



Uganda Consumer Segmentation

Prepared by Fraym
July 2021

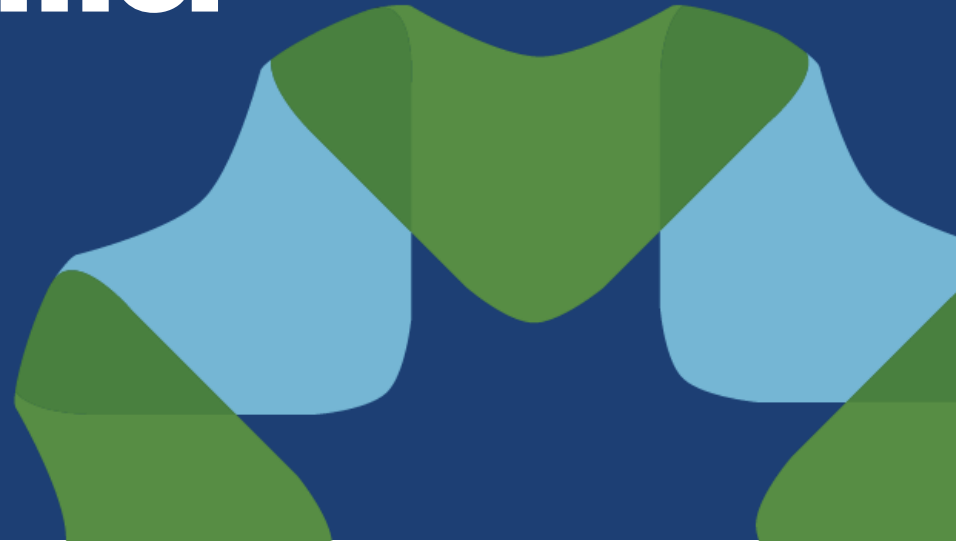




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01

Scope of Work



Scope of Work

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 km² 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

National Context



Household Characteristics

There are around 8.6 million households in Uganda, with nearly 13 percent residing in urban areas and 87 percent in peri-urban and rural areas.¹

Access to mobile money is more common than formal bank accounts throughout the country. Over 40 percent of Ugandan households have access to a mobile money account compared to just over 30 percent that have access to a traditional bank account.

Although rural households are more likely to have a mobile money account than a formal bank account, both types of financial services are limited in rural areas.

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, Uganda 2019 MIS, Uganda 2016 DHS, Uganda 2017 FI

Uganda Snapshot

Demographics

	National	Urban	Rural
Population ²	42M	5.4M	36.6M
Number of households	8.6M	1.3M	7.3M
Female headed household	30%	32%	27%
Household head completed at least primary education	46%	68%	39%
Household head completed at least secondary education	13%	28%	8%
Household head completed higher education	5%	12%	3%
All high-quality housing material ³	33%	69%	23%
Bank account	31%	52%	25%
Mobile money account	43%	60%	37%
Smartphone	16%	32%	7%

Cooking Fuels

Only about 1 percent of households nationwide use clean cooking fuel.

Even in urban areas, only 4 percent of households use clean cooking fuel.

Wood is by far the most common cooking fuel in rural areas and charcoal is the most common in urban areas. Around 88 percent of rural households use wood for cooking, while 57 percent of urban households use charcoal.

On average, households spend around 18,000 Shillings per month on wood for all energy purposes and 30,000 Shillings on charcoal.³

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

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

Note 3: Spending data is in 2019 UGX and includes spending on the fuel for cooking, heating, and lighting.

Source: Fraym, Uganda 2019 MIS, Uganda 2019 NPS

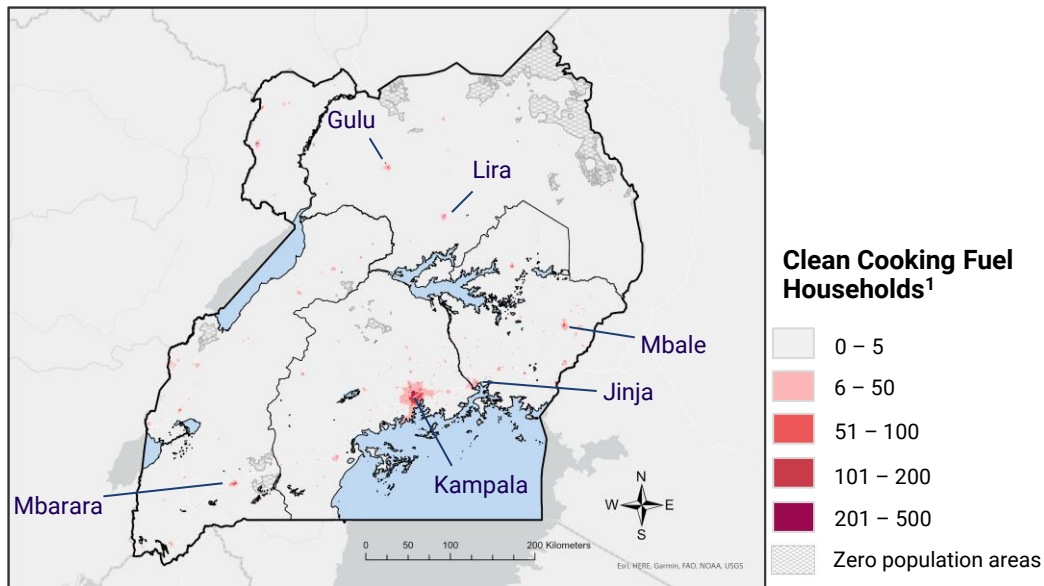
Uganda Snapshot

Household energy use

	National	Urban	Rural
Primarily use clean cooking fuel ¹	1%	4%	1%
Primarily use LPG to cook	1%	2%	< 1%
Primarily use biogas to cook	< 1%	< 1%	< 1%
Primarily use electricity to cook	1%	1%	< 1%
Primarily use wood to cook	74%	35%	88%
Primarily use charcoal to cook	23%	57%	10%
Primarily use kerosene to cook	< 1%	1%	< 1%
Primarily use other solid fuels to cook ²	< 1%	< 1%	< 1%
Average monthly spending on wood (UGX)	18,000	16,000	20,000
Average monthly spending on charcoal (UGX)	30,000	30,000	29,000
Average total monthly spending (UGX)	497,000	809,000	335,000
Access to electricity	40%	71%	31%

Clean Cooking Fuel

The roughly 150,000 households that use clean cooking fuels are concentrated in urban areas and rely on electricity and LPG as their primary cooking fuels.



Note 1: This map shows the estimated number of households that use clean cooking fuel per 1km². Clean cooking fuel includes electricity, LPG, and biogas.

