Are They Really Being Served?
Assessing Effective Infrastructure Access and Quality in 15 Kenyan Cities

Sumila Gulyani
Andrea Rizvi
Debabrata Talukdar
Abstract

This paper proposes a framework that examines three levels of access to infrastructure—nominal, effective, and quality-adjusted access. Most conventional indicators measure nominal access—whether a household has physical access to a service in or near the house. By contrast, effective access incorporates functionality and use of service, and quality-adjusted access raises the bar by incorporating quality metrics. The paper illustrates the analytical utility of this conceptual framework by deploying data from a survey of 14,200 households in 15 Kenyan cities in 2012–13.

First, the analysis finds that these cities fall far short of delivering universal access to basic infrastructure. Second, for most services there a large gap—3 to 41 percentage points—between nominal and effective access. When the bar is raised to include quality of service, the drop-off in the proportion of those with access is even more dramatic. These findings suggest that conventional nominal measures overreport the level of service in urban communities, and that current approaches to infrastructure delivery might be enhancing availability of a service without ensuring that the service is usable—that is, functional, reliable and affordable. Third, there is an infrastructure access gap between nonpoor and poor households, as well as formal and informal settlements. Fourth, hedonic regression analysis reveals that four services—electricity, water, toilets, and garbage collection—are associated with higher rents. The analysis has broader implications for understanding and measuring service access. It raises important questions as global discussions turn to indicators for the Sustainable Development Goals.
Are They Really Being Served?
Assessing Effective Infrastructure Access and Quality in 15 Kenyan Cities

Sumila Gulyani
Andrea Rizvi
Debabrata Talukdar

JEL: O18, R22
Keywords: Infrastructure access, service quality, household demand, Kenya, Africa.
Acknowledgments

This paper is a product of the Urban Strategy and Analytics Global Solutions Group in the Social, Urban, Rural and Resilience Global Practice (GPSURR). For their excellent comments and guidance, we are grateful to William Kingdom, Sudeshna Ghosh Banerjee, Paul Kriss, Catherine O’Farrell, Fernanda Ruiz Nunez, Jordan Schwartz, Bernice Van Bronkhorst, Marianne Fay, Sheila Kamunyori, Abdu Mwonge and Wendy Ayres. We are also grateful for the inputs from clients and partners at a multi-sectoral workshop held in Nairobi on Feb 14, 2017 where this study was discussed. The paper has benefited from funding from the Global Partnership for Output-Based Aid (GPOBA). The underlying dataset was drawn from the Kenya State of the Cities Baseline Survey (2016) which was funded by the Government of Kenya, World Bank, Government of Sweden, Cities Alliance, and Bill and Melinda Gates Foundation.
1 Introduction

Access to infrastructure—especially to basic services such as electricity, water, and toilets—is vital to urban well-being (World Bank 1994). Yet, in far too many countries we know very little about the level of access to different services. Data that are reported tend only to measure whether a service is physically available—i.e. the physical presence of a piped water connection, or proximity of households to public transport (Martinez-Santos 2017). In many instances this physical measure of access provides information on potential access but provides little insight on the actual level of usage or functionality of any given service, let alone the quality of service supplied (Shaheed et. al. 2014, Nganyanyuka et. al. 2014, UNICEF/WHO 2012). To understand if households are really being served, we need new ways to measure access.

In this paper, we differentiate between three levels of access—nominal, effective, and quality-adjusted access. A household is deemed to have ‘nominal access’ if it has physical access to a service at home, in the yard, or in proximity. A household is deemed to have ‘effective access’ only if two conditions can be satisfied (i) the household has physical access or connection, and (ii) this service works and is relied on by that household. The measure captures a household’s revealed preference – measuring availability as well as ability and willingness of the household to both use and pay for service. It has powerful implications for policy, particularly output-based approaches as it reflects a concern not just for the accessibility of service, but its usefulness and functionality in a way that aligns with global Sustainable Development Goals (SDGs). To take it one step further, we capture the quality and performance of services using a ‘quality-adjusted’ measure of access that accounts not only for functionality but desirable levels of access. For example, in the water sector, effective access measures the number of households with a physical connection that is used as a primary source. In contrast, an appropriate quality-adjusted access indicator might be one that limits this to include only those households with connections that provide continuous 24/7 water supply. This quality-adjusted access measure can be used as a benchmarking tool for achieving not just widespread coverage, but also high-quality service.

Drawing on empirical data from 14,200 households across 15 Kenyan cities, we employ our alternative measures of access to examine how effectively households are being served, how much households are spending and how many are benefiting from high-quality service. We then apply our three measures of access to understand how service varies by settlement type and poverty level in urban Kenya. Using hedonic regression analysis, we explore the perceived value of infrastructure services using data from rental markets. First, we investigate the aggregate impact of infrastructure variables on rent. Then, we examine the relative impact of different infrastructure services on rent and whether higher-quality services translate into higher rents. Finally, we analyze our data to identify factors that systematically impact the likelihood of access for a household to each of the selected infrastructure services.

2 Survey Data and Methodology

To examine questions of access, this study draws on the results of a comprehensive “Kenya State of the Cities” baseline study of over 14,200 urban households in 15 cities, commissioned by the World Bank and the Government of Kenya. The study used face-to-face household interviews to capture key indicators related to the demographic, infrastructure, and economic profile of the following 15 Kenyan

1 World Bank. 1994. World Development Report 1994: Infrastructure for Development. New York: Oxford University Press. World Bank. [http://hdl.handle.net/10986/5977](http://hdl.handle.net/10986/5977).
cities: Eldoret, Emu, Garissa, Kakmega, Kericho, Kisumu, Kitui, Machakos, Malindi, Mombasa, Nairobi, Naivasha, Nakuru, Nyeri and Thika. The sample is representative of households in both formal and informal (slum) settlements. Field data collection began in July 2012 and continued through to March 2013. Two caveats are important here. This survey was completed before the onset of devolution under the new Kenyan constitution – that is, prior to the establishment of counties and abolition of municipalities in Kenya in 2013. Although the process of reestablishing municipalities has commenced in Kenya in 2018, the new jurisdictions may not necessarily align with the ones that existed prior to 2013. Second, we use the term “city” broadly to refer to all the urban areas studied, rather than use administrative terminology, specified in Kenya’s Urban Areas and Cities Act, that distinguishes between municipalities, cities and towns.

Unlike prior research in Kenya, this survey provides a more comprehensive picture of living conditions and infrastructure service throughout urban Kenya. It offers previously unavailable data on formal and informal urban settlements in 15 of Kenya’s major urban centers and is one of only a few known multi-sectoral studies of this scale that covers urban Africa (Arimah 2003, Steckel et. al. 2017).

2.1 Survey Methodology

Details of the survey sampling and data collection methodology can be found in the Kenya State of the Cities Baseline Survey: Overview Report (World Bank 2016). Table 2.1 summarizes the household composition of the final sample by location and income poverty level. Overall, the sample draws on a data set of 14,583 household surveys. Of these, 14,204 are classified as urban households; almost a third of the households interviewed (32.7%) were located in informal areas and over half the households (51.1%) surveyed were poor.

---

2 For the purposes of this survey, ‘poor’ households are defined as those below the national expenditure-based criteria for the poverty line. The Kenya national poverty line was adjusted for inflation at the start of the survey. This poverty line varies according to number and age of household members, but it is calculated based on the following: 5,547 Ksh/month for each adult>15 years; 3,619/month for youth 5-14 years; and 1,336/month for children<5 years (NORC study, 2012).
TABLE 2.1: Settlement and Poverty characteristics of survey sample

| City       | Proportion of Urban HH in INFORMAL AREAS | Proportion of Urban HH who are POOR |
|------------|------------------------------------------|-----------------------------------|
|            | N | Value | N       | Value  |
| Eldoret    | 976 | 30%   | 970     | 69%    |
| Embu       | 1,014 | 13%   | 1,007  | 49%    |
| Garissa    | 1,035 | 2%    | 1,035  | 47%    |
| Kakamega   | 967 | 6%    | 952     | 48%    |
| Kericho    | 1,035 | 11%   | 1,031  | 85%    |
| Kisumu     | 671 | 62%   | 642     | 49%    |
| Kitui      | 591 | 6%    | 562     | 74%    |
| Machakos   | 630 | 6%    | 629     | 63%    |
| Malindi    | 956 | 5%    | 953     | 64%    |
| Mombasa    | 1,095 | 26% | 1,091  | 59%    |
| Nairobi    | 1,182 | 41%   | 1,145  | 43%    |
| Naivasha   | 1,007 | 10%   | 1,000  | 71%    |
| Nakuru     | 1,095 | 5%    | 1,079  | 62%    |
| Nyeri      | 959 | 5%    | 952     | 50%    |
| Thika      | 988 | 18%   | 981     | 47%    |
| ALL 15 Cities | 14,201 | 33% | 14,029 | 51% |

2.2 Poverty and settlement characteristics of the survey sample

Within the sample there were wide variations in both the level of informality, and the level of poverty across cities. This is shown in Table 2.1. A few cities (e.g. Kisumu 62%; Mombasa 26% and Nairobi 41%), had a disproportionately large proportion of informal settlements, whereas in most other cities the level of informality did not exceed 10 percent (Garissa 2%; Kakamega 6%; Kericho 11%; Kitui 6%; Machos 61%; Malindi 5%; Naivasha 10%; Nakuru 5%; Nyeri 5%).

In general, the percentage of households that were poor in monetary terms was much higher than the percentage of households that lived in informal settlements. Surprisingly, there was little correlation observed between levels of informality and poverty. Nairobi, which had one of the highest levels of informality, also benefited from the lowest level of poverty with only 43% of households sampled below the poverty lines. Poverty rates were much higher in other cities such as Kericho (85%); Kitui (74%) and Naivasha (71%). Overall, 8 of the 15 cities had a higher proportion of poor households (>50%) than non-poor households showing the high rates of poverty overall across urban Kenya. The poverty rate for the sample for all 15 cities across settlement types was 51.1%.
Figure 2.1 depicts the variations in both informality and poverty. It shows the relatively high, but varying rates of poverty across cities. It also demonstrates the limited correlation between the two variables. The two cities with the highest rates of informality (e.g. Embu and Kakamega) also have among the lowest rates of monetary poverty.

When the data are consolidated for all 15 cities, we find that the proportion of poor is very similar in formal and informal settlements across the sample (50% poor in formal settlements vs 53% poor in informal settlements). The difference in poverty level is not significant between formal and informal settlements overall. This implies that poverty is pervasive across Kenya, with poor households also living outside slums.

3. Measuring Infrastructure Access

In this section, we examine different ways to understand and measure infrastructure access. We first review traditional measures of “nominal” access – looking at indicators that focus on physical access or connection. We compare this to a more nuanced understanding of access that incorporates functionality and use of service. This we name ‘effective’ access. We review how these different interpretations of access yield strikingly different understandings of service coverage and discuss the critical importance of addressing this gap for efficient service delivery.

We then expand the discussion by incorporating additional performance metrics into our access indicator – developing a ‘quality-adjusted’ measure of access. The aim is to develop a benchmark indicator that not only offers a ‘desirable’ goal for service coverage but also can be compared to effective access indicators to provide insights into the quality of overall service coverage and sector investment priorities. Clearly the desirable benchmark for quality will vary according to context and has cost implications that
should be locally determined. In this paper we offer example quality indicators that we believe reflect the ‘minimum’ level of service in most contexts.3

Finally, because a discussion of access is incomplete without considering issues of affordability, we examine monthly household expenditures on different services. Affordability powerfully influences how much of a service reaches or is used at the household level. Towards the end of this section we therefore discuss the relative affordability of different services and its implications for access, before concluding with a summary of findings by providing a sector snapshot for urban Kenya.

