CASE STUDY

HOUSEHOLD ENERGY MANAGEMENT IN INFORMAL SETTLEMENTS OF ADDIS ABABA

Abnet Gezahegn Berhe, 2019
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There is a gap in information about the infrastructure adequacy in informal settlements to actually understand the energy provision, use and management. Accessibility, both economically and physically, to adequate and reliable energy sources is vital for social and economic development in any country. This is also in line with SDG-7 ‘to ensure access to affordable, reliable, sustainable and modern energy for all’. The issue of inclusiveness also surfaces when it comes to the accessibility and affordability of energy. Studies show that the bulk of energy in Ethiopia is still consumed by households. This study focuses on the energy management in selected informal settlements of Addis Ababa with the objective to acquire and analyse information on the use pattern, access and affordability of energy at household levels and to identify potentials of the case study areas in terms of achieving access to modern/renewable energy for all. Purposeful systematic selection of four representative case study sites was conducted among different typologies of informal settlements in Addis Ababa. Selam Sefer, Goro and Ayat in the peripheries and Gedam Sefer, in the inner city of Addis Ababa. Mixed data collection techniques were employed including sample survey, in-depth interview of key informants, structured interview on households, mapping, photography, sketching secondary data through literature and contextual review. A total of 520 household survey was conducted. GIS mapping and SPSS were used for the analysis. The analysis outcome is a detailed picture of the energy management in the case study areas. The preliminary findings were further triangulated and validated through FGD.

With regards to the energy use pattern, hydroelectric power appears to be cheaper and more accessible to the case study areas. The households in the informal settlements predominantly use renewable energy source for light. More than half of the households also use modern energy for cooking. Most of the households in the case study areas have access to modern energy even though the acquisition method is informal in some cases. Access to main grid also plays a significant role in securing tenure in case study areas at the outskirts of Addis Ababa. Households without any form of tenure documentation also struggle to acquire main grid connection. These households either end up paying extra for electricity per light point from their neighbours or engage in illegal taping from the main grid in their effort to acquire modern energy source. More than 2/3rd of the low income households cannot afford modern energy and spend more than the energy expenditure threshold. Almost three quarter of the households earning decent monthly income, to the contrary, spend less than the energy expenditure threshold. The households in the case study areas exhibit great awareness on the health and environmental benefits of using modern energy. The substandard infrastructure provision and further informal intervention of the settlers in the case study areas also result in high rates of fire and electricity related accidents. The study recommends to fully exploit the existing social bonds and community involvement to provide universal access for modern energy in the case study areas. This can be achieved by encouraging the formal sector to be more inclusive instead of depriving the settle of their basic right to tenure and infrastructure including access to modern energy.

Keywords:
Informal settlement, Household energy, sustainable energy management, energy use pattern, access and affordability
CONTENTS

Abstract 3
Abbreviations 5
List of Tables & Figures 6

PART 1
Introduction 7

PART 2
Literature Review 8

PART 3
Contextual Review 11

PART 4
Methodology 13

PART 5
Study Area Description 15

PART 6
Findings and Discussion 19

PART 7
Conclusion and Recommendation 33

References 34
Annexes 35
ABBREVIATIONS

FGD – focus group discussion
GWh – Giga Watt Hour
IEA – International Energy Agency
kWh – Kilo Watt hour
MW – Mega Watt
NGO – None Governmental Organizations
WBO – World Bank Overview
WHO – World health organization

Definition of local terms
Kebele – Local government, the smallest administrative unit
Woreda – Local administrative unit, one level higher than kebele
LIST OF TABLES & FIGURES

List of Tables
Table 1: Sampling: Case study areas 13
Table 2: Source of energy for cooking 19
Table 3: Source of energy for light 24
Table 4: Access to main grid 26
Table 5: Formal versus informal Acquisition of electric Meter 27
Table 6: Electricity acquired through informal means on different tenure types 28
Table 7: Income per month 29
Table 8: Energy expenditure as percentage of household income 30
Table 9: List of causes for electrocution 30
Table 10: Initiative to acquire Electricity 31
Table 11: Impact of increase in main grid Connection 32

List of Figures
Fig. 1: Parcellation map of the Arada site prepared based on 2003 topographic map 15
Fig. 2: Arada site located on Google 16
Fig. 3: Parcellation map of the Goro site prepared based on the 2003 topographic map 16
Fig. 4: Goro site located on 2018 Google Image 16
Fig. 5: Parcellation map of the Selam Sefer site prepared based on 2001 topographic map 17
Fig. 6: Selam Sefer site located on 2018 Google Image 17
Fig. 7: Parcellation map of the Ayat site prepared based on 2003 topographic map 18
Fig. 8: Ayat site located on 2018 Google Image 18
Fig. 9: Map distribution of sustainable energy use for cooking - Gedam Sefer, Goro, Selam Sefer and Ayat 20
Fig. 10: Map distribution of sustainable energy use for light - Gedam Sefer, Goro, Selam Sefer and Ayat 22
Fig. 11: Households Häring electricity form neighbors and informally from the main grid 25
PART 1
INTRODUCTION

The growth in urban populations in the developing world has rapidly overtaken the capacity of national and municipal governments to provide formal housing and servicing to the urban population. As a result, the growth of informal settlements in urban areas of the developing world has been high (Putti, 2011). Informal settlements have profound impact on the planning, intervention and expansion of a city. Studying and documenting their characteristics is essential to plan effective interventions. Given the spontaneity and impermanent nature of informal settlements, the social, economic and physical aspects of the settlements are not usually documented. There is a gap in information about the infrastructure adequacy in informal settlements to actually understand the energy provision, use and management. Accessibility, both economically and physically, to adequate and reliable energy sources is vital for social and economic development in any country. This is also in line with SDG-7 'to ensure access to affordable, reliable, sustainable and modern energy for all'. The issue of inclusiveness also surfaces when it comes to the accessibility and affordability of energy.