Source: Fraym, Uganda 2019 MIS, Uganda 2016 DHS

150,000 Households use clean cooking fuel

30% of households are headed by a woman

3.6 Average household size

69% of household heads have completed secondary education

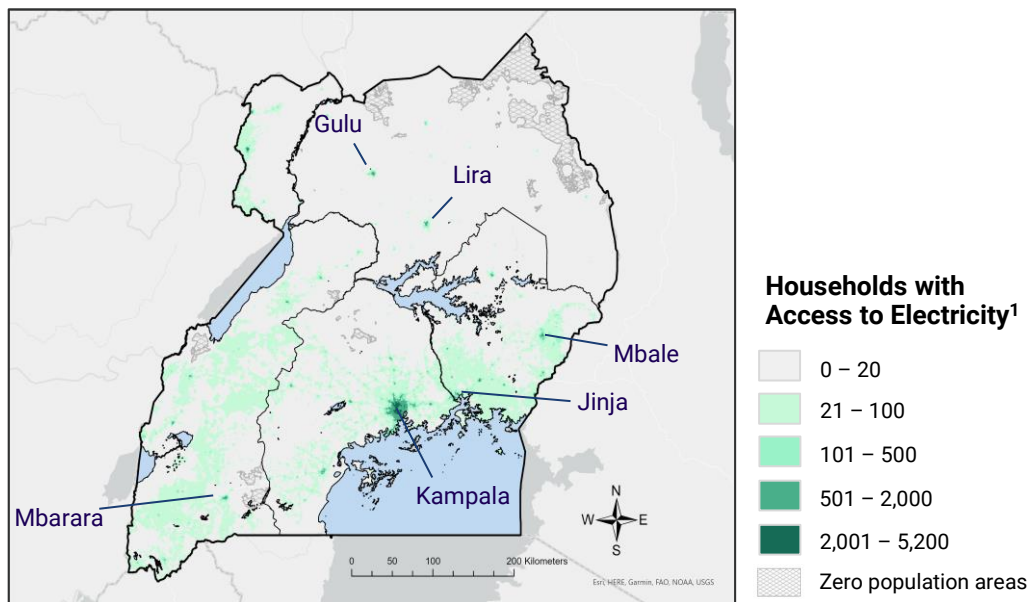
50% use electricity as their primary cooking fuel

44% use LPG as their primary cooking fuel

6% use biogas as their primary cooking fuel

Electricity Access

Around 40 percent of all households in Uganda have access to electricity. Most electrified households still use wood or charcoal as their primary cooking fuel.



Note 1: This map shows the estimated number of households that have electricity access per 1km².

Source: Fraym, Uganda 2019 MIS, Uganda 2016 DHS

3.8M Households with access to electricity

27% of households are headed by a woman

5.0 Average household size

31% of household heads have completed secondary education

54% use wood as their primary cooking fuel

40% use charcoal as their primary cooking fuel

2% use electricity as their primary cooking fuel

Identifying key characteristics

Over 90 percent of households that use clean cooking fuel have access to electricity, which is also the most common clean cooking fuel.

Two thirds of clean cooking fuel households are urban and they are much more likely to have completed secondary education and own at least one high cost asset than solid cooking fuel households.

Around one third of solid cooking fuel households 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, 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.

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, Uganda 2019 MIS, Uganda 2016 DHS

Uganda Snapshot

Characteristics by cooking fuel type

	Clean Cooking Fuel Households ¹	Solid Cooking Fuel Households
Number of households	150,000	8.5M
Urban	66%	25%
Female headed household	30%	31%
Access to electricity	90%	39%
Primary cooking fuel	Electricity (50%) LPG (44%) Biogas (6%)	Wood (76%) Charcoal (23%) Kerosene (1%)
Bank account ²	70%	30%
All high-quality housing material ³	67%	32%
Own at least 1 high cost asset ⁴	61%	18%
Own a radio	75%	56%
Household head has completed secondary education ⁵	69%	13%

Communications

Radio is the most common media outlet used by Ugandan adults.

In rural areas, only about ten percent of adults read print media or watch television weekly, while two thirds of adults regularly listen to the radio.

Rates of television ownership and viewership are much higher in urban areas. Roughly half of all urban adults watch TV weekly.

Rates of mobile phone ownership are high throughout the country, particularly in urban areas where 90 percent of households have at least one mobile phone.

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, Uganda 2019 MIS, Uganda 2016 DHS

Uganda Snapshot

Household communications access¹

	National	Urban	Rural
Television ownership	18%	50%	8%
Radio ownership	56%	64%	57%
Mobile phone ownership	75%	90%	72%
Regular print media readership	14%	27%	9%
Regular television viewership	25%	53%	14%
Regular radio listenership	68%	73%	66%