3.1 Comparing nominal and effective access

Prior to evaluating relative levels of service access, it is important that we define our understanding of this term. As discussed above, we will consider two discrete measures of access for this analysis. The first, ‘nominal access’ reflects the existence of physical access or connection. For example, in the water sector, nominal access measures the physical presence of a household-level connection to water service. It is relatively easy to record and as a result is a commonly employed indicator. Nominal access indicators for nine sectors for which we collected data are listed below:

Nominal access indicators:
- Electricity: %HH with in-house electricity
- Water: %HH with in-dwelling or in-compound (shared or private) piped water
- Toilet: %HH with non-public toilet facility (shared or not)
- Sewage Disposal: %HH with connection to public sewer or septic/soak pit
- Access Roads: %HH with ‘surfaced’ access roads (paved/tarmac/gravel/murram – but not earth)
- Public Transport: %HH who have public transport service within 20-minute walk
- Garbage Collection: %HHs with some form of organized garbage collection (private or public)
- Street Lights: %HHs who have street lights or lamp posts on their streets
- Phones: %HH with phone/mobile connection

The use of nominal access however does not provide any information about the functionality of the access provided – whether the piped connection works or provides potable water or reliable service. To better capture these aspects of access we have introduced a second measure that we refer to as ‘effective access’. This measure records not just whether a physical connection exists, but also whether it works, and is relied on. Thus, in the water sector, effective access would be recorded where there is a physical connection, that is also used as a primary source. The shift from nominal to effective access mirrors the transition that is happening globally with the move from the Millennium Development Goals (MDGs) to the SDGs as a means of measuring development success. Specifically, as compared to MDGs, SDGs are more holistic in nature and capture performance dimensions of services. For instance, SDG 7 focuses on energy and sets the goal as “ensuring access to affordable, reliable and modern services for all by 2030.” In setting the bar for effective energy access in our study, we incorporate the affordability and reliability of service by using the following indicator – percent of households with in-house electricity access who also use it as their primary lighting source.

---

3 In the instance of water and electricity, we use 24-hour service as a minimum benchmark. We offer this as a desirable minimum standard and worthy goal in most contexts, while also emphasizing that it may not be a relevant target for all services or settings, especially where resources are constrained.
For the purposes of this analysis, we defined indicators of effective access for the nine sectors as follows:

**Effective access indicators:**
- Electricity: %HH with in-house electricity who also use it as primary source of lighting
- Water: %HH with in-dwelling or in-compound (shared or private) piped water and it is their most important source
- Toilet: %HH with non-public toilet facility (shared or not), but shared with fewer than 20 people
- Sewage Disposal: %HH with connection to public sewer or septic/soak pit that is emptied by truck or manually
- Access Roads: %HH with ‘surfaced’ access roads, and road is in good condition during the most recent dry season
- Public Transport: %HHs who have at least one HH member whose main mode of transportation to work or school is a microbus/matatu/regular bus
- Garbage Collection: %HHs with some form of garbage collection and it is collected weekly
- Street Lights: %HHs who have street lights or lamp posts and they work most of the time
- Phone: %HH with functioning phone/mobile

Table 3.1 provides data on the level of nominal and effective access across sectors for all 15 urban centers. In urban Kenya, nominal access varies widely across services. Phone service (predominantly privately delivered mobile service) and public transport are outliers with high rates of access. The vast majority (93%) of households can access public transport within 20 minutes of their home. Mobile phones are also readily available in households throughout urban Kenya with impressive levels of access of 90%. There has also been some success in rolling out household connections in the electricity sector. Over three-quarters of households report an electricity connection (76%). However, even with this relatively high penetration rate, there remains approximately one in four urban households without electricity. Approximately two-thirds of households in urban Kenya are also served by toilets, with 66.9% of households recording nominal access (or almost one-third with no in-house facilities). More than half (58%) of households have an in-dwelling or in-compound piped water connection. The remaining four services for which we have measures of nominal access – sewage disposal, access roads, garbage collection and street lights - have coverage rates between 40-50% (i.e. less than half of households have nominal access, let alone functional service).

---

4 It also provides results broken down by settlement type (formal/informal) and household poverty (non-poor/poor) as well as information on quality-adjusted access. In this section we will focus our discussion on the third column presenting data for “ALL urban centers” which provides information on the overall percentage of households with access to a given standard of service. Discussion of quality-adjusted access as well as the observed differences in infrastructure access between formal/informal and non-poor/poor households is the subject of section 2.2 and section 4.0 respectively.

5 For the purposes of this analysis we have chosen to use a fairly broad definition of water access – that recognizes both in-dwelling and in-compound piped connections that are both private and shared. The inclusion of shared connections was deemed necessary because of the relatively high proportion of residents who lived in shared living arrangements (e.g. compounds) where private piped connection alone is not a realistic service standard.
## TABLE 3.1: Infrastructure access by sector

| Access          | Urban N | By settlement type | By poverty level |
|-----------------|---------|--------------------|------------------|
|                 | ALL     | Formal | Informal | Non-Poor | Poor |
| **Electricity** |         |        |          |          |      |
| Nominal         | 14,202  | 14,202 | 14,202   | 14,030   | 76%  |
| Effective       | 14,202  | 14,202 | 14,202   | 14,030   | 75%  |
| Quality-adjusted| 14,202  | 14,202 | 14,202   | 14,030   | 46%  |
| **Water**       |         |        |          |          |      |
| Nominal         | 14,202  | 14,202 | 14,202   | 14,031   | 58%  |
| Effective       | 14,202  | 14,202 | 14,202   | 14,031   | 55%  |
| Quality-adjusted| 14,202  | 14,202 | 14,202   | 14,031   | 34%  |
| **Toilet**      |         |        |          |          |      |
| Nominal         | 14,199  | 14,199 | 14,199   | 14,027   | 67%  |
| Effective       | 14,199  | 14,199 | 14,199   | 14,027   | 48%  |
| Quality-adjusted| 14,199  | 14,199 | 14,199   | 14,027   | 34%  |
| **Sewage Disposal** |       |        |          |          |      |
| Nominal         | 13,715  | 13,715 | 13,715   | 13,546   | 46%  |
| Effective       | 13,715  | 13,715 | 13,715   | 13,546   | 42%  |
| Quality-adjusted| 13,715  | 13,715 | 13,715   | 13,546   | 41%  |
| **Access Roads**|        |        |          |          |      |
| Nominal         | 14,203  | 14,203 | 14,203   | 14,031   | 41%  |
| Effective       | 14,203  | 14,203 | 14,203   | 14,031   | 33%  |
| Quality-adjusted| 14,203  | 14,203 | 14,203   | 14,031   | 24%  |
| **Public Transport** |      |        |          |          |      |
| Nominal         | 14,202  | 14,202 | 14,202   | 14,030   | 93%  |
| Effective       | 14,204  | 14,204 | 14,204   | 14,031   | 52%  |
| Garbage Collection |      |        |          |          |      |
| Nominal         | 14,196  | 14,196 | 14,196   | 14,024   | 48%  |
| Effective       | 14,196  | 14,196 | 14,196   | 14,024   | 38%  |
| **Street Lights** |        |        |          |          |      |
| Nominal         | 14,198  | 14,198 | 14,198   | 14,028   | 46%  |
| Effective       | 14,197  | 14,197 | 14,197   | 14,027   | 32%  |
| **Phone**       |         |        |          |          |      |
| Nominal         | 14,166  | 14,166 | 14,166   | 13,998   | 90%  |
| Effective       | 14,166  | 14,166 | 14,166   | 13,998   | 90%  |

Notes:
1. Statistical significance is denoted 'a' (sig. at <=1%); 'b' (sig. at <=5%); "c" (sig. <=10%)
2. For phones, there was no measurable difference between nominal and effective access. A very small percentage of landlines were non-working, but these households also owned a working mobile phone.

However, as discussed earlier, nominal access data can be misleading as they do not accurately reflect either the functionality of service, or whether the service is used. Figure 3.1 depicts both nominal and effective levels of access, showing the significant disparity that can occur between variables. For example, we find that while 93% of households are located within a 20-minute walk of public transport facilities (or nominal access), only 52% of households have a member who regularly uses these facilities. This suggests that while there has been considerable investment, mostly by the private sector, in expanding the public transport network, only about half of households need to use it. It illustrates not only the potential pitfalls of relying solely on nominal access data as a measure of service coverage, but
highlights that there may be other sector issues such as service reliability, quality and/or affordability that need to be addressed.

Similar findings emerge across sectors. For most services, there is a decline in access levels when a more rigorous effective access criterion is applied. For water, electricity and phone service this decline is negligible. In these sectors service provider(s) appear to have been effective at ensuring that delivered household connections are for the most part, functional and used. But for all other sectors the discrepancy is more marked—toilets, sewage disposal, access roads, public transport, garbage collection and street lights have levels of effective access that are 50% or less, with differentials between nominal and effective access rates for most sectors of 10-20%. For public transport, the differential is even larger at 41%.

These differentials show that measures of access that rely solely on recording physical connection may be greatly overestimating actual or ‘effective’ levels of service coverage. More importantly however they reveal that investments in physical connections in some sectors have been misplaced and are not delivering service as anticipated. For example, while public transport routes may be relatively extensive, other hurdles such as affordability, reliability and frequency of service may be preventing households from using public transport. This information suggests that investment strategies may need to be revisited for public transport and other sectors – shifting the focus from further extension to service adjustment and quality improvements. Addressing and understanding this mismatch between nominal and effective access should be a core concern in sector discussions and should guide sector investment strategies.

FIGURE 3.1: Infrastructure polygon for urban Kenya
3.2 Comparing service quality across sectors

As we have discussed, effective access provides useful insights into the level of functional service coverage, and whether investments are yielding effective outcomes. Yet, even this more rigorous standard fails to provide much information on service quality. While a private piped connection may serve as a household’s primary source, its value to users can be diminished if water supply is intermittent and/or not potable. Information on the quality of service is important for refining investment priorities.

The baseline survey included questions on service quality for most sectors. We used these responses to develop a ‘quality-adjusted’ access variable that records what we deem is the minimum ‘desirable’ level of service in each sector. Notably this includes a 24-hour service requirement for the water and electricity sectors. Though this is a reasonable expectation in most contexts, it may be unrealistic where resources are highly constrained. Because quality is a subjective measure and requires trade-offs with affordability, the desirable threshold for each indicator in any particular setting will need to be determined in consultation with local groups, neighborhoods and context. Table 3.1 above records the threshold indicators we developed across five services - electricity, water, toilets, sewage disposal, and access roads. For the purposes of this analysis, we have defined indicators for quality-adjusted access as follows:

**Quality-adjusted access indicators:**
- Electricity: %HH with in-house electricity who also use it as a primary source of lighting, and 24-hour supply and rare outages
- Water: %HH with in-dwelling or in-compound (shared or private) piped water who use it as their primary source and have 24/7 supply
- Toilet: %HH with non-public toilet facility (shared or not), but shared with fewer than 10 people
- Sewage Disposal: %HH with connection to public sewer or septic/soak pit that is emptied by truck (non-manual)
- Access Roads: %HH with ‘surfaced’ access roads, and road is in good condition during the most recent dry season and usable last rainy season (i.e. proxy for all-weather access).

A graphic presentation of these data is provided in Figure 3.2 – showing the relative proportion of households with access to quality-adjusted service standards across sectors, and how this compares with nominal and effective service levels within sectors.

For the most part, the new quality-adjusted variable follows similar patterns across sectors to measures of both nominal and effective access. In relative terms, the electricity sector performs the best with almost half (46%) of the households achieving this standard (i.e. in-house electricity that is used as a primary source of lighting, offers 24-hour supply and outages are rare). Access roads performs the worst, with under a quarter (24%) of households reporting quality-adjusted levels of service.7

There are however some noticeable deviations in the relative rates of access across these three variables. For example, in the electricity sector both nominal and effective access is relatively high at 76% and 75% respectively, but quality-adjusted access is only 46%. While there is very little difference between nominal and effective access rates for electricity, there is a noticeable decline in coverage when we consider only quality-adjusted levels of electricity service. This hints at problems with electricity supply –

---

6 As discussed in section 3.1, access indicators include an implicit measure of quality that is captured by its usage and functional dimensions to determine an ‘acceptable’ level of service. However, many dimensions of service quality are omitted from this variable. We argue that a separate variable is warranted that defines a ‘desirable’ level of service.

7 Defined as a ‘surfaced’ access road that is in good condition during the most recent dry season and usable during the last rainy season.
while most households have and use physical connections, a significant portion of these households have issues with duration and reliability of supply. In other words, almost 30% of households experience less than 24-hour service and regular outages. When determining sector investment priorities, decision makers need to weigh the need for supply upgrades against the value of expanding coverage to remaining households which have no service.

