CLEAN COOKING ALLIANCE

fraym

Rwanda Consumer Segmentation

Prepared by Fraym

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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 km^2 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 3.2 million households in Rwanda, with roughly 16 percent residing in urban areas and 84 percent in peri-urban and rural areas.[1]

Mobile money accounts are nearly as common as traditional bank accounts throughout the country. Over 40 percent of rural households and 60 percent of urban households have access to either of these financial resources.

Educational attainment is low in Rwanda – only six percent of household heads have completed secondary education. The urban rural divide is also apparent as urban household heads are twice as likely to have completed primary education than rural household heads.

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, Rwanda 2017 MIS, Rwanda 2015 DHS, Rwanda 2016 FinScope

Rwanda Snapshot

Demographics

	National	Urban	Rural
Population[2]	13.5M	1.9M	11.6M
Number of households	3.2M	500,000	2.7M
Female headed household	37%	44%	36%
Household head completed at least primary education	35%	62%	29%
Household head completed at least secondary education	6%	23%	3%
Household head completed higher education	2%	9%	1%
All high-quality housing material[3]	22%	66%	13%
Bank account	45%	64%	41%
Mobile money account	43%	60%	37%

Cooking Fuels

Only about 1 percent of households nationwide use clean cooking fuel, with almost all residing in urban areas.

Wood is the most common cooking fuel throughout the country, although charcoal is more common in urban areas.

Straw is the second most common cooking fuel – around one in five rural households use straw as their primary cooking fuel.

Households spend around 3,000 Rwandan francs (RWF) per month on wood for cooking. Spending on charcoal for cooking is around 2 to 3 times higher, especially in urban areas.

Note 1: Clean cooking fuel is defined as LPG, electricity, natural gas, and biogas.
Source: Fraym, Rwanda 2017 MIS, Rwanda 2017 EICV 5

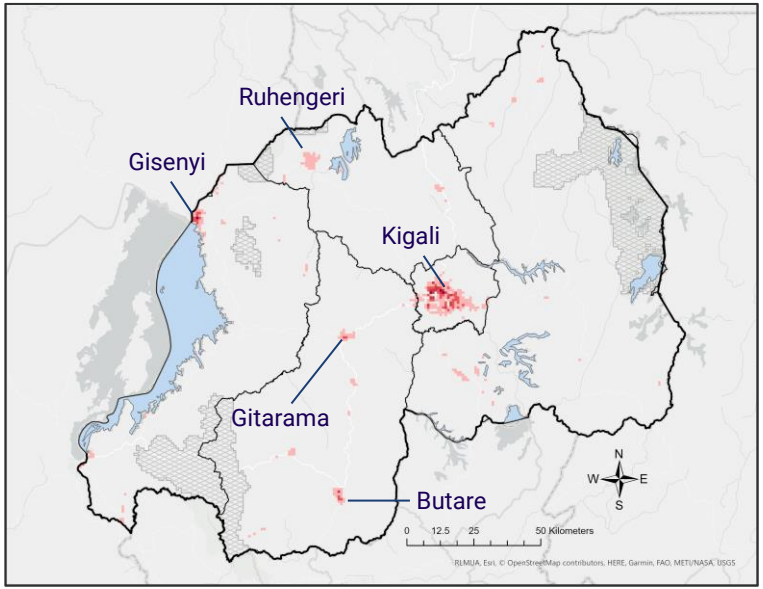
Rwanda Snapshot

Household energy use

	National	Urban	Rural
Primarily use clean cooking fuel[1]	1%	7%	< 1%
Primarily use LPG to cook	< 1%	< 1%	< 1%
Primarily use natural gas or biogas to cook	1%	6%	< 1%
Primarily use electricity to cook	< 1%	< 1%	< 1%
Primarily use wood to cook	65%	27%	73%
Primarily use straw to cook	18%	3%	21%
Primarily use charcoal to cook	15%	61%	5%
Primarily use kerosene to cook	< 1%	< 1%	< 1%
Average monthly spending on wood for cooking (RWF)	3,000	3,000	3,000
Average monthly spending on charcoal for cooking (RWF)	7,000	8,000	4,000
Average total monthly spending (RWF)	61,000	170,000	35,000
Access to electricity	31%	83%	20%

Clean Cooking Fuel

The roughly 30,000 households that use clean cooking fuels are concentrated in urban areas and mainly rely on natural gas as their primary cooking fuel.



Clean Cooking Fuel Households[1]

- 0 – 5
- 6 – 50
- 51 – 100
- 101 – 200
- 201 – 600
- Zero population areas

Note 1: This map shows the estimated number of households that use clean cooking fuel per 1km^2. Clean cooking fuel includes electricity, LPG, natural gas, and biogas.
Source: Fraym, Rwanda 2017 MIS, Rwanda 2015 DHS

30,000 Households use clean cooking fuel

28% of households are headed by a woman

3.5 Average household size

75% of household heads have completed secondary education

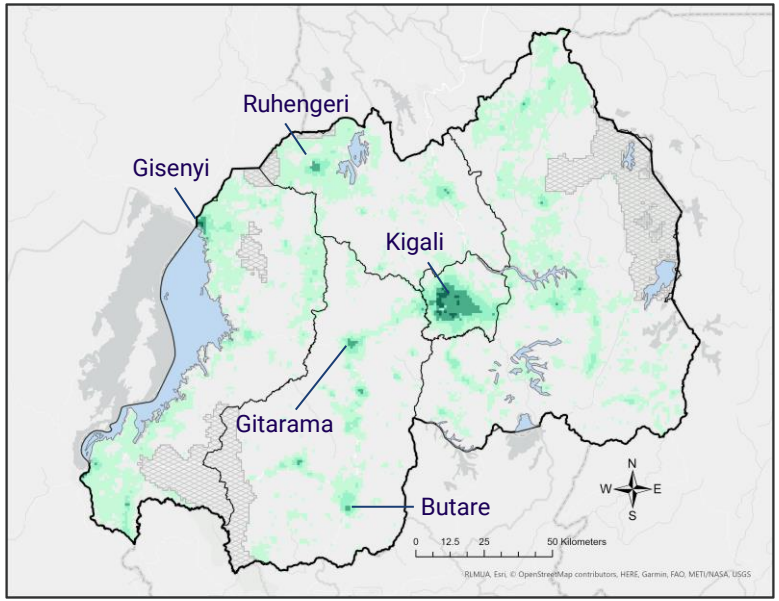
82% use natural gas as their primary cooking fuel

9% use biogas as their primary cooking fuel

6% use electricity as their primary cooking fuel

Electricity Access

Around 30 percent of all households in Rwanda have access to electricity. Wood, charcoal, and straw are still the most popular cooking fuels for electrified households.



