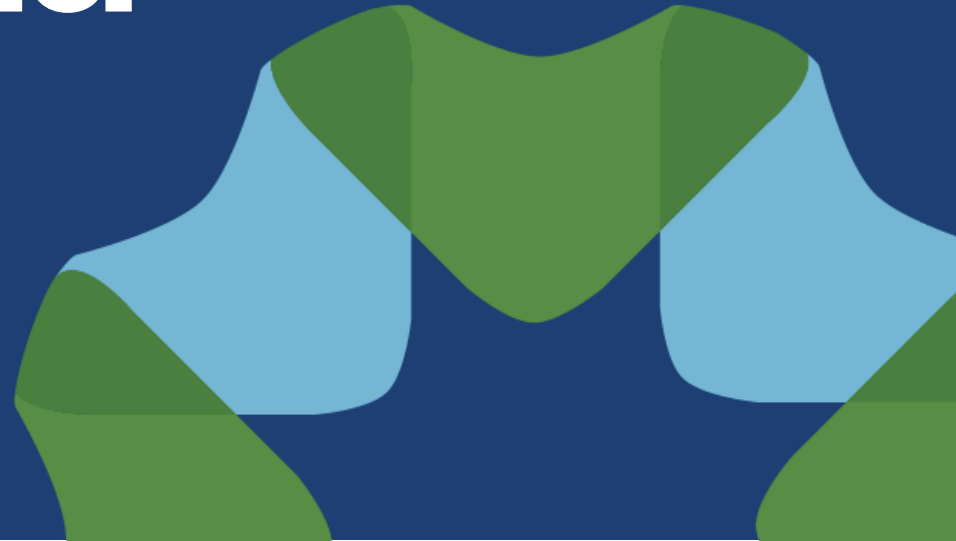




# Kenya Consumer Segmentation

Prepared by Fraym  
July 2021





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# Scope of Work



# Scope of Work

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**The Clean Cooking Alliance commissioned Fraym to produce consumer segmentations for Kenya, Nigeria, Ghana, Ethiopia, Rwanda, and Uganda.**

Assessments include an overview of demographic and socioeconomic characteristics and use of energy at the national and urban/rural level, national maps of four consumer segments, and market sizing and hyperlocal mapping at the subnational level for each consumer profile.

Fraym worked with the Clean Cooking Alliance to identify four target consumer groups: urban early-adopters, peri-urban and rural early-adopters, fast-followers, and secondary-followers.

Fraym then identified where there are pockets of high demand within the country by generating hyperlocal maps of the four target consumer segments. Initially, these maps can provide a snapshot understanding of where different customers and overall demand are concentrated.

# How it works

Fraym uses advanced machine learning models to produce unprecedented, local information on human and population characteristics in critical geographies around the world – down to 1 km<sup>2</sup> even in remote areas.



## ACQUIRE DATA

Geo-tagged household surveys

Satellite imagery

Partner datasets



## HARMONIZE DATA

Validate

Clean

Geospatially enable



## MACHINE LEARNING

Proprietary algorithms

Human-centric QA/QC

Automation



## GEOSPATIAL INSIGHT

Predictive modeling

API enabled

Analytic services

Front-end tools

02

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# National Context



# Household Characteristics

**There are roughly 14 million households in Kenya, with only 21 percent living in cities and the remaining 79 percent in peri-urban and rural areas.<sup>1</sup>**

There are some education attainment disparities between urban and rural households. Half of urban household heads have completed secondary school, while only two-fifths of their rural counterparts have accomplished the same.

Almost three-quarters of rural households have active mobile money accounts, suggesting overall financial inclusion among rural households is relatively similar to urban households.

**Note 1:** Urban areas were defined using the EU Global Human Settlement Layer (GHSL). Urban centers, dense urban clusters, and semi-dense urban clusters are classified as urban. Suburban or peri-urban and all rural areas are classified as peri-urban and rural.

**Note 2:** The source of all population data in this report is WorldPop.

**Note 3:** High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor.

**Source:** Fraym, Kenya 2014 DHS, Kenya 2017 FII

## Kenya Snapshot

### Demographics

	National	Urban	Rural
Population <sup>2</sup>	55M	8M	47M
Number of households	14M	3M	11M
Female headed household	33%	27%	36%
Household head completed at least primary education	61%	82%	51%
Household head completed at least secondary education	29%	50%	19%
Household head completed higher education	3%	7%	2%
All high-quality housing material <sup>3</sup>	43%	81%	26%
Bank account	44%	66%	34%
Mobile money account	72%	80%	68%
Smart Phone	37%	51%	27%

# Cooking Fuels

**Around 10 percent of households nationwide use clean cooking fuel.**

Clean cooking fuel use is limited in rural areas. Only 2 percent of rural households using clean fuels.

Most households in Kenya use solid cooking fuels, primarily wood and charcoal. In rural areas, over 80 percent of households use wood as their primary source of cooking fuel.

Monthly household spending for wood for various energy needs is over 700 shillings. While household spending on charcoal is about 560 shillings and kerosene is about 230.<sup>3</sup>

**Note 1:** Clean cooking fuel is defined as LPG, natural gas, electricity, and biogas.

**Note 2:** Other solid cooking fuels include straw, agricultural crops, and dung.

**Note 3:** Spending data is in 2016 Shilling and includes spending on the fuel for cooking, heating, and lighting.

**Source:** Fraym, Kenya 2014 DHS, Kenya 2016 KIHBS

## Kenya Snapshot

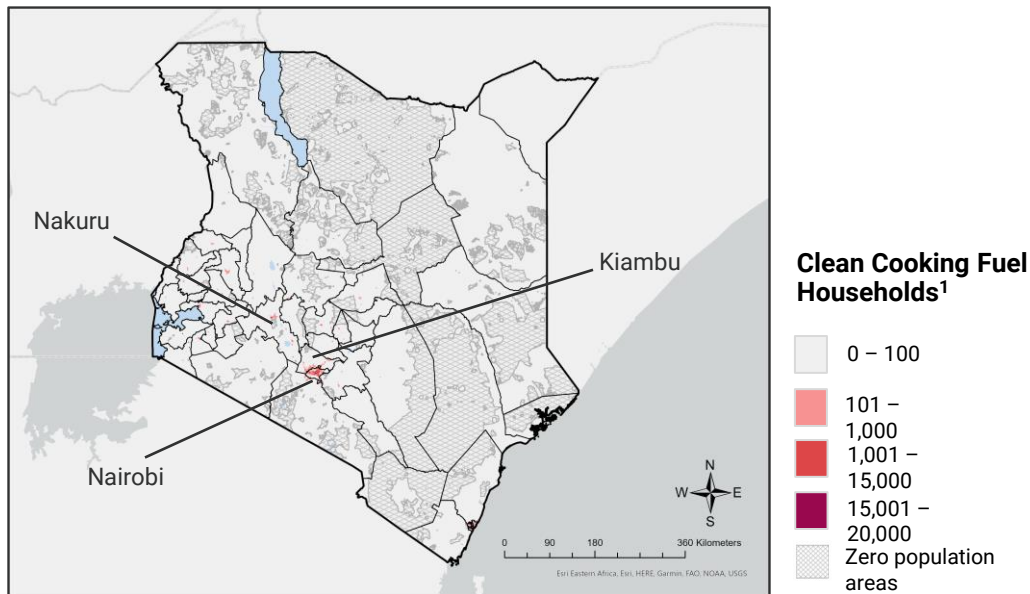
### Household energy use

	National	Urban	Rural
Primarily use clean cooking fuel <sup>1</sup>	10%	27%	2%
Primarily use LPG to cook	9%	25%	2%
Primarily use natural gas or biogas to cook	1%	1%	0%
Primarily use electricity to cook	<1%	1%	<1%
Primarily use wood to cook	63%	16%	84%
Primarily use charcoal to cook	15%	26%	9%
Primarily use kerosene to cook	<1%	28%	1%
Primarily use other solid fuels to cook <sup>2</sup>	3%	2%	3%
Average monthly spending on charcoal (Shilling) <sup>3</sup>	560	580	540
Average monthly spending on kerosene (Shilling) <sup>3</sup>	230	310	180
Average monthly spending on wood (Shilling) <sup>3</sup>	760	720	770
Average total monthly spending (Shilling) <sup>3</sup>	16,000	22,000	11,000
Access to electricity	31%	70%	13%



# Clean Cooking Fuel

More than half of households using clean cooking fuel are concentrated in major urbanized areas in central Kenya, including Nairobi, Kiambu, and Nakuru.