In the water sector there is also a marked decline in coverage of ‘quality-adjusted’ service, despite little difference between nominal and effective access. The data reveal that 58% of households have in-dwelling or in-compound piped connection (nominal access), and 55% have this level of connection and use it as their primary source (effective access). There is a marked drop to 28% of those households that have this level of connection, use it as their primary source, and benefit from continuous 24/7 supply.

For the toilets and access roads sectors we observed significant declines between nominal, effective and quality-adjusted rates of access. This pattern of results suggests that investments to date in coverage expansion for these sectors have not been highly effective, and that further investigation of underlying supply, affordability and/or quality issues is necessary before additional investment in service expansion.

Conversely, for sewage disposal, the data show that there are only marginal declines between nominal, effective and quality-adjusted service levels. We can infer from these results that the existing delivery mechanism has been successful at providing sewage disposal of desirable quality. However, the relatively low coverage levels overall – 46%, 42% and 41% respectively – indicate that investment in service coverage expansion is a priority.

As can be seen from above, the comparison of nominal, effective and quality-adjusted measures of access allows policy makers to develop a more nuanced understanding of the functionality and quality of existing services leading to the development of more informed sector investment strategies. We now turn to a discussion of affordability and how it too impacts access.

FIGURE 3.2: Comparing levels of infrastructure service
### 3.3 Comparing spending across sectors

In addition to compiling access and quality data, the household survey collected valuable information on household spending patterns across infrastructure services. Typically, this type of data is collected as part of sectoral studies that focus exclusively on household expenditures for a particular service. By offering comparison across sectors the data set provides a rare comparative insight into household spending by sector. It reports household expenditures on different services and consumption items simultaneously, allowing us to examine absolute expenditures – and their share of household budgets – in relative terms.

Table 3.2 provides data on monthly infrastructure spending for four sectors - electricity, water, garbage collection, and phone. For comparative purposes, data on cooking fuel costs and rents were added to the compilation. As before, this section will focus on data for all cities. Comparative analysis of spending by settlement type and household poverty is discussed in Annex 4.

#### TABLE 3.2: Monthly household spending on infrastructure services

| Infrastructure Monthly Expenditure (Ksh/month) | N | ALL Urban KSH | By Settlement Type | By Poverty Level |
|---------------------------------------------|---|----------------|-------------------|-----------------|
|                                             |   |                |                   |                 |
| Electricity                                 |   |                |                   |                 |
| Mean                                        | 5,167 | 5,167 | 5,167 | 5,167 | 5,167 |
| Median                                      | 5,167 | 5,167 | 5,167 | 5,167 | 5,167 |
| Water (piped)                               | 6,843 | 6,843 | 6,843 | 6,843 | 6,843 |
| Mean                                        | 6,843 | 6,843 | 6,843 | 6,843 | 6,843 |
| Median                                      | 6,843 | 6,843 | 6,843 | 6,843 | 6,843 |
| Garbage Collection                          | 1,995 | 1,995 | 1,995 | 1,995 | 1,995 |
| Mean                                        | 1,995 | 1,995 | 1,995 | 1,995 | 1,995 |
| Median                                      | 1,995 | 1,995 | 1,995 | 1,995 | 1,995 |
| Phone                                       | 10,858 | 10,858 | 10,858 | 10,858 | 10,858 |
| Mean                                        | 10,858 | 10,858 | 10,858 | 10,858 | 10,858 |
| Median                                      | 10,858 | 10,858 | 10,858 | 10,858 | 10,858 |
| Home Cooking Fuel                           | 13,602 | 13,602 | 13,602 | 13,602 | 13,602 |
| Mean                                        | 13,602 | 13,602 | 13,602 | 13,602 | 13,602 |
| Median                                      | 13,602 | 13,602 | 13,602 | 13,602 | 13,602 |
| House Rent                                  | 10,868 | 10,868 | 10,868 | 10,868 | 10,868 |
| Mean                                        | 10,868 | 10,868 | 10,868 | 10,868 | 10,868 |
| Median                                      | 10,868 | 10,868 | 10,868 | 10,868 | 10,868 |

Notes:
1. Conversion using 84.5 Ksh equivalent to 1 USD (WDI exchange rate for 2012)
2. Our data suggests that 40% of households have electricity and/or water charges included in their rent. These costs could not be disaggregated and are therefore not represented in above estimations.

The data reveal that phone service (predominantly mobile phones) is on average the most expensive infrastructure service on a monthly basis for households. Households allocate an estimated 1,501 Ksh/month (17.75 USD) to phone service. This is 20% more than the mean amount allocated to home cooking fuel (1,234 Ksh/month; 14.60 USD), and a third of the amount allocated to monthly house rent (4,515 Ksh/month; 53.41 USD). It is however 50% more than the next most expensive infrastructure service which is electricity at 986Ksh/month (11.66 USD).

The four other services are less expensive on a monthly basis. Piped water (shared or private) averages 555 Ksh/month (6.57 USD) which is significantly less than that spent on cooking fuels or rent, and about...
a third of that spent on phones. Organized garbage collection, which has decent overall frequency of collection but low coverage, is even less expensive than water, costing only 163 Ksh/month (1.93 USD).

It is interesting to note that for all infrastructure services, as well as for home cooking fuels and house rent, the value of the mean is significantly higher than the median. This suggests that the distribution of monthly expenditures for these services is skewed to the right – i.e. the majority of the households pay less than the mean, but a few households pay significantly more. Thus, mean values may not be a good representation of typical expenditures. This is particularly the case for water, where the mean value of 555 Ksh/month is 20 times higher than the calculated median of 28 Ksh/month.

### 3.4 Sector snapshot: Urban infrastructure in Kenya

The data compiled thus far provide a snapshot of the state of urban infrastructure in Kenya. Not only do they show the considerable variability in infrastructure service access and spending across sectors in urban Kenya, but they also reveal the important nuances in service access which emerge when access is defined differently. But our data also reveal certain patterns in infrastructure provision that are consistent across the 15 Kenyan cities that are worth reviewing.

Firstly, our data reconfirm the telecoms story – that private delivery of mobile phone service has been a success story in urban Kenya. This relatively new technology has universally achieved the highest rates of coverage across cities, and 9 of 10 households use mobile phones despite the relatively high costs associated with this service. Landlines are present in only a small number of households, and all households with this service also have a working mobile phone.

Public transport, which is delivered in large part by private sector providers, also records high levels of nominal access. Our survey revealed that 93% of all the households report that public transport – bus, microbus or matatu service – is available within a 20-minute walk of their residence. Despite the relative proximity of these services however, the level of effective access (i.e. those households that use public transport service) is much lower; representing only about half of the households (52%). Prior to new investments in or policies for urban public transit systems, policy makers would be wise to investigate what other barriers might be inhibiting the use of public transport in Kenyan cities.

Electricity performs consistently well across cities in Kenya, with high levels of both nominal and effective access over 75%. The data confirm that investment over the last decade in expanding service coverage from its low base has been largely successful.

The picture is less satisfactory for other essential services. Piped water is available to only 58% of households, and only 55% of these households use it as a dominant source of water. Though these numbers are disappointingly low, the gap between nominal and effective access is small, suggesting existing delivery methods are largely effective. However, the data reveal that supply quality is a problem. Only approximately one in every four households (28%) benefit from continuous household water supply.

For other sectors, effective access is poor, with a marked decline between nominal and effective rates of coverage. Fewer than half of households (48%) have effective access to toilets even though nominal coverage is higher at 67% or 2 in 3 households. Only 42% of households have effective access to sewage disposal (42%) – comprised predominantly of privately financed soak pit and septic tanks. And only about a third of households have effective access to surfaced, all-weather roads (33%), working street lights (32%) or weekly garbage collection (38%).
As shown in figure 3.2, of the five sectors for which quality data are available, it appears that the electricity and water sectors are the most in need of service quality improvements, with both of these services recording large gaps of over 20% between effective and quality-adjusted access measures.

Finally, the spending data reveal that infrastructure expenditures are significant. Phone is both the most popular service, as well as the most expensive and costs 50% more each month than other infrastructure services. Other sectors such as electricity, water and garbage collection represent a fraction of other expenses such as rent and cooking fuel payments. Further analysis is required to understand the affordability implications by sector.

4. Infrastructure Gap

In this section, we examine how access levels vary across formal and informal settlements as well as poor and non-poor households. We start by comparing relative measures of effective access by sector. We then compare and discuss patterns of nominal, effective and quality-adjusted access by settlement type and poverty level to demonstrate how these different measures change our understanding of levels of service and investment priorities.

4.1 Comparing effective access

Table 3.1 outlines nominal, effective and quality adjusted access indicators for each sector by settlement type, and household poverty levels. We draw on these data to compare effective access levels for each sector by settlement type and poverty level.\(^8\) The aim is to highlight the extent and nature of the infrastructure gap that exists between formal/informal settlements and non-poor/poor households. For comparison purposes, these data are displayed visually in Figure 4.1a and b.

\(^8\) Effective access is selected (rather than nominal or quality-adjusted access) as the appropriate measure for comparison purposes because it best represents the actual level of service experienced at the household level.
FIGURE 4.1a Comparing access by settlement type

FIGURE 4.1b Comparing access by poverty level
As can be seen, there is a fairly consistent and significant gap in access across sectors between formal and informal settlements and non-poor and poor households. Access to services is universally higher in formal settlements relative to informal ones. Likewise, the non-poor are better served than the poor in terms of access.

However, the absolute gap is higher between formal and informal settlements compared to the gap between poor and non-poor households. This finding is consistent with the literature (Pierce 2017). The most extreme example of this disparity occurs for toilets. While 59% of households in formal settlements have effective access to toilets, this drops to 25% in informal settlements. In contrast, effective access in non-poor households is 55%, and drops only to 41% for poor households (i.e. 34% compared to 14% decline). The absolute gap is also higher for the key water and sanitation sectors, and is most noticeable between formal and informal settlements. Figure 4.1a shows clearly the considerable gap in service coverage for water, toilets, and sewage disposal in particular in informal settlements compared to formal settlements. Though a gap is also present between non-poor and poor households for these sectors, the size of this gap is more consistent across sectors. In the remainder of this section we discuss these findings in more detail by sector.

Phone is consistently the most readily available service for all urban households and is the only sector where settlement type and household poverty levels make little difference to access. There is no significant difference in access levels between formal and informal areas, and only a small (but significant) difference in phone access between non-poor (93%) and poor (87%) households. The high rates of coverage overall are testament to the impressive penetration levels achieved predominantly by mobile phone services throughout urban Kenya.

In the road and public transport sectors, formal settlements have better rates of effective access than informal settlements. In formal areas, 38% of households have accessible surfaced roads during the dry season, compared with 24% in informal settlements. This difference is statistically significant. At the household level, those who are poor are less likely to have a surfaced access road in good condition during the dry season (39%) than those who are non-poor (27%). Similarly, for public transport, those who reside in formal settlements are more likely to have a household member that uses public transport (54%) than those who live in informal settlements (48%), whereas non-poor households are more likely to use public transport (57%) than poor households (46%). Both these differences are statistically significant, but in this case the ‘gap’ is largest between non-poor and poor households. It is possible that this indicates that affordability is a more significant concern than availability. This issue warrants further investigation as it has implications for sector investment.

Settlement type and household poverty level are predictors of access for most essential services, including electricity, water, sanitation and waste services. Consistent with earlier findings (refer section 3.1) electricity tends to have high coverage rates. Effective access to electricity is highest in formal settlements (80%) compared to informal settlements (65%); and is also higher in non-poor households (81%) compared to poor households (69%). As for most other sectors, the service gap in electricity is higher by settlement type than poverty level.