Households with Access to Electricity[1]

- 0 – 20
- 21 – 100
- 101 – 500
- 501 – 2,000
- 2,001 – 4,100
- Zero population areas

Note 1: This map shows the estimated number of households that have electricity access per 1km^2.
Source: Fraym, Rwanda 2017 MIS, Rwanda 2015 DHS

900,000 Households with access to electricity

37% of households are headed by a woman

4.1 Average household size

24% of household heads have completed secondary education

47% use wood as their primary cooking fuel

41% use charcoal as their primary cooking fuel

6% use straw as their primary cooking fuel

Identifying key characteristics

Around three quarters of households that use clean cooking fuel have high quality housing, own a high-cost asset, and have access to electricity and a bank account.

Nine in ten clean cooking fuel households are urban, have access to a bank account, and live in households with all high-quality materials.

Around 10 percent 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.
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, Rwanda 2017 MIS, Rwanda 2015 DHS

Rwanda Snapshot

Characteristics by cooking fuel type

	Clean Cooking Fuel Households[1]	Solid Cooking Fuel Households
Number of households	30,000	3.2M
Urban	88%	17%
Female headed household	28%	38%
Access to electricity	96%	30%
Primary cooking fuel	Natural Gas (82%) Biogas (9%) Electricity (6%) LPG (3%)	Wood (66%) Straw (18%) Charcoal (16%)
Bank account[2]	91%	45%
All high-quality housing material[3]	90%	21%
Own at least 1 high cost asset[4]	75%	9%
Own a radio	83%	41%
Household head has completed secondary education	75%	6%

Communications

Radio is by far the most common media outlet used by Rwandan adults.

About 41% of Rwandan households have a radio and 77 percent of adults are weekly radio listeners.

Television ownership is much higher in urban than rural areas and around 60 percent of urban adults watch TV at least once a week.

Around three in five adults own a mobile phone, although the rate is substantially higher in urban areas.

Rwanda Snapshot

Household communications access[1]

	National	Urban	Rural
Television ownership	10%	38%	3%
Radio ownership	41%	62%	37%
Mobile phone ownership	61%	88%	56%
Regular print media readership	16%	33%	12%
Regular television viewership	27%	60%	20%
Regular radio listenership	77%	89%	75%

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, Rwanda 2017 MIS, Rwanda 2015 DHS

03

Mapping Consumer Segments

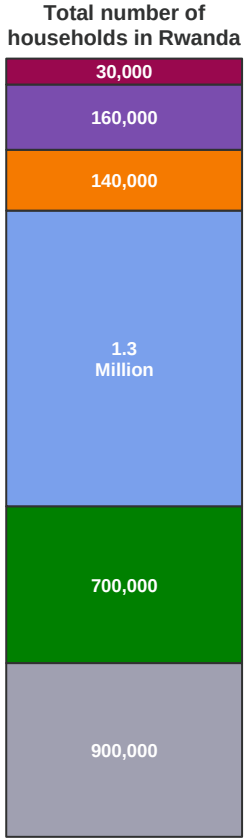
The total population is segmented into six groups, with four target consumer segments

Total population

- **Population using clean cooking fuels** — *Households that already using clean cooking fuels as their primary source for cooking are not considered to be target customers.*
- **Population not using clean cooking fuels**

Target consumers

- **Urban Early-Adopters** — *Urban Early-Adopter households are the most likely to afford clean cookstoves in urban areas.*
- **Peri-urban and Rural Early-Adopters** — *Peri-urban and Rural Early-Adopter households are the most likely to afford clean cookstoves in peri-urban and rural areas.*
- **Fast-Followers** — *Fast-Follower households may be able to afford lower-cost clean cookstoves or higher-cost products with financing.*
- **Secondary-Followers** — *Secondary-Follower households may be able to afford lower-cost clean cookstoves.*
- **Consumers with limited demand** — *Consumers with limited demand are at the bottom of the pyramid and may be able to afford clean cookstoves through innovative solutions.*



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 160,000 urban early-adopter households in Rwanda.

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 140,000 peri-urban and rural early-adopter households in Rwanda.

Fast-Follower Households are any remaining households that own high-cost assets that did not fit the premium 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 1.3 million households in Rwanda are fast-followers.

Secondary-Follower Households are any remaining households that own high-cost assets that did not fit the premium 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 about 700,000 secondary-follower households in Rwanda.

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, Rwanda 2017 MIS, Rwanda 2015 DHS

160,000 Urban Early-Adopter households

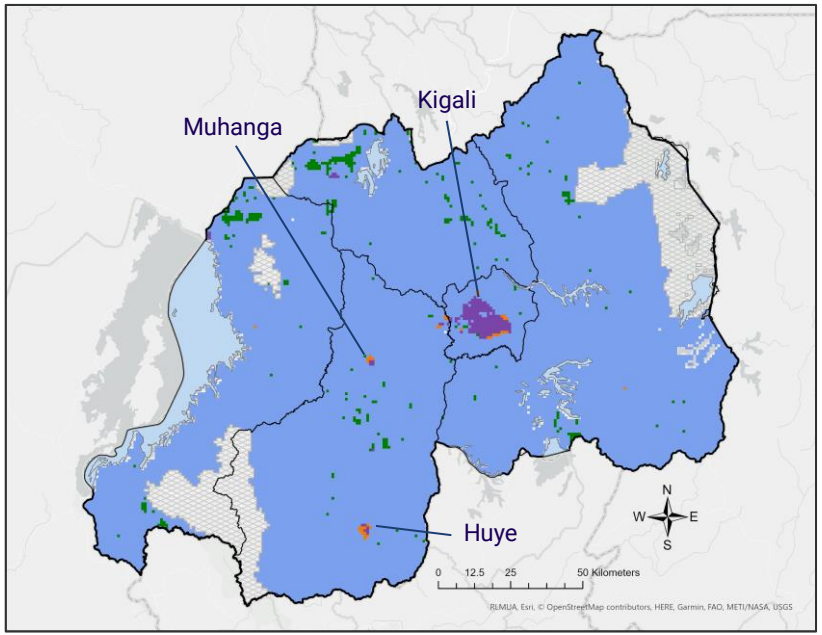
140,000 Peri-urban and Rural Early-Adopter households

1.3M Fast-Follower households

700,000 Secondary-Follower households

Consumer Segment Distribution

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



Most Common Consumer Segment[1]

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

Urban Early-Adopters are most common in Kigali.