Electricity in Ethiopia, is mostly used by urban households (Mondale et al. 2018). This study focuses on the energy management in selected informal settlements of Addis Ababa with an objective to acquire and analyse information on the use pattern, access and affordability of energy at household levels and identify potentials of the case study areas in terms of achieving access to modern/ renewable energy for all. Given Addis Ababa’s context, the study focuses on household energy consumption for cooking and light. Though energy management, in broader meaning, includes energy use, costs and efficiency. This study only focuses on the use and cost/ affordability aspect. The efficiency is out of the scope of this study. In the context of this study, the efficiency aspect is only seen as the level of utilization of sustainable energy sources.
Informal settlements are defined by different scholars but according to (UN Habitat, 2015), informal settlements are residential areas where 1) inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit, with modalities ranging from squatting to informal rental housing, 2) the neighborhoods usually lack, or are cut off from, basic services and city infrastructure and 3) the housing may not comply with current planning and building regulations, and is often situated in geographically and environmentally hazardous areas. In addition, informal settlements can be a form of real estate speculation for all income levels of urban residents, affluent and poor. Slums are the most deprived and excluded form of informal settlements characterized by poverty and large agglomerations of dilapidated housing often located in the most hazardous urban land. In addition to tenure insecurity, slum dwellers lack formal supply of basic infrastructure and services, public space and green areas, and are constantly exposed to eviction, disease and violence. According to the SDG indicators report, 2019, the absolute number of people living in informal settlements in the world, grew to over 1 billion out of which, 238 million belong to sub-Saharan Africa. The growing number of informal settlers is the result of both urbanization and population growth that are outpacing the construction of new affordable homes. Adequate housing is a human right, and the absence of it negatively affects urban equity and inclusion, health and safety, and livelihood opportunities. Availability of services, materials and infrastructure should also be considered in line with adequate housing. All beneficiaries of the right to adequate housing should have sustainable access to natural and common resources, clean drinking water, energy for cooking, heating and lighting, sanitation and washing facilities, food storage facilities, refuse disposal, site drainage and emergency services.

Energy, in the context of this study, is the energy used to meet the needs of a household particularly for light and cooking purposes. The following terms are defined in the context of this study. Energy use pattern, is the type of energy (renewable and non-renewable) consumed in households. This is used to determine whether the energy consumption in the case study areas is to a certain extent sustainable or not. Accessibility of Energy, is considered both physically and economically. The physical access is studied in terms of the availability of modern, clean and renewable energy in the case study areas. The economical aspect is considered as affordability. Affordability of energy, is defined as a household’s ability to pay for necessary levels of modern or renewable energy for light and cooking uses. Conceptually energy access means that modern energy services should be physically accessible and available to people and should be of acceptable quality, reliable and preferred. Further, it should be affordable in terms of low capital and operating cost in the context of income (Balachnadra, 2010). Energy management at household level includes the energy use, costs, and efficiency initiatives. In the context of this study, the efficiency aspect is only seen as the level of utilization of sustainable energy sources that promotes the use of energy efficient electric appliances which intern impact climate/environmental protection.

Energy is often considered as a basic human need. But its adequate provision is always a pre- requi-
site for meeting the human needs. Energy has a great potential to influence the most fundamental components of development. It is highly associated with the socio-economic aspects of development like income, education, health and gender. With regards to health, using modern energy reduces exposure to hazardous pollutants, moreover, avoiding drudgery such as collecting fuelwood improves health conditions of women and children. With regards to education, lighting appliances enables to study at night, moreover, utilization of modern energy results in freeing up from drudgery and creating time for study. Electricity also helps narrow the digital divide through information and communication technologies. With regards to Income, enterprise development through electrification creates job, moreover, small scale energy system generates local industry. With regards to the environment, reduction in use of fuelwood prevents deforestation and the use of efficient electric appliances saves energy consumption. Application of renewable energy promotes climate protection (Kanagwa and Nakata 2008).