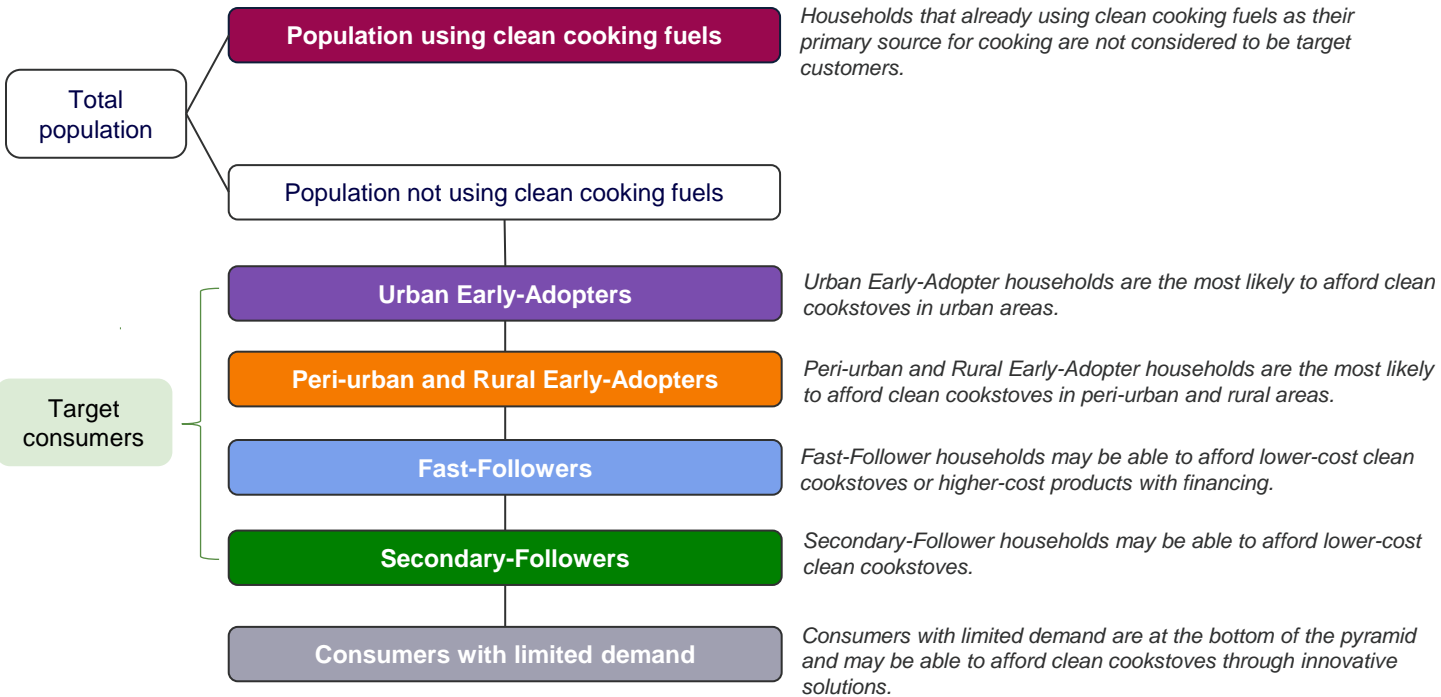
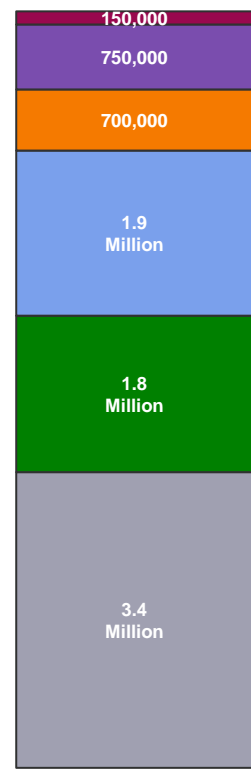
03

Mapping Consumer Segments



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

Total number of households in Uganda



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.¹ There are an estimated 750,000 urban early-adopter households in Uganda.

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.¹ There are around 700,000 peri-urban and rural early-adopter households in Uganda.

Fast-Follower Households are any remaining households that own high-cost assets that did not fit the early-adopter 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. Roughly 1.9 million households in Uganda are fast-followers.

Secondary-Follower Households are any remaining households that own high-cost assets that did not fit the early-adopter profiles and fast-follower 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 about 1.8 million secondary-follower households in Uganda.

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, Uganda 2019 MIS

750,000 Urban Early-Adopter households

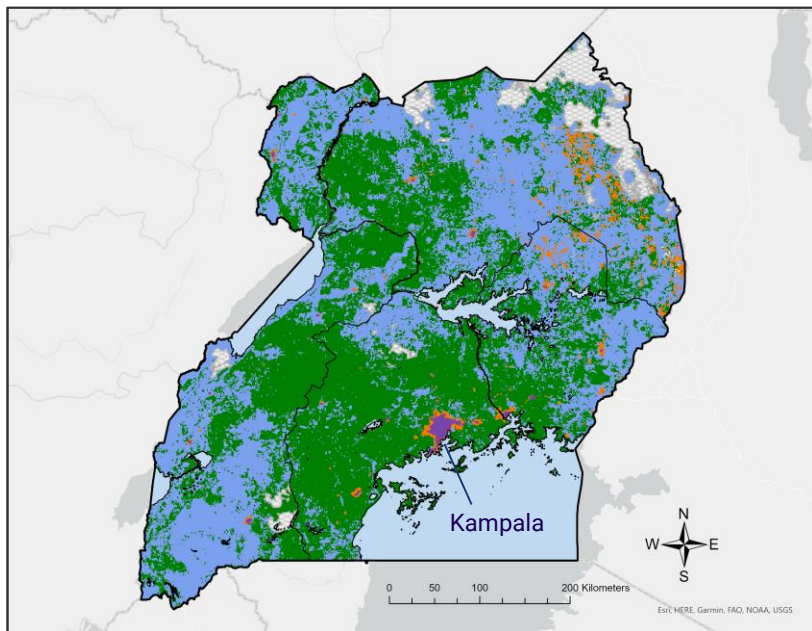
700,000 Peri-urban and Rural Early-Adopter households

1.9M Fast-Follower households

1.8M Secondary-Follower households

Consumer Segment Distribution

Consumer segments are clustered within different areas of Uganda, indicating that strategies for market entry will differ by location.



Note 1: This map shows the most common consumer segment among all households per 1km² area.

Source: Fraym, Uganda 2019 MIS

Urban Early-Adopters are most common in Kampala, with pockets in other large cities.

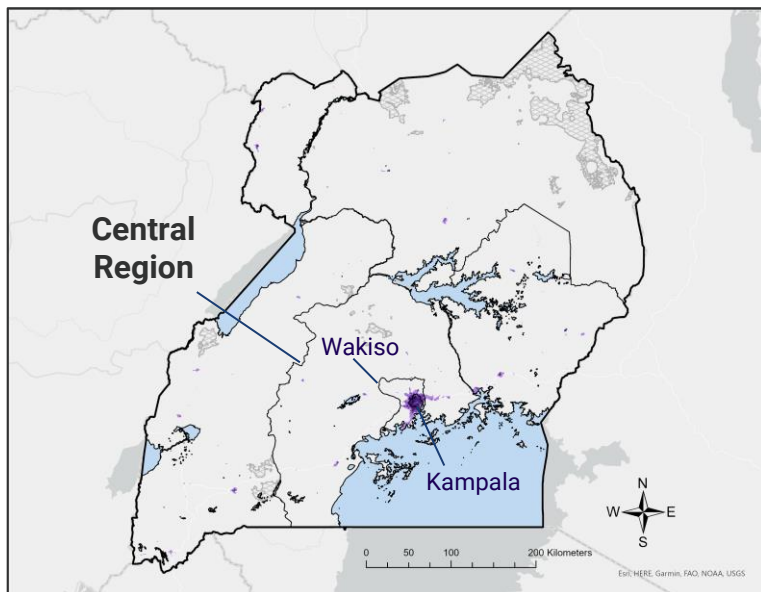
Peri-urban and Rural Early-Adopters are most common in the areas surrounding large cities and in pockets in the North.

Fast-Followers are highly concentrated in the Southwest and pockets of the Northeast.

Secondary-Followers are spread throughout the country but are most common in the Central Region.

Urban Early-Adopters

There are around 750,000 urban early-adopter households, representing around 9 percent of all households in Uganda. They are mainly concentrated in the Wakiso and Kampala districts of the Central Region.