**Note 1:** This map shows the estimated number of households that use clean cooking fuel per 1km<sup>2</sup>. Clean cooking fuel includes electricity, LPG, natural gas, and biogas.

**Source:** Fraym , Kenya 2014 DHS

**1M** Households use clean cooking fuel

**32%** of households are headed by a woman

**2.4** Average household size

**85%** of household heads have completed secondary education

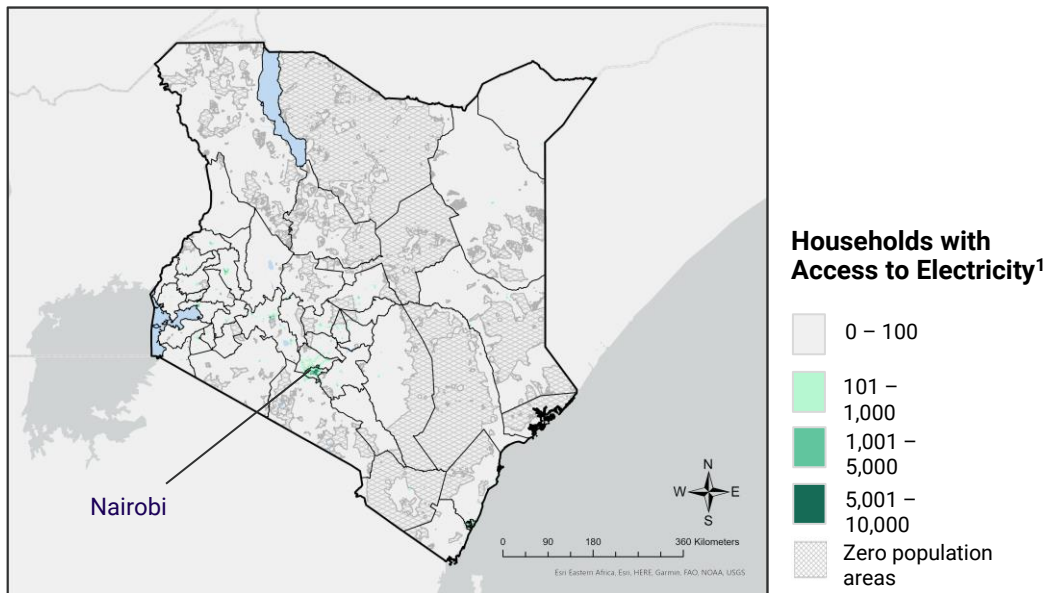
**93%** use lpg as their primary cooking fuel

**4%** use electricity as their primary cooking fuel

**3%** use biogas as their primary cooking fuel

# Electricity Access

Around 30 percent of all households have access to electricity, and they are mainly concentrated in Nairobi. More than a quarter of electrified households use LPG.



**Note 1:** This map shows the estimated number of households that have electricity access per 1km<sup>2</sup>. Estimates Northern and Upper West regions failed to pass Fraym standard quality checks and should thus be interpreted with caution.

**Source:** Fraym, Kenya 2014 DHS

**5M** Households with access to electricity

**26%** of households are headed by a woman

**3.2** Average household size

**60%** of household heads have completed secondary education

**28%** use lpg as their primary cooking fuel

**25%** use charcoal as their primary cooking fuel

**24%** use kerosene as their primary cooking fuel

# Identifying key characteristics

**Most households that use clean cooking fuel own a high-cost asset, living in high quality housing, and have access to electricity and a bank account.**

Households that use clean cooking fuel are concentrated in cities and have more educated household heads.

Only a small proportion of solid cooking fuel households own high-cost assets, live in households constructed with all high-quality materials, and have access to bank accounts and electricity. These indicators are suggestive of relatively high consumption power.

**Note 1:** Clean cooking fuel households are households that use liquified petroleum gas (LPG), electricity, natural gas, or biogas as the primary cook fuel.

**Note 2:** Bank account ownership is defined as any household member having a formal bank account. Mobile money accounts are not included. Data is from the Kenya 2014 DHS.

**Note 3:** High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor.

**Note 4:** A high-cost asset is defined as a television, refrigerator, or car.

**Source:** Fraym, Kenya 2014 DHS

## Kenya Snapshot

### Characteristics by cooking fuel type

	Clean Cooking Fuel Households <sup>1</sup>	Solid Cooking Fuel Households
Number of households	1M	13M
Urban	85%	25%
Female headed household	28%	34%
Access to electricity	96%	23%
Primary cooking fuel	Electricity (91%) LPG (5%) Natural gas or biogas (4%)	Wood (80%) Charcoal (10%) Dung (7%)
Bank account <sup>2</sup>	93%	39%
All high-quality housing material <sup>3</sup>	97%	37%
Own at least 1 high cost asset <sup>4</sup>	89%	26%
Own a radio	84%	64%
Household head completed at least secondary education	82%	23%

# Communications

**Media consumption trends, particularly in television and print media, vary across urban-rural lines.**

Urban households own and watch television at higher rates. Urban households are also twice as likely to regularly read print media. However, radio listenership are high in both urban and rural areas.

Mobile phone ownership is high nationwide, in both rural and urban areas, with ownership rates reach 77 and 89 percent, respectively.

**Note 1:** Regular use of a media form is defined as the adult household head (age 15-49) using the media at least once a week.

**Source:** Fraym, Kenya 2014 DHS

## Kenya Snapshot

### Household communications access<sup>1</sup>

	National	Urban	Rural
Television ownership	31%	57%	19%
Radio ownership	65%	73%	62%
Mobile phone ownership	84%	94%	79%
Regular print media readership	36%	56%	28%
Regular television viewership	51%	77%	40%
Regular radio listenership	81%	89%	77%

03

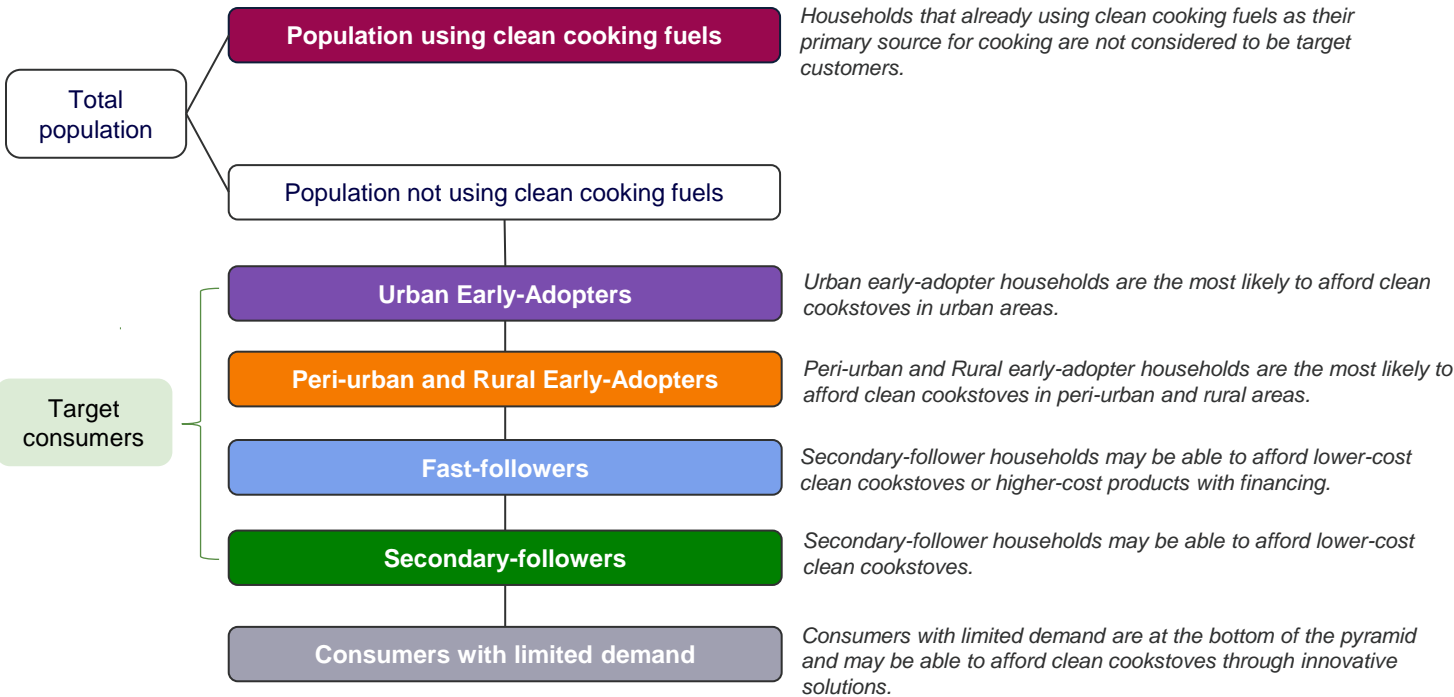
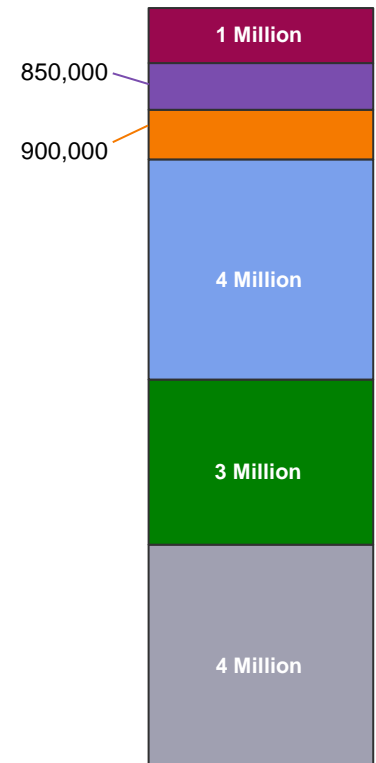
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# Mapping Consumer Segments