Sustainable energy management: stable access to energy, especially electricity is considered to be one of the key factors in the development of civilization (Lemaire, 2010). The concept of “sustainable energy”, which is often mistakenly replaced with “renewable energy”. The first expression is much wider, as the issue of sustainability applies not only to generate energy, but also its consumption. Analysing a balanced approach to energy should be considered not only a problem of sustainability, but also the inclusion of social and environmental needs for economic development (Prandecki, 2014). H. Rogall cited in (Prandecki, 2014), describes sustainable energy policy in three dimensions: ecological, economic and socio-cultural. In this way, the sustainability criteria adopted are: The ecological dimension: including global warming, natural tolerance, consumption of non-renewable resources, overuse of renewable resources, hazards to human health. In the economic dimension: the impact on the national economy, meeting the energy needs, short-term security of supply, the relevant prices, preventing concentration and cost-effectiveness of the energy market, the economic dependence on raw material supply and the efficiency and competition for the use by different sectors of the economy (e.g., energy and chemical industry) are included. In terms of socio-cultural: social tolerance, permanent assurance of supply, the integration with the existing infrastructure, avoiding participation in global conflicts, security is included. The three-pillar division of sustainable energy is also provided by G.P. Hammond and C.I. Jones as cited by (Prandecki, 2014), who use slightly different criteria to be met by energy considered to be sustainable. These include: the environmental pillar, the economic pillar and the social pillar, which is more difficult to use measurable criteria, but partly possible, for example, by the level of involvement of stakeholders, customer research, mapping preferences, etc. On the other hand, it is also advisable to use ethical assessment of the impact of existing and future energy systems on society and the environment. One aspect of this assessment is also the issue of intergenerational equity in terms of access to sources of energy and the cost of its acquisition.

According to (IEA, 2019), close to 600 million people are still without access to electricity in sub-Saharan Africa. Africa’s electrification rate of 45% in 2018 remains very low compared with other parts of the world. The 600 million people still without access to electricity there represents more than two-thirds of the global total. About half of the sub-Saharan African population without access to electricity live in five countries: Nigeria, DR Congo, Ethiopia, Tanzania and Uganda. (Lemaire et al, 2016) argue that ‘the legal status of an informal settlement can be a barrier to any formal municipal authority from attempting to service the settlement. Settlements that exist on land that is already owned by the local authority or by another entity, for example a property developer, often have a tenuous or lacking legal
status from the perspective of municipal service authorities. This lack of a formal legal presence can prevent municipal service authorities from attempting to engage with informal settlements due to a lack of a mandate. Due to the difficulties that municipalities often face in providing electricity services to informal communities in developing cities, rates of electricity theft among residents of these communities are often high. These illegal connections can take the form of distributing electricity to several households from one legal connection, or through directly tapping into medium-voltage electricity line to distribute at a local level.

*Environmental impact of modern energy deprivation* (Keller, 2012) argues that ‘One of the primary distinguishing features about the world’s poor is their lack of access to modern, clean energy sources. Globally, 2.5 billion people meet their primary energy needs through the consumption of biomass (TERI, 2008) The World Health Organization (WHO) reports indoor smoke from household air pollution is a serious health risk for some 3 billion people who cook and heat their homes with biomass fuels and coal. Some 3.8 million premature deaths were attributable to household air pollution in 2016 (WHO, 2018).

*Affordability of energy:* (Longe et al. 2018) argue that the percentage of household income spent on energy is one of the indicators of energy poverty. Electricity consumption by households is largely dependent on household income, lifestyle, and appliances owned. Energy expenditure is important, because it is one of the indicators of household energy poverty. The energy expenditure threshold is the approved maximum income-dependent amount that a household should spend on energy costs. It is usually set by the government of any nation, and it is 10% to 15% of household income.

In Summary, the affordability of energy used in a household can also be calculated using the energy expenditure threshold ranging between 10% to 15% of household income. The environmental aspect of sustainable energy management at household level can be seen in terms of the energy use pattern, how renewable and sustainable are the energy sources utilized for cooking and light. This could further be investigated in light of the health and environmental impact of the sources of energy. The economic aspect could be studied in terms of the affordability of the energy sources at the households. The social aspect will look at equity, the right of the informal settlers to infrastructure and particularly access to modern energy. The potentials of existing social bonds and community involvement could also be investigated further to ensure access of modern energy for all.
Addis Ababa, the political capital and the most important commercial and cultural center of Ethiopia, is a primate city and the home of roughly 25% of the total urban population in the country. Land is public property in Ethiopia. All land and housing related policies, strategies, rules and regulations are adopted in light of the basic land ownership right of the public and government in the past thirty years. The informal settlements in Addis Ababa are either in the inner or expansion areas of the city. The informal houses in the inner areas of the city have formalized tenure and evolved along the past century from their beginning around the emergence of Addis Ababa as a garrison town. The majority are owned by the government after 1975, and are commonly referred to as the Kebele houses. Almost 70% (Yitbarek, 2009) of the houses in the inner city are Kebele houses that are single storey and made of mud and wood walls, mud floors and iron sheet roofs. The houses at the expansion areas are not as old as the inner city informal houses and almost all are the results of squat-round by farming community in the Oromia regional state. There are therefore farmer communities that informally sell a parcel of their land to migrants. While the city keeps increasing its limits these communities become integrated within the city proper. The informal settlers keep being encouraged to squat due to the continual government history of land titling of the informal settlements. The government has periodically given land tenures to the settlers with a certain amount of land regularization that tries to correct faulty road alignments & standards (City profile, 2017). There are two types of tenure documentation: households with secure tenure own title deed, while those without title deed hold on to tax receipts paid to local administration for land lease and other services.