Note 1: This map shows the estimated number of urban early-adopter households per 1km². 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, Uganda 2019 MIS, Uganda 2016 DHS

750,000 Urban Early-Adopter households

32% of households are headed by a woman

4.7 Average household size

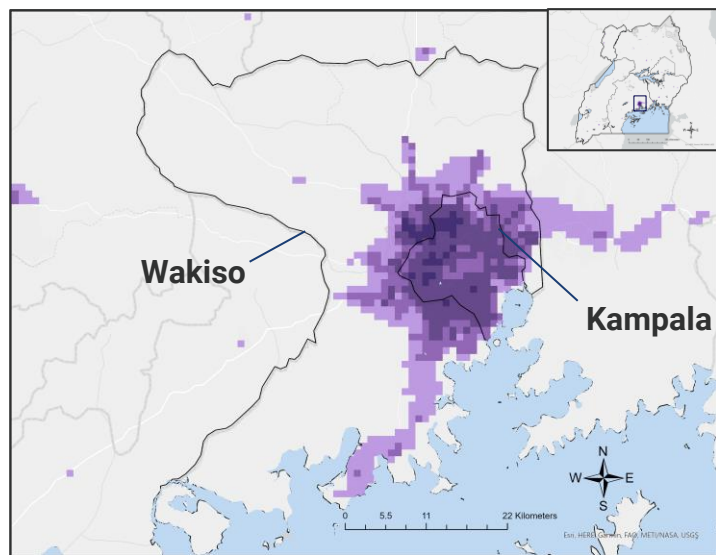
45% of household heads have completed secondary education

87% use charcoal as their primary cooking fuel

10% use wood as their primary cooking fuel

Urban Early-Adopters

Over three quarters of all urban early-adopter households are in the Wakiso and Kampala districts. Roughly 66 percent of all households in Kampala and 41 percent of households in Wakiso are urban early-adopters.



Note 1: This map shows the estimated number of urban early-adopter households per 1km². 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.

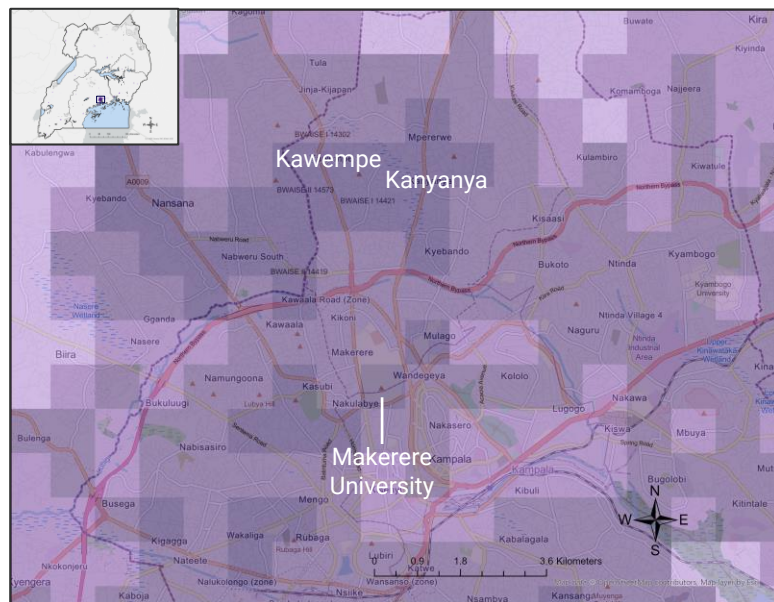
Source: Fraym, Uganda 2019 MIS

Top Districts with Urban Early-Adopters

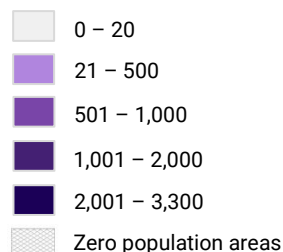
Region	District	Number of Urban Early-Adopter Households
Central	Wakiso	290,000
Central	Kampala	280,000
Central	Mukono	18,000
Eastern	Jinja	17,000
Northern	Arua	15,000
Western	Mbarara	14,000
Eastern	Iganga	13,000
Eastern	Mbale	13,000
Central	Masaka	11,000
Northern	Lira	10,000

Urban Early-Adopters

Neighborhoods in the center of Kampala have the highest density of urban early-adopters.



Urban Early-Adopter Households¹



High density neighborhoods in the center of Kampala, like Kawempe and Kanyanya have the highest concentrations of urban early-adopter households.

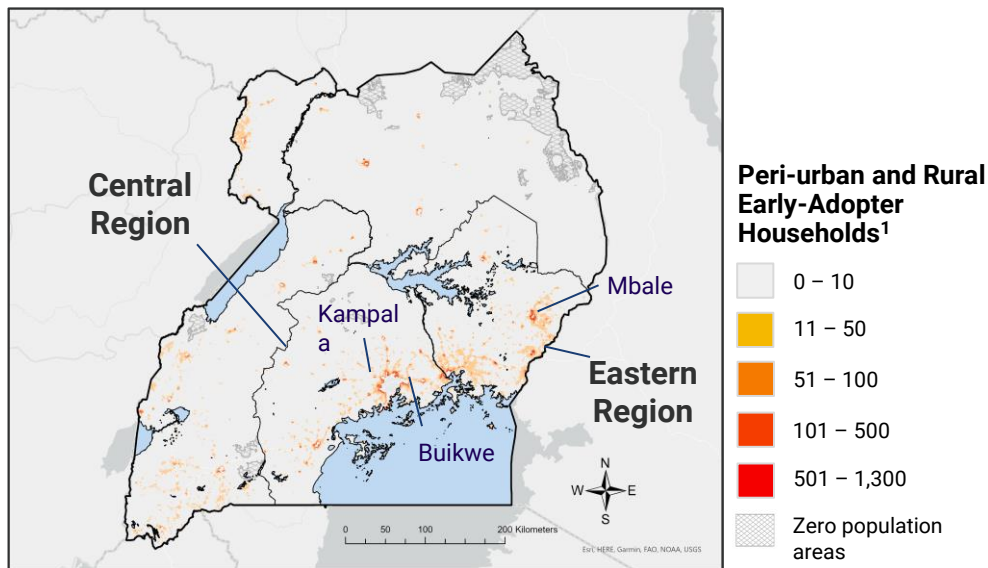
Additionally, the area surrounding Makerere University has many urban early-adopter consumers.