The infrastructure gap however is most noticeable in the water and sanitation sectors, where the coverage gap is much larger between formal and informal settlements than non-poor and poor households. Effective access to water is 67% in formal areas compared to 30% in informal areas – representing a significant 37% drop. The difference in service is less marked between non-poor households (63%) and poor households (47%). Large gaps in effective coverage were also observed for the toilet and sewage disposal sectors. As discussed above, the disparity in toilet coverage is far greater between formal and informal settlements than non-poor and poor households. In fact, the poor overall have a higher rate of access to private toilets than those who live in informal settlements. Similar results emerge for sewage
disposal. While 51% of households in formal settlements have access to non-manual disposal methods, only 24% of households in informal settlements benefit from this service. The gap is smaller between non-poor (52%) and poor (33%) households. Again, we see that in absolute terms the poor have better access to sewage disposal than those in informal settlements – or in other words, the type of settlement in which you live is more important than household poverty level in determining access to water and sanitation services. These data highlight the need to expand investment in water, toilets and sewage disposal services in Kenya’s urban slums.

For other essential services the discrepancies between settlement type and poverty level are less distinct. Weekly garbage collection services reach 15% fewer households and working street lights are available to 4% fewer households in informal settlements compared to formal settlements. For these same sectors, there are equivalent differences in service levels between non-poor and poor households. Weekly garbage collection reaches 12% fewer poor households, and working street lights are accessible to 8% fewer poor households than their non-poor equivalent.

Overall there is a clear disparity between access levels for essential services between both formal and informal settlements and non-poor and poor households as can be seen in Figure 4.1a & b above. This infrastructure gap exhibits a different pattern between formal and informal settlement than between non-poor and poor households. Generally, the differences in access to infrastructure tend to be more consistent across sectors for non-poor/poor households, averaging 13%, and ranging from 6 to 26%. In contrast, the infrastructure gap between formal and informal settlements has a greater mean of 17% and far larger variance from 0 to 37%. The disparity between effective service levels in formal and informal settlements is particularly marked for the water and sanitation sectors, but zero or reversed for others (e.g. public transport, roads). In the next section, we examine how additional access indicators – representing nominal, effective and quality-adjusted access – change our understanding of the level of service in formal/informal settlements and non-poor and poor households.

4.2 Comparing nominal, effective and quality-adjusted access

How do different measures of access vary by settlement types and poverty levels? What is the relationship between nominal, effective and quality-adjusted metrics in these different settings? Do high rates of physical connection necessarily correlate to higher effective access, and a higher quality service? We examine different indicators of access and how they vary across formal/informal settlements and non-poor/poor households with a view to better understanding investment needs by location and economic situation.

The survey extracted quality data for five services – electricity, water, toilets, sewage disposal and access roads. These data are presented in Table 3.1 for all urban households and also broken down by settlement type and poverty level. Figure 4.2 a & b shows graphically how these indicators varied between formal and informal settlements; and figure 4.2 c & d shows the variation by non-poor and poor households.

The results show that the differences between nominal, effective and quality-adjusted access in each sector vary significantly by settlement type, but not as markedly by poverty level. Figure 4.2 a & b shows that households in formal settlements not only have significantly higher levels of all measures of access than in informal settlements, but the decline in coverage between nominal, effective and quality-adjusted access is less marked than the decline observed between these variables in informal settlements.
The discrepancy between nominal and effective access in informal settlements is greatest in the water and toilet sectors. For the water sector it suggests that there are issues surrounding the physical water connections that are preventing them from being used as a dominant water supply in a number of informal settlements. Likewise, although non-public toilet facilities are available in informal settlements, efforts are required to reduce the number of people with whom these are shared.

Also worrisome is the significant decline in quality-adjusted access in informal settlements. This is visually evident in the decline of the size of the shaded quality-adjusted polygon in Figure 4.2a compared to Figure 4.2 b. Overall, there are not only fewer nominal services, but far fewer higher quality services in informal settlements.

Overall, our findings suggest that settlement type is not only a strong predictor of service access but also of the availability of usable and quality services. Informal settlements have disproportionately lower levels of both effective and quality-adjusted access. There is a clear need to expand investment across sectors in informal settlements. However, as previous research clearly shows, it is crucial to account for
the high rates of tenancy in informal settlements to ensure that the benefits actually accrue to current residents (Gulyani et. al. 2008, 2014). Our findings support an approach that targets geographically by settlement type rather than by socioeconomic needs.

The same analysis directed towards non-poor/poor households yields slightly different conclusions. Not surprisingly, poor households do tend to report lower levels of nominal, effective and quality-adjusted access than non-poor households. It is interesting to observe however that the relationship between these variables is relatively unchanged for non-poor and poor groupings. This can be seen by the relatively consistent pattern exhibited across the different access polygons in Figure 4.2 c&d. A single anomaly exists for toilets. We can see that the discrepancy between nominal and effective rates of access for toilets is significantly higher for poor than non-poor households. Though nominal access rates are comparable, the rates of effective access – i.e. those that share non-public facilities with fewer than 20 people – drop significantly in poor households. The findings suggest the need to target toilet investments towards initiatives that reduce the number of people sharing toilet facilities in poor households.

Figure 4.2 c & d Comparing infrastructure quality by household poverty level
5. Analyzing Infrastructure Valuation and Variation in Access

In this section, we use regression analysis to examine: a) the value placed by households on infrastructure services; and b) correlates of access to a given service. First, we use a hedonic analysis of rental data to gain insights into the implicit valuation of different services. Then, we apply a logistic regression to each of five selected infrastructure services (electricity, private piped water, private toilet, organized garbage collection and sewage disposal) to identify factors that systematically affect the likelihood of a household having access to that service. Further analysis of the housing dimensions of this data set can be found in a paper by Gulyani, Talukdar and Bassett (July 2018), titled “Housing choices in urban Kenya: Shared housing, living conditions, and the rental market in 15 cities.”

5.1 Revealed valuations for services: Insights from housing rents

To properly guide and inform decisions regarding the financing and prioritization of basic public infrastructure services, it is important to understand how such services are valued by recipients. In section 3.3 we compiled data on household spending on different infrastructure services. Household spending can serve as a crude but generally incomplete proxy for relative demand between services. Another more accurate way to develop insights into implicit valuation of any services is to examine a functioning ‘product market’ where the product’s market value (thus, price) is expected to be driven by product attributes that include the service in question. For infrastructure services, the rental housing market with observations on characteristics of housing units versus rents (“products versus prices”) represents such a functioning product market. Accordingly, we undertook a statistical analysis of the rental housing market in urban Kenya to examine the following questions: To what extent do various infrastructure services explain the observed variations in rents paid across urban Kenya? What do the observed variations in rents paid across rental housing units reveal about the implicit valuations of various infrastructure services by tenants?

**Revealed valuation approach**

The statistical approach that we use is the hedonic form of regression analysis (Follain and Jimenez 1985; Gulyani, Bassett, and Talukdar 2012), with the log of "monthly rent" as the dependent variable. The hedonic form of regression analysis is a well-established approach in the economics literature to estimate implicit valuations of product attributes by analyzing observed market prices of products as a function of their attributes (Nelson 1970; Rosen 1974).

In keeping with previous theoretical and empirical studies utilizing the “Living Conditions Diamond” framework (see Gulyani and Bassett 2010; Gulyani and Talukdar 2008), we use four sets of explanatory variables in the rent regression analysis—the unit, neighborhood, tenure, and infrastructure. In analyzing and discussing the results, we focus on: (a) the aggregate impact of infrastructure variables on rent; (b) the impact of specific infrastructure variables; and (c) whether higher quality infrastructure services are, indeed, valued more and translate into higher rent.

A complete list of explanatory variables and their subcomponents are listed below.

**Housing (unit size and quality):**
- Number of rooms in the unit
- Enumerators’ assessment of unit quality
- Does it have permanent walls?
- Does it have permanent floors?\(^9\)
- Housing type (single-family house, self-contained apartment, dormitory-style unit, shared house/room, or compound house, with compound house as “base”)

**Neighborhood and location:**
- Does it have a primary school?
- Is it considered safe?
- Does it have public transport services?
- Is it prone to flooding?
- City location\(^10\)

**Tenure:**
- Does tenant perceive tenancy agreement as secure?
- Tenant’s length of stay in months in the unit

**Infrastructure (level of access to):**
- Electricity
- Piped water
- Reasonable access to toilet
- Drain outside
- Paved access road
- Street lights outside
- Sewage disposal services (public sewer or soak pit or septic tank)
- Organized garbage collection service

We run four different hedonic regression models with four different service-level scenarios for our selected set of infrastructure variables to understand: a) the extent to which infrastructure services explain variations in rent in urban Kenya; b) how such services are implicitly valued in the rental housing market; and c) whether and how the former two depend on the level and/or performance of services.

Specifically, for Model 1 and Model 2 we use 8 infrastructure indicators associated with nominal and effective access, respectively. For Model 3, we use quality-adjusted infrastructure indicators for four services for which they are available and relevant (electricity, water, toilet and roads), while keeping effective access indicators for the remaining services. Finally, based on insights from the previous three models, we create Model 4 to test a mixed scenario: quality adjusted levels for water, toilet, and road services; effective levels for electricity, garbage, and street lights; and nominal levels for sewage and drain. Across all four models, the variables corresponding to the unit, neighborhood, and tenure dimensions of the Living Condition Diamond are kept identical.

**Revealed valuation findings**

As a first step to understanding the impact of infrastructure on rent, we ran each of the four rent regression models with only its specific set of infrastructure variables (i.e. excluding the variables for unit, neighborhood, and tenure). We find that the infrastructure variables alone have strong explanatory power and that the impact of infrastructure on rents rises as the level of access increases from nominal to effective to quality-adjusted service. Specifically, access to nominal infrastructure explains 40% of the variation in rents in Model 1. In Model 2, access to effective infrastructure, explains 43% of the variation in rents. In Model 3, higher quality infrastructure access variables explain 55% of the variation in rent. In Model 4

\(^9\) We do not include whether a unit has permanent roof material because there is very little variation in this variable in our data.

\(^10\) City location dummies are included to capture unobserved city-specific effects on rents paid.
infrastructure variables explain 45% of the variation in rents—that is, their explanatory power is slightly higher than in model 2 but much lower than in model 3.

These results show that access to infrastructure service not only explains a significant portion of rent variation across urban Kenya, but also that the explanatory power of these variables increases as the level of access and/or service improves from nominal to effective to higher quality access.

Each of the four hedonic rent regression models were subsequently run in full, deploying data on rent from 15 cities together. The results are presented in Table 5.1. The results show that each of the four regression models explain about 64-66% of the observed variations in rents in urban Kenya. Compared to similar hedonic rent regression studies in Sub-Saharan Africa (e.g. Gulyani, Bassett, and Talukdar 2012), the explanatory powers of our rent regression models are quite high. That suggests that the four sets of explanatory variables used in our analysis do a reasonably good job of capturing the key determinants of rent in urban Kenya.

As for individual infrastructure services, we find four services--electricity, water, toilets, and garbage collection--to have statistically significant (at p < 0.05 level) positive impact on rent across all the three models and one (sewage disposal infrastructure) to have statistically significant positive impact in two of the three models. On the other hand, the other three infrastructure services--drains, street lights, and paved internal roads--are found to be statistically insignificant across all the three models. This finding is similar to the findings by Gulyani, Bassett, and Talukdar (2012) in the specific context of Nairobi and Dakar. As they note, this is not to suggest that such infrastructure has no value in terms of rent. Rather, this finding likely reflects the fact that availability of certain types of infrastructure varies more across cities than across units within a settlement. Any systematic effects of such neighborhood-level infrastructure are thus being captured by the city-specific "location" dummy variables in our regression models.

Next, we focus on what insights Table 5.1 results shed in terms of the implicit valuations of various infrastructure services by tenants in urban Kenya. It is pertinent to note here that since we use semilog rent regression models, the marginal effects of an explanatory variable on rent can be inferred from its estimated coefficient in Table 5.1 as \((\text{e}^y - 1)\times100\%\) where \(y\) is the value of the estimated coefficient. We discuss the marginal effect findings for the five infrastructure services that showed statistically significant coefficients across the models. In the discussion below, we focus on results from Models 1, 2 and 3.

We find that electricity access raises monthly rent on average between 35% and 39%. Access to water boosts monthly rent on average by 14% to 21%. The corresponding ranges, regarding impact on rent, for toilet, sewer and garbage collection services are 9% to 51%, 2% to 7%, and 9% to 17%, respectively.