# The total population is segmented into six groups, with four target consumer segments.

Total number of households in Kenya



**Note 1:** The same segment criteria was applied across the six countries examined by Fraym, which resulted in significant variations in segment sizes across countries.  
Source: Fraym

# Overview of Target Consumers

**Urban Early-Adopter Households** are those with the highest ability to afford clean cooking technologies. Only households that live in urban areas were included in this group. They own high-cost assets, live in homes made of high-quality materials, and have access to electricity. These households are expected to be the consumer segment most able to afford clean cooking technologies.<sup>1</sup> There are an estimated 850,000 urban early-adopter households in Kenya.

**Peri-urban and Rural Early-Adopter Households** are wealthy households with a high ability to afford clean cooking technologies. These households own high-cost assets, live in households made of high-quality materials, and have access to electricity. Only households that live in peri-urban or rural areas are included in this consumer group.<sup>1</sup> There are roughly 900,000 peri-urban and rural early-adopter households in Kenya.

**Fast-Follower Households** are any remaining households that own high-cost assets that did not fit the early-adopters profiles. Also included in this group are households with homes partially constructed from high-quality materials and with formal bank accounts, making these households better positioned to maintain savings and/or take out loans for the purchase of household assets. There almost 4 million households in Kenya are fast-followers.

**Secondary-Follower Households** are any remaining households that own high-cost assets that did not fit the early-adopters profiles and fast-followers profile. They have homes partially constructed from high-quality materials and own radios, suggesting modest consumption power and some ability to afford clean cooking technologies. Their lack of access to services, like electricity and bank accounts, suggests a lower-middle class in both urban and rural markets. These households are mostly found in rural areas but have some presence in urban markets as well. There are almost 3 million secondary-follower households in Kenya.

**Note 1:** High-cost assets are defined as televisions, refrigerators, and cars. High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor. Urban areas were defined using the EU Global Human Settlement Layer (GHSL). Urban centers, dense urban clusters, and semi-dense urban clusters are classified as urban. Suburban or peri-urban and all rural areas are classified as peri-urban and rural.

**Source:** Fraym, Kenya 2014 DHS

**850,000** Urban Early-Adopter households

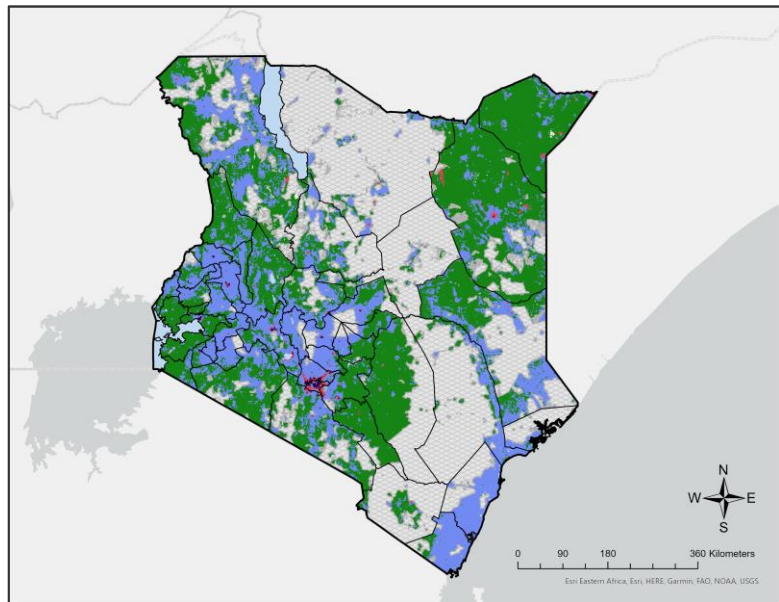
**900,000** Peri-urban and Rural Early-Adopter households

**4M** Fast-Follower households






**3M** Secondary-Follower households

# Consumer Segment Distribution

**Fast-followers are common in populated parts the country, while secondary followers are common in more rural areas. The different segment concentrations require different market strategies depending on location.**



## Most Common Consumer Segment<sup>1</sup>

-  Urban Early-Adopters
-  Peri-urban and Rural Early-Adopters
-  Fast-Followers
-  Secondary-Followers
-  Zero population areas

**Urban early-adopters** are mainly concentrated in Nairobi.

**Peri-urban and rural early-adopters** are most common in the outskirts of Nairobi and some parts of Kiambu.

**Fast-followers** are the most common in counties located in the central and southeast areas.

**Secondary-followers** are common in less dense areas, particularly in the northeast area.

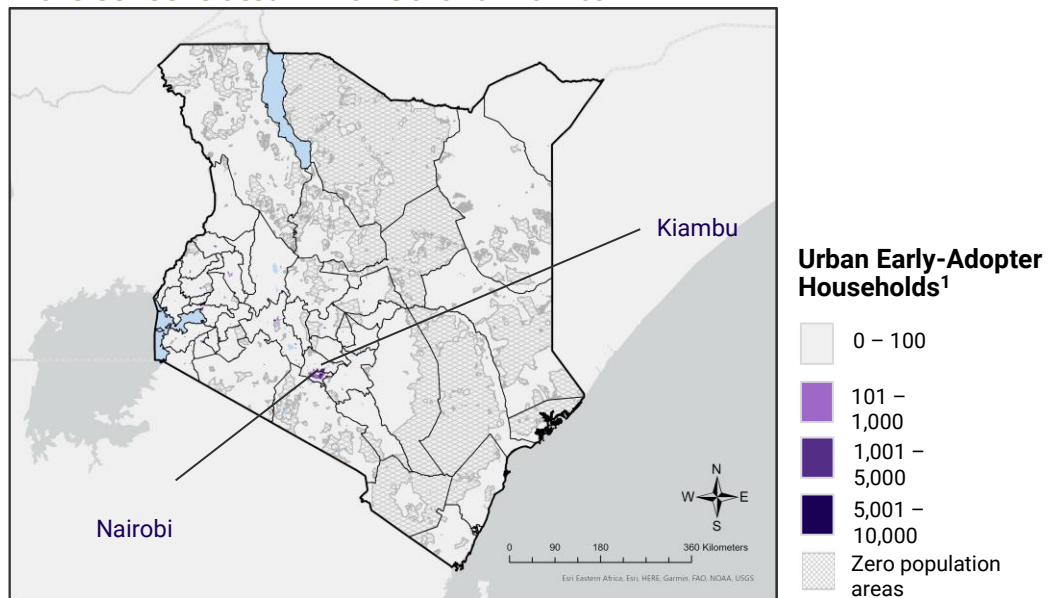
**Note 1:** This map shows the most common consumer segment among all households per 1km<sup>2</sup> area. Each 1km<sup>2</sup> area varies in population density.