Peri-urban and Rural Early-Adopter are most common in the areas surrounding Kigali and around Muhanga and Huye.

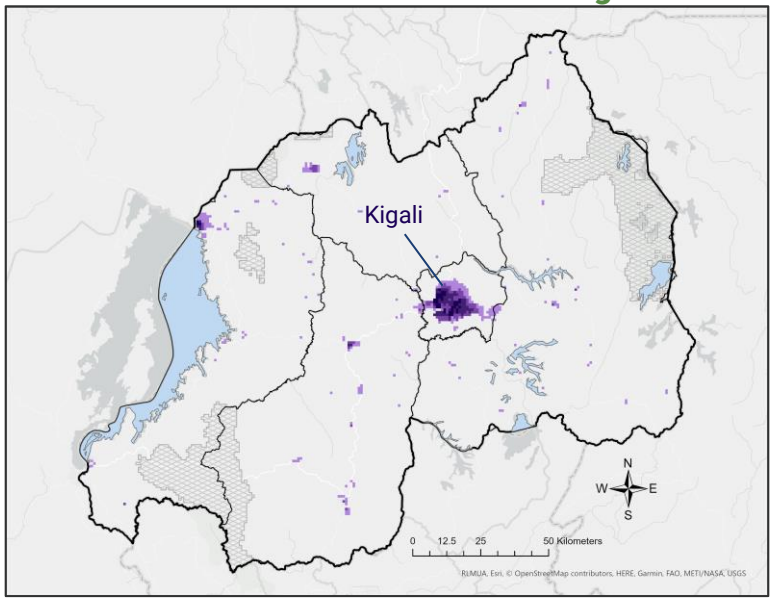
Fast-Followers are the most common consumer segment spread across every province.

Secondary-Followers are most common in pockets of rural areas throughout the country.

Note 1: This map shows the most common consumer segment among all households per 1km^2 area.
Source: Fraym, Rwanda DHS 2015

Urban Early-Adopters

There are around 160,000 urban early-adopter households, representing 5 percent of all households in Rwanda. They are mainly concentrated in the three districts of Kigali.



Urban Early-Adopter Households[1]

- 0 – 20
- 21 – 250
- 251 – 500
- 501 – 1,000
- 1,001 – 2,400
- Zero population areas

Note 1: This map shows the estimated number of urban early-adopter households per 1km^2. 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, Rwanda 2017 MIS, Rwanda 2015 DHS

160,000 Urban Early-Adopter households

42% of households are headed by a woman

4.3 Average household size

41% of household heads have completed secondary education

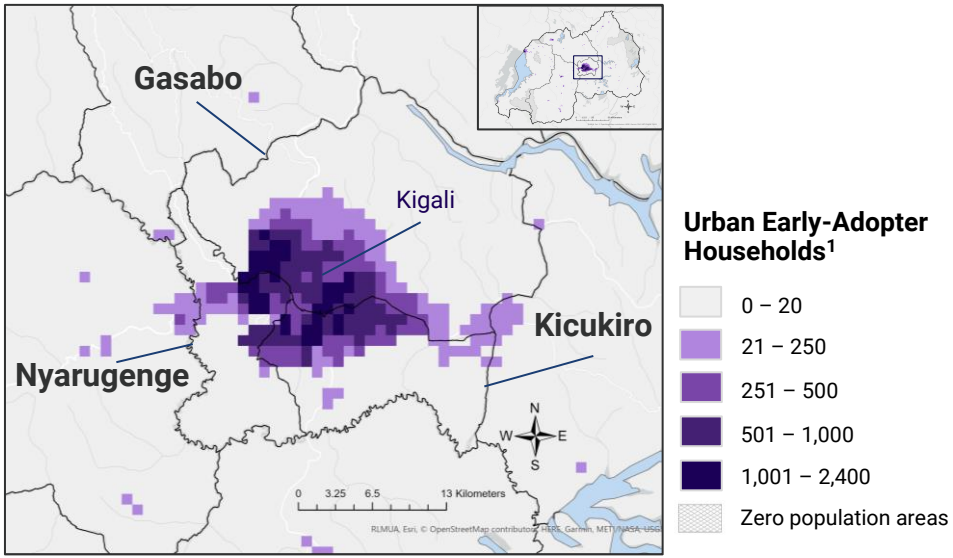
86% use charcoal as their primary cooking fuel

13% use wood as their primary cooking fuel

1% use straw as their primary cooking fuel

Urban Early-Adopters

Over 80 percent of all urban early-adopter households are in the Kigali districts of Gasabo, Kicukiro, and Nyarugenge. Nearly 37 percent of households in the Kicukiro district are urban early-adopters.



