetables and imported or non-traditional products like tomatoes and potatoes. No study has yet decomposed FV consumption into these types of items.

These five literature gaps taken together are important, pointing to a dearth of understanding of how important are domestic sources versus imports in national FV consumption and thus to evaluate whether there should be real concern about imports; of purchases and thus rural-rural and urban-rural supply chains for rural consumption and thus how important it is to have public attention to and investments in supply chain infrastructure; and of the extent to which FV consumption has transformed from traditional, indigenous FV to non-indigenous, non-traditional products and thus to assess what Pingali (2007) called in Asia the "westernization" of traditional diets with implications for agricultural research.

This paper will address the above five gaps using unique nationally representative cross-section datasets from primary household surveys of FV consumption and production conducted in urban and rural Senegal in 2017/18. These data are at present the only such data on Senegal, as there are no panel or earlier cross-section surveys.

2. Data

We utilize data collected under the Agricultural Policy Support Project (PAPA), which involved the Senegalese Ministry of Agriculture, the Senegalese Agricultural Research Institute (ISRA), the International Food Policy Research Institute, and Michigan State University. Nationwide stratified two-stage random sampling followed by surveys were done in urban and rural areas. Sample weights are attributed to all observations in the dataset.

For the rural survey, a list of rural districts (enumeration areas (EAs)) was compiled. The probability of an EA being drawn was proportional to its population. In total, 1,268 EAs were selected out of 9,115. In each EA, we undertook a census of households. Five farm households were randomly drawn in each EA. The FV consumption survey was then administered to a sub-sample of 4,314 farm households located in three of the five rural agroecological areas where rainfed agriculture is practiced. The excluded agroecological zones are the areas of mainly irrigated agriculture, the Niayes, the main commercial horticulture areas and the Senegal River Valley, the main rice area and the second horticultural area. As a result, consumption of own-produced FV is slightly underestimated in our data ("slightly" because the rural populations of these two irrigated areas are a small share of all rural households in Senegal). The rural data were collected in April 2018.

For the urban survey, a list of urban districts (i.e., enumeration areas (EAs)) was compiled. The survey covered the cities of Dakar, Pikine, Rufisque, Guediawaye, Touba and the other 13 regional capitals. With about 25% of Senegal's population, Greater Dakar is considered a primary city (Dakar and conurbations Pikine, Rufisque and Guediawaye (~4 million). Touba, Mbour and Thies are considered secondary cities (~0.3–1 million) and the other capitals are considered towns (~50,000). The probability of an EA being drawn was proportional to its population. In total, 117 EAs were drawn out of 8,050. In each EA, a list of households was compiled. Households were randomly drawn from each EA proportionally to its population with a minimum of 50 households per city. The total urban sample included 2,014 households. The urban survey was conducted between March and May 2017.

Both questionnaires covered household sociodemographic characteristics, non-food expenditures and all food consumption from various sources (purchased, home-produced and gifts-in). The consumption module interview was with the household head and at least one woman (typically most knowledgeable about food sourcing and consumption in Senegalese households). The recall was of all food consumed in the past month from all sources. Data on incomes were not collected, so we approximate them with total household consumption (the total of all home production and purchases and gifts-in of food and all purchases of non-food).

To differentiate spatial categories in the descriptive analyses and account for them in the regressions, we stratify the urban sample into the three urban strata noted above. Rural households are stratified into spatial terciles (called zones below) of peri-urban, intermediate and hinterland based on the GPS-measured distance of each household from the center point of the nearest main town of the commune of which there are 133 in the 45 departments of Senegal. The rural households were ranged from nearest to furthest and then grouped into distance terciles. The mean distance and the distance ranges are as follows: (1) peri-urban, mean of 4.7 km, minimum of 0.3 km and maximum of 8.5 km; (2) intermediate, mean of 11.7 km, minimum of 8.6 and maximum of 15.0 km; (3) hinterland, mean of 24.5 km, minimum of 15.1 km and maximum of 80.1 km. Note that the roads to rural households are generally not paved so that households in the hinterland can take hours to get to the nearest small town.

3. Descriptive results

Table 1 shows the shares of FV in total food consumption (purchases plus own-production plus gifts-in) in urban and rural areas. In urban areas, the share is 26%, with little difference over city types and 17% in rural areas, with little difference over rural zones (peri-urban, intermediate and

Areas	Total food consumption (%)
Urban	
Greater Dakar	27
Secondary cities	26
Towns	25
Overall urban	26
Rural	
Peri-urban	17
Intermediate	17
Hinterland	16
Overall rural	17
Overall	21

Note(s): Food expenditures include food purchases and home consumption in value terms (FCFA)
Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 1.
Shares of FV in total food consumption, urban and rural

hinterland). The overall share is 21% of all food, in value terms. These shares are close to those found in extant SSA studies and similar to those for South/Southeast Asia as noted above.

Table 2 shows the shares of purchases compared with own production, as well as gift or payment in kind received. The most striking result is that purchases constitute 76% of rural FV consumption, similar to 80% in rural Mali (Smale *et al.*, 2020); that share varies little from peri-urban to hinterland. This contradicts the common image of rural households mainly consuming the FV that they grow in their home gardens or farms, and the image that engagement in food markets, let alone FV markets, drops fast as one goes from rural areas near towns to hinterland rural areas. As the sampled rural areas are not in commercial horticultural zones (which supply the great majority of their output to domestic urban and rural markets), the important implication of our finding on purchases is that rural households depend a lot on FV supply chains for most of their FV consumption.