**Source:** Fraym, Kenya 2014 DHS



# Urban Early-Adopters

There are roughly 850,000 urban early-adopter households, representing only 6 percent of all households. These households are concentrated in Nairobi and Kiambu



**Note 1:** This map shows the estimated number of urban early-adopter households per 1km<sup>2</sup>. Urban early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in urban centers, dense urban clusters, and semi-dense urban clusters according to the EU Global Human Settlement Layer.

**Source:** Fraym, Kenya 2014 DHS

**850,000** Urban Early-Adopter households

**22%** of households are headed by a woman

**3.6** Average household size

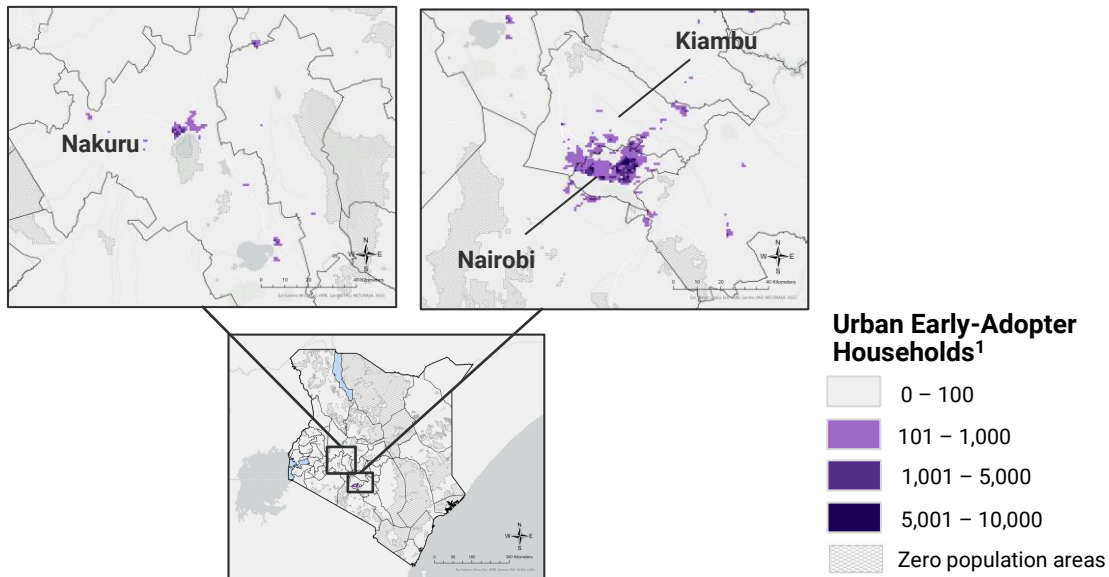
**53%** of household heads have completed secondary education

**48%** use kerosene as their primary cooking fuel

**43%** use charcoal as their primary cooking fuel

# Urban Early-Adopters

Urban early-adopter households are heavily concentrated in Nairobi. 60 percent of all urban early-adopter households reside in Nairobi. Other counties with high numbers of urban early-adopters are Nakuru and Kiambu



**Note 1:** This map shows the estimated number of urban early-adopter households per 1km<sup>2</sup>. Urban early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in urban centers, dense urban clusters, and semi-dense urban clusters according to the EU Global Human Settlement Layer.

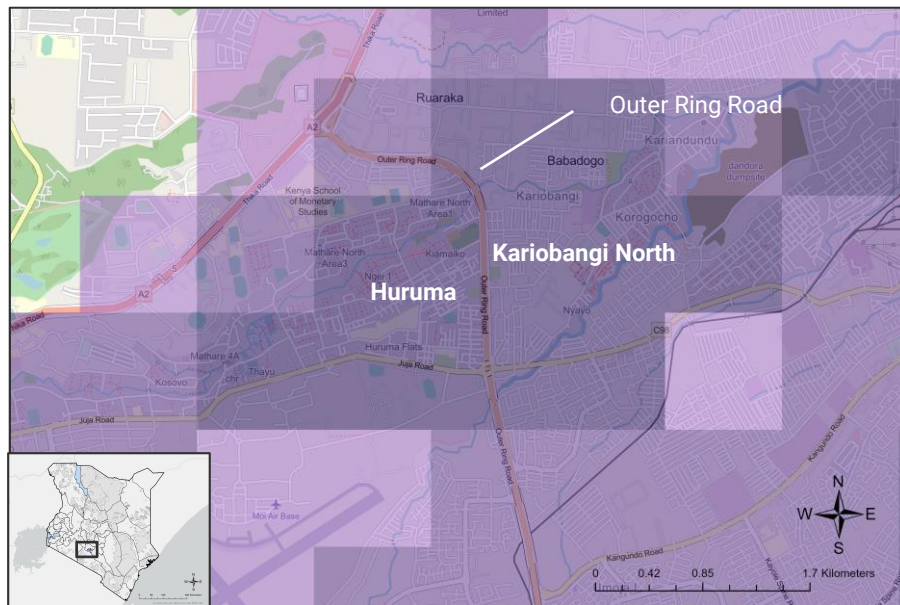
Source: Fraym, Kenya 2014 DHS

## Top Local Government Areas with Urban Early-Adopters

County	Sub-County	Number of Urban Early-Adopter Households
Nairobi	Embakasi North	51,000
Nairobi	Kamukunji	40,000
Nairobi	Ruaraka	39,000
Nairobi	Dagoretti North	38,000
Nairobi	Embakasi Central	36,000
Nairobi	Makadara	33,000
Nairobi	Embakasi West	32,100
Nairobi	Embakasi South	30,000
Nairobi	Dagoretti South	29,000
Mathare	Mathare	27,000

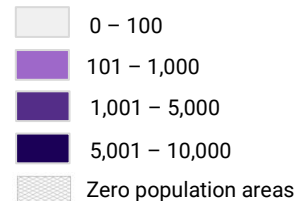
# Urban Early-Adopter Households

Neighborhoods in the Embakasi North Constituency have a large number of urban early-adopter households.



Neighborhoods around the Outer Ring Road, such as Huruma and Kariobangi North see a high density of urban early-adopter households.

## Urban Early-Adopter Households<sup>1</sup>

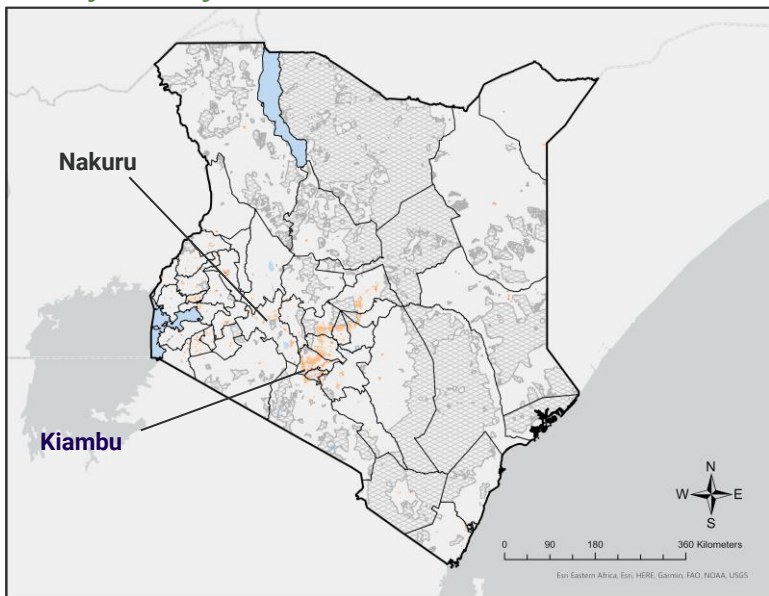


**Note 1:** This map shows the estimated number of urban early-adopter households per 1km<sup>2</sup>. Urban early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live urban centers, dense urban clusters, and semi-dense urban clusters according to the EU Global Human Settlement Layer.

