Factors that Enable or Hinder Sustained Access to Sustainable and Effective Cooking Energy Services: The Case of the Informal Settlement of Kibera in Nairobi, Kenya

Von der Fakultät Wirtschafts- und Sozialwissenschaften der Universität Stuttgart zur Erlangung der Würde einer Doktorin der Wirtschafts- und Sozialwissenschaften (Dr. rer. pol.) genehmigte Abhandlung

Vorgelegt von

Grace Kageni Mbungu

aus Chuka, Kenya

Hauptberichter: Prof. Dr. Dr. h.c. Ortwin Renn

Mitberichter: Prof. Dr. Ilan Chabay

Tag der mündlichen Prüfung: 15.07.2020

Institut für Sozialwissenschaften der Universität Stuttgart

2020

Acknowledgement

This thesis would not have been possible without the advice, help, support, guidance, and love of many people.

I would like to thank my mother and father for the gift of life and their unconditional love. They have always been there, allowing me the freedom to be who I am, and to take unconventional paths in life, even in times when, as parents, they could have wished for clearer and better defined paths.

There is no way I could have completed this thesis without the advice, guidance, and support of my two supervisors, Prof. Dr. Ortwin Renn and Prof. Dr. Ilan Chabay. Thank you both, for challenging me to produce the best that you saw in me, for helping me grow and learn, for your encouragement, and for your help throughout my PhD journey.

A very special thanks goes to the residents of Kibera, to whom this work is dedicated. In all honesty, this body of work is a collaborative effort between Kibera residents, especially those that welcomed me into their homes and generously gave me their precious time. Without their acceptance and trust, the conditions necessary to deeply understand the challenges of cooking energy access, and the opportunities that often go unexplored or dismissed in the mainstream energy access discourse, would have been virtually impossible.

I would also like to thank my host institution, the Kibera Town Centre (KTC). Anyone who has worked or carried out research activities in Kibera knows that it is not an easy place to be. However, it became my home for three months, mostly because of the support I received from the staff at the KTC. My special thanks go especially to Stella Muania, who often accompanied me and introduced me to Kibera and her residents, who I come to know and respect for their handiwork, endurance, resilience, and determination, towards a better and fulfilling life, despite the heavy weight of their challenges and obstacles.

My special thanks go to Dr. Rebecca Freeth, who over a very short period of time became not only a dear friend, but a member of my chosen family. I credit Rebecca for helping me see that there had to be an end to a PhD, and for selflessly and generously giving me the support, love, and time I needed to get there.

I will always be indebted to Dr. Marco Sonnberger for his enduring support, long before I began this journey and until the very end. Your comments and feedback on my often messy work, and your encouragement, have been invaluable. Thank you so very much!

There is always that one person at the start of a journey that shows you the way and always provides the much needed support. In my career here in Germany and PhD journey, that person is Diana Gallego Carrera. Diana, thank you so much for your love and friendship, and for ensuring that my Abstract is legible and understandable in German.

I would like to thank the Institute for Advanced Sustainability Studies (IASS) Potsdam, for offering me the resources, including the time I needed, to work on this project. I would particularly like to thank the Fellowship Program staff, especially Achim Maas and Judith von Pogrell, for their support during my time as a fellow at the Institute. Thank you, too, to all the people that supported me in this processes as family, friends, and mentors, at the IASS and beyond. There are too many of you to name, but I am grateful to each one of you.

Finally, my heartfelt gratitude goes to my beloved daughter, Thea. You are the compass of my life, and a big reason why this thesis was completed. A caring, loving, and supportive child who knew, even with constant but justified complaining, that it was important for me to get this done. I admire you for your courage and thank you especially for your patience and endurance during my data collection in Kenya during 2017. Thank you so much from the bottom of my heart!

Abstract

Access to sustainable and effective energy services is central to every challenge and opportunity that humanity and the planet face today. As a result, there is unprecedented consensus that the ways in which energy is produced, distributed, and consumed can have major positive or negative consequences for humans, the environment, and the broader ecosystem, and therefore, a direct or indirect effect on achieving the United Nations Sustainable Development Goals (SDGs) and complying with the Paris Agreement. The situation in the developed and middle-income countries is such that most households have sustained and effective access to cooking energy services. In contrast, almost 80–90% of household in developing countries, especially in Sub-Saharan Africa, lacks such access or face constant interruptions due to financial insecurities, and unreliable or insecure energy services.

Technological development has widely been viewed and supported as the solution to these challenges. However, while technological development is an important element in addressing this challenge, the central role of individual and societal factors in influencing the acceptance, sustainable access, and effective uses of technologies is often overlooked. Nevertheless, technological processes are negotiated, developed, implemented, and used within social contexts. The objective of this thesis is to understand and contextualize the factors that facilitate or hinder sustainable and effective access to cooking energy services within households in the informal settlement of Kibera, with a focus on biomass improved cookstoves (ICSs).

Guided by the needs–opportunity–ability model (NOA), this thesis first examines the needs that households seek to fulfil through cooking energy services. It then assesses the state of abilities and opportunities in order to understand the limitations and opportunities available and accessible to households to meet their desired needs. Lastly, the role of individual and societal factors are examined at the micro, meso, and macro levels in enabling or hindering sustainable access and effective use of the cooking energy services sought and desired by households. This approach is especially important because it recognizes that energy access processes are also shaped by a broad spectrum of influences that lie outside the households' direct control or the nature of technological outcomes.

The findings of this thesis show that households have multiple and diverse needs that they seek to fulfil through cooking energy services. Moreover, the findings confirm, as emphasized in the NOA model, the influential and interconnected roles of factors at the micro and macro levels in influencing consumer behavior and outcomes. Furthermore, it is found that meso-level factors also have significant influence on sustained access and effective use of cooking energy services, and might even exert stronger influence than macro-level factors, due to their immediacy and direct connection to the user and their day-to-day activities and livelihoods.

This thesis concludes that, rather than household resistance to embracing sustainable and effective cooking energy services, the most persistent barriers to the adoption of sustainable and effective cooking energy services relate to how user needs are understood or fail to be understood, and the lack of appropriate and secure abilities and opportunities. Therefore, while several opportunities to address the challenges of access to clean and effective cooking energy services were identified, a range of individual and structural challenges would also need to be overcome to facilitate sustainable and effective progress.

To overcome these challenges in Kibera, a range of options are proposed to improve and strengthen sustained access and effective use of cooking energy services. These recommendations emphasize the need for ongoing and holistic understanding of households' needs and realities, as well as the central role played by interacting forces at the micro, meso, and macro levels in influencing access conditions and outcomes for humans and the environment of advocated cooking energy services. More specifically, the recommendations call for greater attention to the social and contextual dimensions and dynamics of cooking energy production, distribution, and consumption processes, as demonstrated in the ‘landscape’ of cooking energy access that is one of the major outcomes of this thesis.

Zusammenfassung

Der Zugang sowie die Möglichkeit zur Nutzung nachhaltiger Energiedienstleistungen sind heutzutage zwei der zentralen Herausforderungen und Chancen für Mensch und Umwelt. So besteht einhelliger Konsens darüber, dass die Art und Weise, wie Energie erzeugt, verteilt und genutzt wird, erhebliche positive oder negative Folgen für die Menschheit, die Umwelt sowie das gesamte Ökosystem haben kann.

Aus diesem Grund ist auch davon auszugehen, dass Energieerzeugung, -verteilung und –nutzung einen direkten oder indirekten Einfluss auf das Erreichen der von den Vereinten Nationen für nachhaltige Entwicklung[1] postulierten Ziele sowie auf das Erreichen der Ziele des Pariser Übereinkommens haben.

Analysen zeigen deutlich, dass die meisten Haushalte in den Industrienationen sowie in den Schwellenländern einen direkten Zugang zu nachhaltigen und effektiven Koch-Energiedienstleistungen haben. Im Gegensatz hierzu verfügen 80 bis 90% der Haushalte in den Entwicklungsländern, insbesondere in der Gegend der Sub-Sahara in Afrika, nicht über einen Zugang zu nachhaltigen und effektiven Koch-Energiedienstleistungen oder aber, sie verfügen über einen Zugang, dieser ist jedoch aufgrund von finanziellen Schwierigkeiten, Unzuverlässigkeit und Unsicherheiten nicht stabil und vielfach unterbrochen.

Technologische Entwicklungen wurden weitläufig als mögliche Lösungen für diese Probleme betrachtet und deren Fortschritte entsprechend unterstützt. In der Tat leisten technologischen Entwicklungen einen wichtigen Beitrag zur Lösung dieser Probleme. Allerdings wird der zentralen Rolle individueller und gesellschaftlicher Einflussfaktoren, welche die Akzeptanz dieser Technologien sowie den nachhaltigen Zugang und die effektive Nutzung der Technologien beeinflussen, vielfach nicht zu genüge Rechnung getragen. Die Berücksichtigung dieser Faktoren ist jedoch wichtig, denn technologische Prozesse werden in sozialen Kontexten ausgehandelt, entwickelt, implementiert und genutzt.

Das Ziel dieser Doktorarbeit ist es daher diejenigen individuellen und gesellschaftlichen Einflussfaktoren zu verstehen und miteinander in den Zusammenhang zu bringen, die einem

[1] United Nations Sustainable Development Goals (SDGs)

nachhaltigen und effektiven Zugang zu Koch-Energiedienstleistungen sowie deren Nutzung förderlich oder hinderlich sind.

Als Fallbeispiele der Untersuchung dienen hierbei die Haushalte der Siedlung Kibera – einem Slum im Südwesten Nairobis, der Hauptstadt von Kenia. Der Fokus der Untersuchung richtet sich auf den Zugang und die Nutzung von Kochöfen, die durch den Einsatz von Biokraftstoffen modernisiert und verbessert wurden. Unter Anwendung des „Bedarfs-, Chancen- und Fähigkeitsmodells“[2] werden in dieser Doktorarbeitet in einem ersten Schritt diejenigen Bedürfnisse erforscht, die die Haushalte durch Koch-Energiedienstleistungen erfüllen möchten. In einem zweiten Schritt sollen sodann die gegenwärtig gegebenen Fähigkeiten und Möglichkeiten in Bezug auf den Zugang und die Nutzung dieser modernen Kochöfen adressiert werden, um anhand deren Betrachtung die Chancen und Hemmnisse zu verstehen, denen Haushalte gegenüber stehen, wenn sie ihre Bedürfnisse durch Kochen-Ergiedienstleistungen befriedigen möchten. Abschließend werden die spezifischen Rollen von individuellen und gesellschaftlichen Einflussfaktoren auf der Mikro-, Meso- und Makroeebene untersucht, die einen nachhaltigen Zugang und eine effektiven Nutzung der Koch-Enegiedienstleistung durch den Haushalt ermöglichen beziehungsweise verhindern.

Dieser ganzheitliche Ansatz wird als wichtig erachtet, da auf diese Art und Weise aufgezeigt werden kann, dass der Zugang zu Koch-Energiedienstleistungen durch eine Vielzahl von Einflussfaktoren geprägt wird, die weder durch die jeweiligen Haushalte selbst noch durch technologischen Fortschritt beeinflusst werden können.