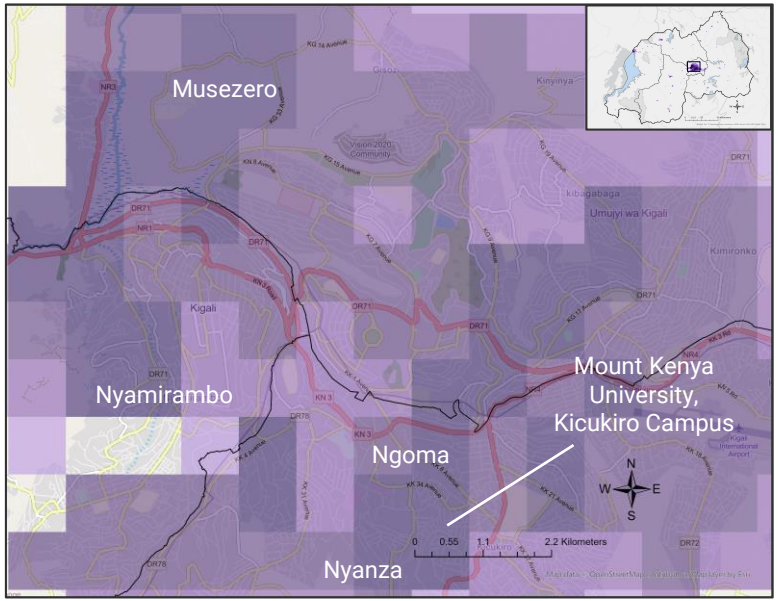
Note 1: This map shows the estimated number of urban early-adopter households per 1km^2. Urban early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in urban centers, dense urban clusters, and semi-dense urban clusters according to the EU Global Human Settlement Layer.
Source: Fraym, Rwanda 2015 DHS

Top Districts with Urban Early-Adopters

Province	District	Number of Urban Early-Adopter Households
Kigali	Gasabo	68,000
Kigali	Kicukiro	42,000
Kigali	Nyarugenge	23,000
Western	Rubavu	10,000
Northern	Musanze	5,000
Southern	Muhanga	3,000
Southern	Huye	2,000
Southern	Kamonyi	1,500
Eastern	Rwamagana	1,500
Eastern	Nyagatare	1,000

Urban Early-Adopters

Pockets of neighborhoods where the three districts of Kigali meet have the highest density of urban early-adopters.



Urban Early-Adopter Households[1]

- 0 – 20
- 21 – 250
- 251 – 500
- 501 – 1,000
- 1,001 – 2,400
- Zero population areas

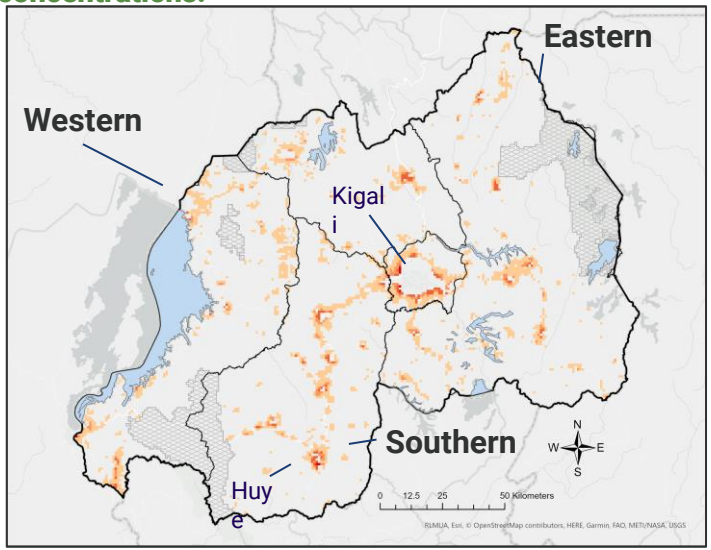
In the Kicukiro district, the area surrounding Mount Kenya University, Kicukiro Campus in the Ngoma and Nyanza neighborhoods has large concentrations of urban early-adopters.

Additionally, Nyamirambo in the Nyarugenge district and Musezero in Gasabo have many urban early-adopter households.

Note 1: This map shows the estimated number of urban early-adopter households per 1km^2. 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, Rwanda 2015 DHS

Peri-urban and Rural Early-Adopters

There are around 140,000 peri-urban and rural early-adopter households, representing a little more than 4 percent of all households in Rwanda. Although the Eastern province has the largest number of these consumers, areas in the Western and Southern provinces have the densest concentrations.



Peri-urban and Rural Early-Adopter Households[1]

- 0 – 10
- 11 – 50
- 51 – 100
- 101 – 400
- 401 – 1,400
- Zero population areas

Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km^2. 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, Rwanda 2017 MIS, Rwanda 2015 DHS

140,000 Peri-urban and Rural Early-Adopter households

24% of households are headed by a woman

5.0 Average household size

35% of household heads have completed secondary education

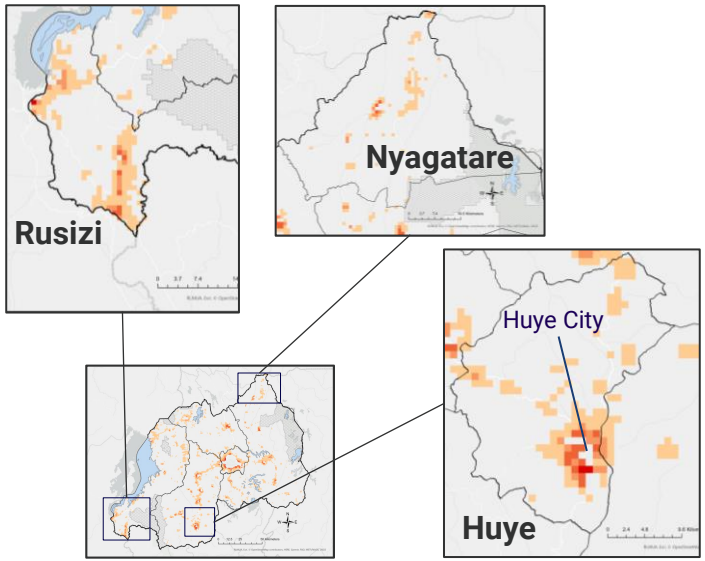
71% use wood as their primary cooking fuel

28% use charcoal as their primary cooking fuel

1% use straw as their primary cooking fuel

Peri-urban and Rural Early-Adopters

Although the highest number of peri-urban and rural early-adopters is in the Nyagatare district, they are much more dispersed. The Rusizi and Huye districts have large, dense populations of these consumers.