According to the energy policy of Ethiopia, 2010, 94% of Ethiopia’s energy consumption is based on biomass energy sources such as fuel wood, charcoal, branches, dung cakes and agricultural residues - the balance is met by commercial energy sources such as electricity and petroleum. 71 million people do not have access to electricity. The policy, nine years ago, highlights the fact that Ethiopia must be boosted before 2025 into a ‘middle-income country’. And that development should not only be ‘climate-proof’ but also CO2. According to the (WBO, 2018), Ethiopia has a final energy consumption of around 40,000 Giga Watt Hour (GWh), whereof 92% are consumed by domestic appliances, 4% by transport sector and 3% by industry. Most of the energy supply thereby is covered by bioenergy, which in case of domestic use is usually stemming from unsustainable sources. The produced electricity of ~ 9000 GWh/a is mainly generated by hydro energy (96%) followed by wind energy (4%), whereof in total 11% get exported. In contrast, the major share of energy supply for transport is imported in forms of petroleum. Ethiopia is endowed with renewable energy sources. These include first of all hydro, but also wind, geothermal, solar as well as biomass. Only a small portion of the potential is harnessed today. Due to its fast-economic growth, the energy demand is increasing enormous. Therefore, it is expected to rise by a rate of 10 -14% per year till 2037. The Ethiopian government has emphasized the importance of sustainable energy development in different policy documents such as Growth and Transformation Plan, green economy strategy, sustainable energy for all and biomass energy strategy.
With regards to the energy use pattern, as has been indicated by (Mondall- et. al, 2018), Power Generation for the electric grid in Ethiopia currently depends almost entirely on hydropower. In urban areas 87% of the population has access to electricity. Electricity is mostly used by urban households and small industry. Per Capita electricity consumption was 23 Kilo Watt hour (kWh) in 2000 and increased to about 41 kWh by 2008 and 70 kWh by 2014. This level is far below the average level of per capita energy consumption across all African countries (500 kWh per capita). The estimated potential for hydropower is 45 GW, wind is 10 GW, geothermal is 5 GW, and solar irradiation ranges from 4.5 kWh/m²/day to 7.5kWh/m²/day in light of this, the Government of Ethiopia’s strategic priorities in the energy sector are: universal electrification access, energy efficiency improvement, decentralized off-grid power generation through the development of renewable energy technologies, and exporting electricity to neighboring countries. In particular, the government is developing large-scale hydroelectric projects with the aim of increasing the supply of renewable energy sources from the present generation capacity of 2000 Mega Watt (MW) to 8000e10,000 MW. The Grand Ethiopian Renaissance Dam is under construction and expected to be completed soon. The hydro-power plant would add 6000 MW to meet the government targets of over 8000 MW capacity.

In summary, the most reliable and sustainable energy source in Ethiopia and particularly Addis Ababa is currently hydroelectric power. According to Addis Ababa city Electric Utility Bureau’s planning office, A household can get 7 kWh of electric power with a tariff of 2 birr/kWh.
PART 4
METHODOLOGY

Purposeful systematic selection of four representative case study sites was conducted among different typologies of informal settlements in Addis Ababa. Selam Sefer, Goro and Ayat in the peripheries and Gedam Sefer, in the inner city of Addis Ababa. Reconnaissance survey was conducted and maps update was done by analyzing existing line maps, aerial photos, satellite images and direct observation. The parcels, given their informal character, do not have official numbers assigned by the authorities. Hence the parcels were numbered using consecutive numbers. Clustering or stratification of each site was conducted to avoid selection bias (unrepresentative sample). Sample size margin of Error was 5% and the confidence level 95%. Simple random sampling of parcels/compounds in each cluster was conducted using randomly generated numbers out of a set of consecutive numbers given to the population (all compounds/parcels) of each cluster. Parcels and samples in each case study area are presented in table 1. Systematic sampling of households in parcels with multiple households was conducted as described on the survey protocol (see Annex -1).

Table 1
Sampling: Case study areas

<table>
<thead>
<tr>
<th>CASE STUDY AREA</th>
<th>ADDRESS</th>
<th>PARCELS</th>
<th>SAMPLE</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedam Sefer</td>
<td>Arada sub city, Woreda 5</td>
<td>411</td>
<td>199</td>
<td>49% (Residential &amp; mixed)</td>
</tr>
<tr>
<td>Ayat</td>
<td>Yeka city, Woreda 13</td>
<td>137</td>
<td>101</td>
<td>73%</td>
</tr>
<tr>
<td>Goro Deley</td>
<td>Bole sub city, Woreda 9</td>
<td>492</td>
<td>216</td>
<td>44%</td>
</tr>
<tr>
<td>Selam Sefer</td>
<td>Bole sub city, Woreda 13</td>
<td>470</td>
<td>212</td>
<td>45%</td>
</tr>
</tbody>
</table>

Mixed data collection techniques were employed including sample survey, in-depth interview of key informants, structured interview on households, mapping, photography, sketching secondary data through literature and contextual review. The key informants are composed of experts and local officials. A single questionnaire, commonly developed by all team members was used for all case study sites. Structured questions were used to reduce interview time and ensure uniformity of the collected data. A set of instructions were also provided to data collectors to document observations (measuring, sketching, labelling and photography). Pilot survey was conducted and the questionnaire was further developed through the feedback. A total of 520 household survey was conducted in all four case study areas.