Die Ergebnisse der Doktorarbeit zeigen deutlich auf, dass die untersuchten Haushalte vielseitige Bedürfnisse haben, die sich durch die Nutzung von Koch-Energiedienstleistungen befriedigen lassen. Darüber hinaus bestätigen die Ergebnisse dieser Arbeit, die durch das NOA-Modell postulierte Annahme, dass miteinander verknüpfte und sich gegenseitig beeinflussende Faktoren auf der Mikro- und der Makroebene einen essentiellen Einfluss auf das Verhalten der Nutzer von Koch-Energiedienstleistungen haben.

Des Weiteren wurde im Rahmen der Analyse festgestellt, dass auch Faktoren auf der Mesoebene einen erheblichen Einfluss auf den Zugang zur nachhaltigen und effektiven Nutzung von Koch-Energiedienstleistungen haben. Diese Faktoren könnten aufgrund ihrer direkten Verknüpfung

[2] Needs–Opportunity–Ability Model (NOA)

zum Nutzer und der Einflussnahme auf dessen Lebensgrundlage und Alltagssituationen sogar einen noch größeren Einfluss ausüben als die zuvor angesprochenen Faktoren auf der Makroebene.

Die Untersuchung kommt daher auch zu dem Schluss, dass das größte Hemmnis bei der Einführung einer nachhaltigen und effektiven Koch-Energiedienstleistung nicht der Wiederstand der Haushalte gegen die Einführung und Nutzung solcher Dienstleistungen an sich ist sondern, dass die größten Barrieren darin bestehen, wie die Bedürfnisse der Haushalte wahrgenommen und verstanden werden bzw. nicht-verstanden werden. Darüber hinaus spielt auch das Fehlen bzw. die Sicherstellung von entsprechenden Fähigkeiten und Möglichkeiten eine zentrale Rolle beim Zugang und der effektiven Nutzung von nachhaltigen Koch-Energiedienstleistungen.

Während somit also bereits verschiedenste (technologische) Lösungswege bezüglich des Zuganges zu sauberem und effektivem Kochen identifiziert und umgesetzt wurden, erscheint es als notwendig, ergänzend hierzu eine Reihe von individuellen und strukturellen Herausforderungen anzugehen, um nachhaltige und effektive Koch- Dienstleistungen in den Haushalten zu etablieren und Fortschritt zu ermöglichen.

Um diese Herausforderungen in Kibera zu bewältigen, werden verschiedene Handlungsempfehlungen vorgeschlagen, die den nachhaltigen Zugang und die effektive Nutzung von Koch-Energiedienstleistungen verbessern und stärken können.

Die Empfehlungen unterstreichen die Notwendigkeit eines übergreifenden und ganzheitlichen Ansatzes zum besseren Verständnis der Bedürfnisse und Alltagswelten der Haushalte. Darüber hinaus ist es zentral, ein Verständnis für die sich gegenseitig beeinflussenden Faktoren auf der Mikro-, Meso- und Makroebene zu entwickeln und deren Relevanz für den Zugang und die Nutzung von umweltschonenden und effektiven Koch-Energiedienstleistungen zu berücksichtigen.

Insbesondere wird anhand der Empfehlungen für das Fallbeispiel deutlich aufgezeigt, dass eine stärkere Berücksichtigung der sozialen und kontextuellen Einflussfaktoren sowie die Beachtung der Dynamiken von Prozessen zur Erzeugung, Verteilung und Nutzung von Koch-Energiedienstleistungen von elementarer Bedeutung ist, wenn technologischer Fortschritt etabliert werden soll.

Dies ist eines der Hauptergebnisse dieser Doktorarbeit.

Table of contents

List of Abbreviations

ALRI	Acute lower respiratory infection
ARI	Acute respiratory infection
BCS	Basic cookstoves
CBD	Central business district
CDM	Clean Development Mechanism
CO	Carbon monoxide
EDI	Energy Development International
FAO	Food and Agriculture Organization
GACC	Global Alliance for Clean Cookstoves
GHG	Greenhouses gases
GIS	Geographical information systems
GoK	Government of Kenya
IAP	Indoor air pollution
ICSs	Improved cook stoves
IEA	International Energy Agency
IFRA	French Institute for Research in Africa
ISO	International Organization for Standardization
KCJ	Kenya Ceramic Jiko stove
KSEP	Kenya Slum Electrification Project
KREDP	Kenya Renewable Energy Development Project

KTC	Kibera Town Centre
LPG	Liquid petroleum gas
MDGs	Millennium Development Goals
NGO	Non-governmental organization
NBCI	National Biomass Cooks Stove Initiative
NPIC	Indian National Programme on Improved Cookstoves
NISP	Chinese National Improved Stove Program
PAYG	pay-as-you-go
PM	Particulate matter
PPP	Public–private partnerships
PCIA	Partnership for Clean Indoor Air
SDGs	Sustainable Development Goals
SEforALL	Sustainable Energy for All
SSA	Sub-Saharan Africa
TCS	Traditional cookstoves
UN	United Nations
USAID	United States Agency for International Development
UNDP	United Nations Development Programme
VNRs	Voluntary National Reviews
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

List of figures

List of Tables

This work is dedicated to the residents of Kibera, and to my beloved daughter, Thea.

1. Introduction

1.1. Background

Universal access to sustainable and effective cooking energy services has been the goal of many national and international policies, initiatives, and financial investments for the last four decades. Most recently, the magnitude of the challenge was highlighted by the inclusion of SDG 7 as one of the 17 goals universally identified and endorsed by the global community, along with the Paris Agreement, to address unstable energy production and consumption practices in order to mitigate the adverse effects on humans and the environment.

However, despite these good intentions, substantial financial investment, improved technological development, and the magnitude of the benefits associated with the adoption and sustained use of clean and fuel-efficient cooking energy services , their acceptance, adoption, and integration into daily household cooking practices is known to be extremely low, especially, in Sub-Saharan Africa (IRENA and OECD/IEA, 2017; OECD/IEA, 2017). Today, despite some modest improvements in access in some regions of the world (The World Bank, 2015; Venkata Ramana, Michael, Sumi, & Kammila, 2015), more than three billion people rely on biomass fuels such as wood, charcoal, dung, crop residue, and fossil fuels (mainly kerosene) for cooking and space heating (FAO, 2010; IEA, 2017; IEA, IRENA, UNSD, WB, & WHO, 2019). These fuels are typically utilized with inefficient and unsafe appliances that expose users and their dependents to health, social, and economic risks.

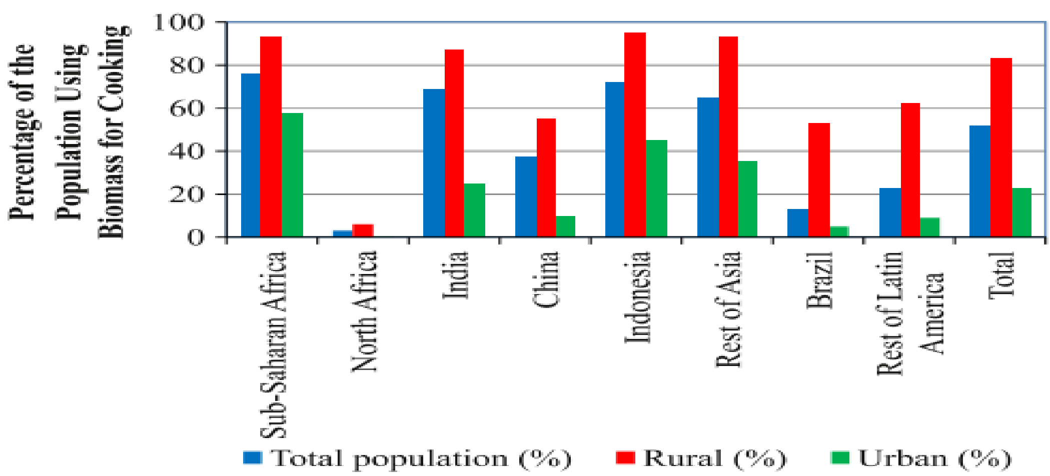
According to the World Health Organization (WHO), household indoor air pollution (IAP) contributes to almost four billion deaths per year.[3] This is more than HIV/AIDS, malaria, and tuberculosis combined (Landrigan et al., 2017; Venkata Ramana et al., 2015). In rural areas, women may spend several hours per day collecting wood fuels, often in precarious conditions, while households in urban low socioeconomic communities, such as Kibera, spend a significant proportion of their income on cooking energy fuels, mainly charcoal and kerosene (Rysankova, Putti, Hyseni, Kammila, & Kappen, 2014). Moreover, the unsustainable production and consumption of inefficient biomass cooking technologies is linked to environmental degradation and climate change (FAO, 2010; IRENA, 2016; IRENA and OECD/IEA, 2017).

---

[3] For more information, see WHO: Household Air Pollution. Available online: https://www.who.int/airpollution/household/en/ (accessed on 11th November, 2019).

To address these challenges, many policies and initiatives have been formulated and implemented over the last 40 years. One such effort has been to encourage households to transition from traditional cookstoves (TCS) to improved cook stoves (ICS). Compared to the TCS , ICS are known to be more energy-efficient when fitted with energy-saving insulation materials; to substantially reduce indoor air pollution (IAP) when fitted with a chimney or hood; to reduce the time spent on cooking and fuel-gathering through their fuel-efficient properties; and to be cleaner and safer than their TCS counterparts (Johnson et al., 2019; Kshirsagar & Kalamkar, 2014; OECD/IEA, 2016; Urmee & Gyamfi, 2014a). However, developments in the last four decades with regard to the acceptance, adoption, and sustainable access and use of clean and environmentally friendly cooking energy services, including ICSs, present a mixed story. The situation in developed and middle-income countries, especially in Western Europe and North America, is such that most households have access to clean and reliable cooking energy services. In contrast, almost 80–90% of households in developing countries, especially in Sub-Saharan Africa, lack such access or face constant interruptions due to financial insecurities or lack of appropriate, reliable, and affordable cooking energy services (Kshirsagar & Kalamkar, 2014; OECD/IEA, 2016; World Bank, 2015). Even more pronounced are the high numbers of people using biomass for cooking in Sub-Saharan Africa compared to other parts of the world, especially in North Africa, as shown in Figure 1.

Figure1. Population percentages using biomass cooking in selected regions of the world



Source:(Urmee & Gyamfi, 2014)

In response to these issues, this thesis seeks to understand the factors that facilitate or hinder access and effective use of sustainable cooking energy services with specific focus on biomass improved cookstoves (ICSs), within households of the informal settlement of Kibera in Nairobi, Kenya.