Purchases constitute 99% of urban FV consumption, regardless of city type. We found urban FV consumption from own-production close to zero, a result of interest to the international discussion on urban FV gardening.

Table 3 shows that only 12% (in value terms) of overall FV consumption is imported. For specific items such as onions, potatoes and bananas, the main products imported, the share is higher, around 40%. The table's figure is lower than the 21% we calculated from FAOSTAT 2018 (https://www.fao.org/faostat/en/#data/FBS) data in tonnage terms. This difference might be for several reasons.

(1) Our consumption survey asked consumers to distinguish consumption of products by domestic versus import if prior knowledge (based on rapid reconnaissance with consumers and traders) revealed that a given product was easily differentiated into imported versus domestic by its variety. This was the case with onions, potatoes, citrus and apples, which together are 65% by tons of imports per FAOSTAT and those noted in Table 4 for all zones.

(2) Apples/pears are noted in the table as not growable in Senegal and all imported. Bananas are noted as imported in our table as consumers distinguish imported and domestic types by size and taste, but FAOSTAT reports no imports of bananas.

Rural	Own-production (%)	Purchases (%)	Free or payment in kind (%)
Peri-urban			
Tercile 1	23.1	74.6	2.2
Tercile 2	22.9	74.0	3.0
Tercile 3	21.4	76.9	1.6
Overall peri-urban	*22.5*	*75.2*	*2.3*
Intermediate			
Tercile 1	24.0	74.1	1.8
Tercile 2	19.3	79.5	1.2
Tercile 3	17.7	81.3	1.0
Overall intermediate	*20.4*	*78.3*	*1.3*
Hinterland			
Tercile 1	30.3	66.6	3.0
Tercile 2	24.4	71.7	3.9
Tercile 3	23.8	74.6	1.5
Overall hinterland	*26.2*	*71.0*	*2.8*
Overall rural	23.1	74.8	2.1

Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 2. Shares of consumption of FV by sources, rural areas and total consumption (proxy for income) terciles

Areas	Share of imported FV (in FCFA) in total FV consumption	Bananas (%)	Onions (%)	Oranges (%)	Potatoes (%)	Apples and pears (%)
Urban						
Greater Dakar	18.4	3.4	6.8		4.6	3.6
Secondary cities	13.3	1.3	6.1		3.3	2.6
Towns	14.2	2.1	6.4		3.9	1.9
Overall urban	*16.0*	*2.6*	*6.5*		*4.0*	*2.9*
Rural						NA
Peri-Urban	8.1	0.6	4.4	0.3	2.8	
Intermediate	7.8	0.9	4.0	0.5	2.4	
Hinterland	8.3	0.6	4.2	0.4	3.0	
Overall rural	*8.1*	*0.7*	*4.2*	*0.4*	*2.8*	
Overall	12.0	1.5	5.4	0.2	3.5	1.4

Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 3. Shares of imports in total consumption of FV, overall and by main items imported

Areas	Bananas (%)	Onions (%)	Oranges (%)	Potatoes (%)	Apples and pears (%)
Urban					
Greater Dakar	74.5	51.6		45.9	100
Secondary cities	24.8	45.9		38.5	100
Towns	41.0	47.4		47.2	100
Overall urban	*57.4*	*48.7*		*45.0*	*100*
Rural					NA
Peri-Urban	25.4	29.7	5.2	39.1	
Intermediate	37.8	27.3	12.8	35.3	
Hinterland	26.9	28.5	12.0	44.2	
Overall rural	*30.7*	*28.5*	*10.6*	*39.6*	
Overall	43.4	38.0	3.9	42.6	100

Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 4. Shares of imports in total consumption (in value terms) of main items imported, in urban and rural areas

(3) There are several products that consumers cannot tell are imported: imported tomatoes, as they go into processing; other products listed as imports in FAOSTAT, including dates, grapes and plantains.

(4) Our import shares are in value terms; many of the non-imported products are more expensive per kg than bulk items like potatoes and onions that are most of the imports.

(5) FAOSTAT may underestimate the production of many FV, such as leafy greens, that are fragmented in production. That would mean FAOSTAT may underestimate the denominator of total FV that is more practicable to capture with a detailed FV consumption survey.

Table 3 also shows that import penetration of urban consumption is twice that of rural, 16 versus 8%. This is especially evident in onions, and somewhat in bananas, but not in potatoes. As informants say that imported onions and bananas are considered of better quality, this may explain why richer urban consumers depend more on imports of those items.

Moreover, it is striking that there is no clear pattern of differential import penetration over types of cities or rural zones except for bananas in Dakar. This suggests supply chains of imports operate "easily" all over Senegal.

Tables 5 and 6 show shares and levels of total FV of the top 15 FV items. Table 5 shows that the top 15 products form 99 and 97% of FV kg per capita in urban and rural areas respectively, and 91% in value terms; this implies that "other" items (not in the top 15) are more costly than the average product of the top 15. The shares are similar over city types and rural zones; Dakar consumes only slightly more "other". The latter are minor items: pumpkins, green beans, local fruit juices, melon, papaya, red pepper, apples, pears, other fruits, other vegetables.