GIS mapping and SPSS were used for the analysis. Intra– and inter–case analysis, paraphrasing, tabulation, examining relationships between variables, comparison, interpretation, spatial configuration and mapping techniques were used. The analysis outcome is a detailed picture of the energy management in the case study areas. The preliminary findings were further triangulated and validated through a focus group discussion (FGD) conducted during a stakeholder’s workshop. The focus group
was composed of: coordinator of the informal settlers, experts and officials from the sub cities and Woredas of the case study areas, Addis Ababa Electric Utility Bureau, Ethiopian Energy Authority, Addis Ababa land development Bureau, Addis Ababa Plan and development commission and Addis Ababa construction permit and control Bureau.
Various types of informal settlements exist in Addis Ababa depending on their location, age, legal status, development pattern and so on. Nevertheless, respective researches have been done in a piecemeal approach with less perspective on comprehensive & comparative pictures. In this study, it was found important to address each type and get an overall understanding of the informal housing development in the city. Broadly, these settlements are categorized in four mainly considering their location and legal status, which are:

a. Inner-city informally developed kebele house areas
b. Informal settlements both in the inner and in the outskirts of the city on environmentally vulnerable areas (riverside)
c. Informal settlements in outskirts of the city, on acquired farm lands
d. Informal settlements in the outskirts of the city, on environmentally vulnerable areas

Taking the above categories into consideration, for more representative coverage, further criteria such as location in terms of proximity to the inner city & distribution, age, pattern and status (legal) of respective settlements, are considered. Accordingly, four case study sites are identified which are Gedam Sefer, Ayat, Selam Sefer & Goro.

Detail description of the case study sites
1. Gedam Sefer is located in Arada Sub-city, Woreda 5 Addis Ababa. It is an old settlement with houses that are legal but informally developed. The site has a total area 30.7ha with a perimeter of 2.6 km. In total, there are 411 parcels with an estimated population size 2,055.
   The new master plan of the city designated the area for a high density mixed development.
2. **Goro** is located in Bole Sub-city, Woreda 9 Addis Ababa. The site is a recently regularized and legalized informally developed settlement in the outskirts of the city which is located along the bank of a river and partly under high-tension line. It has a total area 26.8 ha with perimeter of 3.56 km. In total there are 492 parcels with an estimated population size 2,460. The settlement is established in the last three decades where its fastest growth is observed only after 2010. The new master plan has designated the area for low density missed residential development.
3. **Selam Sefer** is located in Bole Sub-city, Woreda 13 Addis Ababa. The site is an informal settlement in the outskirts of the city located along a river on a former quarry site which is hazardous & degraded area. It has a total area 23.9ha with a perimeter of 3.27 km. In total there are 470 parcels with an estimated population size 2,350. The settlement is established in the last three decades where its fastest growth is observed only after 2010. The new master plan has designated the area for low density missed residential development.
CASE STUDY
HOUSE HOLD ENERGY MANAGEMENT IN INFORMAL SETTLEMENTS OF ADDIS ABABA

4. Ayat is located in Yeka Sub-city, Woreda 13 Addis Ababa. It is an informal settlement which is acquired farm land in the outskirts of the city. It has a total area 30.7ha & with 2.6 km perimeter. In total there are 79 parcels with an estimated population size 395. Its fastest growth is observed during the last decade. The area was left for green development in the previous master plans of the city, however, the new master plan designated the area for low-density mixed residential area development.

Figure 7
Parcellation map of the Ayat site prepared based on 2003 topographic map

Figure 8
Ayat site located on 2018 Google Image
PART 6
FINDINGS AND DISCUSSION

With regards to the energy use pattern, 56% of the respondents use hydroelectric (modern/renewable energy) and 44% use Charcoal and firewood (traditional) energy for cooking as presented in table 2 and figures 9.

Table 2
Source of energy for cooking

<table>
<thead>
<tr>
<th></th>
<th>Renewable Energy</th>
<th>Non-Renewable Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedam Sefer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ayat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selam Sefer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goro</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 9a
Map distribution of sustainable energy use for cooking - Gedam sefer and Goro,
Figure 9 b
Map distribution of sustainable energy use for cooking - Selam Sefer and Ayat
Figure 10 a
Map distribution of sustainable energy use for light - Gedam Sefer and Goro
Figure 10 b
Map distribution of sustainable energy use for light - Selam Sefer and Ayat
CASE STUDY
HOUSE HOLD ENERGY MANAGEMENT IN INFORMAL SETTLEMENTS OF ADDIS ABABA

Table 3
Source of energy for light

Contrary to the characteristics and definition of informal settlements, modern/renewable energy is utilized to a higher degree for light. More than half of the respondents also use modern energy source for cooking.

With regards to access to modern energy, similar to the formal housing in Addis Ababa, 89% of the respondents are connected to main grid hydroelectric power and own electric meters, while only 11% of the households do not. As presented in detail in table 4, 97% of the respondents from Gedam Sefer, in the inner city, are connected to the main grid taking the lead with this regard, followed by 90% in Ayat, an acquired farm land in the outskirts of the city and 89% in Goro, a recently regularized and legalized settlement in the outskirts of the city. The case study area with the least - 74% respondents that are connected to the main grid is Selam Sefer located in a hazardous & degraded area in the outskirt of the city. It’s interesting to understand how the newly formed settlement in Ayat has more grid connection than that of the regularized settlement in Goro. It’s worth looking in to the driving forces at play in acquiring main grid electric meters.