1.2. Why is sustained access and effective use of sustainable cooking energy services important?

In the context of this thesis, sustained access to cooking energy services is defined as the presence of appropriate and secure abilities and opportunities, both within households and the broader societal context, to enable households the freedom and choice to procure and use their desired cooking energy services in a sustainable and effective way. Sustainable access is understood in thesis as the potential for households to access and use cooking energy services to meet their needs, without compromising the ability of future generations to do so, and while ensuring the wellbeing of the planet. This understating is in line with the sustainable development definition provided in the United Nation's Brauntland Report (World Commission on Environment and Development (WCED), 1987)

Sustained and sustainable access to ICSs and other clean, safe, affordable cooking energy services is important because it enables the fulfilment of immediate and basic needs for food, safe drinking water, and warm living environments, and the enhancement and preservation of social–cultural values and the general wellbeing of individuals and communities. In addition, sustained access and use of sustainable and effective cooking energy services enables most if not all aspects of social and economic development activities; facilitates local transformations; enables global sustainable development and the protection of entire ecosystems.

The importance of sustainable access to cooking energy services for all is underscored by the inclusion of a separate goal specifically focused on universal energy access, within the current United Nations Sustainable Development Goals (SDG) framework (UN, 2015), wherein Goal 7 reads: "Ensure access to affordable, reliable, sustainable and modern energy for all." The serious intention of the global community to achieve this goal is particularly notable, given that energy did not feature as a stand-alone goal of the previous United Nations Millennium Development Goals (MDGs). However, one of the major arguments made in this thesis is that it is not sufficient to advocate for sustainable access to cooking energy services, but it is also important to ensure that such access can be sustained over the long-term, and that it is effective in meeting intended goals. This is the more important because the benefits of achieving SDG 7 are not limited to ensuring access to affordable, reliable, sustainable, and modern energy for all. Given the systemic and interconnected nature of energy production and consumptions practices, with humanity and the environment, the attainment (or not) of SDG 7 will impact the short and long-term state and wellbeing of humans, the entire ecosystems and, indeed, the planet. For example, the attainment of SDG 7 directly or indirectly influences the outcomes of other goals prioritized within the SDG framework[4] such as: (SDG 1) End poverty in all its forms everywhere; (SDG 3) Ensure healthy lives and promote wellbeing for all at all ages; (SDG 4) Ensure inclusive and equitable and quality education and promote lifelong learning opportunities for all; (SDG 5) Achieve gender equality and empower all women and girls; (SDG 12) Ensure sustainable consumption and production patterns; (SDG 13) Take immediate action to combat climate change and its impacts; and (SDG 15) Protect, restore and promote sustainable use of territorial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt diversity loss. The rest of the goals either require energy for their achievement or their success, or else their outcomes are dependent on processes of energy production and consumption. This thesis is motivated by the need to understand why there has only been limited acceptance and uptake of ICSs to date, and the conditions needed to ensure sustained and sustainable access and effective use, by focusing on the informal settlement of Kibera.

1.3.Why focus on improved cook stoves?

While improved biomass cook stoves have been a topic of research and a target for large-scale technological development and financial investments for more than 40 years, they have had limited success, especially in Sub-Saharan Africa (IEA et al., 2019; OECD/IEA, 2017). Nevertheless, their staying power demonstrates their importance in addressing the cooking energy challenges currently being experienced by the vast populations of Sub-Saharan Africa and Asia.

For example, research suggests that "distributing improved cook stoves to Kenya's 6 million rural households could potentially reduce fuelwood consumption by 50 per cent, saving up to 8.4 million tons of carbon a year" (Finighan, Schaefer, Sembres, Schaefer, & Forests Philanthropy

[4] A list of the sustainable development goals is available at: https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals

Action Network (FPAN), 2011). It is also estimated that a transition from the traditional three-stone cooking fire to a simple ceramic woodstove could reduce acute respiratory infections (ARI) by approximately 25% and acute lower respiratory infections (ALRI) by 20% among children (Douglas F Barnes, Openshaw, Smith, & Plas, 1994).

With regard to implementation, ICS enjoy a level of familiarity with end-users, as they share similar operational requirements and fuels with BCSs and open fires. Their fuel needs are also more flexible than other modern, clean, fuel-efficient cooking technologies such as LPG, electric cookers, and bioethanol fueled stoves, which either requires a specific fuel or infrastructure that often necessitates bulk purchases and involves substantial financial investments. Additionally, ICSs are easy to install (fixed type) or easy to move from place to place within the household (portable type). They can also be used with no or minimal additional infrastructure, adjustments to the cooking area, or the need to change cooking appliances, such as cooking pots. Lastly, but importantly, they are easy to operate and use.

In addition, if appropriately designed and implemented, the secure and sustainable access and use of the ICS provides feasible short-term cooking energy solutions for the vast majority of the socioeconomically disadvantaged populations of Sub-Saharan Africa who otherwise rely predominantly on polluting and fuel-inefficient technologies. In the long term, ICS could contribute to a broader energy strategy that seeks to preserve and enhance valued social–cultural cooking practices, while at the same time safeguarding health and improving economic status. Moreover, the widespread acceptance and use of ICSs could contribute to attainment the United Nations SDGs, the achievement of climate goals, and a just and equitable sustainable development, more broadly.

In essence, the adoption ICSs encompasses several noble goals. In fact, these potential benefits are even more relevant today than in the early 1980s, when fewer people were dependent on biomass fuels; when populations were mostly concentrated in rural areas; and when naturally occurring biomass fuel resources were less threatened than today (M. Arnold, Köhlin, Persson, & Shepherd, 2003). However, several questions remain. Why have ICSs seen comparatively little uptake and sustained use, especially in Sub-Saharan Africa? And what can be done to ensure that these stoves are accepted, sustainably accessed, and used effectively?

1.4.Problem definition

The vast majority of the global population can barely meet their basic needs for food, safe drinking water, and a warm living space without harming their health and general wellbeing, their livelihoods, and those of future generations; or without compromising the sustainability and wellbeing of the planet (Health Effects Institute, 2018; OECD/IEA, 2017). While there are modest improvements in the overall numbers of people with access to cooking energy services, and success stories in parts of the world such as China and Indonesia (IEA, 2017; IRENA and OECD/IEA, 2017), the vast majority of people in Sub-Saharan Africa, still lack opportunities and abilities to sustainably and reliably access and use clean and fuel-efficient cooking energy services.

According to the (IEA et al., 2019), more than 3 billion people globally still lack access to clean cooking energy services—one billion more people than were estimated to depend on biomass fuels for domestic energy needs during the 1980s (Bonan, Pareglio, & Tavoni, 2017). Sub-Saharan Africa is disproportionally affected, where an estimated 80% of the populations primarily rely on solid fuels for cooking. The magnitude of this challenge is demonstrated by the case of Kenya, where the government in its 2017 voluntary national reviews (VNRs)[5] estimated that only 11.9 percent of the Kenyan population had access to clean cooking energy services (Government of Kenya, 2017a). This leaves almost 90% of the Kenyan population without access to clean cooking energy services. Yet, these numbers are expected to keep growing as a result of population growth and growing inequalities (Lall, Henderson, Venables, & Lall, 2017; UN-Habitat and IHS-Erasmus University Rotterdam, 2018). Despite increased investment in the sector, the IEA projects that the number of people without access to clean cooking energy services will drop back to the 2009 numbers of 2.7 billion in 2030 (IEA, 2011:19). This is a clear indication that not enough has happened at the speed that is necessary, or at a scale that matches that of the challenge and the demographic changes being experienced in the continent. Moreover, it shows that if business-as-usual approaches and strategies remain the norm, large

[5] "The voluntary national reviews (VNRs) aim to facilitate the sharing of experiences, including successes, challenges and lessons learned, with a view to accelerating the implementation of the 2030 Agenda. The VNRs also seek to strengthen policies and institutions of governments and to mobilize multi-stakeholder support and partnerships for the implementation of the Sustainable Development Goals." For more information about the VNRs see: https://sustainabledevelopment.un.org/hlpf/2019#vnrs

populations will continue to lack sustainable and effective cooking energy services. As a result, the achievement of all other global sustainable development and climate protection goals could be compromised.

1.5.Socioeconomically disadvantaged communities stand to lose the most

Lack of access to sustainable and sustained access to cooking energy services disproportionally affects socioeconomically disadvantaged and vulnerable groups (Landrigan et al., 2017). These observations were underscored by the former United Nations Secretary General Ban Ki-Moon, who acknowledged in his foreword to the 2015 MDG Report that: “Progress tends to bypass women and those who are lowest on the economic ladder or are disadvantaged because of their age, disability or ethnicity. Disparities between rural and urban areas remain pronounced”(United Nations, 2016 : 3). These groups make up the largest percentage of the population (children, youths, and women) and also include people who are not perceived as belonging to mainstream society, such as refugees. In other cases, this divide appears in economic activities. For example, people employed in informal economic sectors are less likely to meet their basic needs or improve their health and general wellbeing than those in secure income-generating activities (Friedman, 1996; United Nations, 2015). Beyond the lack of access to sustainable and sustained access to cooking energy services, their lives are affected by rising population, increasing stress on natural resources, unemployment, environment degradation, and social barriers and vulnerabilities.

1.6.The invisible plight of low socioeconomic urban communities

Living in urban areas does not provide refuge against energy poverty or poverty more broadly. Quite the opposite: Informal settlements are epicenters for immense human suffering, inequality, and lack of basic needs such as food, water, healthcare, housing, education; and clean, affordable, reliable, sustainable energy services(Cuming et al., 2015; UN-Habitat, 2014). Current research shows that people in slum or informal settlements, especially women and children under the age of 5 years, suffer disproportionately from environmental pollution (Landrigan et al., 2017) and are at risk of poverty and social and economic exclusion (N. Stern, 2006; UN-Habitat and IHS-Erasmus University Rotterdam, 2018; UN Habitat, 2007b). The lack of sustainable access to clean, reliable, and effective cooking services could exacerbate these challenges. However, the lack of access to clean cooking energy services is mistakenly perceived as being predominantly a rural problem (UN Habitat, 2009), whereas in fact a crisis concerning sustained access to clean and sustainable cooking energy services is unfolding in low socioeconomic urban communities, but remains invisible to both local government and the international community.

This social exclusion of disadvantaged and vulnerable urban households has produced a knowledge vacuum concerning cooking energy needs, resulting in the lack of appropriate, acceptable, accessible, and effective cooking energy solutions. This is problematic, because estimates show that in 2005 more than 60% of Nairobi's population lived in informal settlements, with more than 75% of future rural-to-urban migrants projected to settle in informal settlements such as Kibera (UN Habitat, 2006a). These estimates are corroborated by the Government of Kenya (GoK), which acknowledges that socioeconomically disadvantaged urban populations are expected keep growing, partly due to poor rainfall and persistent drought (Government of Kenya, 2017b). Poor rainfall negatively impacts the agricultural sector, the main rural employer, thereby driving migration to urban areas in search of employment and livelihood opportunities. Hence, the present focus on Kibera aims to contribute towards identifying household cooking energy needs, and the factors that facilitate or hinder access to and effective use of more sustainable cooking energy services. This is important, because this group has predominantly been excluded from efforts to address the challenge of access to clean and fuel-efficient cooking energy services. Nevertheless, they stand to benefit the most from such efforts, given their current situation of poverty, deplorable physical environment, but most importantly the need for long-term abilities and opportunities to enable sustained access to sustainable and effective cooking energy services that they truly want.