Peri-urban and Rural Early-Adopters Households[1]

- 0 – 10
- 11 – 50
- 51 – 100
- 101 – 400
- 401 – 1,400
- Zero population areas

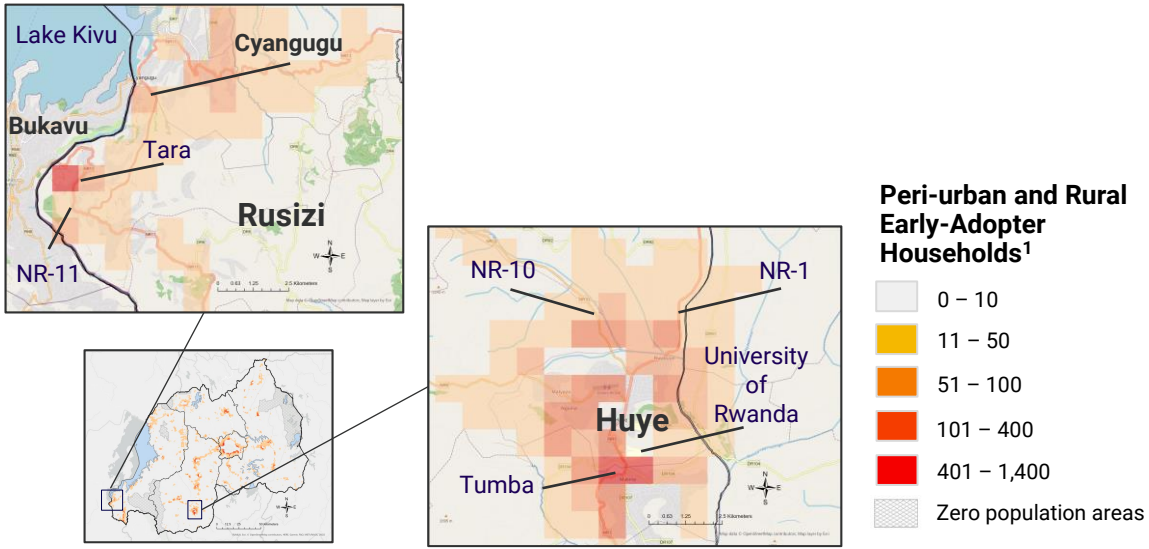
Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km^2. Peri-urban and rural early-adopter households own at least one high-cost asset, have housing made of all high-quality material, have access to electricity, and live in suburban or peri-urban rural areas according to the EU Global Human Settlement Layer.
Source: Fraym, Rwanda 2015 DHS

Top Districts with Peri-urban and Rural Early-Adopters

Region	District	Number of Peri-urban and Rural Early-Adopter Households
Eastern	Nyagatare	9,000
Kigali	Gasabo	8,000
Western	Rusizi	8,000
Southern	Huye	7,000
Eastern	Bugesera	7,000
Eastern	Gatsibo	6,000
Eastern	Kayonza	6,000
Northern	Gicumbi	6,000
Kigali	Kicukiro	5,000
Kigali	Nyarugenge	5,000

Peri-urban and Rural Early-Adopters

Neighborhoods on the outskirts of Huye and near the Southern tip of Lake Kivu on the border with the DRC have some of the densest concentrations of peri-urban and rural early-adopters.



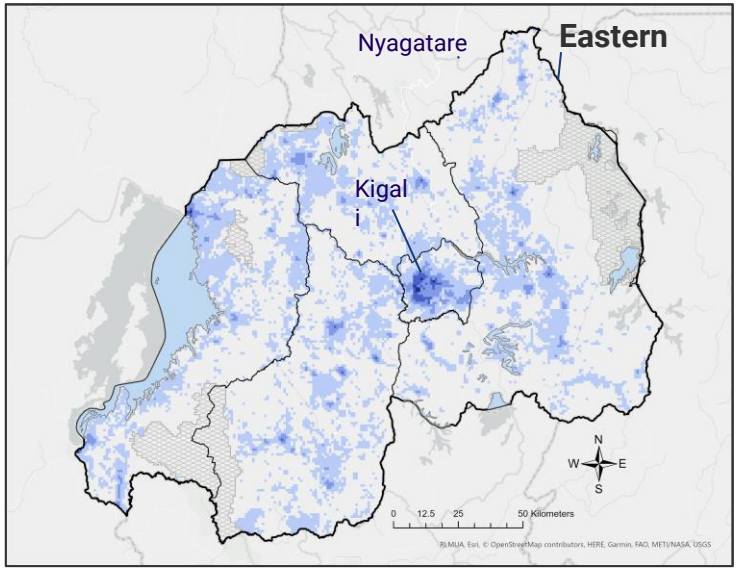
In Rusizi district, peri-urban and rural early-adopters are common along the NR-11 from Tara to the capital of Cyangugu. These areas around Lake Kivu are connected to the city of Bukavu in the DRC.

Concentrations of peri-urban and rural early-adopters are common outside of the Huye city center near the University of Rwanda in Tumba and where the NR-10 and NR-1 roads fork.

Note 1: This map shows the estimated number of peri-urban and rural early-adopter households per 1km^2. 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, Rwanda 2015 DHS

Fast-Followers

There are around 1.3 million fast-follower households, representing nearly 41 percent of all households in Rwanda. Several districts in the Eastern province along with the Kigali district of Gasabo have the highest concentration of fast-follower households.



Note 1: This map shows the estimated number of fast-follower households per 1km^2. 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, Rwanda 2017 MIS, Rwanda 2015 DHS