Respondents on all case study areas indicated that, the number of households that acquired the main grid legally are 91% as compared to those that

78% of the respondents use hydroelectric power for lighting followed by candle users that account only to 12% of the total respondents, as presented in table 3 and figures 10.
acquired the electric meters informally 9%. See table 5. However, this data is further elaborated during the FGD. According to the newly proposed ‘Electricity Customer Service Policy and Procedure’ at the Addis Ababa Electric Utility Bureau, informal residents in the case study areas are not allowed to own electric meter. The document indicates that a household is entitled to electric meter if they have title deed (proof of ownership of the house) or if they acquire a Woreda permit, a support letter proofing that they own the house with parcel number and that they are permanent residents. This however, only applies to domestic use and was intended to address the original/local settlers of the area. According to the FGD respondents, this is the loophole in the legal electric meter acquisition, through which not only original settlers, but also informal settlers acquire support letter from The respective Woreda. Those that are not able to acquire their own electric meters either buy electricity from neighbors or else acquire connection from the main grid informally. Figure 11 shows how households share electricity from neighbors and even directly tap in to the main grid line using substandard poles and wires.

Figure 11
Households sharing electricity from neighbors and informally from the main grid
One interesting fact is that the Addis Ababa Electric Utility Bureau considers their power demand during energy audit. Energy audit and forecast is done using the measurement on grid and not on individual electric meters. The residents’ power demand is included on the planning process indirectly, though it is not official. The Bureau also conducted a study and found out that the capacity of the power supply in Addis Ababa is actually underutilized. The informal settlers are considered as ‘potential customers’.

In conclusion, informal settlers are provided with power services from the main grid one way or another. Substations are located at the peripheries of Addis Ababa on the west, east, north and south ends. Physical access to main grid, is no concern but legal consumers are scare in these areas. Hence, densification of potential customers is required regardless of their informality.

**Table 4**

*Access to main grid*

<table>
<thead>
<tr>
<th>Substation</th>
<th>Private Meter</th>
<th>Shared from a Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gadam Sefer</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Ayat</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Selam Sefer</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Goro</td>
<td>60%</td>
<td>40%</td>
</tr>
</tbody>
</table>

If Main Grid, Ownership of Meter (Energy Source)

- [ ] Private Meter
- [ ] Shared from a Neighbor
Table 5
Formal versus informal Acquisition of electric Meter

<table>
<thead>
<tr>
<th>Site</th>
<th>Direct Formal Request</th>
<th>Indirect Though Informal Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedam Sefer</td>
<td>95.4%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Ayat</td>
<td>95.9%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Selam Sefer</td>
<td>78.1%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Goro</td>
<td>92.6%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Total</td>
<td>91.0%</td>
<td>9.0%</td>
</tr>
</tbody>
</table>

If Main Grid, Method to Get Connection (Energy Source)
The tenure, property documentation type in the case study areas fall in to three main categories: 48% of the respondents have title deed, 31% only have tax receipts and 21% do not have any proof of ownership. Based on the key informant interviews with Woreda officials and experts, there is a tendency to acquire electric meter as a means to secure tenure in the informal settlements at the outskirts of the city. This is also demonstrated in detail in Table 6. Out of the households that have acquired electric meters through informal means, the majority – 80% do not have title deed yet. This is mainly seen at Goro and Ayat case study areas where 100% of households without title deed acquired electric meter through informal means. There are even informal houses that are repeatedly demolished by the Woredas and the main challenge was placement of the electric meters salvaged from the demolished houses.

With regards to affordability of modern energy, the study reveals that 28% of the respondents earn less than 2,044 (Two thousand and forty four) birr per month while the remaining 72% earn more. 2,044 birr is the monthly income calculated from the current per capita income of Ethiopia, which is 790 United states dollars converted to birr using the current exchange rate. See table 7.
The affordability of energy is calculated using the energy expenditure threshold, which is the maximum income-dependent amount that a household should spend on energy cost ranging from 10-15% of the household income. The affordability is calculated in two income categories: households earning less than 2,044 birr per month and those earning more. As depicted in table 8: 60% of the households with lower income spend more than 15% of their earnings on energy expenditure. 70% of the households earning monthly income of more than 2,044 actually spend less than 10% of their income on energy expenditure. Households with relatively lower income in the case study areas struggle to afford energy.
Households that own their own electric meter sell out electricity as a source of income. According to the FGD respondents, a single household sells electricity for 25 birr per single bulb or light point per month, this is very expensive in comparison to the normal tariff which is only 2 (1.94) birr.

With regards to environmental factors, 66% of the respondents have increased the use of hydroelectric main grid power for cooking and light since they moved in the area. 42% of the respondents preferred this renewable energy source since its affordable, 16% preferred the positive impact on health and 9% preferred the convenience. 53% and 34% of the households have shifted from using firewood and charcoal respectively due to health hazards showing more awareness and demand for modern energy. The major cause of fire in the case study areas is cooking fire hazard (38%) followed by faulty electricity connections (25%). Respondents in the case study area also indicated that electricity connected accidents are common as depicted in table 9. Most causes of electrocution are related to the mismanagement and tapering of the main power grid lines.