Table 6 shows the levels of kg and (value) FCFA per capita. Urban consumers eat 2 times more FV in kg and value terms than rural consumers. That the urban-rural ratios are the

Areas	Top 15 - in kgs (%)	Top 15 - in FCFA (%)
Urban		
Greater Dakar	99	90
Secondary cities	99	89
Towns	100	94
Overall urban	*99*	*91*
Rural		
Peri-urban	99	90
Intermediate	96	90
Hinterland	97	90
Overall rural	*97*	*90*
Overall	97	91

Note(s): Total FV consumption calculated in kgs and FCFA. Secondary data on prices were used to compute quantities of mangoes, watermelon, citrus and leaves. We used national averages of prices collected by the National Agency of Statistics and Demography in 2017 and 2018
Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 5.
Shares of top 15 fruits and vegetables in total FV consumption per capita

	Top 15 - in kgs (kg/capita/year)	Top 15 – in FCFA (000 FCFA/capita/year)	All FV- in kgs (kg/capita/year)	All FV- in FCFA (000 FCFA/capita/year)
Urban				
Greater Dakar	146	64	147	71
Secondary cities	134	56	135	62
Towns	109	48	109	51
Overall urban	*127*	*55*	*128*	*61*
Rural				
Peri-urban	59	26	60	29
Intermediate	59	25	61	28
Hinterland	65	28	67	31
Overall rural	*61*	*26*	*63*	*29*
Overall	78	35	80	39

Note(s): Annual per capita consumption calculated in kgs and FCFA. Secondary data on prices were used to compute quantities of mangoes, watermelon, citrus and leaves. We used national averages of prices collected by the National Agency of Statistics and Demography in 2017 and 2018
Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 6.
Annual per capita consumption of FV by areas

same for kg and value terms implies that urban consumers do not on average consume higher priced FV than rural consumers.

FV consumption in kg is 35% higher in Dakar and 24% higher in secondary cities compared to towns; perhaps this indicates easier access to FV in bigger urban areas. The rural hinterland has a 12% higher kg/capita consumption than peri-urban and intermediate rural zones, a small effect. As most rural FV consumption is purchased, this implies that supply chains are at least functioning even relatively far from the towns and cities.

The FV consumption in Senegal (80 kg/capita per year) is similar to Ruel *et al.* (2005) finding for Ghana, 75 kg/capita/year. The Dakar level of 137 kg is somewhat below the only study we found with urban levels, Ayieko *et al.* (2005) for Nairobi, of 197 kg/AE. As Nairobi's average income is higher than Dakar, the difference is expected.

Table 7 shows the shares of the various top 15 FV items in consumption in value terms. The results paint a picture of somewhat greater diet transformation (away from traditional (indigenous African species) toward non-traditional items) in urban areas compared with rural areas. Several results stand out.

First, Table 7 shows that what we can call "traditional indigenous" vegetables are 11% of the urban and 24% of the rural FV diet (of the top 15 items):

	Rural				Urban			
FV	Peri-urban (%)	Intermediate (%)	Hinterland (%)	Overall (%)	Dakar (%)	Secondary cities (%)	Towns (%)	Overall (%)
Indigenous vegetables	25	24	23	24	11	11	12	11
African eggplant	7.9	9.0	7.6	8.1	2.9	3.7	3.4	3.3
Leaves	10.8	9.9	9.6	10.1	4.4	3.8	4.1	4.2
Okra	6.2	4.9	6.2	5.8	3.2	3.0	4.8	3.7
Fruits	15	15	19	16	30	26	28	28
Bananas	2.4	2.6	2.6	2.5	4.9	5.6	5.2	5.2
Citrus	5.4	4.1	3.8	4.4	7.0	7.2	5.9	6.6
Mango	5.9	7.1	10.9	8.1	6.6	5.3	7.5	6.6
Watermelon	1.3	1.2	1.2	1.3	11.6	7.6	9.6	9.9
Non-indigenous vegetables	57	58	55	57	57	61	58	58
Cabbage	6.7	8.1	6.7	7.2	4.6	5.3	5.4	5.0
Carrot	5.0	5.6	4.3	5.0	4.7	5.8	5.6	5.3
Cassava	4.4	4.3	3.2	3.9	5.2	6.8	5.9	5.8
Onion	16.2	15.7	16.1	16.0	14.3	14.4	14.5	14.4
Potatoes	7.8	7.3	7.4	7.5	11.2	9.3	8.9	9.9
Sweet potato	3.8	3.8	4.1	3.9	4.3	4.2	4.3	4.2
tomato, fresh	5.9	7.0	5.6	6.2	4.7	7.4	5.3	5.6
tomato, processed	7.3	6.3	7.5	7.1	8.0	8.2	8.3	8.2
Top 15	97.1	96.9	96.9	97.0	97.7	97.6	98.5	98.0

Note(s): Annual per capita consumption calculated in FCFA
Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 7.
Shares of top 15 FV in annual per capita FV consumption in value terms

(1) African eggplant (3.3% urban, 8.1 rural)

(2) okra (3.7% urban, 5.8 rural)

(3) leaves (4.2 urban, 10.1 rural)

The hinterland does not differ much from peri-urban, as these three products have 22% of FV consumption in hinterland versus 25% in peri-urban areas. This finding is in sharp contrast to accounts of traditional Senegalese cuisine 50 years ago when these 3 traditional items dominated the use of vegetables.