Note 1: This map shows the estimated number of urban early-adopter households per km². 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, Uganda 2019 MIS

Peri-urban and Rural Early-Adopters

There are around 700,000 peri-urban and rural early-adopter households, representing around 8 percent of all households in Uganda. Many of these consumers are concentrated in the Central and Eastern Regions.



Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km². 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, Uganda 2019 MIS, Uganda 2016 DHS

700,000 Peri-urban and Rural Early-Adopter households

25% of households are headed by a woman

5.6 Average household size

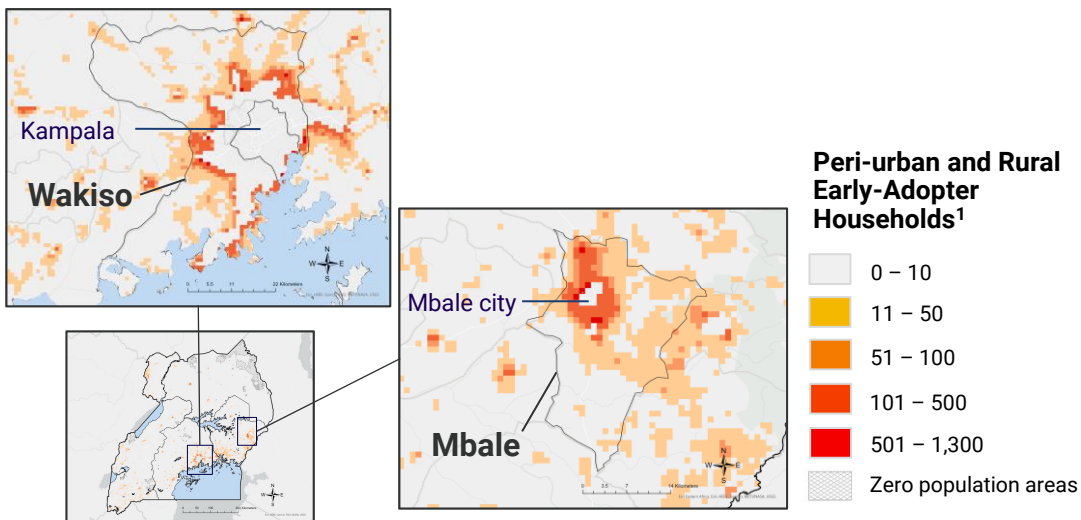
36% of household heads have completed secondary education

63% use wood as their primary cooking fuel

36% use charcoal as their primary cooking fuel

Peri-urban and Rural Early-Adopters

Although Wakiso has the highest number of peri-urban and rural early-adopters, they make up only 9 percent of the households in this district. By comparison, 20 percent of households in Mbale are peri-urban and rural early-adopters.



Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km². 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.

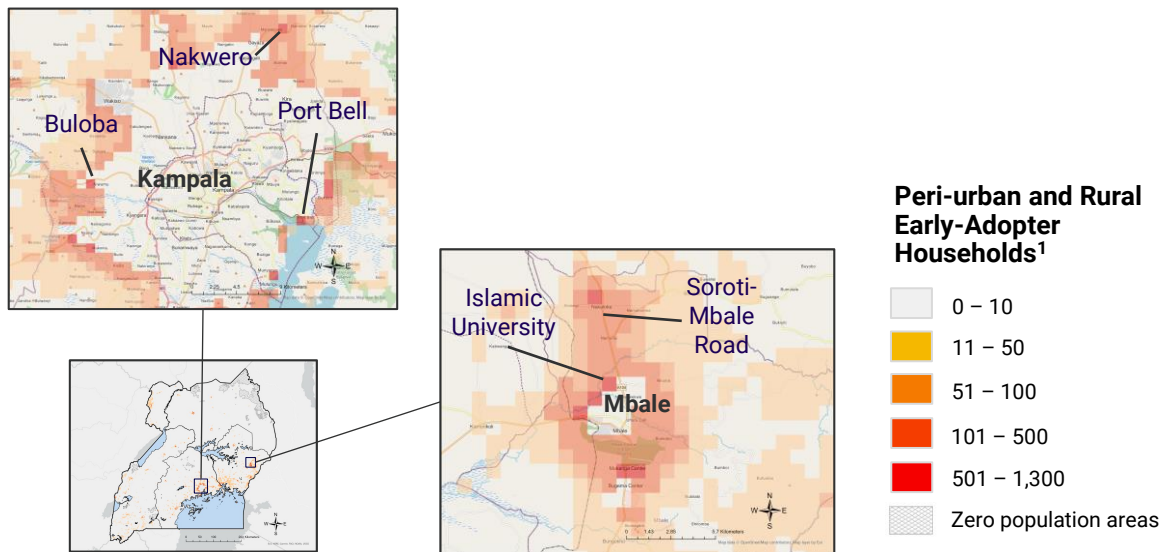
Source: Fraym, Uganda 2019 MIS

Top Districts with Peri-urban and Rural Early-Adopters

Region	District	Number of Peri-urban and Rural Early-Adopter Households
Central	Wakiso	61,000
Eastern	Mbale	26,000
Central	Buikwe	21,000
Central	Mukono	20,000
Eastern	Jinja	19,000
Eastern	Tororo	18,000
Western	Kasese	15,000
Western	Ntungamo	15,000
Central	Arua	14,000
Central	Mayuge	14,000

Peri-urban and Rural Early-Adopters

Neighborhoods on the outskirts of Kampala and Mbale have the highest concentrations of peri-urban and rural early-adopter households.



Neighborhoods surrounding Kampala like Port Bell, Nakwero, and Buloba have dense pockets of peri-urban and rural early-adopter consumers.

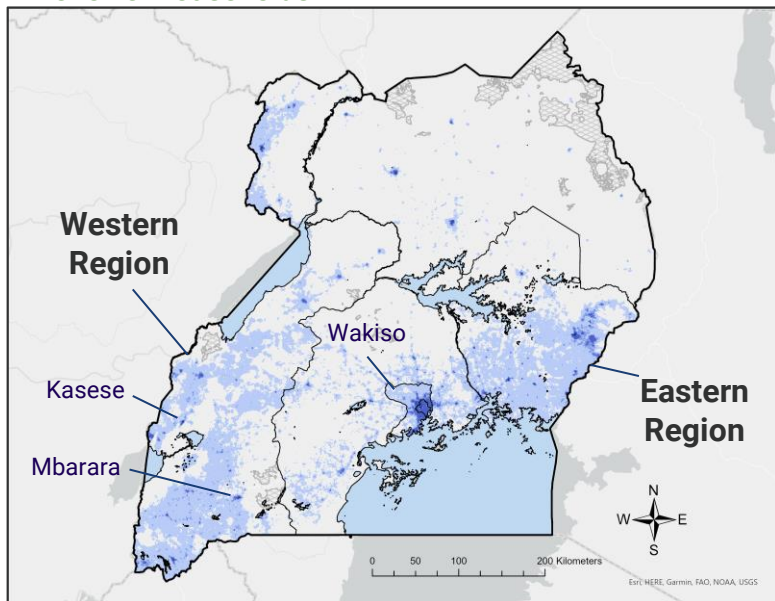
Concentrations of peri-urban and rural early-adopter consumers are common outside of Mbale near the Islamic University and along the Soroti-Mbale Road.

Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km². 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, Uganda 2019 MIS

Fast-Followers

There are around 1.9 million fast-follower households, representing over 22 percent of all households in Uganda. The Western and Eastern Regions, in addition to the Wakiso District, have the largest concentration of fast-follower households.



Note 1: This map shows the estimated number of fast-follower households per 1km². 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, Uganda 2019 MIS, Uganda 2016 DHS

1.9M Fast-Follower households

22% of households are headed by a woman

5.4 Average household size

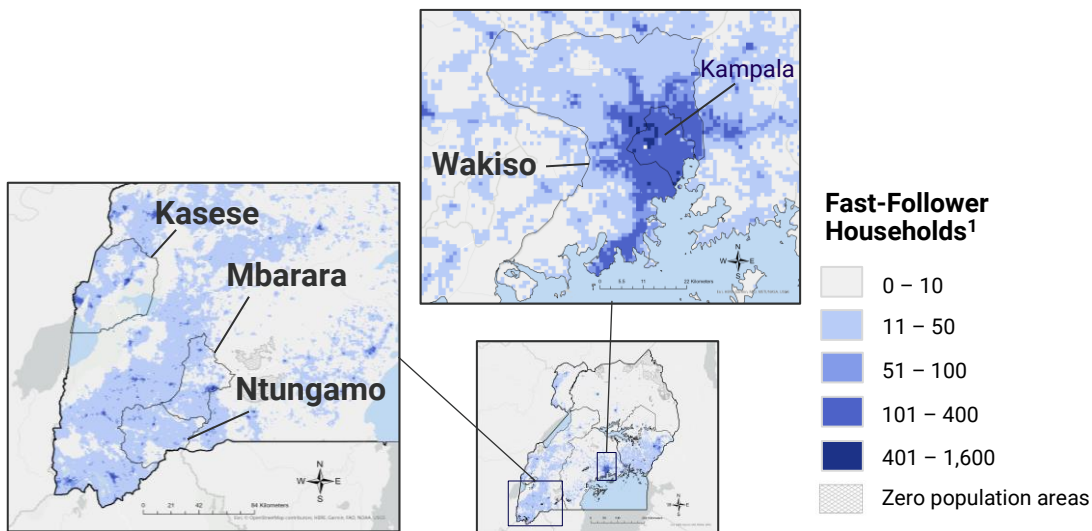
16% of household heads have completed secondary education

74% use wood as their primary cooking fuel

25% use charcoal as their primary cooking fuel

Fast-Followers

Although the Wakiso district has the largest number of fast-followers, these consumers are also heavily concentrated in the Western Region districts of Kasese, Ntungamo, and Mbarara.



Top Districts with Fast-Followers

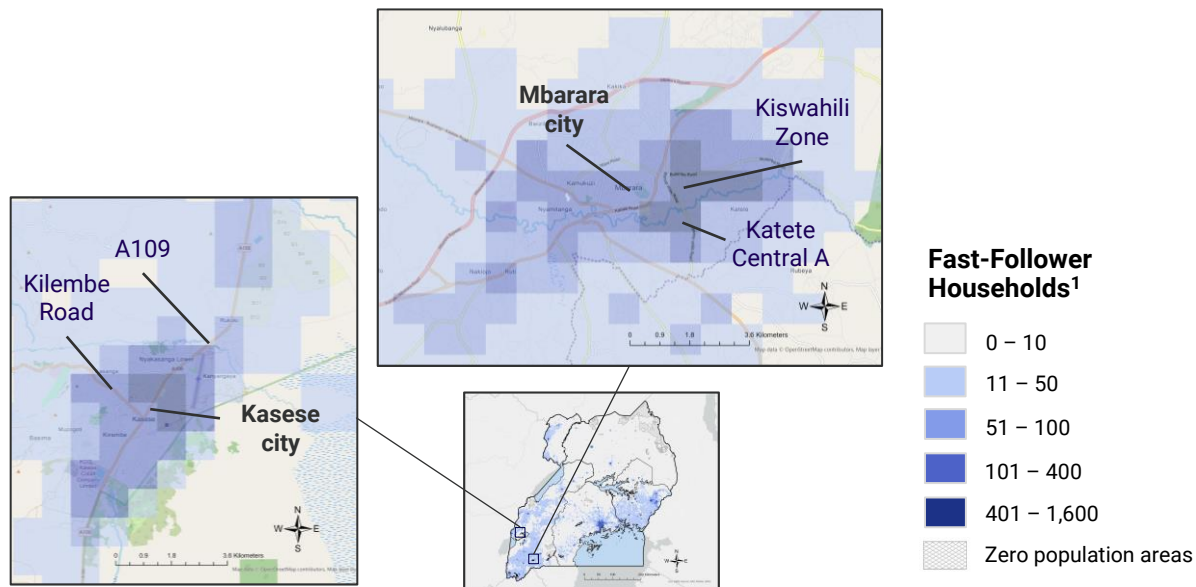
Region	District	Number of Fast-Follower Households
Central	Wakiso	121,000
Western	Kasese	56,000
Central	Kampala	53,000
Western	Ntungamo	47,000
Western	Mbarara	43,000
Central	Mubende	41,000
Eastern	Mbale	40,000
Western	Isingiro	37,000
Northern	Arua	37,000
Western	Hoima	36,000

Note 1: This map shows the estimated number of fast-follower households per 1km². 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, Uganda 2019 MIS

Fast-Followers

There is a high density of fast-follower households along the A109 highway in Kasese and on the outskirts of the Mbarara city center.



A high density of fast-follower consumers live along the A109 through Kasese and at the junction of Kilembe Road and A109.