### Table 8
Energy expenditure as percentage of household income

<table>
<thead>
<tr>
<th>Site</th>
<th>Gedam Sefer</th>
<th>Ayat</th>
<th>Selam Sefer</th>
<th>Goro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10%</td>
<td>15.4%</td>
<td>13.3%</td>
<td>21.9%</td>
<td>16.0%</td>
</tr>
<tr>
<td>10 - 15%</td>
<td>3.8%</td>
<td>40.0%</td>
<td>28.1%</td>
<td>24.0%</td>
</tr>
<tr>
<td>More than 15%</td>
<td>80.8%</td>
<td>46.7%</td>
<td>50.0%</td>
<td>60.0%</td>
</tr>
<tr>
<td>Less than 10%</td>
<td>64.3%</td>
<td>69.0%</td>
<td>68.8%</td>
<td>81.1%</td>
</tr>
<tr>
<td>10 - 15%</td>
<td>14.8%</td>
<td>24.1%</td>
<td>12.5%</td>
<td>9.5%</td>
</tr>
<tr>
<td>More than 15%</td>
<td>20.9%</td>
<td>6.9%</td>
<td>18.8%</td>
<td>9.5%</td>
</tr>
<tr>
<td>Total</td>
<td>17.3%</td>
<td>22.4%</td>
<td>60.2%</td>
<td>70.3%</td>
</tr>
</tbody>
</table>

### Table 9
List of causes for electrocution

<table>
<thead>
<tr>
<th>Site</th>
<th>Pole Collapse</th>
<th>Transformer Problem</th>
<th>Faulty Wiring</th>
<th>Faulty Appliance</th>
<th>Lack of Proper Setback</th>
<th>Electric Lines Falling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedam Sefer</td>
<td>27.5%</td>
<td>24.2%</td>
<td>17.6%</td>
<td>12.1%</td>
<td>3.3%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Ayat</td>
<td>55.6%</td>
<td>0.0%</td>
<td>22.2%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>22.2%</td>
</tr>
<tr>
<td>Selam Sefer</td>
<td>18.2%</td>
<td>9.1%</td>
<td>4.5%</td>
<td>29.5%</td>
<td>13.6%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Goro</td>
<td>0.0%</td>
<td>57.1%</td>
<td>7.1%</td>
<td>21.4%</td>
<td>0.0%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Total</td>
<td>24.0%</td>
<td>21.5%</td>
<td>13.3%</td>
<td>17.1%</td>
<td>5.7%</td>
<td>18.4%</td>
</tr>
</tbody>
</table>
Respondents indicated that, there is low crime rate in terms of homicide, robbery and theft. Social ills, such as addiction, begging, juvenile delinquency, prostitution and sexual assault are also infrequent in the case study areas. This data is further corroborated by the Woreda officials during the key informant interview. They even indicated that the crime and social ills occurrences are even lower than the formal neighbourhoods in the Woredas and sub cities of the case study areas.

With regards to achieving access to modern/renewable energy for all: looking closely at the actual initiation of the main grid connection in the case study area revealed that, the lion share of electric meter acquisition to the households was initiated by None Governmental Organizations (NGOs), followed by the government and community, showing high potential of social bond and community involvement. See Table 10.

**Table 10**

<table>
<thead>
<tr>
<th>Initiative to acquire Electricity</th>
<th>Gedam Sefer</th>
<th>Ayat</th>
<th>Selam Sefer</th>
<th>Goro</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPCO Initiative</td>
<td>80%</td>
<td>60%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>Community Initiative</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
<td>80%</td>
</tr>
<tr>
<td>Woreda Initiative</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>NGO Initiative</td>
<td>5%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>Individual Request</td>
<td>95%</td>
<td>90%</td>
<td>80%</td>
<td>70%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initiative to get Meter (Energy Source)</th>
<th>Gedam Sefer</th>
<th>Ayat</th>
<th>Selam Sefer</th>
<th>Goro</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEPCO Initiative</td>
<td>90%</td>
<td>80%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Community Initiative</td>
<td>10%</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Woreda Initiative</td>
<td>5%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>NGO Initiative</td>
<td>95%</td>
<td>90%</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>Individual Request</td>
<td>95%</td>
<td>90%</td>
<td>80%</td>
<td>70%</td>
</tr>
</tbody>
</table>
The respondents also put the need to acquire reliable, affordable and modern energy on the top of their list of aspirations and expectations from the neighbourhood. The respondents also revealed that the increase in main grid connection in the settlements over the courses of their stay improved their neighbourhoods in many aspects as detailed in Table 11. Security is enhanced, residents have better health conditions thanks to cleaner cooking methods, the household incomes increased due to better small-scale business opportunities, and the land use was changed from purely residential to mixed use, incorporating more economic activities.