Second, fruits (bananas, citrus, mangoes and watermelons) form 28.3% of FV consumption in urban areas and 16.3% in rural areas.

(1) bananas (5.2% of urban, 2.5% of rural)

(2) citrus (6.6% of urban, 4.4% of rural)

(3) mangoes (6.6% of urban, 8.1% of rural)

(4) watermelons (9.9% of urban, 1.3% of rural)

The greater share in urban compared with rural areas fits the image of fruits being a luxury and consumed by higher income, in this case urban, consumers. But given that fruit traditionally was an occasional luxury and treat, it is striking that a quarter of FV consumption now is in fruit. Note that the "semi-traditional" mango (indigenous to South Asia), associated partly with backyard production, is only a quarter of fruit consumption in urban areas and half in rural areas; this suggests fruit diversification in markets over time, with the rise of watermelons (indigenous to Southern Africa), bananas (indigenous to Southeast Asia) and citrus (indigenous to East/Southeast Asia).

Third, Table 7 shows that what can be termed "non-indigenous vegetables" constitute 57–58% of rural and urban FV diets in value terms. It is striking that the penetration of non-indigenous items does not differ between these two areas, against the common image that rural areas stick to traditional patterns and urban areas are the transformers.

Fourth, Table 7 shows that what can be called "common non-indigenous" items include the following from greatest to least share in the overall FV diet:

(1) onions (14.4% of urban and 16% of rural)

(2) potatoes (9.9% of urban and 7.5% of rural)

(3) processed tomatoes (8.2% of urban and 7.1% of rural)

(4) sweet potatoes (4.2% of urban, 3.9% of rural)

(5) cassava (5.8% of urban, 3.9% of rural)

(6) fresh tomatoes (5.6% of urban, 6.2% of rural)

(7) carrots (5.3% of urban, 5.0% of rural)

(8) cabbage (5% of urban and 7.2% of rural)

It is useful to split these non-indigenous vegetables into groups based on their cuisine function, both in recent non-traditional dishes and in common traditional dishes. The latter include thiebou djenn (rice and fish, with traditional flavoring of onions, semi-traditional of cabbage, sweet potato and carrots, and recently, tomato puree), chicken yassa (onions), and chicken mafe (with peanut butter and sweet potato). We distinguish five groups among the non-indigenous vegetables, ranking them by their share in consumption.

The first group is the traditional but non-indigenous product, onions. It is versatile, as it is a common flavor for all the main dishes and easily adapts to new dishes and is easily storable since it does not require refrigeration. Onions are the most important FV in Senegalese consumption and a basic necessity: (1) their share in FV is 15% of rural consumption, with all households consuming it, with no variation over the three zones; (2) in urban areas its share is 13% with little variation over city types and 95% of households consuming it. Onion consumption is highly "marketized". No consumption comes from own-production in urban areas and only 13% comes from own-farming in rural areas, with little variation over zones.

Onions have been present in Senegalese consumption for many decades but show a rapid increase in the past several. FAOSTAT shows Senegal produced 387,000 tons, imported 132,000 tons and exported 4,000 tons in 2018. With a population of 15.9 million, and consumption-by-disappearance measured as output plus imports less exports, which is 32.4 kg/year/capita, with an import share of 34%. By the same method, in 2000, Senegalese consumed 12.8 kg/year/capita, with an import share of 58%; in 1980, it was 7.2 kg/year/capita, with an import share of 30%.

The second set, potatoes, is non-indigenous, and mainly in non-traditional side dishes such as potato fries (usually made by the households). They form 9% of urban consumption in value terms, similar over the city types and nearly all is purchased. In rural areas, potatoes have, somewhat surprisingly, attained nearly the same importance, at 7% of rural consumption in value terms and 91% of the consumption is purchased, with home production only at 7%. As potato production zones are in the main commercial horticulture pockets on the coast, and a lot of potatoes come in as imports, potato supply chains cross Senegal to rural areas and cities alike.

Potatoes also have been present in Senegalese consumption for decades, but at a low level with little growth until a rapid increase in the past two decades, coming in as a diet innovation. FAOSTAT shows Senegal produced 79,000 tons, imported 54,000 tons and exported 1,000 tons in 2018. Per capita consumption-by-disappearance was thus 8.3 kg/year/capita, with an import share of 41%. In 2000, Senegalese consumed 3.5 kg/year/capita, with an import share of 77%; in 1980, it was 3.8 kg/year/capita, with an import share of 61%.

The third set includes tomatoes, a recent non-indigenous innovation in the diet. They constitute 13% of FV consumption in both rural and urban areas. In rural areas, 92% of tomato consumption is purchased, with only 5% of rural households producing their own tomatoes. Processed tomatoes are a recent innovation in traditional dishes such as a coloring/flavoring for the rice/fish dish tcheb djenn. The processed form allows households without refrigerators to store them. As fresh tomatoes, they are used for a dish innovation, salads. Surprisingly, the processed form is only a quarter more important than fresh tomatoes and that ratio is similar in rural and urban areas, and in urban areas, similar over city types, and in rural areas, over zones. This equality again counters the common image of diet innovations occurring mainly in urban areas while rural areas staying traditional. Diet innovations penetrate rural hinterlands and small towns.