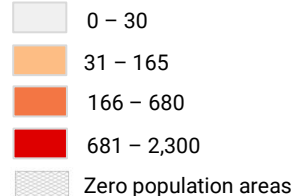
**Source:** Fraym, Kenya 2014 DHS

# Peri-urban and Rural Early-Adopters

There are about 900,000 peri-urban and rural early-adopter households, accounting for over 6 percent of all households in Kenya. Many of these consumers are in Kiambu and Nakuru.



## Peri-urban and Rural Early-Adopter Households<sup>1</sup>



**Note 1:** This map shows the estimated number of peri-urban and rural early-adopter households per 1km<sup>2</sup>. Peri-urban and rural early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in suburban or peri-urban rural areas according to the EU Global Human Settlement Layer.

**Source:** Fraym, Kenya 2014 DHS

**900,000** Per-urban and Rural Early-Adopter households

**28%** of households are headed by a woman

**3.9** Average household size

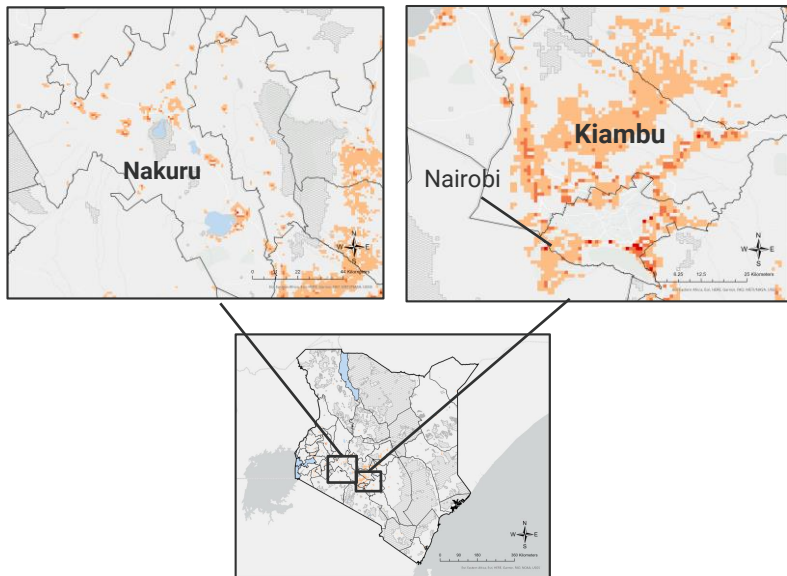
**54%** of household heads have completed secondary education

**59%** use wood as their primary cooking fuel

**35%** use charcoal as their primary cooking fuel

# Peri-urban and Rural Early-Adopters

Almost two-fifths of peri-urban and rural early-adopter households are in Nakuru and Kiambu. In Kiambu 15 percent of all households are peri-urban and rural early adopters.



## Top Local Government Areas with Peri-urban and Rural Early-Adopters

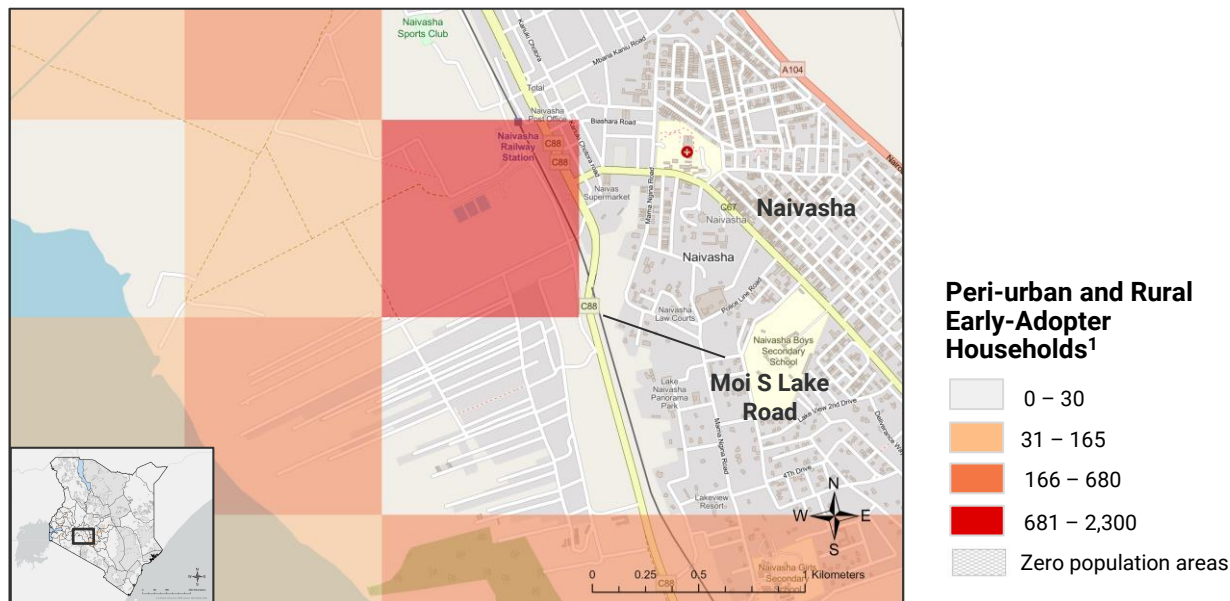
County	Sub-County	Number of Peri-urban and Rural Early-Adopter Households
Nakuru	Naivasha	15,404
Kiambu	Limuru	13,139
Kiambu	Githunguri	12,369
Nairobi	Langata	12,184
Kiambu	Juja	11,281
Meru	Imenti South	11,033
Muranga	Kiharu	10,968
Kericho	Ainamoi	10,325
Muranga	Gatanga	10,055
Kiambu	Lari	9,990

**Note 1:** This map shows the estimated number of peri-urban and rural early-adopter households per 1km<sup>2</sup>. Peri-urban and rural early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in suburban or peri-urban rural areas according to the EU Global Human Settlement Layer.

Source: Fraym, Kenya 2014 DHS

# Peri-urban and Rural Early-Adopters

Naivasha, a town in Nakuru, has the highest concentration of peri-urban and rural early-adopters.



A high number of peri-urban and rural early adopters reside in a concentrated pocket in the outskirts of Naivasha, east of the Moi S Lake Road.

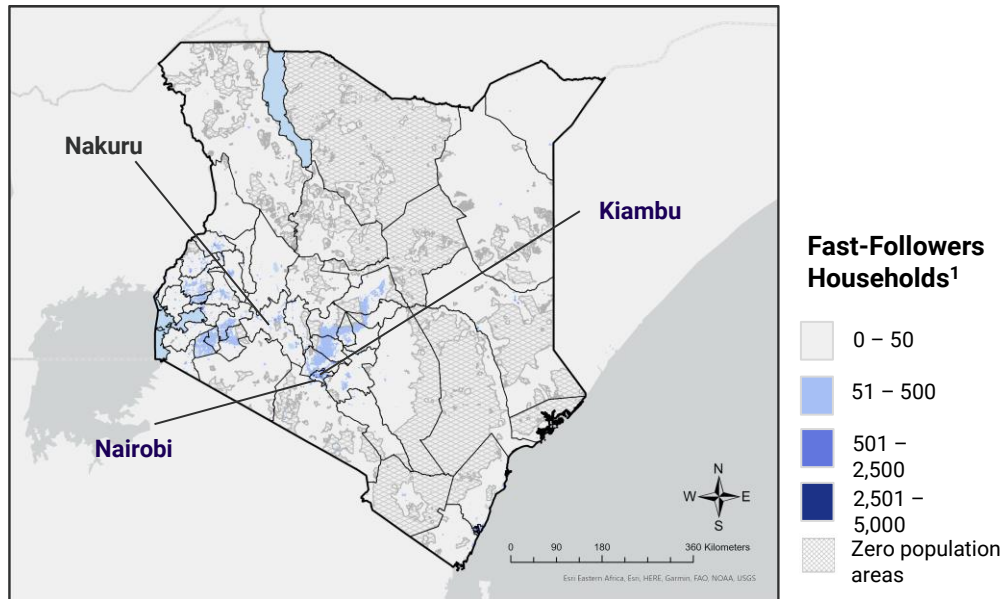
**Note 1:** This map shows the estimated number of peri-urban and rural early-adopter households per 1km<sup>2</sup>. Peri-urban and rural early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in suburban or peri-urban rural areas according to the EU Global Human Settlement Layer.