Table 11
Impact of increase in main grid Connection

<table>
<thead>
<tr>
<th>Site</th>
<th>Increased Income</th>
<th>Better Health</th>
<th>Better Security</th>
<th>Change of Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedam Sefer</td>
<td>23.9%</td>
<td>21.8%</td>
<td>54.3%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Ayat</td>
<td>42.1%</td>
<td>21.0%</td>
<td>21.0%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Selam Sefer</td>
<td>27.9%</td>
<td>27.1%</td>
<td>34.9%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Goro</td>
<td>23.4%</td>
<td>36.6%</td>
<td>40.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total</td>
<td>27.7%</td>
<td>26.8%</td>
<td>38.4%</td>
<td>7.1%</td>
</tr>
</tbody>
</table>
In conclusion, with regards to the energy use pattern, hydroelectric power appears to be cheaper and more accessible to the case study areas. The households in the informal settlements predominantly use renewable energy source for light. More than half of the households also use modern energy for cooking. Most of the households in the case study area have access to modern energy even though the acquisition method is informal in some cases as discussed in the data presentation section. Access to main grid also plays a significant role in tenure security as seen in case study areas in the outskirts of Addis Ababa. Households without any form of tenure documentation also struggle to acquire main grid connection. These households either end up paying extra for electricity per light point from their neighbours or engage in illegal taping from the main grid in their effort to acquire modern energy source.

More than 2/3 of the low-income households cannot afford modern energy and spend more than the energy expenditure threshold. Almost three quarter of the households earning decent monthly income, to the contrary, spend less than the energy expenditure threshold. The households in the case study areas exhibit great awareness on the health and environmental benefits of using modern energy. The substandard infrastructure provision and further informal intervention of the settlers in the case study areas also result in high rates of fire and electricity related accidents.

The study recommends to fully exploit the existing social bonds and community involvement to provide universal access for modern energy in the case study areas. This includes the full utilization of the energy potential of the Addis Ababa Electric Utility Bureau and further investigation of decentralized energy provision through other renewable sources. Settlers in the case study areas are predominantly law-abiding citizens with acute shortage of housing. The Addis Ababa city administration should take the lead in housing and infrastructure provision through a shift to self-help, community involvement and controlled development. This can be achieved by encouraging the formal sector to be more inclusive instead of depriving the settles of their basic right to tenure and infrastructure including energy.
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Abnet Gezahegn Berhe, Dawit Benti Erena, Imam Mahmoud Hassen, Tson Lemma Mamaru, Yonas Alemayehu Soressa (2017), City profile
CASE STUDY
HOUSE HOLD ENERGY MANAGEMENT IN INFORMAL SETTLEMENTS OF ADDIS ABABA

ANNEXES

Survey protocol

Introduction Note (የልጓጭ ይትእን multiplicity)


Survey protocol

SES-EABC Sample Survey Protocol

1. Two of the interviewers/students may join together during the interview of any of the households assigned for each of them; however, each of the two students will be fully responsible for the compounds assigned specifically for him/her and the completion of the work within the given time.

2. If a questionnaire is submitted not filled properly or not fully completed, a new household shall be assigned for the student to replace it.

3. Before starting the interview, please check and confirm the actual existence of all the sample parcels/compounds assigned for you, as they are shown on the given map.

4. Please select one of the sample compounds assigned for you, introduce yourself, and identify the number (how many) and tenure situation (owner or renter) of the household(s) in the compound.

   (This information shall be included in the site plan drawing of the parcel.)

5. If you find only one household in the parcel, please introduce yourself according to given Amharic "Introduction Note (አገርካር መስጡ ተማማሚ)") and ask for the willingness of the household head (HH) to participate in the survey.

6. If you find more than one household in the parcel, please select the household living in a house where its main-entrance is found first as you move in the courtyard counterclockwise starting from the gate (to your right-side from the gate as you enter the compound); then, please introduce yourself according to given Amharic "Introduction Note (አገርካር መስጡ ተማማሚ)" and ask for the willingness of the HH to participate in the survey.

7. If the HH is willing to be interviewed, please proceed with the interview using the given structured questionnaire.

8. If the HH is unavailable for interview at the time of your visit, please try to find out the convenient time for him/her to be interviewed and proceed to the next compound assigned to you.

   Please make sure to go back to the skipped household at the agreed time to complete the survey.

9. If the HH is still unavailable after your three visits or is unwilling to be interviewed (participate in the survey), please inform the situation to your instructor(s) as soon as possible.

10. If the respondent HH is unwilling to respond to a specific question, please write "999" next to the question.

   (In such cases, please make sure that the household's response is based on understanding the intended meaning of the question)

11. If a question is not applicable for the specific respondent, please write "222" next to the question.

12. If a question in a table is not applicable for the specific respondent, please use ".-" in the given space.

   No space should be left open in the table.

13. If the respondents include more than one of the given options in the tables, please write all the selected options in the given space by using ".’" between the selected options.

14. The tenure condition of at least 20% of the households you interview are expected to be either owners or renters (from private owners or government). In the event of either of the two are not included in the samples you interviewed after you finished about half of the total number of compounds assigned for you, please focus on finding the missing tenure type in the remaining compounds assigned for you.

   If you find more than one household of the missing tenure type in any of the remaining compounds, please select the household living in a house where its main-entrance is found first as you move in the courtyard counterclockwise starting from the gate (to your right-side from the gate as you enter the compound).

15. Please submit the completed questionnaire to your instructors at the end of each day of survey.

16. Please make sure to have your EiABC student identification (ID) card with you during the survey.

THANK YOU!