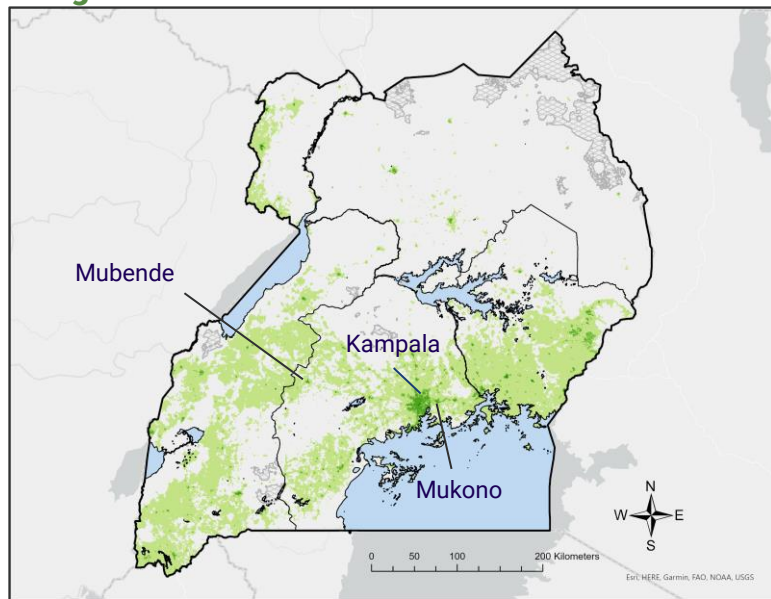
Outside of the Mbarara city center, fast-followers are concentrated in the Kiswahili Zone and Katete Central A neighborhoods.

Note 1: This map shows the estimated number of fast-follower households per 1km². 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, Uganda 2019 MIS

Secondary-Followers

There are around 1.8 million secondary-follower households, representing 21 percent of all households in Uganda. Concentrations of secondary-follower consumers can be found throughout southern Uganda.



Note 1: This map shows the estimated number of secondary-follower households per 1km². 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, Uganda 2019 MIS, Uganda 2016 DHS

1.8M Secondary-Follower households

24% of households are headed by a woman

4.6 Average household size

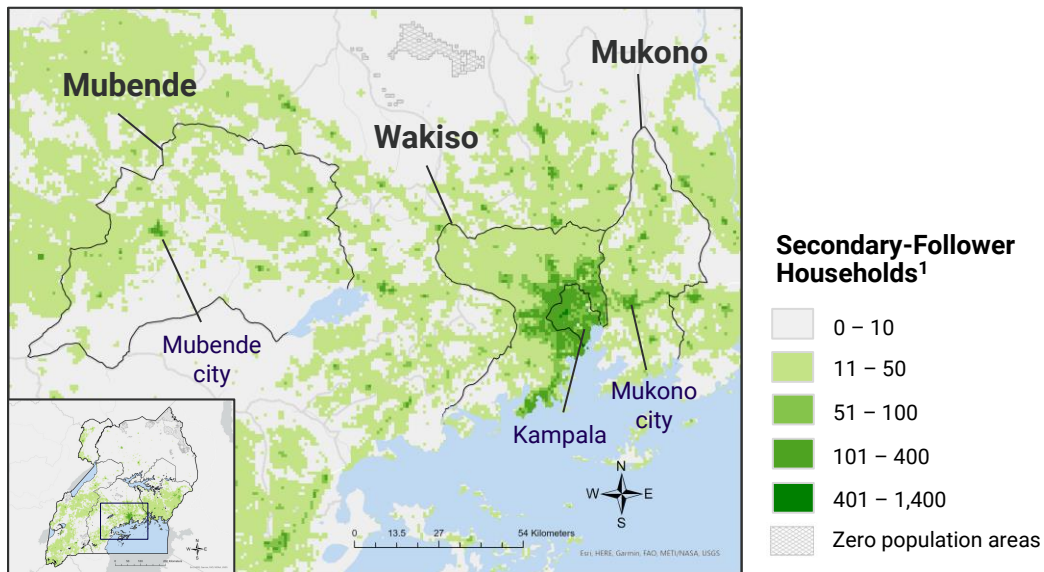
4% of household heads have completed secondary education

85% use wood as their primary cooking fuel

15% use charcoal as their primary cooking fuel

Secondary-Followers

Although Wakiso has the highest number of secondary-follower consumers, they make up only 15 percent of all households. By comparison, around a quarter of households in Mukono and a third in Mubende are secondary-followers.



Note 1: This map shows the estimated number of secondary-follower households per 1km². 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.

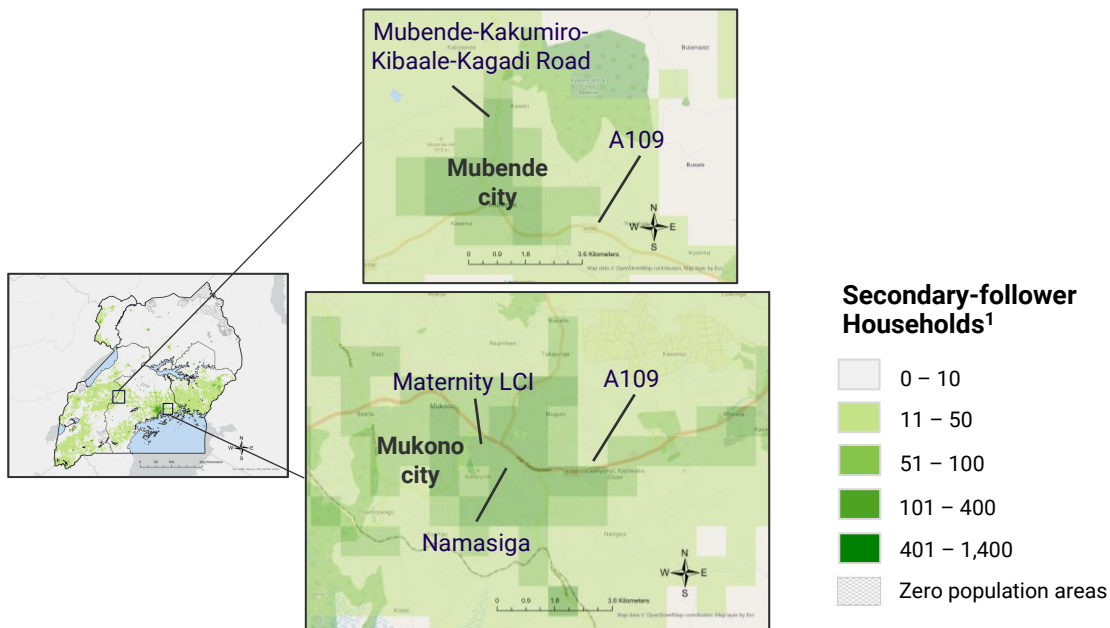
Source: Fraym, Uganda 2019 MIS

Top Districts with Secondary-Followers

Region	District	Number of Secondary-Follower Households
Central	Wakiso	105,000
Central	Mubende	62,000
Central	Mukono	41,000
Western	Hoima	39,000
Western	Kyenjojo	37,000
Western	Kasese	37,000
Central	Luweero	34,000
Eastern	Mayuge	34,000
Central	Kampala	33,000
Western	Kakumiro	32,000

Secondary-Followers

Secondary-follower households are more concentrated in smaller Ugandan cities along major roadways.