**Source:** Fraym, Kenya 2014 DHS



# Fast-Followers

There are roughly 4 million fast-follower households, representing around 29 percent of all households in Kenya. Nairobi, Kiambu, and Nakuru have the largest number of fast-follower households.



**Note 1:** This map shows the estimated number of fast-follower households per 1km<sup>2</sup>. Fast-follower households own at least one high-cost asset or have access to a bank account and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

**4M** Fast-Follower households

**27%** of households are headed by a woman

**4.2** Average household size

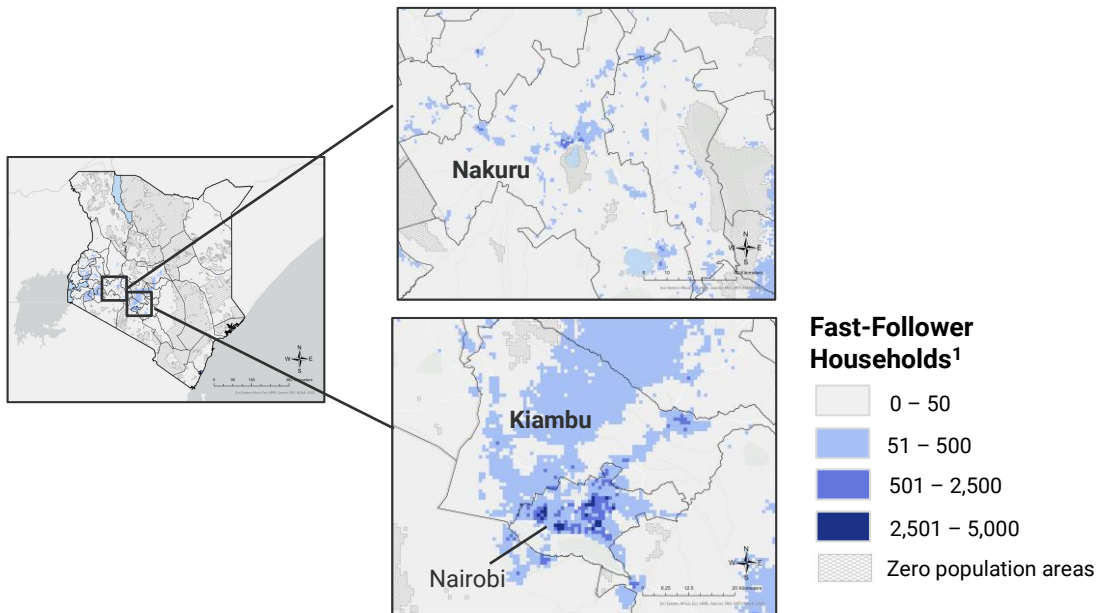
**34%** of household heads have completed secondary education

**70%** use wood as their primary cooking fuel

**17%** use charcoal as their primary cooking fuel

# Fast-Followers

Fast-followers are the most common consumer segment and reside mainly in Nairobi, Kiambu, and Nakuru. In Nakuru, 28 percent of all households are fast-followers.



**Note 1:** This map shows the estimated number of fast-follower households per 1km<sup>2</sup>. Fast-follower households own at least one high-cost asset or have access to a bank account and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

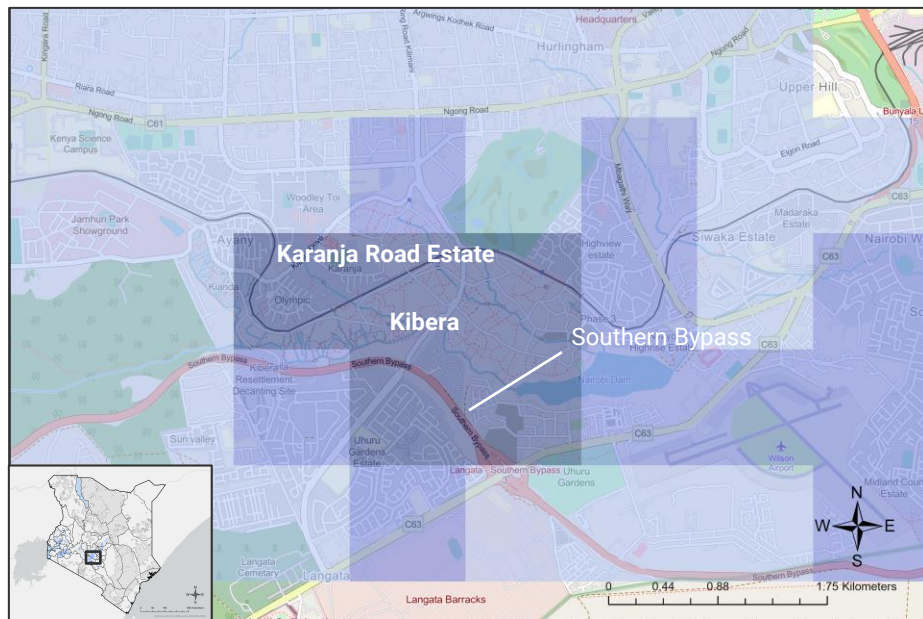
## Top Local Government Areas with Fast-followers

County	Sub-County	Number of Fast-Follower Households
Bomet	Konoin	33,812
Nairobi	Kibera	30,397
Muranga	Kiharu	30,393
Meru	Imenti South	29,557
Nairobi	Langata	29,444
Nairobi	Dagoretti North	26,891
Embu	Manyatta	26,446
Nakuru	Naivasha	26,276
Kericho	Bureti	26,230
Kericho	Ainamoi	25,863



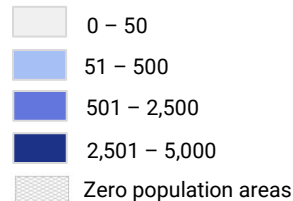
# Fast-Followers

There is a heavy concentration of fast-followers in the Kibera division in Nairobi.



Neighborhoods north of the Southern Bypass, in Kibera and Karanja Road Estate, see a high density of fast-followers.

## Fast-Followers Households<sup>2</sup>

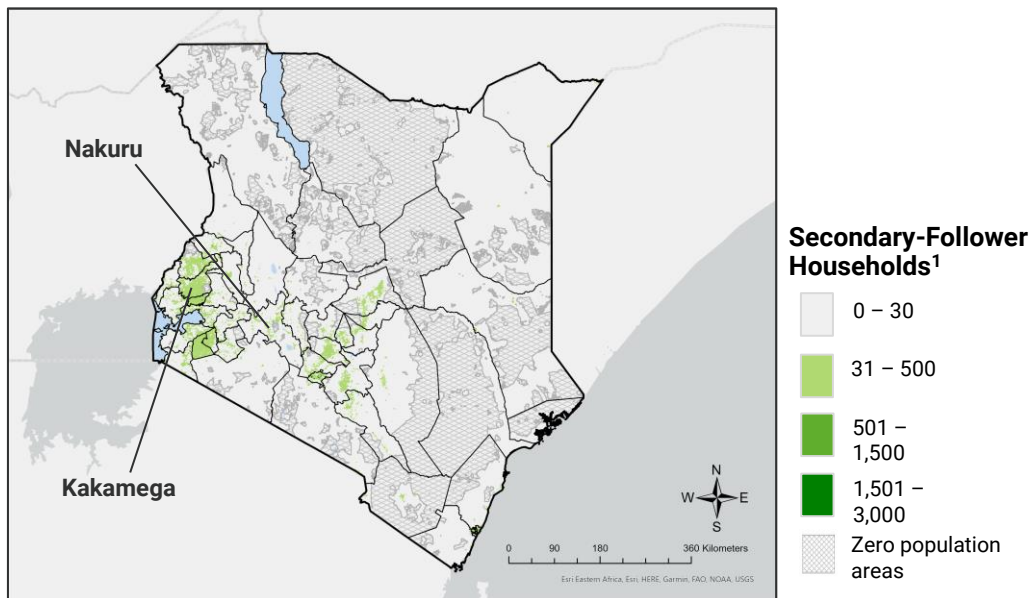


**Note 1:** This map shows the estimated number of fast-follower households per 1km<sup>2</sup>. Fast-follower households own at least one high-cost asset or have access to a bank account and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

# Secondary-Followers

There are about **3 million secondary-follower households**, which is about **21 percent of all households in Kenya**. A large number of secondary-follower households can be found in Nakuru and Kakamega.