The trajectory of tomatoes in consumption, production and imports mirrors the onion and potato paths, with which they share the "food innovation" characteristic. In 2018, FAOSTATA data show that consumption per capita was 10.9 kg/year, with 22% of imports; in 2000, 6.7 kg/year, with 36% imports, and in 1980, 4.7 per year, with 38% imports.

The third set is semi-traditional but non-indigenous. This includes, in descending order of shares in consumption, cabbage, carrots and sweet potatoes. These together represent 16% in rural areas (100% purchased) and 14% in urban areas (99% purchased).

The above non-indigenous FV items, none of genetic origin in West Africa, are now often used as ingredients in traditional dishes, or as the base of new kinds of dishes (like French fries). Overall, they are about 80% of all FV consumption. In most cases urban areas rely on them more than rural areas, as an index of transformation and certainly de-indigenization of

the FV diet. The exceptions include onions, carrots and fresh tomatoes, each of which has a nearly equal role in urban and rural FV intake.

A surprise in Table 7 is the similarity of shares of the non-indigenous FV items over city sizes and rural zones. We had expected Dakar to have much higher shares than towns and peri-urban rural areas higher than hinterland rural areas-and vice versa for indigenous FV. The only exception is for mangoes, which have a much higher share in the hinterland than in the other two rural zones, mainly because of more home-production of mangoes (backyard trees).

Table 8 shows that while nearly all rural households consume some of each of the top 15 FV, the shares of households growing them differ sharply. Only two FV are widely home-produced: mangoes and leaves have 50 and 73%, respectively, of households' home-producing. The next nearest are okra, citrus and watermelon, with a fifth to a quarter of the rural households growing them. Few households' home-produce other FV items for their consumption. There is only minor variation in these patterns across the rural zones.

Table 9 shows that the great majority of urban households consume all the top 15 items. Extremely few (usually 0% and sometimes 1%) households grow their own FV. (Recall that we class peri-urban areas as rural.) These patterns change little over city sizes.

Table 8 shows that the share of purchases in rural areas in total consumption of most FV items is very high (in the 80–90s%), a key finding. The exceptions are mangoes and leaves: two-thirds of their consumption is from home production and only a third is from purchases. Yet the traditional and indigenous okra is 73% purchased, despite a quarter of the households growing some. Watermelon is the other exception; overall 39% is own-produced and 57% purchased. Surprisingly, for mangoes, the purchase share has an inverted U shape going from peri-urban to intermediate to hinterland. The purchase share for leaves is around 33% for peri-urban and intermediate zones and then interestingly rises in the hinterland (where we expected it to be lower) to 42%. Markets are at work even for traditional indigenous FV.

4. Empirical strategy

We assume that a household chooses FV consumption that maximizes its utility subject to its budget constraint. Optimal consumption is determined by income, prices and other economic and socio-demographic household characteristics, as follows:

$$Ci = \alpha_0 + \beta_1 TOTEXP_i + \beta_2 HH_h + \beta_3 Assets_h + \beta_4 Prices_i + \beta_5 Area_h + \mu_i \quad (1)$$

C_i is the level of consumption of FV i per capita in the past month in FCFA (value) terms or the share of FV i in total FV consumption in the past month. *TOTEXP* is a proxy for income per capita and is total consumption (purchases plus own-production that is home-consumed plus gifts received of food plus purchases of non-foods) per year per capita. *HH* are the socio-demographic characteristics of household h's household head and household.

Assets include vehicles, electronics and house construction material as a proxy for wealth. In the rural regressions we include a binary variable for belonging to a farmers' organization, a binary for home production of FV, and the total farm area of the household. In the urban regressions we included the number of TVs and cell phones. These variables are not available in the rural dataset.

Area is household location. In the urban regressions, the locations are in Dakar, in a secondary city (one of three), or in a town (one of 13 towns). In rural areas, they are in a peri-urban, intermediate, or hinterland area.

Table 8.
Shares of households consuming, producing FV and top 15 FV in total FV consumption by sources in rural areas

Rural areas	Onion (%)	Potato (%)	Processed tomato (%)	Mango (%)	Leaves (%)	Cabbage (%)	Fresh tomato (%)	Eggplant (%)	Water-melon (%)	Citrus (%)	Carrot (%)	Cassava (%)	Okra (%)	Sweet potato (%)	Banana (%)
Peri-Urban															
HHs consuming	100	99	100	100	100	100	100	100	97	100	100	100	100	100	100
HHs producing	11	7	5	50	73	10	16	13	17	23	6	14	26	10	10
Purchased %	87	89	94	30	34	88	82	85	70	66	93	79	72	84	80
Own-produced %	11	9	5	68	62	10	17	14	26	30	5	19	27	15	13
Gift, %	2	2	0	2	3	2	1	1	4	4	2	2	1	2	7
Intermediate															
HHs consuming	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100
HHs producing	10	5	5	42	74	7	11	12	19	18	4	9	22	6	9
Purchased	86	95	94	43	31	93	89	90	55	78	95	87	76	92	91
Own-produced	14	4	5	55	67	7	10	10	41	20	4	11	22	6	8
Gift	0	1	1	2	2	0	1	1	4	1	1	2	2	2	1
Hinterland															
HHs consuming	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100
HHs producing	13	10	8	54	71	11	14	16	19	17	9	14	25	15	12
Purchased	84	89	89	26	42	88	85	82	46	73	90	83	71	81	77
Own-produced	15	9	10	71	56	12	14	17	48	19	10	15	26	17	16

(*continued*)

Table 8.