1.3M Fast-Follower households

32% of households are headed by a woman

4.3 Average household size

8% of household heads have completed secondary education

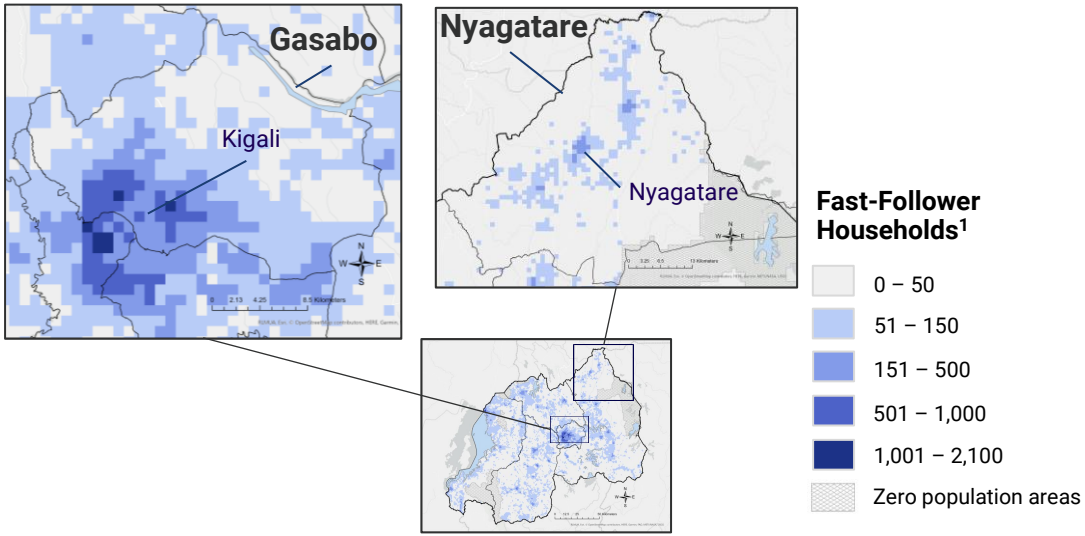
69% use wood as their primary cooking fuel

15% use charcoal as their primary cooking fuel

15% use straw as their primary cooking fuel

Fast-Followers

Two in five households in the Eastern province are fast-followers with a similar proportion in the district of Nyagatare. The Gasabo district in Kigali also has a high concentration of fast-followers, representing over 30 percent of households in the district.



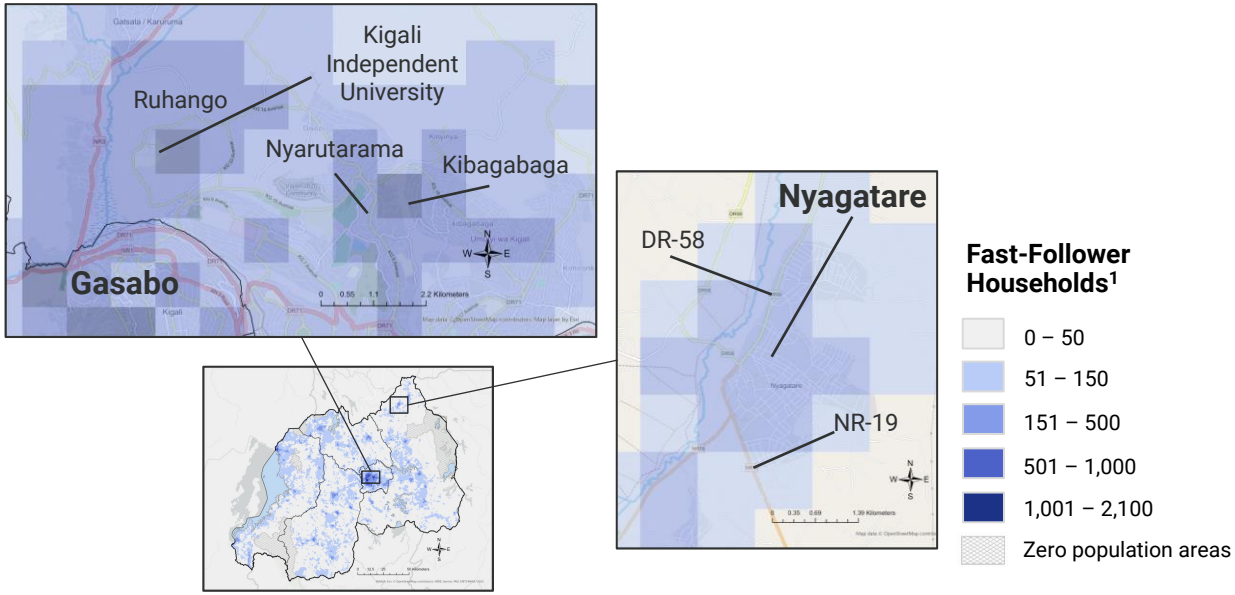
Note 1: This map shows the estimated number of fast-follower households per 1km^2. Fast-follower households own at least one high-cost asset or have access to a bank account and have housing made of at least one high-quality material.
Source: Fraym, Rwanda 2015 DHS

Top Districts with Fast-Followers

Region	District	Number of Fast-Follower Households
Eastern	Nyagatare	75,000
Kigali	Gasabo	68,000
Eastern	Gatsibo	62,000
Eastern	Kayonza	54,000
Eastern	Bugesera	47,000
Eastern	Kirehe	46,000
Northern	Ngoma	46,000
Southern	Nyamagabe	44,000
Western	Rusizi	43,000
Southern	Kamonyi	42,000

Fast-Followers

There is a high density of fast-follower households in the Southwest of Kigali's Gasabo district and in the town of Nyagatare.



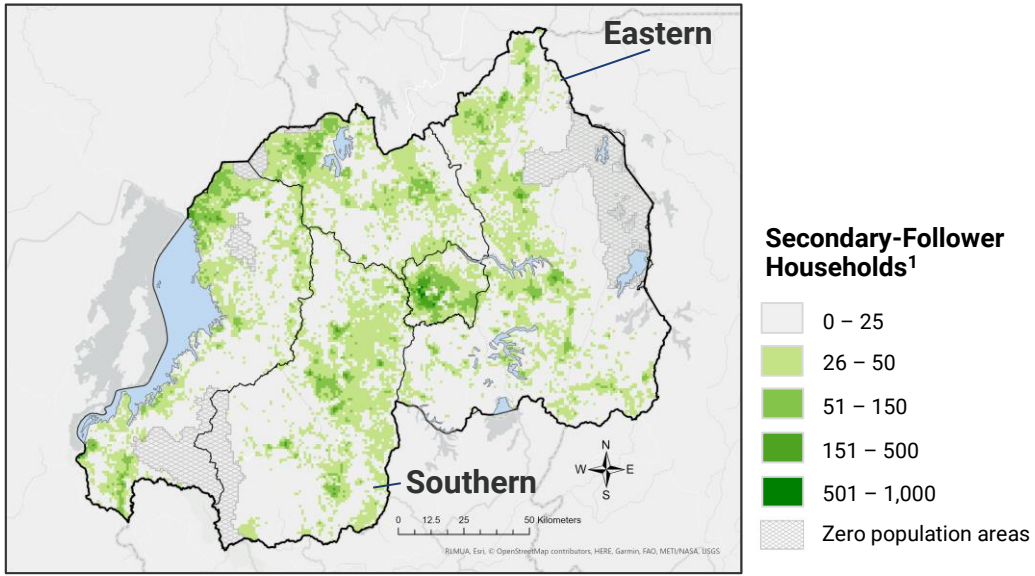
A high density of fast-follower consumers live in the affluent Kigali suburbs of Nyarutarama and Kibagabaga as well as in Ruhango around the Kigali Independent University.