**Note 1:** This map shows the estimated number of secondary-follower households per 1 km<sup>2</sup>. Secondary-follower households own at least one high-cost asset or own a radio and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

**3M** Secondary-Follower households

**35%** of households are headed by a woman

**4.2** Average household size

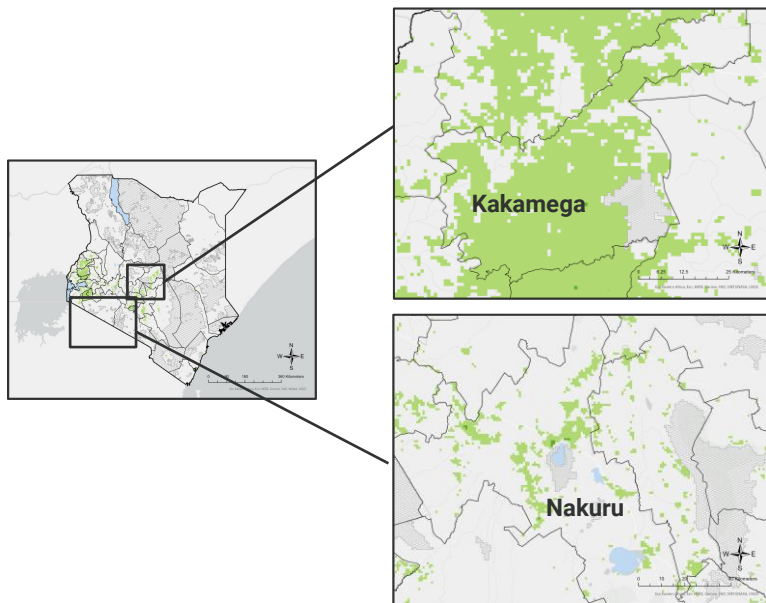
**12%** of household heads have completed secondary education

**79%** use wood as their primary cooking fuel

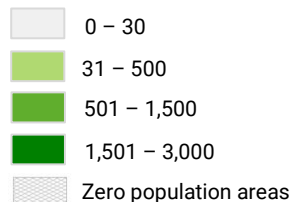
**12%** use charcoal as their primary cooking fuel

# Secondary-Followers

**Secondary-followers are more dispersed than other consumer segments. Nakuru and Kakamega have the highest number of secondary-follower households.**



**Secondary-Follower Households<sup>1</sup>**



## Top LGAs with Secondary-followers

County	Sub-County	Number of Secondary-Follower Households
Nakuru	Njoro	22,119
Makueni	Makueni	20,935
Machakos	Mwala	19,651
Makueni	Mbooni	19,435
Kakamega	Malava	19,344
Laikipia	Laikipia West	19,109
Narok	Narok North	18,029
Kakamega	Shinyalu	17,660
Siaya	Alego Usonga	17,374
Homa Bay	Karachuonyo	16,600

**Note 1:** This map shows the estimated number of secondary-follower households per 1km<sup>2</sup>. Secondary-follower households own at least one high-cost asset or own a radio and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

# Secondary-Followers

**Njoro, a small agricultural town in Nakuru, has a high number of secondary-follower households.**



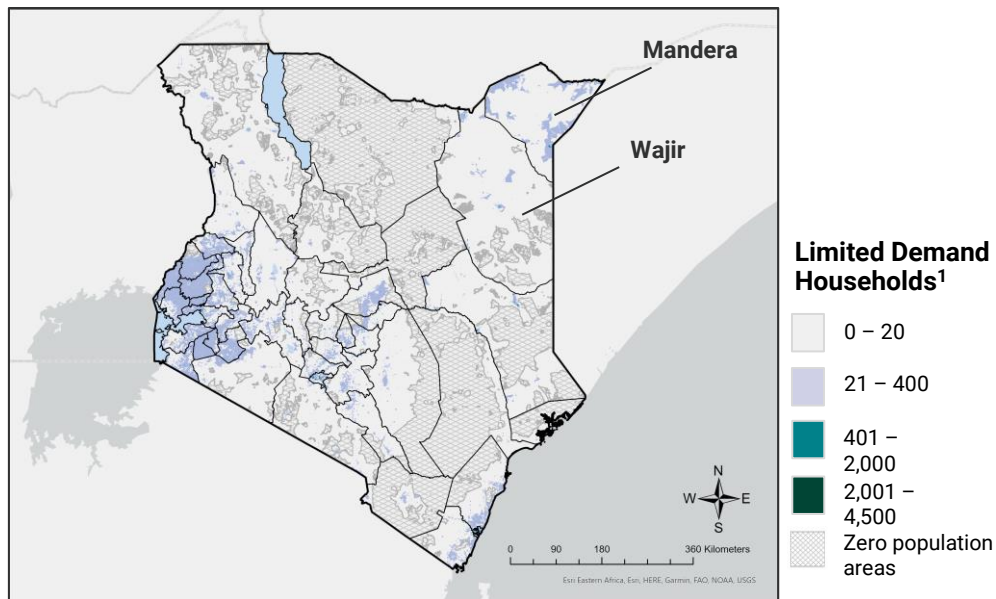
Secondary-follower households are located near Egerton University and around the C57 Road.

**Note 1:** This map shows the estimated number of secondary-follower households per 1 km<sup>2</sup>. Secondary-follower households own at least one high-cost asset or own a radio and have housing made of at least one high-quality material.

**Source:** Fraym, Kenya 2014 DHS

# Limited Demand

There are around 4 million limited demand households, representing more than 29 percent of all households in Kenya. A high number of these households can be found dispersed in the northeast.



**Note 1:** This map shows the estimated number of limited demand households per 1km<sup>2</sup>. Limited demand households do not fit any of the four core consumer profiles due to their limited consumption ability.

**Source:** Fraym, Kenya 2014 DHS

**4M** Limited Demand households

**45%** of households are headed by a woman

**4.4** Average household size

**7%** of household heads have completed secondary education

**87%** use wood as their primary cooking fuel

**8%** use charcoal as their primary cooking fuel

04

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# Data Sources and Methodology



# Asset-Based Consumer Segmentation

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**Improving upon previous studies of African consumers, Fraym fills two critical gaps by offering reliable market estimates and sub-national specificity. Consumer segments provide a useful framework for thinking about different markets for clean cooking technologies. The goal of this effort is to understand different levels of consumption power within each group of potential clean cooking fuel consumers.**

To understand the potential market for different types of clean cooking technologies, Fraym segmented households that primarily use solid cooking fuels into four groups. Instead of basing the profiles on consumers' income and spending, which can be susceptible to seasonal fluctuations, Fraym used a composite measure that classifies households based upon key characteristics such as asset ownership, household building material, and access to services. Each consumer segment only includes households not currently using clean cooking fuel, and each of these groups are mutually exclusive, with each household being classified into the highest tier for which it is eligible.

**Early-Adopter households** are those with high consumption power, as evidenced by their ownership of high-cost assets, access to electricity, and homes made from high-quality materials.<sup>1</sup> Early-Adopter households were segmented into two groups: *Urban Early-Adopter* and *Peri-urban and Rural Early-Adopter* households.

**Follower households** have moderate consumption power as evidenced by asset ownership, home construction material, and financial inclusion. Follower households were segmented into two groups: *Fast-Followers* are households with bank accounts suggesting some access to financial tools to facilitate larger purchases, and *Secondary-Followers* are households that own a radio, suggesting some discretionary spending power. Both groups can be found in both urban, peri-urban, and rural areas.