1.7.Thesis statement

In this thesis, I have chosen to focus on the role of social dimensions and dynamics in influencing sustained and sustainable access, and effective use of ICSs. More specifically, this thesis seeks to understand households' needs from their perspective; and, based on these needs, attempt to understand the factors that enable or prevent these groups from addressing their needs in a sustainable and effectiveness way by focusing on ICSs. I take this approach because technologies such as ICSs are intended to facilitate user needs, and therefore, such needs ought to be understood before technologies are developed and implemented. Moreover, while households are the main end-users of household cooking technologies such as ICSs, they are embedded in societal contexts that influence their needs, abilities, and opportunities and hence, ultimately their access and usage patterns. In other words, while technologies such as ICS present potential benefits, these can only be accrued if technologies are accepted, accessed and used in a sustainable way and within appropriate environments, to maximize their potential benefits. An informal settlement like Kibera is a unique focus for such a study because successfully reaching such populations to develop acceptable, accessible, and effective cooking energy services would not only address the challenges of access to cooking energy, but would also have immediate and lifesaving impacts on current and future generations as well as the environment, in Kibera and beyond.

This thesis is motivated by the need to understand why ICSs have not been more widely adopted, especially in Sub-Saharan Africa, despite extraordinary technological advancement, improved distribution and transportation infrastructure, information and communication technologies, diverse financing opportunities, as well as efforts driven by specific initiatives at the global level, such as the UN programs Sustainable Energy for All (SEforALL) and the Global Alliance for Clean Cookstoves (GACC).

The level of investment over the last 40 years and the presence of various ICS models suggest that it is not a lack of technological ideas or innovation that has hindered universal adoption and sustained access to clean, safe, reliable, affordable, appropriate, and effective use of cooking energy services as underscored in SDG 7. Instead, the factors holding back progress in the sector could be deeply rooted in the manner in which the problem is understood and addressed, resulting in technological development and social–economic arrangements that deter end-users from available solutions, or mean that they fail to access and use them sustainably and effectively.

While the need to ensure sustainable access to cooking energy services are predominately addressed in the national and international policy, issues of what it would take to implement such policies and solutions in a sustained and sustainable way, without leaving anyone behind are often not given considerable attention. There is limited focus on the readiness and willingness of individuals and communities to accept and adopt new technologies such as ICSs and to incorporate them into their daily social–economic activities and cooking practices. However, the benefits of using improved cook stoves are conditional on end-users' willingness to accept a technology (such as ICSs) and their abilities and opportunities to access and use these sustainably and effectively. This was underscored by (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981: 42) who note that: “stove design may be splendid in theory but ineffective in practice if it is not readily accepted by the population.” Hence, the first step towards addressing any challenge is to acknowledge that one exists. In the context of this thesis, the challenge is that households are not able to meet their cooking energy-related needs in a sustainable and effective way. Therefore, the identification of needs and existing challenges and opportunities ought to be the first step in designing cooking-energy solutions.

Moreover, decisions on cooking energy services and use of available services are not taken in isolation. Instead, households are embedded in diverse contexts, which influence their needs, day-to-day activities, and abilities and opportunities available and accessible to them. However, in attempting to understand the factors that enable or hinder novel technologies, most studies have focused on rural contexts, and have predominantly assessed ICS programs and the numbers of stoves distributed. While this knowledge is important in revealing the scale of the challenge, little is known about the stories behind these numbers, because limited attention has been paid to the needs of the main users of cooking services (households), or the role of social and structural elements in influencing the success or failure of technological and economic strategies.

Some lessons have been learned, as evidenced by successes in China and Indonesia (IEA, 2017; IRENA and OECD/IEA, 2017). However, there is no evidence that such lessons have played a role in shaping ICS development and implementation processes in Sub-Saharan Africa. For example, studies have pointed to households' financial constraints, technological inadequacies, lack of attention to the social and cultural needs of end-users, and poor program design and implementation processes as major barriers to ICS programs in Sub-Saharan Africa (D F Barnes, Openshaw, Smith, & Van der Plas, 1994; Douglas F Barnes et al., 1994; Clough, 2012a; Jeuland et al., 2014; Silk et al., 2012). However, the literature contains little evidence that funding and implementation bodies have taken these recommendations seriously or sought to redesign biomass ICS technologies and implementation processes to align them with the needs, values, and realities of their intended beneficiaries (individuals and communities). On the contrary, the evidence shows that donors and international organization still largely focus on technological and economic approaches at the expense of non-technological and non-economic factors (Elizabeth Shove & Walker, 2014; Van Der Kroon, Brouwer, & Van Beukering, 2013).

Moreover, evidence on the adoption and long-term use of ICSs has shown that in programs where stoves were offered at no cost, the acceptability rate and continued use was extremely low (Douglas F Barnes et al., 1994; Mobarak, Dwivedi, Bailis, Hildemann, & Miller, 2012). Elsewhere, research has shown that even with an improved cook stove and other cooking technologies and energy sources, basic ICSs and open fires are widely used in households as backups (Masera, Bailis, Drigo, Ghilardi, & Ruiz-Mercado, 2015a). In addition, despite technological access and economic wellbeing leading to the procurement and use of cleaner and more fuel-efficient cooking energy services (Hosier & Dowd, 1987), households are known to retain previously used technologies (mainly traditional biomass-fueled technologies and kerosene stoves) for backup purposes and to address other needs not accounted for in currently available clean devices (Heltberg, 2005; Masera, Saatkamp, & Kammen, 2000; UNDP, The World Bank, & ESMAP, 2003). Other studies have shown that economic wellbeing, subsidies, and freely distributed cookstoves can indeed enhance initial adoption, but that sustained access and use diminishes over time (Usmani, Steele, & Jeuland, 2017).

From these examples, it is clear that while technological and financial investments are important, household are not solely drawn by the presence of a technology, but also by the technological functions that enable them to meet their needs and enhance their wellbeing. Therefore, the willingness of end-users to embrace and purchase a technology depends on its functional value, their own abilities, and on available and accessible opportunities as argued in the NOA model (Gatersleben & Vlek, 1997, 1998), the conceptual framework applied in this thesis (see Chapter 4). These conditions are also underscored by Rogers (2003) work on the diffusion of innovations, which argues that the acceptance and adoption of new innovation is partly dependent on whether or not it is perceived as advantageous compared with currently available technologies. These examples not only demonstrate the interconnectedness between energy access processes and human needs, values, and norms; as well as their state of structural conditions and living environments; but also places cooking energy at the center of human and societal affairs, which makes it impossible to understand the factors that allow or hinder access to cooking energy if individual and societal contexts are excluded (Gatersleben & Vlek, 1998; Lucas, Brooks, Darnton, & Jones, 2008).

Therefore, technical advances such as ICSs and financial support mechanisms, while important, address only a fraction of the conditions needed for the universal acceptance, sustainable access, and effectiveness of cooking energy solutions. Beyond the focus on technological advancement, addressing the questions of what people really want from their cooking energy services, and balancing often conflicting demand and supply dynamics and challenges associated with the production, distribution, and context realities of end-users, is also part of the cooking energy access processes.

1.8.Research objectives and questions

The primary objective of this study is to understand and contextualize the factors that enable or hinder the sustained acceptance, access, use, and effectiveness of sustainable cooking energy services, with a focus on ICSs for household use in the informal settlement of Kibera, in Nairobi, Kenya. This is achieved by addressing the following overarching question: Why have ICSs largely failed to replace traditional cooking energy technologies despite widespread need for cleaner and fuel-efficient cooking energy services, the benefits associated with the use of biomass ICSs, and the technological and financial investment in ICS development and implementation over the last 40 years? To address this overarching question, the following guiding research questions were formulated:

1) What needs do households seek to address through the use of cooking energy services?
2) What factors enable or hinder households to address those needs in the most preferred, appropriate, effective sustainable way?
3) What is the status of adoption and sustained use of improved cook stoves in Kibera?
4) What household related factors enable or hinder the sustainable access to cooking energy services, and more specifically to ICSs?
5) What societal factors / realties / conditions / circumstances limit or support the sustained access and effective access to ICSs and other desired cooking energy services?

The broader approach addressed in these research questions is important because households do not access or address cooking-energy-related needs in isolation, but amidst other often urgent, emerging, and valued individual and social needs and within societies in which they are embedded. Such knowledge is important for understating the underlying forces that enable or hinder sustained access and effective use of sustainable cooking energy services. Moreover, such knowledge could be critical not only for understanding why ICSs have shown poor adoption rates and sustained use over the last 40 years, but could also provide insights on how to provide cooking energy solutions that are truly valuable to households for meeting their needs both sustainably and effectively. The focus on a disadvantaged urban setting is especially significant because previous studies on the successes and failures of ICSs have predominantly focused on rural settings.

1.9.Thesis structure

This thesis is divided into nine chapters. Following this introduction, chapter 2 introduces the case study that forms the core of the research.

Chapter 3 reviews the literature on cooking energy access challenges and opportunities, and on biomass cooking energy policies and solutions proposed and implemented during the past 40 years. This literature spans the global, national, and local scales but focuses on Sub-Saharan Africa and, more specifically, Kenya.

Chapter 4 introduces the conceptual framework used to guide this thesis, its underlying assumptions, core concepts, and its contributions to the body of research. It concludes by making the case for using the NOA model in this line of work.

Chapter 5 describes the research methods and discusses the rationale for employing a case study approach, the unit of analysis, and context of data collection. Lastly, the data collection methods, procedures, documentation, and analysis are outlined. This chapter concludes by outlining the challenges encountered during data collection.

Chapter 6 presents the results of the field study.

Chapter 7 interprets the findings and presents implications for current cooking energy access policies and implementation processes, especially ICSs. The chapter concludes with a brief summary, study limitations, and the needs for further research.

Chapter 8 proposes options for strengthening the acceptance, sustained and sustainable access, as well as the effective use of cooking energy services in informal settlements such as Kibera.

Finally, chapter 9 provides an overall conclusion to this thesis, outlines the main findings, and their implications for policy and research, and the contribution made by this study.