In terms of sensitivity of marginal effects of these infrastructure services with respect to measures by performance level, we find three services -- water, toilet, and garbage collection -- show significant jumps with better service levels. For instance, the positive effect of water services on rent jumps from 15% to 21% when access improves from nominal to higher quality service (defined as a private or shared connection, in the house or compound, with 24/7 service). The corresponding jump for toilet services is from 9% to as much as 51%. For garbage collection services, a change in service from nominal to effective level results in about 8 percentage points (9% to 17%) jump in terms of rent paid. At the same time, while exhibiting statistically significant positive marginal effects on rent as noted earlier, those effects do not show much sensitivity with respect to service levels for electricity and public sewer services. That result is most likely because there were not many additional observations in our data at the effective levels compared to those at the nominal levels for both these services.

Taken together, our hedonic rent regression results suggest that the rent amounts paid by tenants in urban Kenya are not only tied in a significant way to the provision of relevant basic infrastructure services, but
they are also tied to relative performance levels of the services in a manner consistent with expectations—that is, better or higher quality service access is associated with higher rent. From the public policy perspective, the results show that the housing rental market in urban Kenya represents a good “valuation or willingness to pay” support base (as reflected through the rents paid in their housing market) to finance provision of basic infrastructure services, and that such willingness to pay is generally contingent on delivered performance level rather than merely on access to the services.

Summary
In sum, households place a significant value on infrastructure—even if it is a nominal level of access. But, as expected, they do place higher values on effective and higher quality access. In and of themselves, nominal infrastructure variables explain 40% of the overall variation in rents. By comparison, quality-adjusted infrastructure variables explain 55% of the variation in rents. Among the seven infrastructure services examined, the following four – electricity, water, toilets, and garbage collection – are associated with higher rents. Further, in each of these services, higher level of access is correlated with higher rents. The impact of quality is most dramatic in the case of toilets—all else being equal, nominal access to a toilet increases rent by 9%, but access to a private toilet increases rent by 51%.

5.2 Factors influencing household access to infrastructure

What factors systematically affect the likelihood of access for a household to each of the selected infrastructure services? A number of studies have attempted to answer this question at a macro country and city level (Arimah 2003, Steckel et al. 2017). In this study we investigate the household determinants of infrastructure access by running a logistic regression analysis for each of five selected infrastructure services – electricity connection, private piped water connection, private toilet, organized garbage collection services and sewage disposal (public sewer or soak pit or septic tank). The dependent variable is whether a household has access to a given service. The independent variables examined are a subset of those included in the previous regression (i.e. a relevant subset of the indicators for housing, neighborhood and location, tenure and infrastructure), in addition to a set of household socio-economic indicators.

The results from our logistic regression analyses are presented in Table 5.2. They show that the overall power of the factors analyzed in explaining the likelihood of household access to selected infrastructure services varies between 32% (garbage collection) and 62% (private toilet). We now discuss the results in terms of how the analyzed factors affect the selected infrastructure services. For assessing whether a factor’s effect is systematic, we use a statistical significance level of below 10% (i.e., p < 0.1).11

Household socio-economic characteristics
The results show that the education of the head of household has a systematic positive effect on a household’s likelihood of access to each of the selected infrastructure services. Similar results hold for household income level. Specifically, as expected, compared to the base case of households with a monthly income of Ksh 6,000 or less, households with higher income are more likely to have access to the selected services. Interestingly, we find that female headed households are systematically less likely to have access to most of these services – the only exception being garbage collection services. As for the effect of family size, the results are mixed; we find no systematic effect for electricity and garbage services, positive effects for private toilet but negative effects for private piped water and public sewer services.

---

11 Please note that the odds ratio for a given factor in the result is the same as \( \exp(\beta) \) where \( \beta \) is the estimated regression coefficient for the factor. So, an odds ratio value above 1.0 indicates a positive effect of the factor and below 1.0 indicates a negative effect.
**Unit size, quality, and type**

As one would expect, we find that the unit’s quality has a systematic positive association with whether the unit has access to each of the five types of infrastructure services analyzed. By contrast, the unit’s size—measured in number of rooms—is found to have no systematic impact on the likelihood of infrastructure access. As for results with respect to the type of the unit, compared to the base case of households residing in compound houses, we find that those living in apartments are systematically more likely to have access to all five types of infrastructure services. In contrast, we find that those residing in dormitory-style units are more likely to have access to electricity, garbage collection, and a sewage disposal system, but they are less likely to have access to either a private piped water connection or a private toilet. For households residing in single-family type houses, we find that they are more likely to have access to private piped water, private toilets, and garbage collection, but exhibit no systematic difference in access likelihood with respect to electricity and sewage disposal services. As for those sharing a house or a room in a house, we find that they are more likely to have access to two of the services—private piped water and private toilet.

**Infrastructure at the unit and neighborhood levels**

Our results show that the likelihood of a household’s access to any of the selected five infrastructure services is, for the most part, strongly and positively associated with the access to other types of infrastructure services. For instance, likelihood of access to electricity for a household is positively correlated with access to private piped water, drainage, street lighting, sewage disposal systems and garbage collection. Since our analyses control for household income level (thus, the role of affordability from the demand side), these results underscore an interesting but perhaps not surprising reality about “neighborhood clustering” when it comes to provision of infrastructure services from the supply side. The upshot of such clustering from the supply side is that households by virtue of residing in certain neighborhoods enjoy potential access to a “bundle” of basic infrastructure services, but at the same time it has de facto access to private type services based only on household income level.

**Neighborhood conditions, location, and city**

We analyze the likelihood of access to each of the five selected infrastructure services with respect to four neighborhood conditions—viz., whether the neighborhood is informal, safe, prone to flooding, and has public transport. Of these, we find that two—informality and access to public transport—generally show systematic associations with infrastructure access likelihoods. Specifically, as one would expect, we find that informal neighborhoods are systematically less likely to have access to any of the analyzed services, with the exception of electricity. This finding supports the results from the descriptive analysis presented in Section 4. From the public policy perspective, the finding that there is no systematic difference between formal and informal neighborhoods in terms of electricity access is very encouraging. As for neighborhood access to public transport, we find it to be positively associated with likelihood of household access to electricity, sewage disposal systems, and garbage collection, but to be negatively associated with access to private water connections and private toilets. One possible explanation of the latter finding might be that the few households who do have private water connections and private toilets typically reside in higher-quality or affluent neighborhoods and such neighborhoods are not likely served by public transport providers due to lack of demand. Finally, as expected, we find a city effect. Taking Embu as a base city, we find that in a majority of the other 14 cities residents’ likelihood of having access to a given service differs systematically. In the case of electricity, for instance, 11 cities are significantly different from Embu—while residents of Kakamega are less likely to have access, those in the other 10 are more likely to have electricity access.
Table 5.1: Hedonic Rent Regression Results for Urban Kenya

| Rent Drivers | MODEL 1 | | | MODEL 2 | | | MODEL 3 | | | MODEL 4 | | |
|--------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|              | Coeff.  | Std. Err. | p-Value | Coeff.  | Std. Err. | p-Value | Coeff.  | Std. Err. | p-Value | Coeff.  | Std. Err. | p-Value |
| **Unit Size, Quality & Type** | | | | | | | | | | | | |
| Rooms        | 0.148   | 0.048    | 0.002   | 0.147   | 0.048    | 0.002   | 0.127   | 0.044    | 0.004   | 0.143   | 0.048    | 0.003   |
| Building quality | 0.210   | 0.045    | 0.000   | 0.216   | 0.046    | 0.000   | 0.172   | 0.055    | 0.002   | 0.217   | 0.048    | 0.000   |
| Perm wall    | 0.243   | 0.026    | 0.000   | 0.255   | 0.027    | 0.000   | 0.282   | 0.025    | 0.000   | 0.326   | 0.027    | 0.000   |
| Perm floor   | 0.291   | 0.036    | 0.000   | 0.305   | 0.036    | 0.000   | 0.324   | 0.036    | 0.000   | 0.381   | 0.036    | 0.000   |
| Kitchen      | 0.651   | 0.098    | 0.000   | 0.624   | 0.102    | 0.000   | 0.384   | 0.160    | 0.016   | 0.570   | 0.116    | 0.000   |
| **Unit Type (Base: Compound house)** | | | | | | | | | | | | |
| Single-family| 0.029   | 0.030    | 0.333   | 0.047   | 0.031    | 0.128   | 0.033   | 0.027    | 0.228   | 0.043   | 0.030    | 0.157   |
| Apartment    | 0.123   | 0.147    | 0.401   | 0.110   | 0.147    | 0.453   | -0.012  | 0.124    | 0.926   | 0.063   | 0.143    | 0.659   |
| Dormitory    | 0.029   | 0.041    | 0.475   | 0.019   | 0.043    | 0.654   | 0.018   | 0.039    | 0.643   | 0.033   | 0.042    | 0.432   |
| Shared house/room | 0.062   | 0.035    | 0.081   | -0.069  | 0.035    | 0.050   | -0.062  | 0.034    | 0.069   | -0.086  | 0.035    | 0.013   |
| Other        | 0.098   | 0.098    | 0.317   | -0.098  | 0.095    | 0.302   | -0.033  | 0.131    | 0.799   | -0.070  | 0.131    | 0.590   |
| **Infrastructure: Unit & Neighborhood Level** | | | | | | | | | | | | |
| Electricity  | 0.332   | 0.023    | 0.000   | 0.297   | 0.040    | 0.000   | 0.310   | 0.038    | 0.000   | 0.109   | 0.037    | 0.003   |
| Piped water  | 0.142   | 0.027    | 0.000   | 0.134   | 0.028    | 0.000   | 0.194   | 0.084    | 0.021   | 0.110   | 0.045    | 0.015   |
| Toilet access| 0.088   | 0.026    | 0.001   | 0.124   | 0.032    | 0.000   | 0.414   | 0.136    | 0.002   | 0.240   | 0.068    | 0.000   |
| Drain outside| 0.004   | 0.028    | 0.899   | 0.009   | 0.032    | 0.790   | 0.012   | 0.025    | 0.625   | 0.005   | 0.032    | 0.877   |
| Roads paved  | 0.025   | 0.035    | 0.461   | 0.031   | 0.037    | 0.403   | 0.037   | 0.049    | 0.450   | 0.017   | 0.048    | 0.719   |
| Street Lights| 0.021   | 0.025    | 0.403   | -0.043  | 0.033    | 0.190   | -0.042  | 0.033    | 0.209   | -0.045  | 0.032    | 0.164   |
| Public sewer | 0.067   | 0.033    | 0.043   | 0.019   | 0.032    | 0.557   | 0.062   | 0.025    | 0.013   | 0.026   | 0.035    | 0.453   |
| Garbage collection | 0.084 | 0.023  | 0.000 | 0.160 | 0.038 | 0.000 | 0.139 | 0.036 | 0.000 | 0.148 | 0.035 | 0.000 |
| **Neighborhood Conditions & Location** | | | | | | | | | | | | |
| Primary school | 0.013  | 0.059  | 0.824 | -0.012 | 0.057 | 0.835 | -0.007 | 0.054 | 0.896 | -0.001 | 0.058 | 0.992 |
| Considers safe | 0.089 | 0.024 | 0.000 | 0.077 | 0.023 | 0.001 | 0.078 | 0.022 | 0.000 | 0.081 | 0.022 | 0.000 |
| Public transport | 0.071 | 0.028 | 0.013 | 0.066 | 0.028 | 0.017 | 0.057 | 0.029 | 0.049 | 0.088 | 0.029 | 0.003 |
| No flooding | 0.073 | 0.025 | 0.003 | 0.078 | 0.023 | 0.001 | 0.070 | 0.022 | 0.001 | 0.066 | 0.023 | 0.005 |
| City location | B | b | b | | | | | | | | | |
| **Tenure** | | | | | | | | | | | | |
| House secure | 0.019 | 0.026 | 0.471 | 0.023 | 0.026 | 0.371 | 0.028 | 0.025 | 0.263 | 0.029 | 0.026 | 0.263 |
| Stay in unit | 0.001 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 |
| Constant | 5.949 | 0.082 | 0.000 | 5.979 | 0.079 | 0.000 | 6.050 | 0.073 | 0.000 | 6.121 | 0.081 | 0.000 |

Number of Obs. | 10,390 | 10,389 | 10,389 | 10,389 | 10,389 |

Adj. R² | 0.646 (0.402) | 0.646 (0.431) | 0.657 (0.546) | 0.667 (0.449) |

Notes: a Each regression model is a semilog model with log of monthly rent (in Ksh, per month) as the dependent variable. It is estimated using the sampling weights for households. Standard error values of the coefficients are based on Huber and White (or, robust) estimator of variance. b The results for the 14 city-specific location dummy variables are not shown here to conserve space. Relative to the “base” city (Embu), 9 of the 14 city locations are statistically significant (at p < 0.1 level) in each of the models. c The adjusted R2 value shown in parenthesis is when the model is run with the set of 8 infrastructure service variables as the only explanatory variables.
With respect to “safe neighborhood”, we find it not having any systematic association with three of five analyzed infrastructure services. The two services for which it shows systematic association are electricity and garbage collection services; and in both these cases, the association is positive. In other words, a household is more likely to have access to electricity and garbage collection services in a neighborhood that is considered safe. As for a neighborhood’s proneness to flooding, we also find it to have systematic association with only two of the five analyzed infrastructure services. Specifically, we find that neighborhoods that are not prone to flooding exhibit a higher likelihood of household access to electricity and public sewer services. We also controlled for city-level location effects on the likelihood of household access to the selected infrastructure services. The results show a strong city-specific location effect on a household’s likelihood to have infrastructure access. Specifically, using Embu as the “base” city, we find that at least 11 of the 14 cities differ systematically from Embu in their access to infrastructure for four of the five services (electricity, water, toilet, and garbage collections). In terms of access to sewage disposal systems, we find 8 of the 14 cities show a statistically significant difference from Embu.