Although more spread out, many fast-follower households are located where the NR-19 meets the DR-58 in Nyagatare's city center.

Note 1: This map shows the estimated number of fast-follower households per 1km^2. 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, Rwanda 2015 DHS

Secondary-Followers

There are around 700,000 secondary-follower households, representing nearly 22 percent of all households in Rwanda. Secondary-follower households are spread throughout the country, with the highest numbers in the Eastern and Southern Provinces.



Note 1: This map shows the estimated number of secondary-follower households per 1km^2. 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, Rwanda 2017 MIS, Rwanda 2015 DHS

700,000 Secondary-Follower households

30% of households are headed by a woman

3.9 Average household size

1% of household heads have completed secondary education

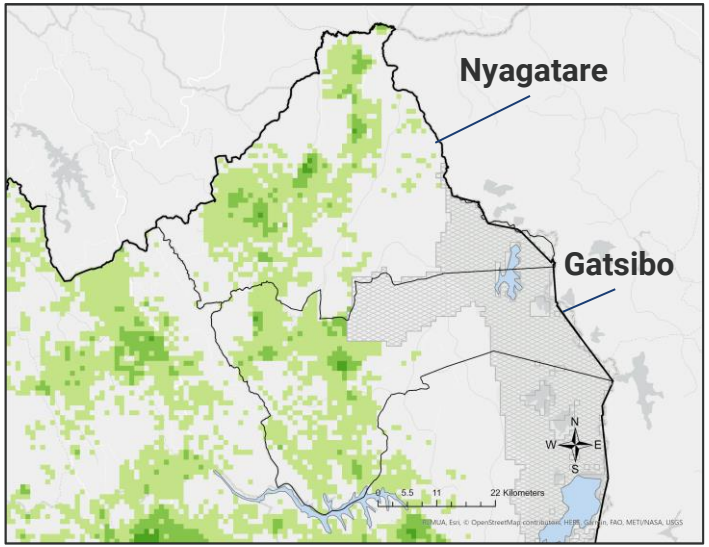
73% use wood as their primary cooking fuel

16% use straw as their primary cooking fuel

11% use charcoal as their primary cooking fuel

Secondary-Followers

Close to 25 percent of all consumers in the Eastern districts of Nyagatare and Gatsibo are secondary-follower households. These households are spread throughout the districts with pockets of high densities around city centers.



Secondary-Follower Households[1]

- 0 – 25
- 26 – 50
- 51 – 150
- 151 – 500
- 501 – 1,000
- Zero population areas

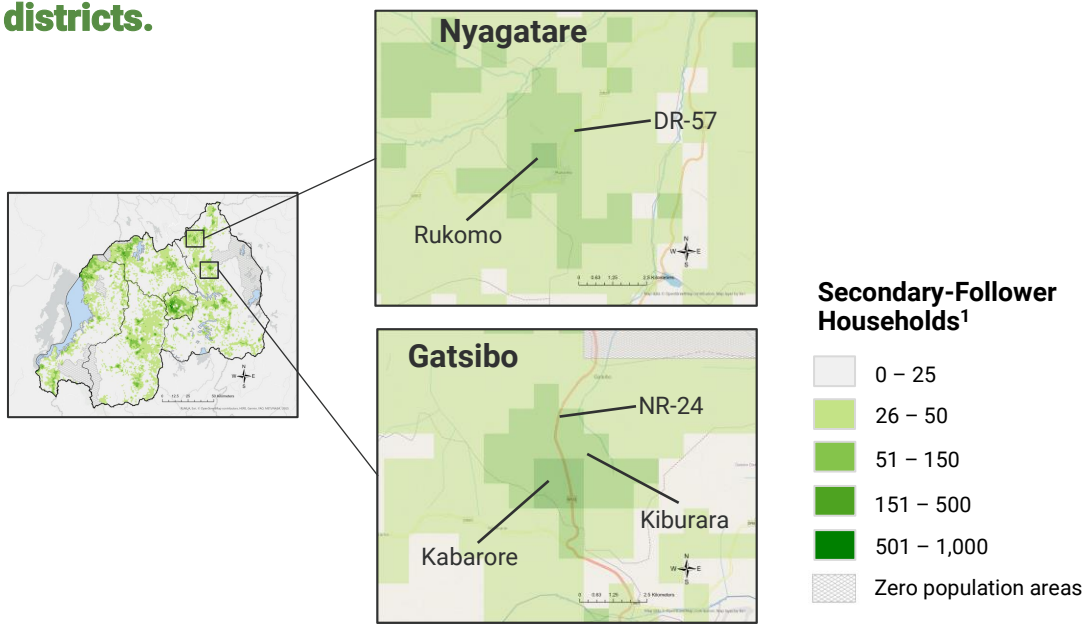
Note 1: This map shows the estimated number of secondary-follower households per 1km^2. Secondary-follower households own at least one high-cost asset or own a radio and have housing made of at least one high-quality material.
Source: Fraym, Rwanda 2015 DHS

Top Districts with Secondary-Followers

Region	District	Number of Secondary-Follower Households
Eastern	Nyagatare	49,000
Eastern	Gatsibo	35,000
Eastern	Kirehe	26,000
Eastern	Kayonza	26,000
Northern	Gicumbi	26,000
Southern	Nyanza	25,000
Western	Rubavu	25,000
Kigali	Gasabo	24,000
Northern	Musanze	24,000
Eastern	Bugesera	24,000

Secondary-Followers

Secondary-followers are dispersed throughout the Eastern province, with concentrated areas in towns near major roadways in Nyagatare and Gatsibo districts.