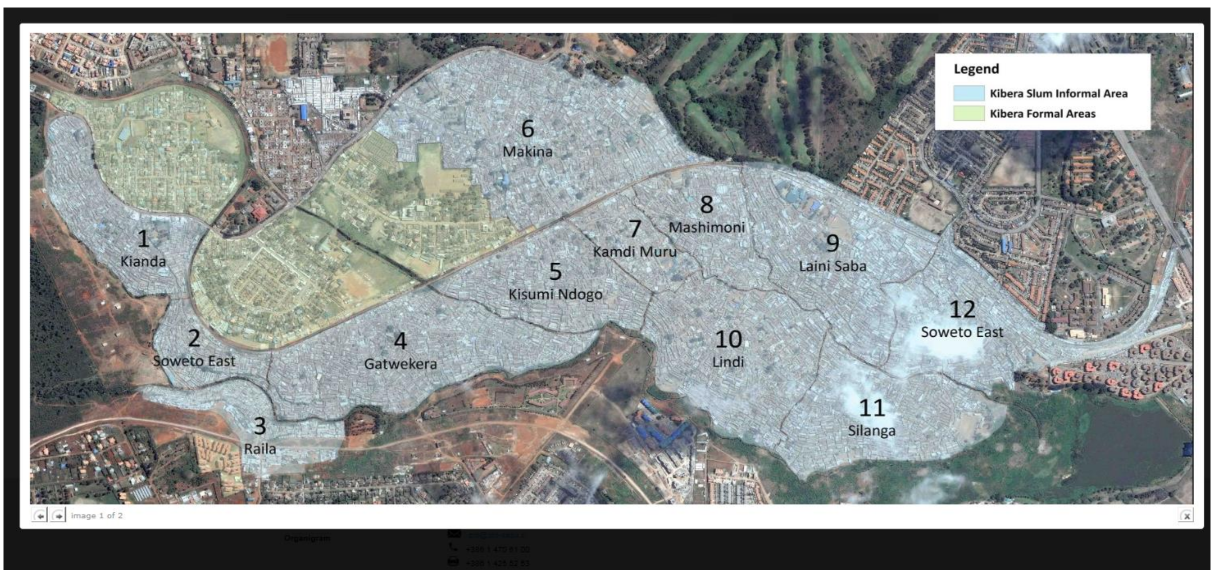
2. Introduction to the Case Study Area

This chapter introduces Kibera, the case study area of this thesis.

2.1. Geographical location

Kibera (also known as Kibra)[6] was established in 1911 by the colonial government as a settlement for Sudanese veterans of the British East African forces (Parsons, 1997; Sandra Joireman and Rachel Sweet Vanderpoel, 2010). Kibera is located in southeast Nairobi, the capital city of Kenya, approximately 5 kilometers from the central business district (CBD). The settlement covers approximately 2.38 square kilometers and is thought to be one of the largest slums[7] in Africa (Desgroppes & Taupin, 2011). Kibera is subdivided into 15 villages: Ayani, Olyphic, Karanja, Kianda, Soweto West, Raira, Gatwekera, Kisumu Ndogo, Makina, Kambi Muru, Mashimoni, Laini Saba, Lindi, Silanga, and Soweto East, as shown in Figure 2.

Figure 2. The geographical areas of Kibera



Source: Map Kibera Trust Kenya and the Institute of Anthropological and Spatial Studies

[6] Kibra is a Nubian word meaning forest. Kibera, the name widely used for the slum, is an adjustment for easier pronunciation, especially for non-native speakers. The native language of Kibera natives, the Nubians, is KiNubi, a mixture of African languages and Arabic vocabulary (Parsons, 1997). Both terms are used interchangeably in this thesis.

[7] A slum is defined by the United Nations as a contiguous settlement where inhabitants lack one or more of the following five social services: 1) durable and safe housing; 2) sufficient living area and poor environmental conditions; 3) access to sufficient, affordable, clean, and safe water improved water (water that is and can be obtained without extreme effort); 4) access to improved sanitation facilities and waste management, and; 5) secure tenure status and protection against forced eviction (UN Habitat, 2007b).

Note: The light-blue areas represent the informal and less developed section of the settlement, while more formal and developed areas of Kibera are shown in light-green. The focus of this thesis was on the informal section.

2.2.Legal status and governance structures

As an informal settlement, Kibera is not formally recognized by local or national governments. This lack of legal recognition has left Kibera as an administrative grey area (Parsons, 1997) or, as noted by or, as noted by Joireman and Sweet Vanderpoel (2010), "a pocket of statelessness located directly in the geographical center of power of the Kenyan state" (p. 17). As a result, there is no legal land ownership or title deeds, and the presence of formal government is either intentionally absent or unwelcome (de Bercegol & Monstadt, 2018). Only Chiefs and Assistant Chiefs[8], the lowest-ranked formal officials, have offices in parts of Kibera. In the absence of robust formal government and institutions, alternative forms of government (both informal and traditional) have emerged to manage social order, human relations, economic activities, and distribution and access to human livelihoods, goods, and services, including cooking energy services. However, the lack of good governance is often exploited by economic mafias, whose businesses provide basic goods and services such water and cooking fuels at exploitative prices (de Bercegol & Monstadt, 2018).

2.3.Population

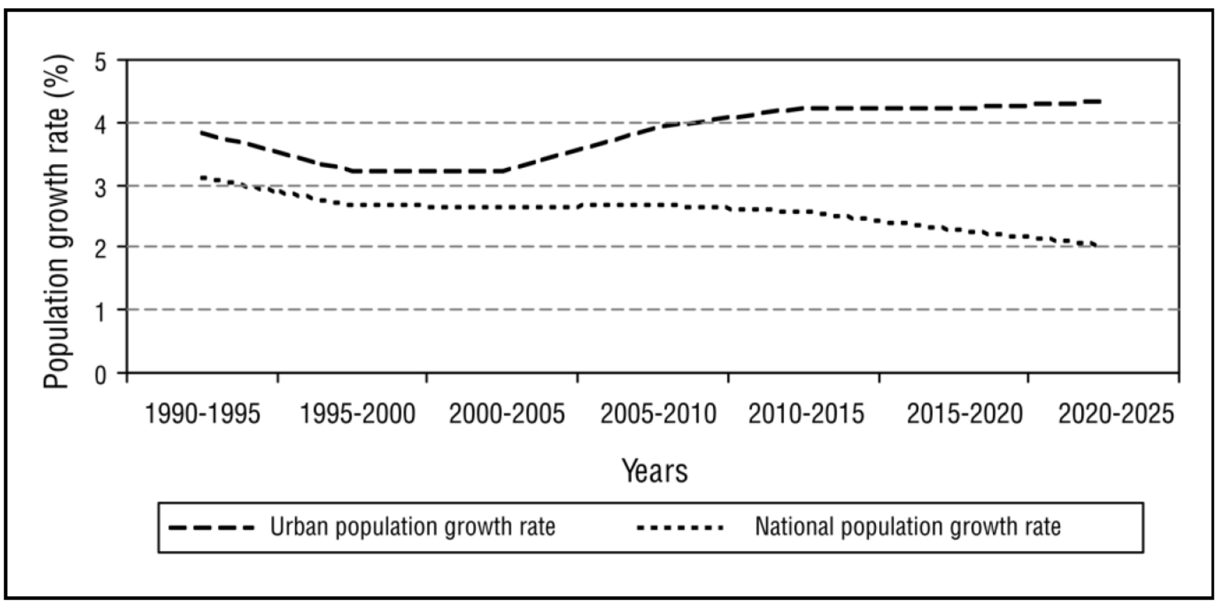
The exact population of Kibera is unknown and remains hotly contested[9]. Estimates range from 170,000 to one million. The most recent population and housing census, conducted by the Kenyan Government in 2009, estimated Kibera's population to be 170,07010. These figures are consistent with the estimate of 200,000 generated in a study conducted by the French Institute for

[8] Chiefs and assistant chiefs represent provincial administration as local government officials. Although Kibera is not officially recognized and the land on which it sits belongs to the state, chiefs are known to issue construction permits in return for payment (Sandra Joireman and Rachel Sweet Vanderpoel, 2010). These permits are not legally binding, but carry weight in Kibera.

[9] The contestation Kibera´s population is prevalent in Kenya due to political and international interests the slum attracts. In some cases, actors with invested interests have been said to exaggerate the figures for their own personal or political interests (Desgroppes & Taupin, 2011) Also see an article highlighting this discourse in a Kenya newspaper: The Daily Nation: *Myth shattered: Kibera numbers fail to add up* http://www.nation.co.ke/News/Kibera%20numbers%20fail%20to%20add%20up/-/1056/1003404/-/13ga38xz/-/index.html : Accessed June 17th 2017

Research in Africa (IFRA) and Keyobs, a Belgian company that applied a geographical information systems (GIS) methodology and a ground survey (Desgroppes & Taupin, 2011). However, while Kibera's exact population is not known, it is clear that the number of people living in slum-like conditions in African urban areas has been rising (UN Habitat, 2014). Kenya's urban population is estimated to be increasing by 4.4% annually (equivalent to 0.5 million people), of which more than 60% are projected to end up in one of its many informal sentiments (Panek & Sobotova, 2015). This trend is expected to continue due to absolute population growth and rural-to-urban migration as people search for economic opportunities and social freedoms (UN- Habitat, 2009; Un-Habitat, 2003; UN-Habitat and IHS-Erasmus University Rotterdam, 2018; United Nations Department of Economic and Social Affairs: Population Division, 2017), as shown in Figure 3.

Figure 3. Population growth rate in Kenya

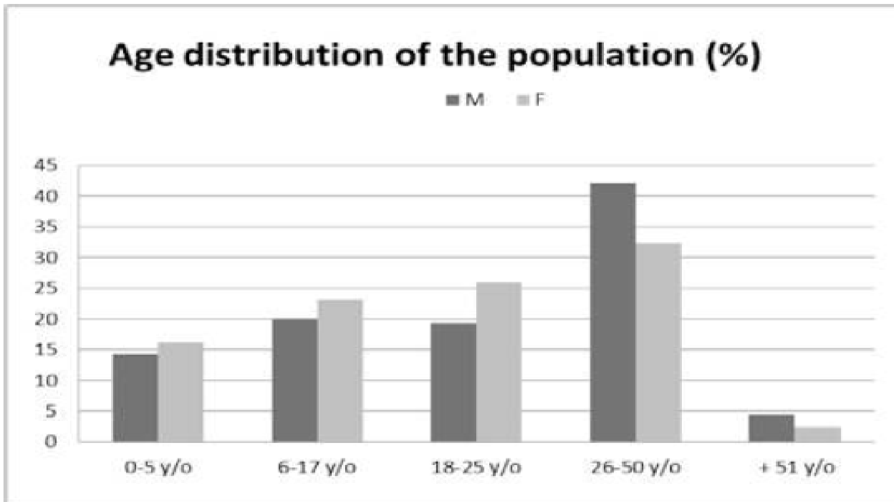


Source:(Karekezi, Kimani, & Onguru, 2008)

2.4.Age and gender dynamics

While it is not uncommon to encounter older people in Kibera, most residents are aged 18 to 50 and males dominate some age groups, as shown in Figure 4.