**Tenure**
In terms of tenure, we analyze the likelihood of access to each of the five selected infrastructure services with respect to three indicators --viz., whether the household is a renter or owner, length of stay in the unit, and whether the household perceives their house tenure to be secure. Of these, we find renting to be systematically associated with the likelihood of access to all of the five types infrastructure services. Specifically, we find that renters are less likely to have access to private piped water and private toilet services, but are more likely to have access to electricity, garbage collection, and a sewerage disposal services. With respect to perceived tenure security, we find it does not have any systematic association with three of five analyzed infrastructure services. The two services for which it shows systematic association are electricity and public sewer services; and in both these cases, the association is positive. As for a household’s length of stay in the unit, we find it to have systematic association with only one of the five analyzed infrastructure services. Specifically, we find a systematic positive association with the likelihood of household access to public sewer services.

**Summary**
Overall, household access to these five services—electricity, private piped water, private toilet, garbage collection, and sewage disposal—is affected by household characteristics, house type and location, and the household’s tenure status. In terms of household characteristics, income, education and gender of the household head matter. Infrastructure access increases with income and education of the head of household. Female-headed households are systematically less likely to have access to these services. Where a household resides matters—the unit, the type of housing, the neighborhood, and the city all affect the likelihood of infrastructure access. Those residing in higher quality housing units have better access. The type of housing also matters—for instance, relative to those residing in compound houses, residents of Eroorsingle-family houses are more likely to have access to private toilets and water connections, while residents of dormitories are less likely to have access to these two services. Residents of informal neighborhoods are systematically less likely to have access than those residing in formal neighborhoods. There is also a city effect. Interestingly, access to any given infrastructure service is strongly correlated with the presence of other infrastructure services. Finally, tenure status influences infrastructure access—renters are more likely to have access to electricity, garbage collection and sewerage disposal services, but are less likely to have either a private toilet or a private piped water connection.
Table 5.2: Factors influencing infrastructure access in Urban Kenya

| Explanatory Variables | Electricity | Pvt piped water | Pvt toilet | Garbage collection | Public sewer (incl septic/soak pit) |
|-----------------------|-------------|-----------------|------------|--------------------|-----------------------------------|
|                       | Odds Ratio  | Std Err p-val   | Odds Ratio | Std Err p-val      | Odds Ratio Std Err p-val           |
| HH characteristics    |             |                 |            |                    |                                   |
| HH head: education at least hschool | 2.397 | 0.145 0.000 | 1.881 | 0.138 0.000 | 2.232 | 0.272 0.000 | 1.287 | 0.089 0.000 | 1.333 | 0.093 0.000 |
| HH head - female      | 0.848 | 0.056 0.012 | 0.889 | 0.060 0.082 | 0.679 | 0.068 0.000 | 0.962 | 0.067 0.577 | 0.812 | 0.052 0.001 |
| Family size           | 0.979 | 0.017 0.214 | 0.922 | 0.018 0.000 | 1.078 | 0.035 0.020 | 0.970 | 0.020 0.127 | 0.950 | 0.018 0.007 |
| Monthly HH Income     |             |                 |            |                    |                                   |
| 6,001-9,000           | 1.538 | 0.121 0.000 | 1.115 | 0.128 0.345 | 1.553 | 0.391 0.090 | 1.200 | 0.129 0.089 | 1.441 | 0.161 0.001 |
| 9,001-13,000          | 2.227 | 0.192 0.000 | 1.167 | 0.138 0.193 | 1.502 | 0.372 0.100 | 1.083 | 0.128 0.499 | 1.759 | 0.198 0.000 |
| 13,001-22,500         | 2.681 | 0.252 0.000 | 1.503 | 0.172 0.000 | 3.199 | 0.768 0.000 | 1.280 | 0.155 0.041 | 2.455 | 0.283 0.000 |
| Above 22,500          | 5.223 | 0.699 0.000 | 3.698 | 0.473 0.000 | 9.029 | 2.348 0.000 | 1.660 | 0.231 0.000 | 5.111 | 0.671 0.000 |
| Unit Size & Quality   |             |                 |            |                    |                                   |
| Rooms                 | 1.068 | 0.043 0.105 | 1.051 | 0.032 0.099 | 1.128 | 0.096 0.156 | 1.021 | 0.014 0.139 | 1.033 | 0.026 0.197 |
| Building quality      | 1.800 | 0.159 0.000 | 1.688 | 0.136 0.000 | 1.809 | 0.200 0.000 | 1.001 | 0.091 0.991 | 1.925 | 0.152 0.000 |
| House Type (Base: Compound House) |             |                 |            |                    |                                   |
| Single-family         | 1.119 | 0.091 0.164 | 1.482 | 0.141 0.000 | 2.864 | 0.422 0.000 | 1.192 | 0.126 0.096 | 0.943 | 0.093 0.552 |
| Apartment             | 2.704 | 0.852 0.002 | 6.446 | 1.339 0.000 | 32.030 | 9.553 0.000 | 1.649 | 0.318 0.009 | 4.615 | 1.148 0.000 |
| Dormitory             | 1.267 | 0.217 0.168 | 0.477 | 0.132 0.007 | 0.391 | 0.120 0.002 | 1.738 | 0.341 0.005 | 1.805 | 0.341 0.002 |
| Shared house/room     | 0.736 | 0.084 0.007 | 1.497 | 0.247 0.015 | 1.986 | 0.433 0.002 | 1.168 | 0.190 0.341 | 0.773 | 0.122 0.101 |
| Other                 | 1.422 | 0.526 0.341 | 5.364 | 1.942 0.000 | 9.598 | 5.891 0.000 | 0.270 | 0.148 0.017 | 0.736 | 0.288 0.434 |
| Infrastructure: Unit & Neighborhood Level |             |                 |            |                    |                                   |
| Electricity           |             |                 |            |                    |                                   |
| Piped water           | 5.078 | 0.469 0.000 | 2.486 | 0.246 0.000 | 3.495 | 0.718 0.000 | 1.592 | 0.173 0.000 | 1.998 | 0.206 0.000 |
| Toilet access         | 0.859 | 0.068 0.056 | 1.637 | 0.181 0.000 | 2.732 | 0.511 0.000 | 1.773 | 0.191 0.000 | 2.146 | 0.223 0.000 |
| Drain outside         | 1.350 | 0.105 0.000 | 1.079 | 0.098 0.404 | 1.238 | 0.161 0.100 | 1.307 | 0.119 0.003 | 1.447 | 0.118 0.000 |
| Roads paved           | 1.166 | 0.086 0.038 | 1.292 | 0.109 0.002 | 2.016 | 0.250 0.000 | 1.210 | 0.109 0.034 | 1.045 | 0.088 0.604 |
| Street Lights         | 1.311 | 0.140 0.011 | 0.906 | 0.094 0.339 | 0.540 | 0.076 0.000 | 1.787 | 0.183 0.000 | 1.900 | 0.184 0.000 |
| Public sewer          | 1.987 | 0.204 0.000 | 3.926 | 0.383 0.000 | 24.116 | 4.085 0.000 | 2.420 | 0.243 0.000 |                                   |
| Garbage collection    | 1.576 | 0.179 0.000 | 1.175 | 0.131 0.150 | 1.783 | 0.241 0.000 |                                   | 2.435 | 0.248 0.000 |
| Neighborhood Conditions & Locations | Consider safe | Public transport | No flooding | Informal/slum | Informal elec. connections in Nhood | City (Base: EMBU) | Eldoret | Garissa | Kakamega | Kericho | Kisumu | Kitui | Machakos | Malindi | Mombasa | Nairobi | Naivasha | Nakuru | Nyeri | Thika | Tenure | House secure | Stay in unit | Renter (vs. owner) | Constant | Number of Obs. | R-squared |
|-------------------------------------|--------------|-----------------|------------|--------------|-----------------|----------------|---------|--------|--------|--------|--------|-------|-----------|---------|---------|--------|---------|---------|--------|--------|-------|--------|----------|-----------|----------------|---------|-------------|-----------|
| 1.196 0.077 0.006 0.917 0.069 0.250 1.071 0.112 0.509 1.377 0.104 0.000 0.868 0.067 0.108 | 1.470 0.133 0.000 0.578 0.063 0.000 0.741 0.121 0.000 1.398 0.104 0.000 | 1.259 0.091 0.001 1.123 0.104 0.211 1.186 0.150 0.175 1.020 0.088 0.814 1.213 0.097 0.016 | 0.926 0.092 0.440 0.630 0.073 0.000 0.712 0.121 0.046 0.713 0.084 0.004 0.614 0.070 0.000 | 1.382 0.191 0.020 | 1.520 0.313 0.042 2.271 0.451 0.000 0.421 0.134 0.006 7.645 3.583 0.000 0.674 0.151 0.078 | 4.187 1.037 0.000 1.327 0.125 0.162 0.210 0.028 0.000 1.775 4.561 0.000 0.492 0.128 0.006 | 0.607 0.115 0.008 0.560 0.110 0.003 0.858 0.222 0.554 0.918 0.546 0.886 0.726 0.153 0.130 | 1.056 0.200 0.776 4.512 0.960 0.000 0.147 0.049 0.000 17.121 8.129 0.000 0.358 0.080 0.000 | 1.528 0.356 0.069 0.290 0.069 0.000 0.403 0.157 0.020 15.492 7.991 0.000 0.912 0.224 0.079 | 1.555 0.425 0.107 0.428 0.118 0.002 0.203 0.075 0.000 2.925 1.934 0.104 0.504 0.136 0.011 | 1.982 0.506 0.007 0.143 0.043 0.000 0.913 0.346 0.810 18.535 8.719 0.000 0.756 0.215 0.325 | 1.794 0.390 0.007 0.850 0.207 0.504 0.532 0.199 0.092 26.261 12.519 0.000 1.430 0.371 0.168 | 4.658 1.064 0.000 0.398 0.110 0.001 0.623 0.195 0.131 79.443 36.976 0.000 0.675 0.173 0.127 | 2.363 0.594 0.001 0.349 0.080 0.000 0.144 0.042 0.000 88.220 40.464 0.000 1.829 0.447 0.013 | 6.778 1.467 0.000 0.266 0.061 0.000 0.238 0.085 0.000 56.255 26.206 0.000 0.500 0.128 0.007 | 1.649 0.370 0.026 0.612 0.136 0.027 0.431 0.127 0.004 131.096 59.161 0.000 0.425 0.096 0.000 | 1.282 0.264 0.227 0.505 0.099 0.000 0.376 0.097 0.000 9.219 4.368 0.000 0.861 0.177 0.465 | 2.927 0.795 0.000 1.074 0.234 0.743 0.290 0.092 0.000 6.140 2.935 0.000 6.443 1.532 0.000 | 1.421 0.106 0.000 1.083 0.095 0.365 1.168 0.146 0.214 0.884 0.076 0.155 1.264 0.110 0.007 | 1.000 0.000 0.206 1.000 0.000 0.352 1.000 0.001 0.739 1.000 0.000 0.742 1.001 0.000 0.002 | 3.738 0.470 0.000 0.529 0.068 0.000 0.837 0.217 0.494 2.274 0.311 0.000 4.532 0.625 0.000 | 0.017 0.004 0.000 0.069 0.019 0.000 0.000 0.000 0.000 0.001 0.000 0.003 0.001 0.000 | 10,982 11,317 11,137 11,137 | 0.330 0.371 0.621 0.317 0.384 | 0.330 0.371 0.621 0.317 0.384 |
6. Conclusion

In this paper, we have defined alternative means of measuring access that go beyond traditional measures of physical access to include functionality, use and service quality, adopting a more holistic understanding of services that mirrors the global transition from MDGs to SDGs. By drawing on a large data set of urban households in Kenya, we have demonstrated how these measures vary across sectors, and how to analyze and interpret these results.