Rural areas	Onion (%)	Potato (%)	Processed tomato (%)	Mango (%)	Leaves (%)	Cabbage (%)	Fresh tomato (%)	Eggplant (%)	Water-melon (%)	Citrus (%)	Carrot (%)	Cassava (%)	Okra (%)	Sweet potato (%)	Banana (%)
Gift	1	1	1	3	3	1	1	1	6	8	0	2	3	2	7
Overall rural															
HHs consuming	100	99	100	100	100	100	100	100	99	100	100	100	100	100	100
HHs producing	11	7	6	49	73	9	13	13	19	20	6	12	24	10	10
Purchased	86	91	92	32	36	90	86	86	57	72	93	83	73	85	83
Own-produced	13	7	7	66	61	10	13	13	39	24	6	15	26	13	12
Gift	1	2	1	3	3	1	1	1	5	4	1	2	2	2	5

Note(s): Total FV consumption calculated in FCFA
Source(s): Authors, based on the PAPA dataset (2017/2018)

Table 9.
Shares of households consuming, producing FV and top 15 FV in total FV consumption by sources in urban areas

Urban areas	Onion	Potato	Processed tomato	Mango	Leaves	Cabbage	Fresh tomato	Eggplant	Water-melon	Citrus fruits	Carrot	Cassava	Okra	Sweet potato	Banana
Greater Dakar															
HHs consuming	100	91	97	85	91	97	97	97	94	88	98	98	93	98	99
HHs producing	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Purchased	99	98	100	100	100	100	100	100	100	100	100	100	100	99	97
Own-produced	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Gift	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Secondary cities															
HHs consuming	100	98	96	87	96	97	98	98	92	90	99	98	98	98	96
HHs producing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Purchased	99	98	100	100	100	98	100	93	100	100	100	98	98	100	97
Own-produced	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Gift	1	1	0	0	0	2	0	7	0	0	00	2	2	0	1
Towns															
HHs consuming	100	90	98	81	87	97	98	97	90	83	97	97	92	93	98
HHs producing	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Purchased	98	99	100	100	100	100	100	100	100	100	100	99	98	98	96
Own-produced	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
Gift	2	0	0	0	0	0	0	0	0	0	0	1	0	1	3

(*continued*)

Table 9.

Urban areas	Onion	Potato	Processed tomato	Mango	Leaves	Cabbage	Fresh tomato	Eggplant	Water-melon	Citrus fruits	Carrot	Cassava	Okra	Sweet potato	Banana
Overall urban															
HHs consuming	100	92	97	83	91	97	97	97	92	87	98	98	94	96	97
HHs producing	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Purchased	99	98	100	100	100	99	100	98	100	100	100	99	99	99	96
Own-produced	0	2	0	0	0	0	0	0	0	0	0	0	1	1	1
Gift	1	0	0	0	0	1	0	2	0	0	0	1	0	1	3

Note(s): Total FV consumption calculated in FCFA
Source(s): Authors, based on the PAPA dataset (2017/2018)

Prices at the commune level are of a subset of i that include carrots, cabbage, okra, fresh tomatoes, eggplants, potatoes and onion. The price variables are measured (derived from transactions data of all but the household in question) at the commune level rather than the household level so they are not endogenous to the consumption behavior of an individual household. These 7 products are shown in Tables 8 and 9 to comprise 44% of urban FV consumption (in value terms) and 52% in rural areas. The prices of the other items were not included because of many missing values (in particular for mangoes, citrus, watermelons and leaves) for purchased consumption in kg to serve as the denominator to derive prices from observations of purchases in value terms aggregated at the rural village/urban commune levels.

We used the variance inflation factor (VIF) to test for multicollinearity. The VIFs do not exceed 10 and the mean VIF is less than two. The correlations between coefficients are also relatively low. Together, these results indicate that multicollinearity is not an issue.

Appendix Table A.1 show the definitions, averages and standard deviations of the dependent and explanatory variables in our urban and rural regression models.

Results for the ordinary least squares (OLS) estimation of the levels of consumption of FV per capita in value terms (FCFA) in urban and rural areas are presented in Table 10. Tables A.2 and A.3 in appendix show the marginal effects of a fractional logistic response model, often used for outcomes such as shares (Wooldridge, 2010; Turner *et al.*, 2021).

5. Regression results

Table 10 shows the determinants of FV consumption per capita in rural and urban areas in value terms. First, total expenditure has a strong and positive effect on FV consumption, as expected from Bennett's Law. "Bennett's Law" (Bennett, 1941) states that the share of the food budget dedicated to non-staples, including FV, rises disproportionately with income. Interestingly, the effect is similar in urban and rural areas.