Figure 4: Age and gender distributions of the Kibera population

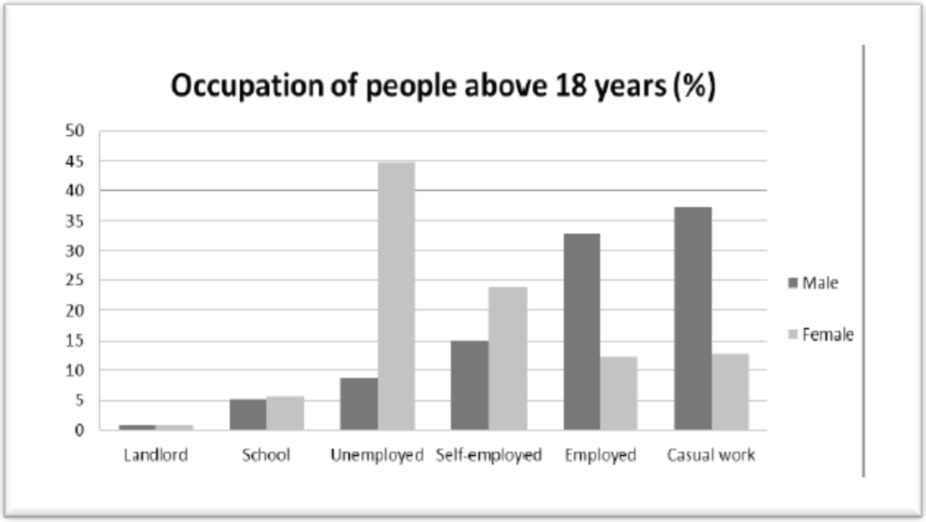


Source:(Desgroppes & Taupin, 2011)

2.5.Economic activity

Most economic activities in Kibera are in the informal sector[11] (Desgroppes & Taupin, 2011), commonly known in Kenya as the *jua kali* (the vicious sun) sector. Enterprises in the informal sector are characterized by easy entry, family ownership, lack of regulation, competitive markets, insecurity, small-scale operations, low productivity, and lack of financing opportunities (Meier & Rauch, 2005; World Bank, 2016). These activities are also not officially recognized and therefore not represented in the formal national statistics (Desgroppes & Taupin, 2011).

Figure 5. Occupations of Kibera residents



Source:(Desgroppes & Taupin, 2011)

Although the informal economy is prominent throughout Kenya, Kibera is unique in that most businesses and economic activities are not only informal but also illegal (Oxfam GB & Kenya, 2009; Quinn et al., 2018; Sandra Joireman and Rachel Sweet Vanderpoel, 2010).

2.6.Social Services

Kibera, like most informal settlements, is a difficult and vulnerable living environment, where social and economic infrastructures, enablers of human development and wellbeing, are either absent, overwhelmed, or in poor condition. The settlement is characterized by high population density; a lack of proper sanitation and drainage infrastructure, solid waste disposal and management services, and clean and safe drinking water; frequent floods; indoor and ambient air pollution, unplanned and crowded housing, among other challenges. For example, in 2006 it was estimated that over 50% of the global poor , especially those living in slum areas, lacked access to clean water (UN-Habitat, 2006b). This problem has since worsened as water demand has grown and the challenges surrounding water provision have become more chronic. Education and health services are also in a poor state in Kibera (UN-Habitat, 2006b). The settlement also lacks proper sanitation and waste management services, including designated wash areas and toilets. This has resulted in what Kibera is most known for: 'flying toilets' or what people in Kibera refer to as '*Kujipanga*,' a Swahili word meaning 'to organize oneself.' This organization involves the use of plastic bags as toilets/latrines, which are then thrown as far as possible from one's immediate point of use, hence the name flying toilet.12 This approach is also used to dispose of other kinds of waste and is a major contributor to the poor environmental and living conditions experienced by the residents of Kibera, its visitors, and neighbors.

2.7.Energy access outlook and uses in Kibera

Kibera has seen many infrastructure improvements since the launch of the Kenya Slum Upgrading Programme (KENSUP) a partnership between the Kenyan Government and the UN - HABITAT established in 2014. Electricity and road infrastructure are the most visible of these improvements. Under the slum electrification program, the Kenya Power and Lighting Company (KPLC) in partnership with the World Bank installed street lighting and connected most slum dwellers to the grid at subsidized prices. However, the presence of the grid in Kibera and the inability of people to pay for their monthly consumption have opened a path for illegal tapping activity (de Bercegol & Monstadt, 2018), making electricity inaccessible, unreliable, and unsafe. In the event that electricity is available and accessible, it is used for lighting, powering information and communication technologies (such as mobile phones, radios, and television sets), and for productive and commercial activities within and beyond the household. More specific to this thesis, most households lack sustained access to clean, sustainable, affordable, reliable, and safe cooking energy services (de Bercegol & Monstadt, 2018; UN-Habitat, 2009). As a result, kerosene and charcoal are the most sought after and used energy sources. More information about technologies and fuels is provided in the literature review chapter.

2.8.Summary

Kibera is a difficult and vulnerable living environment where social and economic infrastructures, enablers of human development and general wellbeing, are either absent or overwhelmed. The settlement is characterized by high population density; lack of proper sanitation and drainage infrastructure, solid waste disposal and management services, and clean and safe drinking water; and by frequent floods and fires, indoor and ambient air pollution, and unplanned and crowded housing, among other challenges. However, while Kibera has also benefited from infrastructure development in the recent past; residents continue to experience high social and economic vulnerabilities. For example, despite the presence of electricity infrastructure, access to sustained and sustainable energy services remains a major challenge due

[12] Clearly, this has major implications for health risks and has been known to cause many serious illnesses such as frequent diarrhea and cholera outbreaks, especially among children. (Author's note)

to illegal activity that interferes with cost stability, quality, and reliability (de Bercegol & Monstadt, 2018). However, despite the extent of such challenges, Kibera offer social and economic advantages and therefore, continue to attract large numbers of socially and economically disadvantaged persons.

3. Review of the Literature

This chapter provides an overview of the literature on cooking energy, access challenges, and proposed and implemented biomass cooking energy policies and solutions from the past 40 years. This literature spans global issues, but with a specific focus on the Sub-Saharan Africa region. The content focus is on the state of knowledge concerning past and present challenges of access to cooking energy, in addition to policies, initiatives, and solutions. More specifically, it focuses on the drivers and barriers to a sustainable transition from traditional and basic improved cookstoves (together referred to here as traditional cookstoves) to intermediate and advance cookstoves (termed improved cookstoves, ICSs). This chapter also briefly introduces biomass fuels. While the focus of this thesis is not on biomass fuels, no biomass cookstove can achieve its stated goals in the absence of an appropriate accompanying fuel. Finally, the chapter concludes with a brief summary of the literature.

3.1. The history of cooking energy access challenges

The challenges surrounding access to cooking energy came to the world's attention in the late 1970s during the oil and wood crisis (E. Eckholm, 1975; D. Wood, 1996). At the time, biomass ICSs were developed and implemented to address environmental concerns linked to biomass fuel production and consumption, especially in the developing world (Douglas F Barnes et al., 1994; E. Eckholm, 1975; Ezzati & Kammen, 2002; Masera, Bailis, Drigo, Ghilardi, & Ruiz-Mercado, 2015b; The World Bank, 2011). Today, however, along with the need to mitigate deforestation and protect the environment by moving away from unsustainable biomass production and consumption[13] (Rob Bailis, Wang, Drigo, Ghilardi, & Masera, 2017), other aspects of human health, and social and economic wellbeing have also dominated the narrative for the need for clean cooking. This has especially been driven by numerous studies linking the use of high-carbon technologies and fuels to poor health, premature deaths, and to social and economic risks and burdens (Bowe et al., 2018; Landrigan et al., 2017; Pope, Bruce, Dherani, Jagoe, & Rehfuess,

---

[13] Biomass naturally occurs in tropical landscapes in the form of trees and shrubs. However, its sustainability depends on the rate of harvest in relation to regrowth. If wood fuels are harvested at a greater rate than the regrowth rate, then consumption is considered unsustainable. It is estimated that nearly 300 million people struggle with acute wood fuel scarcity as a result of their depletion, especially in Sub-Saharan Africa and Asia (Bailis et al., 2017).

2017; WHO, 2014). The United Nations' Sustainable Development Goals (SDGs) framework and the Paris Agreement on climate change have become the most recent international frameworks to bring attention to the challenges that the world faces as a result of the growing number of people without clean, safe, and sustainable energy access, and hence the need for increased efforts to address and mitigate associated risks and burdens.

3.2.Biomass cookstoves

The technology examined here is the biomass ICSs. Since the early 1980s these have been the main technological pathway proposed and implemented in many parts of the developing and emerging countries as alternatives to BCS and open fires (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Dewees, 1989; Hugh, 1991; Manibog, 1984; Namuye & Namuye, 1989). However, while their use is thought to have positive consequences for people and environment, their sustainable access and use in most parts of the developing world, especially within households in Africa, is limited (Kumar & Igdalsky, 2019; Quinn et al., 2018; Rosenthal, Quinn, Grieshop, Pillarisetti, & Glass, 2018;Venkata Ramana et al., 2015; World Bank, 2015). According to Kshirsagar and Kalamkar (2014), a biomass cook stove is a "physical structure that contains air–fuel combustion for heat release, and subsequently, directs the heat of combustion towards a cooking target (pot/pan/griddle)" (p. 582). Biomass cookstoves are used in millions of homes worldwide to facilitate several individual and social functions such as cooking, space heating, water treatment, lighting, grain drying, food preservation, and to deter insects such as mosquitos. While the history of biomass stoves is as old as that of human energy needs, they continue to evolve to meet dynamic human needs and changes in human living environments (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Kshirsagar & Kalamkar, 2014). Their design and use is known to have dramatic effects on humans and the environment (Health Effects Institute, 2018; Johnson et al., 2019; Landrigan et al., 2017; Mortimer et al., 2017). The risks and burdens posed by the use of traditional stoves to humans and the environment have been the main factors motivating the improvement and distribution of safer and more energy-efficient biomass cookstoves. Today, however, along with the need to protect the environment, other aspects of (health, social, and economic) issues have also gained international attention due to research linking the use of high-carbon technologies and fuels within households to poor health, premature deaths, and greenhouse gas (GHG) emissions. The two major categories of biomass cookstoves are termed traditional and improved.

3.2.1. Traditional biomass cookstoves

Traditional cookstoves have been used for thousands of years and still define the character of everyday life, food cultures, cooking practices, and livelihoods in many rural and urban low socioeconomic contexts of the developing world, especially in Sub-Saharan Africa. Their evolution is associated with locally available food and fuel resources and local cooking methods, eating practices, and social–cultural values (Kammen, 1995; Ramana et al., 2015). Today, the most commonly known and used traditional stoves include two- and three-stone open fires and built-in models constructed from mud, brick, mortar, sand, or clay (Kshirsagar & Kalamkar, 2014; Urmee & Gyamfi, 2014a). Biomass (dung, firewood, charcoal, crop residues) comprises the main accompanying fuels in the Global South, although other renewable and non-renewable solid fuels are also compatible with these kinds of stoves. Some of the main advantages of traditional cookstoves include: low or no cost, easy construction and operation, ability to burn many forms of biomass and other solid fuels, and multi-functionality. Some disadvantages include low energy efficiency, and high levels of smoke, indoor air pollution, and other pollutants such as carbon monoxide (CO), particulate matter (PM), and other GHGs (Akolgo et al., 2018; Bonan et al., 2017; The World Bank, 2015). However, some traditional stoves have been known to perform better on fuel efficiency and emissions than improved cookstoves (Douglas F Barnes et al., 1994; De Lepeleire G, Krishna Prasad K, Verhaart P, 1981). This high performance is associated with modifications of the fireplace using a technique known as fire shielding, which involves control of draft direction, influencing airflow, smoke direction, and the concentration of energy to the cooking pot (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981). Examples of traditional cookstoves used in Kibera are shown below.