The findings from our analysis have real implications for sectoral policies and infrastructure investments in Kenyan cities. Our data show that an infrastructure gap exists between formal and informal communities and non-poor and poor households. Poor households, and those who live in informal settlements suffer from lower levels of access, and fewer quality services. Interestingly, we find that the size of this gap is significantly larger by settlement type than poverty level. Or in other words, those who live in informal settlements, irrespective of poverty level, are more likely to have lower access to services – at nominal, effective or quality-adjusted levels. This suggests that policy makers in urban Kenya need to seriously examine the drivers of spatial inequality and find mechanisms for closing this gap. The existence of both coverage and quality deficiencies also implies that investment strategies should address both expansion as well as quality improvement in each sector.

Our data on service access by sector suggest that investment in water supply and sanitation is a high priority. Overall, these sectors perform poorly on a relative basis, and also have the largest service gap, which is particularly evident between formal and informal settlements. Delivery mechanisms will need to take into account the high rates of tenancy in informal settlements that can hinder service expansion. Finally, our data reveal that mean spending on infrastructure services is high. Cumulatively these expenses represent a significant part of the household budget. In relative terms, phone and electricity expenditures are high, while expenditures on water and garbage collection services are low. Non-poor households and those who live in formal settlements generally spend more for all services – possibly reflecting higher levels of consumption (rather than higher unit costs). Further investigation is recommended to understand the unit costs and relative affordability of each of these services.

Regressions analyses of rental data reveal that households place considerable value on access to infrastructure. In and of themselves, nominal infrastructure variables explain 40% of the overall variation in rents. By comparison, quality-adjusted infrastructure variables explain 55% of the variation in rents. Among the seven infrastructure services examined, the following four – electricity, water, toilets, and garbage collection – are associated with higher rents. Overall, rent paid by tenants is tied not only to the availability of basic infrastructure services (with higher rents paid for housing with access to services), but also to the quality of these services (that is, better quality services yielded even higher rents).

Our analysis also identifies key factors that contribute to a household’s likelihood of having access to infrastructure services. Household characteristics matter – infrastructure access is higher in households with higher income, male household heads, and more educated household heads. The location of the household and housing characteristics also matter. Larger and better-quality housing is associated with better access. Residents of certain types of housing are systematically more likely to have access. For example, residents of single-family housing are more likely to have access to private toilets and water connections than residents of compounds or dormitories. Residents of informal neighborhoods are systematically less likely to have access to service than those in formal neighborhoods. And there is also a city effect. Interestingly, access to any given infrastructure service is strongly correlated with the presence of other infrastructure services. Tenure status also influences infrastructure access, with renters more likely to have access to electricity, garbage collection and sewerage disposal services, but less likely to have either a private toilet or a private piped water connection.
While our analysis provides useful insights into service levels and performance across sectors and cities in Kenya specifically, the results of our analysis have implications that extend well beyond urban Kenya. We argue that our data provide compelling evidence for the importance of defining new measures of access that take into account how services are actually being used. This requires looking beyond easy-to-measure indicators of nominal access, to capture additional data on both effective and quality-adjusted access.

Our efforts to capture quality dimensions of service build on numerous ongoing initiatives at the sectoral level. The uniqueness of our research lies in its attempt to develop a more systematic, comprehensive and comparable reporting of quality across sectors. Our research introduces a common language for discussing service access and performance across sectors in a manner that key stakeholders can meaningfully interpret. The results can be broadly applied in both policy and practice. For example, at a policy level this common ‘language’ could be used by the Minister of Finance to assess how services and Ministries are performing relatively and to identify key priorities in each sector. At a more granular level within a country or city these indicators can be used to highlight which cities/neighborhoods are doing poorly relative to others. Within a sector it can be used to identify development needs and the relative priority of expansion versus quality improvement efforts. It can also be analyzed to develop a more nuanced understanding of demand and willingness to pay for different types and quality of services, and for identifying factors that contribute to expanding access.

Our research demonstrates the value of collecting, compiling and analyzing indicators for each of the three levels of access for all cities/countries. As a next step, it would be useful to test and adapt this methodology, expanding it to other countries and testing alternative faster and more economical means of collecting data that do not rely on large-scale expensive household surveys. In particular, it would be worthwhile to investigate ways of incorporating observational data (e.g. nightlights to look at coverage and quality of infrastructure services).

Finally, in this paper we have selected our own indicators of what each level of service – nominal, effective, and quality-adjusted – may look like for each sector. These indicators could be modified to reflect specific circumstances and contexts, while also balancing the need for consistency and comparability across countries and regions. The power that this kind of easily-digestible, demand-side data offer is that they are accessible, facilitate discussions and relate well to policy. The data therefore enable more participatory discussion on investment priorities while also offering metrics against which public and private service providers can be held accountable. As countries around the world set targets for their SDGs, it is timely that we revisit how we measure access. Our research suggests that it is crucial for policy makers to set targets that extend beyond nominal access, to at least measures of ‘effective’ access, while explicitly also addressing appropriate quality and performance standards for their cities or countries.
References

Arimah, Ben. C. 2003. “Measuring and explaining the provision of infrastructure in African cities.” International Planning Studies. Vol 8(3), pp 225-240.

Follain, James R., and Emmanuel Jimenez. 1985a. "The Demand for Housing Characteristics in Developing Countries." Urban Studies Vol 22 (5), pp 42132

Gulyani, Sumila, Ellen M. Bassett, Debabrata Talukdar. 2014. A tale of two cities: A multi-dimensional portrait of poverty and living conditions in the slums of Dakar and Nairobi. Habitat International. Vol 43, pp98-107.

Gulyani, S., E. Bassett and D. Talukdar (2012), “Informal Housing Markets: Living Conditions, Rents, and Their Determinants in the Slums of Nairobi and Dakar,” Land Economics, Vol. 88(2), pp 251-274.

Gulyani, Sumila and Ellen M. Bassett. 2010. The living conditions diamond: an analytical and theoretical framework for understanding slums. Environment and Planning A Vol. 42, pp2201-2219

Gulyani, Sumila, and Debabrata Talukdar. 2008. “Slum Real Estate: The Low-Quality High-Price Puzzle in Nairobi’s Slum Rental Market and Its Implications for Theory and Practice.” World Development 36(10). Elsevier Ltd: 1916-37.

Nelson, Philip J. (1970), "Information and Consumer Behavior," Journal of Political Economy, Vol. 78 (2), 311-29

Nganyanyuka, K., J. Martinez, A. Wesselink, J. Lungo, Y. Georgiadou. 2014. “Accessing water service in Dar es Salaam: Are we counting what counts? Habitat International. Vol 44, pp 358-366.

Pierce, Gregory. 2017. “Why is basic service access worse in slums? A synthesis of obstacles”. Development in Practice. Vol 27 (3), pp 288-300.

Rosen, Sherwin (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," Journal of Political Economy, Vol. 82 (1), pp. 34-55.

Shaheed, A., J. Orgill, M. A. Montgomery, M. A. Jeuland, and J. Brown. 2014. “Why ‘improved’ water sources are not always safe. Bulletin of the World Health Organization. Vol 92, pp 283-289.

Steckel, Jan Christoph and Narasimha D. Rao and Michael Jakob. 2017. “Access to infrastructure services: Global trends and drivers,” Utilities Policy, Vol. 45, 109-117.

UNICEF/WHO. 2012. Progress on drinking water and sanitation: 2012 update. New York: UNICEF and World Health Organization, 66pp.

World Bank. 2016. Kenya State of the Cities Baseline Survey: Overview Report. World Bank.

World Bank. 1994. World Development Report 1994: Infrastructure for Development. New York: Oxford University Press. World Bank. http://hdl.handle.net/10986/5977
## ANNEX 1: SOCIOECONOMIC DATA OF KENYAN CITIES

| Poverty | Avg HH Size | N     | Mean % of HH members aged… | Under 5 | 5-14 | 15-60 | Over 60 | N     |
|---------|-------------|-------|-----------------------------|---------|------|-------|---------|-------|
| All     | Poor        | 3.3   | 8,536                       | 14      | 19   | 63    | 1       | 27,637 |
|         | Non-poor    | 2.9   | 5,840                       | 13      | 18   | 66    | 1       | 16,296 |
| Eldoret | Poor        | 3.1   | 660                         | 15      | 21   | 62    | 1       | 2,063  |
|         | Non-poor    | 3.0   | 308                         | 14      | 20   | 65    | 1       | 928    |
| Embu    | Poor        | 2.6   | 470                         | 10      | 19   | 66    | 4       | 1,222  |
|         | Non-poor    | 2.0   | 537                         | 10      | 16   | 72    | 2       | 1,063  |
| Garissa | Poor        | 3.6   | 493                         | 16      | 22   | 60    | 2       | 1,741  |
|         | Non-poor    | 3.7   | 539                         | 15      | 26   | 58    | 1       | 1,964  |
| Embu    | Poor        | 3.6   | 470                         | 14      | 23   | 59    | 4       | 1,746  |
|         | Non-poor    | 3.0   | 481                         | 13      | 18   | 66    | 2       | 1,537  |
| Kericho | Poor        | 3.2   | 879                         | 19      | 18   | 62    | 1       | 2,889  |
|         | Non-poor    | 2.6   | 147                         | 13      | 14   | 71    | 1       | 432    |
| Kisumu  | Poor        | 4.3   | 346                         | 13      | 25   | 54    | 2       | 1,515  |
|         | Non-poor    | 3.8   | 362                         | 13      | 22   | 57    | 2       | 1,361  |
| Kitui   | Poor        | 4.3   | 418                         | 12      | 26   | 58    | 4       | 1,704  |
|         | Non-poor    | 2.8   | 201                         | 11      | 19   | 66    | 4       | 549    |
| Machakos| Poor        | 3.2   | 420                         | 11      | 20   | 65    | 4       | 1,267  |
|         | Non-poor    | 3.0   | 249                         | 10      | 18   | 70    | 2       | 730    |
| Malindi | Poor        | 3.4   | 664                         | 16      | 22   | 61    | 1       | 2,210  |
|         | Non-poor    | 2.4   | 359                         | 12      | 17   | 70    | 1       | 885    |
| Mombasa | Poor        | 3.0   | 638                         | 16      | 19   | 65    | 1       | 1,896  |
|         | Non-poor    | 2.6   | 435                         | 13      | 16   | 69    | 2       | 1,167  |
| Nairobi | Poor        | 3.3   | 535                         | 14      | 18   | 65    | 1       | 1,783  |
|         | Non-poor    | 3.0   | 606                         | 13      | 17   | 67    | 1       | 1,864  |
| Naivasha| Poor        | 3.0   | 793                         | 16      | 20   | 61    | 2       | 2,313  |
|         | Non-poor    | 2.2   | 271                         | 13      | 15   | 70    | 1       | 593    |
| Nakuru  | Poor        | 3.3   | 693                         | 17      | 23   | 59    | 2       | 2,288  |
|         | Non-poor    | 2.8   | 386                         | 12      | 20   | 65    | 2       | 1,022  |
| Nyeri   | Poor        | 3.0   | 510                         | 16      | 19   | 61    | 4       | 1,495  |
|         | Non-poor    | 2.2   | 507                         | 13      | 16   | 68    | 3       | 1,115  |
| Thika   | Poor        | 2.8   | 543                         | 12      | 20   | 65    | 1       | 1,505  |
|         | Non-poor    | 2.5   | 435                         | 11      | 14   | 70    | 2       | 1,086  |
### ANNEX 2: SUMMARY INDICATOR TABLE BY SECTOR