Second, the older the household head the greater, and the larger the household the smaller the FV consumption. The latter may be because in traditional Senegalese dishes the sauce ratio to grains might decrease to feed a larger group. In urban but not in rural areas the number of children has a strong positive effect on FV consumption, perhaps from more knowledge in urban areas of FV nutrition effects. In rural areas, more women in the household increases FV intake, perhaps from more female labor to prepare vegetables and sauces. Education does not have much effect on FV consumption in urban areas except for that of university education, perhaps linked to a more Westernized lifestyle and more knowledge about health effects of FV. By contrast, education at all levels has a strong effect in rural areas.

Third, compared with Dakar, secondary cities and small towns do not have a significant effect on consumption of FV. By contrast, rural space differences matter, with the intermediate zone causing a "bump" in FV consumption, relative to peri-urban and hinterland areas.

Fourth, in rural areas, as expected own production of FV spurs FV consumption. Controlling for income (total expenditure), having a larger farm spurs FV intake, but the effect is small.

Finally, all prices are significant, except for onion and eggplant in urban and okra in rural areas. The product signs differ but tend to indicate that price increases dampen FV intake as expected.

Tables A.1 and A.2 (appendix) report the marginal effects from the FLR estimations of the FV share equations. First, the share of FV in food consumption rises with total expenditure as expected from Bennett's Law. Interestingly the rural and urban effects are similar.

Variables	Urban Natural log of consumption of FV per month per capita (in FCFA)	Rural Natural log of consumption of FV per month per capita (in FCFA)
Household variables		
TOTEXP per capita	0.928*** (0.0280)	0.955*** (0.0164)
Male	0.0203 (0.0465)	−0.0688 (0.0441)
Age	0.00229*** (0.000803)	0.00214*** (0.000781)
Size	−0.00866 (0.00732)	0.00600 (0.00475)
Married	−0.144*** (0.0431)	−0.00270 (0.0435)
Elementary	−0.00281 (0.0350)	0.0810*** (0.0291)
High school	−0.00183 (0.0321)	0.0427 (0.0267)
University	0.0692 (0.0433)	0.122*** (0.0306)
Other schooling	0.0119 (0.128)	0.0599 (0.156)
Women	7.74e-05 (0.00939)	0.0176*** (0.00642)
Children	−0.0309*** (0.00905)	−0.0547*** (0.00564)
Refrigerator	−0.0831*** (0.0247)	
TV	0.0377*** (0.0125)	
Cellphone	−0.00612 (0.00542)	
Organization		0.0146 (0.0339)
Production		0.202*** (0.0227)
Cultivated area		0.00203** (0.000828)
Semi-concrete		0.0177 (0.0487)
Non-concrete		−0.00743 (0.0277)
Spatial variables		
Intermediate		0.0498** (0.0231)
Hinterland		0.0157 (0.0244)
City	0.0163 (0.0367)	
Town	−0.0317 (0.0301)	
Price variables		
Carrot	−0.256*** (0.0645)	−0.0696* (0.0391)

(*continued*)

Table 10.
Consumption of FV per capita: Urban and Rural OLS regression

Variables	Urban Natural log of consumption of FV per month per capita (in FCFA)	Rural Natural log of consumption of FV per month per capita (in FCFA)
Cabbage	0.145**	0.130***
	(0.0683)	(0.0329)
Okra	0.289***	0.0421
	(0.0793)	(0.0272)
Fresh tomato	0.151***	−0.127***
	(0.0402)	(0.0264)
Eggplant	−0.0402	−0.00180
	(0.0717)	(0.0356)
Onion	0.0311	0.160***
	(0.0731)	(0.0406)
Potato	−0.208***	0.116***
	(0.0706)	(0.0449)
Constant	−1.886**	−3.723***
	(0.759)	(0.401)
Observations	2,014	4,314
R-squared	0.611	0.585
Prob > F	0.000	0.000

Note(s): Robust standard errors in parentheses. *** $p < 0.01$. ** $p < 0.05$. * $p < 0.1$
Source(s): PAPA dataset (2017/2018)

Table 10.

The share of FV in food consumption dips with "towns". This may imply FV access constraints in the small towns perhaps due to supply chain limitations or that consumer education about the nutrition value of FV is less in small towns. But the share of FV is not affected by rural zone (distance from urban areas), appearing again to point to the penetration of FV supply chains in rural space. The rural FV share (unlike in urban areas) is strongly correlated with education, the number of women in the family (perhaps due to labor supply for FV preparation or to attitudes regarding nutrition) and own production of FV.

Second, the share of purchases in rural FV consumption is spurred by income and education (especially university), controlling for whether the household produces FV. The latter reduces purchases; that is not tautological as a household might produce tomatoes but buy fruit. Moreover, the effect of being far from cities (in the hinterland) strongly reduces the share of purchases. As we control for own farming, this may imply that FV supply chains may not penetrate well areas far from cities perhaps due to road constraints.

Third, the import share of FV in urban (but not rural) FV consumption rises with income and education, perhaps due to easier access to imported FV in urban areas or urban consumers being more aware of or sensitive to quality differences between domestic and imported products such as onions. By contrast, in rural areas higher income reduces the import share and education has no significant effect.