Metal stove	Improvised stove	Three-stone fire	Kenya Ceramic Jiko	Two-stone fire
				

Examples of traditional cookstoves

Source: author

3.2.2. Improved Biomass cookstoves

There is no consistent or internationally agreed definition or classification for biomass improved cook stoves (ICSs). Over the years, improved cooks stoves have evolved into different shapes and forms, and have been intentionally designed and constructed to improve thermal and fuel efficiency and to minimize harmful emissions such as CO2 and particulate matter (Urmee & Gyamfi, 2014a; Venkata Ramana et al., 2015). Kshirsagar and Kalamkar (2014) define an improved cookstove as: “a stove designed using certain scientific principles, to assist better combustion and heat transfer, for improving emissions and efficiency performance.” (p. 583) In the 1980s, ICSs were categorized into three broad categories “closed heavyweight, shielded heavyweight, and shielded lightweight” (Manibog, 1984: 202) with their improved status based on fuel efficiency compared with a traditional open fire (Manibog, 1984). Other classifications and definitions have included factors such as: construction material, functional value (single or multiple burners), safety features (insulated and non-insulated), fuel efficiency, potential to direct pollution away from the user (fitted with hood or chimney), fitted with grates or not, and flexibility of technology (fixed or portable) (Akolgo et al., 2018; Bonan et al., 2017; De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Manibog, 1984). In an attempt to establish internationally standardized terminology, the Energy Sector Management Assistance Program (ESMAP), World Bank, and GACC introduced the concepts of ‘clean’ and ‘improved’ cooking solutions, defined respectively as “cooking solutions with low particulate and carbon monoxide emissions levels and cooking solutions that improve, however minimally, the adverse health, environmental, or economic outcomes from cooking with traditional solid fuel technologies" (Venkata Ramana et al., 2015: xi). In this categorization, biomass improved cook stoves are defined as "(s)olid- fuel stoves that improve on traditional baseline biomass technologies in terms of fuel savings via improved fuel efficiency" (Venkata Ramana et al., 2015: xi). This definition covers all biomass cook stoves known to have better thermal efficiency than traditional cook stoves. However, efficiency levels are variable, leading to further categorization as follows.

3.2.3. Basic portable improved cookstoves

The basic portable improved cookstove (BPICS) improves the thermal efficiency of open fires while ensuring low cost and ease of use. The Kenya Ceramic Jiko[14] (KCJ), an improved version of the Thai bucket, is an example of a stove in this category (Venkata Ramana et al., 2015). Unlike a traditional metal stove made of cast iron, the KCJ has a metal casing with ceramic lining. This slight improvement has been shown to improve heat direction to the stove from 10–20% in the traditional metal stove to 25–40% (Kammen, 1995). KCJs are produced in Kenya and cost an average of 2 to 8 Euros depending on their size and place of purchase. In Kenya they are common in households with both low and high socioeconomic conditions.

Examples of the KCJs are presented below, showing the stove prior to adding fuel and then during use. The stove shown here was designed for use with a larger pot. It has therefore been slightly modified to fit a smaller pot, which is a common practice in addressing households' individual cooking needs.

Source: author

[14] Jiko is a Swahili word meaning cookstove.

3.2.4. Intermediate Improved Cookstoves

Intermediate improved cookstoves(IICS) are an improvement on the basic portable improved cook stoves such as KCJs, but are known to provide only limited health and environmental benefits in comparison to advanced and modern cookstoves such as LPG-fueled and electric models (Venkata Ramana et al., 2015). Unlike basic portable improved cook stoves, IICS have an insulated outer surface that protects users against contact burns. Examples of these stoves in Kenya include portable Jiko Koa stoves and EcoZoom, as shown in the pictures below.

Source: author

Note: On the left is an example of a Jiko Koa stove and right is an example of an EcoZoom stove

3.2.5. Advanced biomass cookstoves (AICSs)

Advanced biomass stoves are designed to significantly reduce emissions of harmful gases and particulates. However, their performance in this regard does not match that of modern cook stoves, which are characterized by high fuel-efficiency and low environmental and particulate matter emissions (Venkata Ramana et al., 2015: xiii). Examples of advanced biomass cook stoves include Gasifier stoves and rocket stoves. According to Kshirsagar & Kalamkar (2014), their advantages include, "higher efficiency, low emissions, better safety, and enhanced durability" (p.583). Some, models, such as the Biolite stove shown below, fulfil several functions simultaneously, such as providing lighting, phone charging, and cooking.

Source: author

Note: an example of a Biolite advanced firewood stove

3.3.Overview of biomass fuels

Biomass is defined as any organic matter that is available on a renewable or recurring basis (Perlack, Stokes, Eaton, & Turnhollow, 2011). Biomass fuels are derived from forests, woodlands, private farmlands, community landscapes, and from agricultural and industrial residues. Examples include, wood fuels (firewood, charcoal, and sawdust), crop or agricultural residues (corn cobs, maize stalks, rice husks, millet stalks, sugar cane peels) as well as animal dung. In most developing countries, biomass is thought to account for approximately 50–90% of fuels used to meet the primary energy needs of cooking, lighting, and heating (Rob Bailis et al., 2017; Tubiello et al., 2013) also illustrated in the figure 6 below. In Kenya for example, the Ministry of Energy estimates that 89% of rural and 7% of urban households use firewood as their primary fuel, while 82% of urban households and 34% of rural households use charcoal to meet their cooking needs[15]. The current and predicted demand in Kenya is thought to exceed supply. The Ministry of Energy estimates that Kenya has a sustainable wood fuel supply of 15 million metric tonnes and a deficit of 20 million metric tonnes, which is met through over-harvesting and the use of agricultural residues.[16] In the absence of policy intervention, demand for biomass is expected to reach 53.4 million tonnes in the year 2020, an increase from approximately 34.3

[15] National Energy Policy "Session Paper No. 4 on Energy" May 2004 (p. 17). available at http://www.renewableenergy.go.ke/downloads/policy-docs/sessional_paper_4_on_energy_2004.pdf

[16] National Energy Policy "Session Paper No. 4 on Energy" May 2004 available at http://www.renewableenergy.go.ke/downloads/policy-docs/sessional_paper_4_on_energy_2004.pdf

tonnes in 2000 (National Energy Policy, 2004: 17[17]). While efforts are underway to develop cleaner biomass fuels such as wood pellets and briquettes (The World Bank, 2015), the biomass fuel referenced in this thesis is charcoal, because it is the main accompanying fuel used with most intermediate and advanced improved cook stoves on the Kenyan market and is preferred over wood as a cooking fuel in most urban households (Girard, 2002b; Zulu & Richardson, 2013).

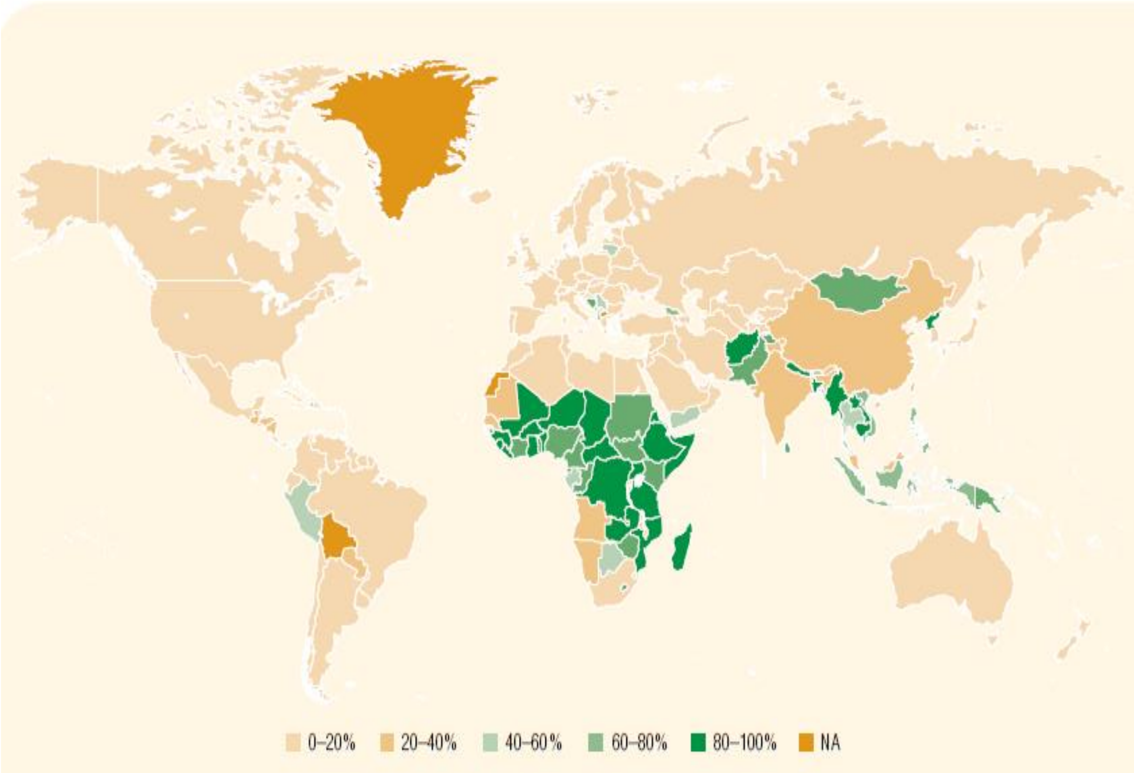
While there is cited effects of fuelwood as a major source of deforestation in African countries(Anderson & Fishwick, 1984; Bishaw, 2001; Specht, Pinto, Albuqueque, Tabarelli, & Melo, 2015), recent research show no link between sustainable domestic raw fuelwood[18]use and deforestation (Quinn et al., 2018). However the unsustainable and inefficient production and use of biomass fuel resources is associated with adverse human and environmental risks and burdens (Landrigan et al., 2017; Wathore, Mortimer, & Grieshop, 2017). For example, the unsustainable production and consumption of fuelwood is known to have significant negative effects on the quality of soil, rainfall patterns, and water sources, and to alter local landscapes (FAO, 2010). The following section provides a brief overview of charcoal production and its use in households in Sub-Saharan Africa, and more specifically in Kenya. Therefore, to achieve SDG 7 (and the other 16 SDGs) and the Paris Agreement, billions of people will need to be provided with sustainable access to fuel-efficient and cleaner cooking energy services.

---

[17] National Energy Policy "Session Paper No. 4 on Energy" May 2004 available at http://www.renewableenergy.go.ke/downloads/policy-docs/sessional_paper_4_on_energy_2004.pdf

[18] Domestic raw fuelwood as used here excludes charcoal and other processed wood fuels (note by Author).