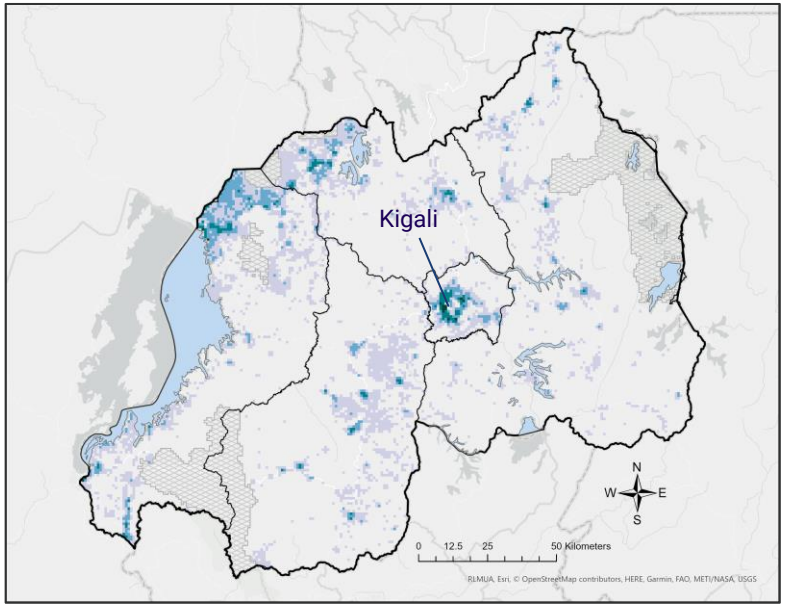
In Nyagatare, secondary-followers are common along the DR-57, especially in the town of Rukomo.

Secondary-followers are also clustered around the towns of Kabarore and Kiburara along the NR-24 in Gatsibo.

Note 1: This map shows the estimated number of secondary-follower households per 1km^2. 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, Rwanda 2015 DHS

Limited Demand

There are around 900,000 limited demand households, representing 28 percent of all households in Rwanda. Limited demand consumers are common just outside of Kigali and in the Northwest of the country.



Limited Demand Households[1]

- 0 – 50
- 51 – 100
- 101 – 200
- 201 – 500
- 501 – 1,000
- Zero population areas

Note 1: This map shows the estimated number of limited demand households per 1km^2. Limited demand households do not fit any of the four core consumer profiles due to their limited consumption ability.
Source: Fraym, Rwanda 2017 MIS, Rwanda 2015 DHS

900,000 Limited Demand households

46% of households are headed by a woman

3.6 Average household size

1% of household heads have completed secondary education

67% use wood as their primary cooking fuel

25% use straw as their primary cooking fuel

8% 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 900,000 limited demand households in Rwanda.

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]

Urban Early-Adopters
High consumption ability

Urban households that:

Owns at least one high-cost cost

AND

All high-quality housing material[2]

AND

Access to electricity

Peri-urban and Rural Early-Adopters
High consumption ability

Peri-urban and rural households that:

Owns at least one high-cost asset

AND

All high-quality housing material[2]

AND

Access to electricity

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	Owns at least one high-cost asset	**OR**	Bank Account **AND** Housing made of at least one high quality material[1]
Secondary-Followers Medium-low consumption ability	Owns at least one high-cost asset	**OR**	Owns a radio **AND** Housing made of at least one high quality material[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

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 2017 Rwanda Malaria Indicator Survey, the 2015 Rwanda Demographic and Health Survey (DHS), the 2016 Rwanda FinScope Survey and the Rwanda 2017 Integrated Household Living Conditions Survey 5 (EICV 5). These surveys are designed to be nationally representative and use a stratified two-stage sample design. The 2017 MIS data were enumerated between October and December 2017, with a total sample size of 5,100 households. The DHS data were enumerated between November 2014 and April 2015, with a total sample size of 12,792 households. The FinScope data were enumerated between October 2015 and January 2016, with a total sample size of 12,480 households. The EICV 5 data were enumerated over a 12-month cycle from October 2016 to October 2017, with a total sample size of 14,580 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 km^2).

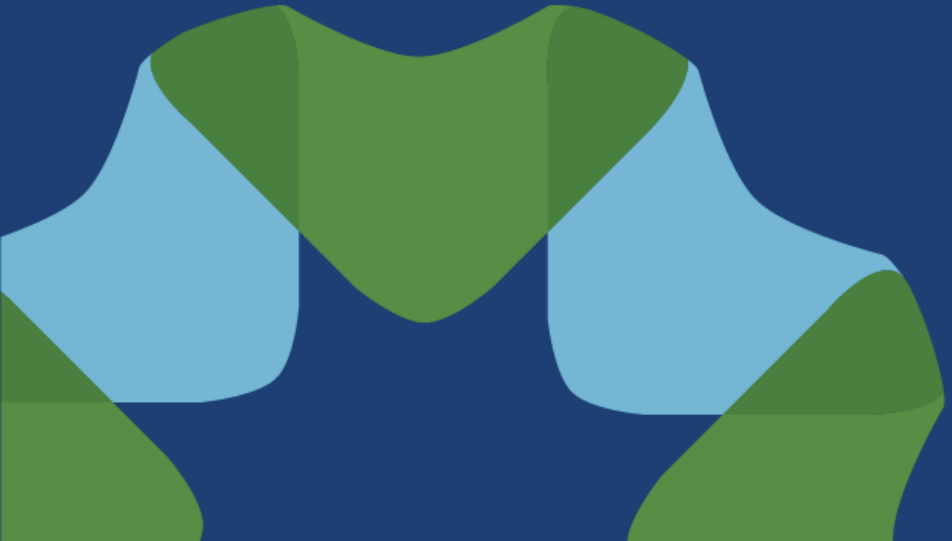
The primary data input is data from existing high-quality, geo-tagged household surveys. Key indications of a high-quality household survey include implementing organization(s), sample design, sample size, and response rates. Fraym has collected, cleaned, and harmonized more than 1,000 of these surveys 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 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



Marina Tolchinsky
m.tolchinsky@fraym.io

Lead Analysts: Carlos Chua, Sean Walsh