| Definitions                        | Nominal                                                                 | Effective                                                                 | Quality-adjusted                                                                 |
|-----------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Electricity                       | %HH with in-house electricity                                           | *Nominal* + used as primary source of lighting                             | *Effective* + 24-hour supply and rare outages                                    |
| Water                             | %HH with in-dwelling or in-compound (shared or private) piped water     | *Nominal* + most important source                                         | *Effective* + 24/7 supply                                                      |
| Toilet                            | %HH with non-public toilet facility (shared or not)                    | *Nominal* + shared with less than 20 people                                | *Nominal* + shared with less than 10 people                                     |
| Sewage Disposal                   | %HH with connection to public sewer or septic/soak pit                  | *Nominal* + emptied by truck or manually                                   | *Nominal* + emptied by truck (non-manual)                                       |
| Access Roads                      | %HH with ‘surfaced’ access roads (paved/tarmac/gravel/murram – but not earth) | *Nominal* + road is in good condition during the most recent dry season   | *Effective* + usable last rainy season (i.e. proxy for all-weather access)      |
| Public Transport                  | %HH who have public transport service within 20-minute walk            | %HHs who have at least one HH member whose main mode of transportation to work or school is a microbus/matatu/regular bus | Not applicable                                                                  |
| Garbage Collection                | %HHs with some form of organized garbage collection (private or public) | *Nominal* + weekly collection                                              | Not applicable                                                                  |
| Street Lights                     | %HHs who have street lights or lamp posts on their streets              | *Nominal* + work most of the time                                           | Not applicable                                                                  |
| Phone                             | %HH with phone/mobile connection                                        | %HH with functioning phone/mobile                                           | Not applicable                                                                  |
### Annex 3: Infrastructure Access by City

| Access                      | URBAN | ELDORET | EMBU | GARISSE | KAKAMEGA | KERICHO | KISUMU | KITUI | MACHAKOS |
|-----------------------------|-------|---------|------|---------|----------|---------|--------|-------|----------|
|                             | N     | %HH     | N    | %HH     | N        | %HH     | N      | %HH   | N        | %HH     |
| **Electricity**             |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,202| 76%     | 975  | 65%     | 1,014    | 64%     | 1,035  | 82%   | 967      | 42%     |
| Effective                   | 14,202| 75%     | 975  | 64%     | 1,014    | 64%     | 1,035  | 80%   | 967      | 42%     |
| Quality-adjusted            | 14,202| 46%     | 975  | 43%     | 1,014    | 24%     | 1,035  | 46%   | 967      | 12%     |
| **Water**                   |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,202| 74%     | 975  | 71%     | 1,014    | 88%     | 1,035  | 96%   | 967      | 51%     |
| Effective                   | 14,202| 55%     | 975  | 62%     | 1,014    | 86%     | 1,035  | 96%   | 967      | 47%     |
| Quality-adjusted            | 14,202| 28%     | 975  | 29%     | 1,014    | 45%     | 1,035  | 56%   | 967      | 25%     |
| **Toilet**                  |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,199| 67%     | 975  | 79%     | 1,013    | 69%     | 1,035  | 77%   | 967      | 79%     |
| Effective                   | 14,199| 48%     | 975  | 53%     | 1,013    | 60%     | 1,035  | 49%   | 967      | 66%     |
| Quality-adjusted            | 14,199| 34%     | 975  | 34%     | 1,013    | 48%     | 1,035  | 23%   | 967      | 47%     |
| **Sewage Disposal**         |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 13,715| 46%     | 864  | 33%     | 989      | 31%     | 1,022  | 19%   | 963      | 22%     |
| Effective                   | 13,715| 42%     | 864  | 31%     | 989      | 26%     | 1,022  | 19%   | 963      | 20%     |
| Quality-adjusted            | 13,715| 41%     | 864  | 31%     | 989      | 26%     | 1,022  | 19%   | 963      | 20%     |
| **Access Roads**            |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,203| 41%     | 975  | 50%     | 1,014    | 30%     | 1,035  | 29%   | 967      | 36%     |
| Effective                   | 14,203| 33%     | 975  | 36%     | 1,014    | 24%     | 1,035  | 25%   | 967      | 22%     |
| Quality-adjusted            | 14,203| 24%     | 975  | 20%     | 1,014    | 19%     | 1,035  | 21%   | 967      | 10%     |
| **Public Transport**        |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,202| 93%     | 975  | 91%     | 1,014    | 66%     | 1,035  | 94%   | 967      | 70%     |
| Effective                   | 14,204| 52%     | 976  | 51%     | 1,014    | 18%     | 1,035  | 26%   | 967      | 15%     |
| **Garbage Collection**      |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,196| 48%     | 974  | 14%     | 1,010    | 3%      | 1,035  | 13%   | 967      | 2%      |
| Effective                   | 14,196| 38%     | 974  | 10%     | 1,010    | 2%      | 1,035  | 6%    | 967      | 1%      |
| **Street Lights**           |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,198| 46%     | 975  | 33%     | 1,014    | 22%     | 1,035  | 1%    | 967      | 1%      |
| Effective                   | 14,197| 32%     | 975  | 16%     | 1,014    | 6%      | 1,035  | 0%    | 967      | 0%      |
| **Phone**                   |       |         |      |         |          |         |        |       |          |         |
| Nominal                     | 14,166| 90%     | 975  | 79%     | 1,014    | 77%     | 1,033  | 86%   | 967      | 88%     |
| Effective                   | 14,166| 90%     | 975  | 79%     | 1,014    | 77%     | 1,033  | 86%   | 967      | 88%     |
| Access             | URBAN | MALINDI | MOMBASA | NAIROBI | NAIVASHA | NAKURU | NYERI | THIKA  |
|--------------------|-------|---------|---------|---------|----------|--------|-------|--------|
|                    | N     | %HH     | N       | %HH     | N        | %HH    | N     | %HH    |
| Electricity        |       |         |         |         |          |        |       |        |
| Nominal            | 14,202| 76%     | 956     | 53%     | 1,182    | 83%    | 1,007 | 70%    |
| Effective          | 14,202| 75%     | 956     | 52%     | 1,182    | 83%    | 1,007 | 70%    |
| Quality-adjusted   | 14,202| 46%     | 956     | 17%     | 1,182    | 52%    | 1,007 | 53%    |
| Water              |       |         |         |         |          |        |       |        |
| Nominal            | 14,202| 74%     | 956     | 44%     | 1,182    | 64%    | 1,007 | 26%    |
| Effective          | 14,202| 55%     | 956     | 44%     | 1,182    | 62%    | 1,007 | 20%    |
| Quality-adjusted   | 14,202| 28%     | 956     | 34%     | 1,182    | 32%    | 1,007 | 8%     |
| Toilet             |       |         |         |         |          |        |       |        |
| Nominal            | 14,199| 67%     | 956     | 57%     | 1,182    | 65%    | 1,007 | 60%    |
| Effective          | 14,199| 48%     | 956     | 42%     | 1,182    | 47%    | 1,007 | 39%    |
| Quality-adjusted   | 14,199| 34%     | 956     | 24%     | 1,182    | 35%    | 1,007 | 25%    |
| Sewage Disposal    |       |         |         |         |          |        |       |        |
| Nominal            | 13,715| 46%     | 868     | 30%     | 1,137    | 61%    | 1,001 | 16%    |
| Effective          | 13,715| 42%     | 868     | 14%     | 1,137    | 58%    | 1,001 | 16%    |
| Quality-adjusted   | 13,715| 41%     | 868     | 11%     | 1,137    | 57%    | 1,001 | 16%    |
| Access Roads       |       |         |         |         |          |        |       |        |
| Nominal            | 14,203| 41%     | 956     | 26%     | 1,182    | 44%    | 1,007 | 11%    |
| Effective          | 14,203| 33%     | 956     | 20%     | 1,182    | 39%    | 1,007 | 6%     |
| Quality-adjusted   | 14,203| 24%     | 956     | 8%      | 1,182    | 31%    | 1,007 | 5%     |
| Public Transport   |       |         |         |         |          |        |       |        |
| Nominal            | 14,202| 93%     | 956     | 87%     | 1,182    | 98%    | 1,007 | 84%    |
| Effective          | 14,204| 52%     | 956     | 6%      | 1,182    | 60%    | 1,007 | 19%    |
| Garbage Collection |       |         |         |         |          |        |       |        |
| Nominal            | 14,196| 48%     | 956     | 19%     | 1,182    | 65%    | 1,007 | 27%    |
| Effective          | 14,196| 38%     | 956     | 14%     | 1,182    | 54%    | 1,007 | 19%    |
| Street Lights      |       |         |         |         |          |        |       |        |
| Nominal            | 14,198| 46%     | 956     | 2%      | 1,179    | 64%    | 1,006 | 5%     |
| Effective          | 14,197| 32%     | 956     | 1%      | 1,178    | 48%    | 1,006 | 1%     |
| Phone              |       |         |         |         |          |        |       |        |
| Nominal            | 14,166| 90%     | 956     | 75%     | 1,174    | 96%    | 999   | 80%    |
| Effective          | 14,166| 90%     | 956     | 75%     | 1,174    | 96%    | 999   | 80%    |
ANNEX 4: INFRASTRUCTURE SPENDING PATTERNS BY SETTLEMENT TYPE AND POVERTY LEVEL

This annex outlines findings related to infrastructure spending by settlement type and household poverty level. Variation in spending across these categories may be a function of differences in consumption patterns, service level and access. Data for mean and median monthly infrastructure spending are available for electricity, water, weekly garbage collection and phone. For comparison purposes, spending data were also collected for home cooking fuel and house rent. Mean and median monthly spending data are presented graphically below for formal/informal settlements and non-poor/poor households in Figure A4.1 a & b.

FIGURE A4.1 a & b Comparing monthly infrastructure spending by settlement type and household poverty
Consistent with earlier findings (section 3.3, main report), we find that phone (predominantly mobile phone) is the most expensive infrastructure service. It exceeds the mean expenditure on home cooking fuels, but is still significantly less than that spent on house rent. Electricity is the next most expensive service of those we reviewed, followed by water and garbage collection. This pattern is consistent across settlement types and poverty levels. It is notable however that the median values reported in Table 3.2 for all infrastructure services, as well as for home cooking fuels and house rent, are significantly higher, and in most cases double the reported means. This suggests that the distribution of monthly expenditures is heavily skewed to the right – or that the majority of households pay substantially less than the mean, but a few households pay significantly more. Thus, while mean values may provide useful information on relative costs, they may not be a good representation of typical household expenditures on these services.

Mean values do however allow us to comment on relative spending on services by settlement type and poverty level. Figure A4.1a shows that households in formal settlements consistently pay more for services than households in informal settlements (with the exception of garbage collection services). This makes sense in light of our earlier findings that service quality tends to be higher in the formal communities. There is a similar, but even larger disparity between non-poor and poor households. As shown in Figure A4.1b, non-poor households pay significantly more than poor households across services. For example, for phone service, water and electricity as well as home cooking fuel and house rent, non-poor households spend 34-68% more on average than their poor counterparts. Garbage collection is the only service where spending is comparable across non-poor and poor households. This finding is particularly interesting, as we have already established that the disparity in service quality and usability is lower for the non-poor/poor grouping of households (refer section 4 of main report).

12 Households in formal settlements pay 149 Ksh/month for weekly garbage collection services, whereas those in informal settlements spend significantly more, at 225 Ksh/month. The reason for this additional cost is unclear but warrants further investigation.