Fourth, the share of the most common leading "staple" vegetables (onions and processed tomatoes) falls with income and education in urban areas but rises with income in rural areas. This suggests richer urban consumers are already differentiating beyond basic commodities to a more varied and higher quality FV set, while rural consumers and the poor in general use income gains to "catch up" and add more of the basics, in this case, staple vegetables. Being in a town instead of a larger city increases the desire for these vegetable staples. But interestingly, being in the hinterland rural area somewhat decreases the share of these staples, perhaps because of a supply chain constraint and because of a stronger propensity to consume indigenous vegetables.

Fifth, the share of African indigenous vegetables shows surprising results. The urban income effect is strongly positive, as is education, yet the city type does not matter. In rural areas, more income is associated with a higher share of traditional items, but the effect is much weaker than in urban areas. Being in a hinterland area increases sharply the share, as expected. More education reduces sharply the share, as do the numbers of women and children. The rural patterns are more as one would expect of a traditional product being increasingly sidelined by the non-traditional staples. The effect of own-production of FV is interestingly negative on these traditional vegetables, suggesting that the own-farming is mainly in marketable non-traditional products such as onions and cabbage.

Sixth, the share of potatoes rises with income and education in both urban and rural areas, corroborating the image of potatoes as a luxury and a "new non-traditional" FV consumed outside the traditional "grains plus condiments" dishes. Being in a secondary city (instead of a small town) has a positive impact; this might be because the secondary cities are near the horticulture belt (Niayes) where potatoes are produced. A higher potato share is correlated with peri-urban compared with intermediate or hinterland zones. The image that emerges is somewhat short supply chains for potatoes aimed at areas near production and urbanized food cultures as one would expect from a food innovation.

Seventh, the share of fruit has by far the strongest income coefficient of any FV product in urban areas – confirming its status as a luxury – but not in rural areas, where the effect is positive but weaker than for other items. This is probably because of the strong consumption of home-produced "backyard" mangoes in rural areas and small towns. Thus, as the breakdown of fruit items and sources in urban versus rural showed in the descriptives, the urban and rural areas are on two different fruit consumption paths for now, with the rural area the traditional and the urban area the diversified, modern, more commercialized fruit consumption path.

6. Conclusions

Our analysis of data from primary surveys of 6,328 rural and urban households in Senegal yielded several key findings.

First, FV are important in Senegalese diets: 21% of total food budgets are allocated to FV at a national level (comparable to Asian patterns), with 26% in urban areas and 17% in rural areas.

Second, we found that nearly all urban and 76% of rural FV consumption is from purchases. Only 24% of rural FV consumption is own-produced. This is at odds with the common image that rural folk mainly grow their own fresh produce. Our regressions finding that income affects FV consumption in rural and urban areas is expected in urban areas and explained in rural areas by the importance of purchases. The importance of purchases also underscores the enormous importance of FV supply chains to national nutrition. Rural people depend on FV markets and supply chains stretching from commercial horticultural zones across the country to their homes. The share of purchases in FV consumption surprisingly barely differed over rural zones, whether near or far from urban areas. This implies that FV supply chains reach far into rural areas, which we think is at odds with conventional wisdom. This suggests that rural logistics and wholesale markets and eventually cold storage facilities are important policy and public investment needs in the next decade.

Third, urban consumers eat 2.1 times more FV in value terms than do rural consumers. Consumption in value terms of FV was 15% greater in Dakar than in secondary cities, which in turn exceeded tertiary cities/towns by 22%. These results imply the need to consider location while designing policies to improve access and consumption of fruits and vegetables.

Fourth, despite the alarm about FV imports in Senegal, we found only 12% of FV consumption is imported, with 16% of FV consumption in urban and 8% in rural areas. In urban areas the share is correlated with income and education, showing imports to be luxuries. We think that the "import alarm" is disproportionate to the actual low importance of imports is that these numbers have not

yet entered the public debate, and that the debate focuses on the few items that are more heavily imported, such as potatoes and onions. Even for the latter the debate has neglected the facts that imports have been dropping and already two-thirds of their consumption is from domestic sources. It is possible (but we could not analyze with our data because ours is cross-sectional) that Senegalese market regulation policies have encouraged consumption of local onions and potatoes; testing that hypothesis requires future research. In any case, policies and investments that reinforce FV wholesale markets and road quality will help both potato and onion producers and supply chain participants, and the other FV that are little imported.

Fifth, we contributed to the literature concerning the "Westernization" of food consumption habits in developing regions by finding that (genetically) traditional or indigenous African FV (okra, leaves, African eggplant) summed to only 24% of FV consumption in rural areas (surprisingly differing little over peri-urban to hinterland zones) and 11% in urban areas. Also, only leaves were mainly home-produced in rural areas and the others were mainly purchased, hence moving via supply chains. The great bulk of vegetable consumption was non-traditional/non-indigenous, with importance of processed tomatoes, potatoes and onions, with the former two not important 30 years ago and a range of other non-indigenous products like carrots and cabbages important. This demonstrates that FV diets are transforming along with the rest of the diet with the urban areas taking the lead.

We conclude by noting that our study was only cross-sectional and thus is limited in its power to infer causality. An important future research agenda is to extend this survey to be a panel survey both for analysis of causality and to track over time the very dynamic and important process of the rise of the consumption of FV in Senegal.

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Appendix

The Supplementary Material for this article can be found online.

Corresponding author

Thomas Reardon can be contacted at: reardon@msu.edu