In Mubende, secondary-follower households are most prevalent in the city center where the Mubende-Kakumiro-Kibaale-Kigadi road intersects the A109 highway.

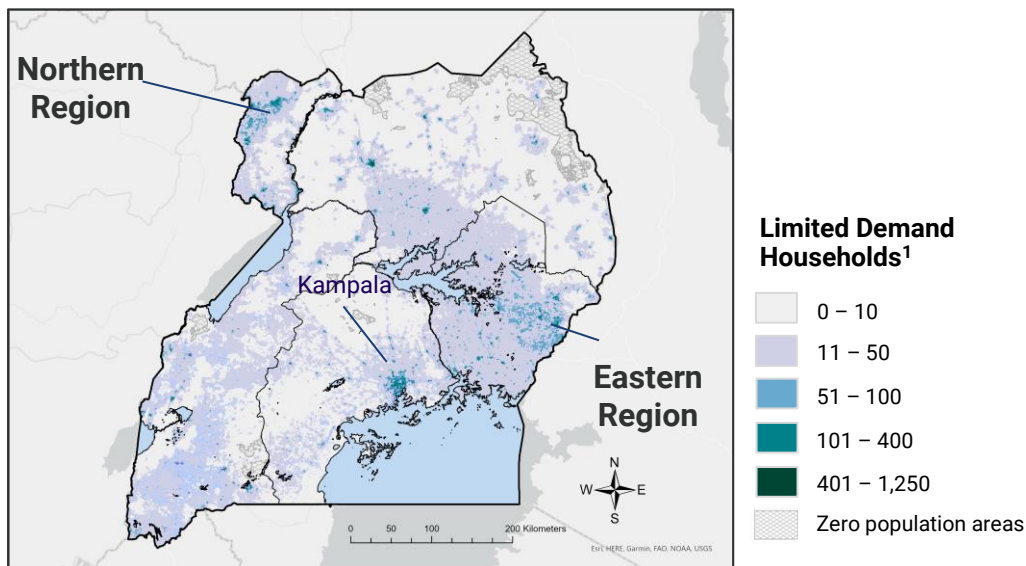
Secondary-follower households are clustered around the city of Mukono in the neighborhoods of Maternity LCI and Namasiga along the A109 highway.

Note 1: This map shows the estimated number of secondary-follower households per 1km². 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, Uganda 2019 MIS

Limited Demand

There are around 3.4 million limited demand households, representing nearly 40 percent of all households in Uganda. Limited demand consumers are common in the Northern and Eastern Regions as well as a large concentration in Kampala.



Note 1: This map shows the estimated number of limited demand households per 1km². Limited demand households do not fit any of the four core consumer profiles due to their limited consumption ability.

Source: Fraym, Uganda 2019 MIS, Uganda 2016 DHS

3.4M Limited Demand households

39% of households are headed by a woman

5.0 Average household size

4% of household heads have completed secondary education

90% use wood as their primary cooking fuel

10% use charcoal as their primary cooking fuel

04

Data Sources and Methodology



Asset-Based Consumer Segmentation

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.¹ 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.

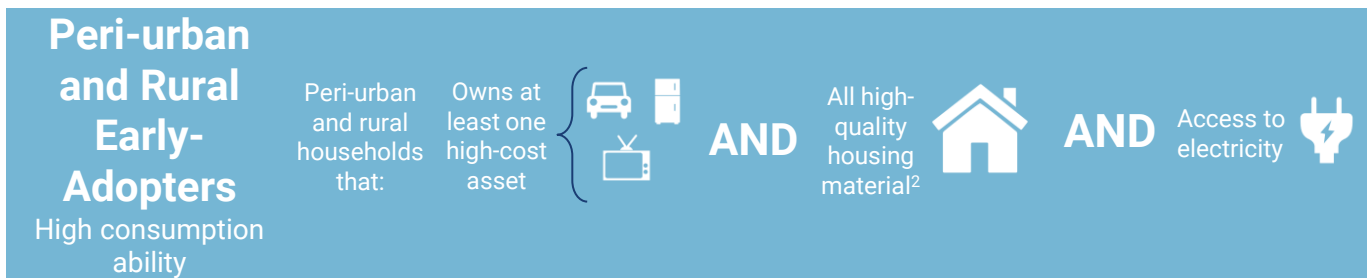
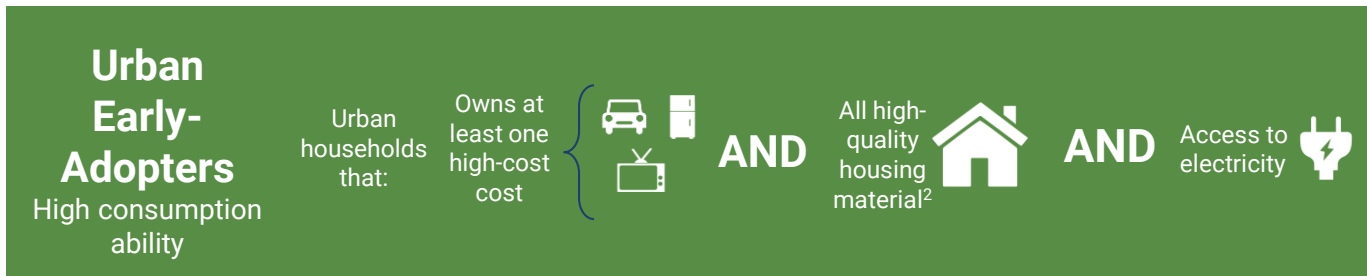
The remaining solid cooking fuel households were categorized into a limited demand profile, with very low consumption ability. There are about 3.4 million limited demand households in Uganda.

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.¹



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 material¹

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 material¹

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

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 2019 Uganda Malaria Indicator Survey, the 2016 Uganda Demographic and Health Survey (DHS), the 2017 Financial Inclusion Insights survey (FII), and the 2019 National Panel Survey (NPS). These surveys are designed to be nationally representative and use a stratified two-stage sample design. The 2019 MIS data were enumerated between December 2018 and February 2019, with a total sample size of 8,351 households. The DHS data were enumerated between June and December 2016, with a total sample size of 19,588 households. The FII data were enumerated between July and August 2017, with a total sample size of 3,001 individuals. The NPS data were enumerated between February 2018 and February 2019, with a total sample size of 3,174 households.

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

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 km²).

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, cleaned, 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.¹

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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