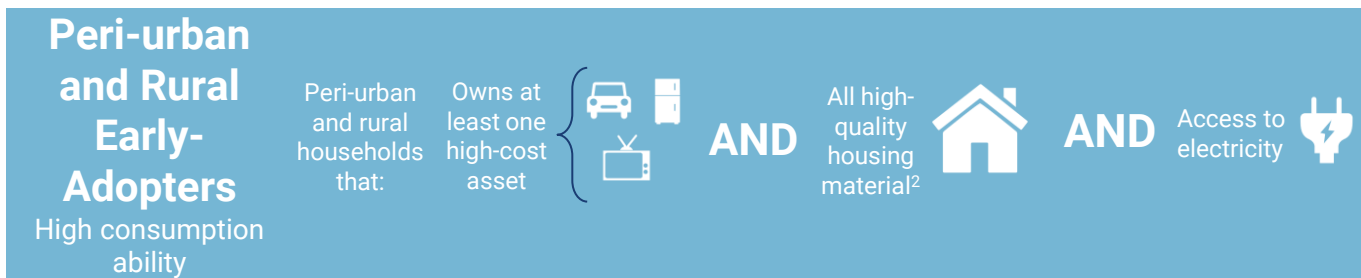
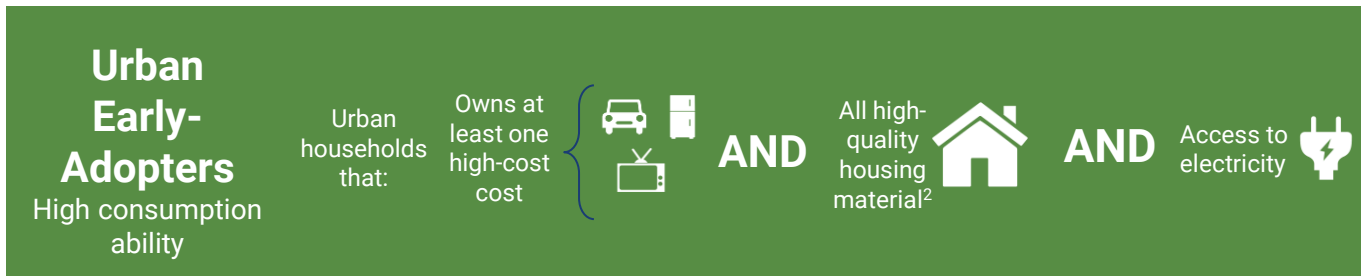
The remaining solid cooking fuel households were categorized into a limited demand profile, with very low consumption ability.

**Note 1:** High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor.

**Source:** Fraym

# Identifying Early-Adopters

Fraym segmented solid cooking fuel households into early-adopter groups based on high-cost asset ownership, housing quality, and electricity access, which are all indicative of wealth. These households were then further segmented based on urbanicity into Urban and Peri-urban and Rural Early-Adopter households.<sup>1</sup>



**Note 1:** Urban areas were defined using the EU Global Human Settlement Layer (GHSL). Urban centers, dense urban clusters, and semi-dense urban clusters are classified as urban. Suburban or peri-urban and all rural areas are classified as peri-urban and rural.

**Note 2:** High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor.

Source: Fraym



# Identifying Followers

**Fraym identified follower consumers from the remaining solid cooking fuel households as households with medium to moderate consumption ability, as suggested by some high-cost asset ownership and some high-quality housing materials. While predominantly rural, there are significant numbers of follow consumers in urban areas, especially among fast-follower households.**

## Fast-Followers

Medium-high  
consumption ability

Owens at least  
one high-cost  
asset

O  
R

Bank Account 

AND

Housing made of at least one high  
quality material<sup>1</sup>

## Secondary-Followers

Medium-low  
consumption ability

Owens at least  
one high-cost  
asset

O  
R

Owens a radio 

AND

Housing made of at least one high  
quality material<sup>1</sup>

**Note 1:** Urban areas were defined using the EU Global Human Settlement Layer (GHSL). Urban centers, dense urban clusters, and semi-dense urban clusters are classified as urban. Suburban or peri-urban and all rural areas are classified as peri-urban and rural.

**Note 2:** High quality housing materials are defined as durable materials like concrete, metal, brick, or finished wood. All housing refers to the roof, wall, and floor.

**Source:** Fraym

# Fraym Data

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**The Fraym database combines satellite imagery and existing household surveys that are harmonized and re-weighted based on population data from third-party sources like multilateral and bilateral development actors, ensuring that indicators are comparable across countries and over time.**

For this study, indicators at the individual and household levels were sourced from the 2014 Kenya Demographic and Health Survey (DHS), the 2018 Multi-Tier Framework Survey (MTF), and the 2016 Kenya Integrated Household Budget Survey (KIHBS). These surveys are designed to be nationally representative and use a stratified two-stage sample design. The KIHBS data were enumerated between January and May 2016, with a total sample size of 4,954 households. The DHS data were enumerated between January 2016 and July 2016, with a total sample size of 16,650 households. The MTF data were enumerated between December 2016 and April 2017, with a total sample size of 3,300 households. The 2017 Financial Inclusion Insights (FII) data were enumerated between June and July 2017, with a total sample size of 3,129 respondents.

Fraym data scientists closely examine representativeness, sampling frames, questionnaire coverage, periodicity, and a range of other factors. Fraym obtains microdata, e.g. individual rows of responses of survey data, in order to avoid any manipulation that could potentially occur during the analysis phase. After data collection, Fraym creates post-hoc sampling weights to account for any oversampling and ensure survey representativeness. The weights and resulting population proportions were triangulated with independent, third-party sources, such as the UN Population Division and the World Bank's World Development Indicators.

Additionally, granular population distribution data comes from WorldPop, a publicly available and detailed population distribution and composition data source that leverages existing census data to produce 100m x 100m resolution estimates of population density. In order to build its datasets, WorldPop relies on census data as the main primary data input, and large geotagged household surveys when they are not available. In order to project into the future from the latest census of a given country, WorldPop uses subnational and urban rural growth rates that are reconciled with UN estimates. For this report, population estimates from 2020 were used.

# Fraym's Interpolation Process

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**Fraym has built an artificial intelligence / machine learning (AI/ML) software that weaves together high-quality household survey data with satellite imagery to create localized population information (1 km<sup>2</sup>).**

The primary data input is data from existing high-quality, geo-tagged household surveys. Key indications of a high-quality household survey include implementing organization(s), sample design, sample size, and response rates. Fraym has collected, cleansed, and harmonized more than 1,000 of these surveys from around the world. Sample sizes are normally 10,000+ households with information for 50,000+ respondents. Response rates are very high, normally higher than 95 percent.

The second major data input is satellite imagery and related derived data products, including earth observation (EO) data, gridded population information i.e. human settlement mapping, and biophysical surfaces like soil characteristics. As with the survey data, Fraym data scientists ensure that the software only uses high-quality imagery inputs. Derived products are carefully assessed for model metrics, contextual checking, and pedigree within the geospatial data science community.

To create spatial layers from household survey data, Fraym leverages machine learning to predict an indicator of interest at a 1 square kilometer resolution. This methodology builds upon existing, tested methodologies for interpolation of spatial data. The resulting model is used to predict the survey data for all non-enumerated areas. A similar approach was pioneered by USAID's Demographic and Health Surveys program in 2015 and since improved upon by Fraym and others.<sup>1</sup>

Once the spatial layer is produced, Fraym performs a series of quality checks including the comparison of the spatial layer's output to the survey at its level of representativeness (national and/or first level administrative division). This survey mean is compared against the implied mean of the surface when all grids are appropriately aggregated through population weighted zonal statistics.

**Note 1:** Gething, Peter, Andy Tatem, Tom Bird, and Clara R. Burgert-Brucker. 2015. Creating Spatial Interpolation Surfaces with DHS Data DHS Spatial Analysis Reports No. 11. Rockville, Maryland, USA: ICF International. Other notable, relevant work includes: Weiss DJ, Lucas TCD, Nguyen M, et al. Mapping the global prevalence, incidence, and mortality of Plasmodium falciparum, 2000–17: a spatial and temporal modelling study. Lancet 2019; published online June 19. DOI: [10.1016/S0140-6736\(19\)31097-9](https://doi.org/10.1016/S0140-6736(19)31097-9) and Tatem A, Gething P, Pezzulo C, Weiss D, and Bhatt S. 2014. Final Report: Development of High-Resolution Gridded Poverty Surfaces. University of Southampton. <https://www.worldpop.org/resources/docs/pdf/Poverty-mapping-report.pdf>

Source: Fraym



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