Figure 6: Percentage of population using biomass worldwide



Source: (Venkata Ramana et al., 2015)

3.3.1 Charcoal

Charcoal is a solid residue resulting from the carbonization of wood (mainly tree trunks and thick branches) through the process of pyrolysis[19] (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981). Charcoal is the primary fuel used with most portable intermediate and advanced biomass improved cook stoves, and the preferred biomass fuel in urban areas of Kenya and in Sub-Saharan Africa more broadly (J. E. M. Arnold, Köhlin, & Persson, 2006). Charcoal use imposes higher adverse environmental and human cost than firewood, mostly because it is produced in highly inefficient traditional kilns (Girard, 2002b). Therefore, charcoal demand in urban areas of developing countries is thought to contribute to the catastrophic destruction of

[19] Pyrolysis is the process of burning wood in a low-oxygen environment. The byproduct of this process is charcoal, a dense, black dense substance composed mostly of carbon (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981). Charcoal production is known cause significant loss of wood mass and to emit a number of harmful particulates and greenhouse gases(Girard, 2002).

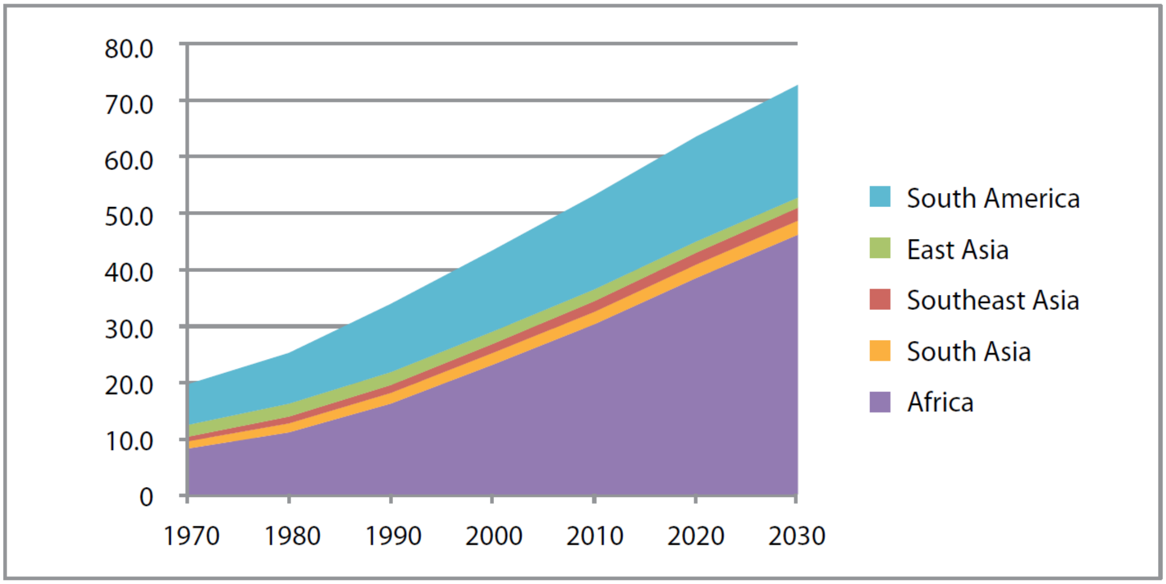
local landscapes, farm lands, and natural forests (Chambers, 1987; Masera, Bailis, Drigo, Ghilardi, & Ruiz-Mercado, 2015c; D. Wood, 1996). Residents of Kibera, like those of other urban and peri-urban areas, lack access to a self-sustaining source of wood and therefore a sustainable supply of charcoal. Hence, all the charcoal burned in urban areas is obtained from rural areas and transported by road over long distances, estimated in some cases to be 300 kilometers (Eni, Mattei, Pareglio, & Tavoni, 2016). High demand for charcoal has made it one of the most lucrative cooking fuel businesses in urban areas, even more so in informal settlements (Venkata Ramana et al., 2015).

Source: author

Note: The picture above shows a street in Kibera lined with charcoal venders.

The demand for charcoal is expected to keep growing in most parts of the developing world, partly because of population growth, urbanization, rural-to-urban migration, and lifestyle changes (J. E. M. Arnold et al., 2006; The World Bank, 2015), as shown in Figure 7.

Figure 7: Estimated charcoal consumption (million tonnes) in regions of the developing world



Source:(Hofstad, O.; Köhlin, G.; Namaalwa, 2009)

This projected charcoal demand makes it all the more important to understand the factors that allow or hinder mass acceptance, adoption, use, and effectiveness of fuel-efficient biomass intermediate and advanced ICSs.

3.4. Brief history of biomass improved cookstoves (ICS)

The idea of an improved cook stove was first introduced in the late 1970s, during the oil crisis and the wood crisis (Agarwal, 1986; E. P. Eckholm, 1975). At the time, the development of a fuel-efficient cooking stove was driven by the desire to mitigate deforestation and promote energy conservation (M. Arnold et al., 2003; Douglas F Barnes et al., 1994; Kshirsagar & Kalamkar, 2014). Organizations such as the World Bank have previously linked the fuel crisis to population growth and the unsustainable use of wood fuels, especially in the Global South (Manibog, 1984). In the developed world, the shift to more efficient fuels and cooking appliances happened without much intervention and was largely dependent on affordability. Households slowly transitioned to more efficient and cleaner cooking fuels and technologies as their incomes improved, a phenomenon widely known as the “energy ladder”[20](Douglas F Barnes et al., 1994; Richard H. Hosier & Dowd, 1987). This, however, was not the case for people in the developing world, which prompted intervention by governments, donors, and non-governmental organizations to promote the improved cookstoves, seen at the time as being more fuel efficient than the traditional three-stone cooking stove (Douglas F Barnes et al., 1994). In the 1980s, energy efficiency and environmental protection were primary motivating factors behind the launch of stove programs (M. Arnold et al., 2003; Douglas F Barnes et al., 1994). Programs promoting improved cookstoves were introduced in developing countries including India, Guatemala, and in Africa's Sahel region. This phase is commonly referred to as the “first wave”(Kshirsagar & Kalamkar, 2014). At the time only 100,000 stoves where thought to have been distributed worldwide, with the majority thought to have fallen into disuse or sporadic use (Manibog, 1984). The two major events at this time occurred in India with the launch of the Indian National Programme on Improved cookstoves (NPIC), which resulted in the development and dissemination of over 35 million stoves program and the Chinese National Improved Stove Program (NISP) hailed as the most successful improved cook stove program in the world (Sutar, Kohli, Ravi, & Ray, 2015; The World Bank, 2011). The period between the mid-1980s and mid-1990s (the “second wave”) was marked by renewed attention to the potential role of ICSs for female empowerment (Danielsen, 2012), livelihood enhancement, and nature conservation (Kshirsagar & Kalamkar, 2014). ICSs were seen as contributing to women's wellbeing by reducing the amount of time they would spend collecting fuelwood. It was also thought that women could use these time savings for personal development and empowerment activities. However, this wave was also marked by limited success due to limited acceptance, sustainable access, and use of these stoves among households (Gill, 1987; Manibog, 1984). Such programs were also time-limited, and often managed, implemented, and funded externally. As a result, once the project funding ended no more stoves were distributed or built, and when those already in use required repair or maintenance no qualified local personnel were able to offer such services (Douglas F Barnes et al., 1994).

[20] The energy ladder is a “concept used to describe the way in which households will move to more sophisticated fuels as their economic status improve” (Hosier & Dowd, 1987).

Informed by the failures of the 1980s and '90s, and by the overwhelming evidence of the burdens and risks associated with biomass fuels and unsafe and inefficient cooking appliances, the past 15 years have seen a renewed focus on ICS interventions along with national and international policies and efforts to address the challenges of ensuring clean and fuel-efficient cooking energy. For example, in 2002, following the World Summit on Sustainable Development in Johannesburg, South Africa, the US Environmental Protection Agency (EPA) launched the Partnership for Clean Indoor Air (PCIA).21 Later, other national and international initiatives where launched, such as the Clean Development Mechanism (CDM)22 in 2008 by the United Nations and the national biomass cooks stove initiative (NBCI) in 2009 by the Government of India. Building on this momentum and the gaps highlighted by the Millennium Development Goals, the United Nations Foundation launched the Global Alliance for Clean Cook stoves23, a public–private partnership with the ambitious goal of increasing the adoption of clean cook stoves and fuels in 100 million households over a period of 10 years (Global Alliance for Clean Cookstoves, 2013). The UN SDG framework and the Paris Agreement on climate change have become the most recent international frameworks to advocate for improved forms of energy production and consumption.

[21] The Partnership for Clean Indoor Air (PCIA) operated from 2002 to 2012. PCIA involved 590 partners targeting four main goals: Meeting the needs of local communities for clean, efficient, affordable, and safe cooking and heating options; Improving cooking technologies, fuels, and practices for reducing indoor air pollution; Developing commercial markets for clean and efficient technologies and fuels; and monitoring and evaluating the health, social, economic, and environmental impacts of household energy interventions. For more information, see: http://www.pciaonline.org/.

22 https://cdm.unfccc.int/about/index.html

23 http://cleancookstoves.org/home/index.html

3.5 Overview of global policies and initiatives for universal access to clean and fuel-efficient cooking energy services (1992–2015)

Table1below summarizes the global policies and initiatives supporting universal access to clean and fuel-efficient cooking energy services between the years 1992 to 2015.

Table1. Summary of international and regional policies addressing energy production and consumption challenges.

Activity or policy	Time and place	Issue of focus / Rationale	Source
United Nations Conference on Environment & Development: AGENDA 21	Rio de Janeiro, Brazil, 1992	Agenda 21 highlights issues of energy production and consumption, projected energy demand due to demographic dynamics; energy challenges in relation to poverty, poor resource management, and underscores the need to use energy resources with the protection and sustainability of humans and the environment in mind.	United Nations Division for Sustainable Development (1992) Document available at: https://sustainabledevelopment.un.org
World Energy Assessment	New York, 2000	Highlights energy access as a global issue, underscoring the connection between energy access and issues of human health, economic, social, environment, and sustainable development	United Nations Development Programme (UNDP, 2000a) Document available at: https://www.undp.org

Commission on Sustainable Development	New York, 2000 and 2001	Countries agreed on widening choices for cleaner, more efficient and renewable energy sources.	Document available at: https://www.un.org/
World Summit on Sustainable Development (WSSD)	Johannesburg, South Africa, 2002	First major global summit after the Millennium Development Goals (MDGs), where energy was not included as a goal but was recognized as central to achieving the MDGs, with an emphasis on sustainable energy production and use globally.	United Nations (2002) Document available at: https://www.un.org
Global Alliance for Clean Cookstoves (GACC)	New York, 2010	Focus on public–private partnership and the mobilization of "high-level national and donor commitments toward the goal of universal adoption of clean cookstoves and fuels"; Aims to "foster the adoption of clean cookstoves and fuels in 100 million households by 2020."	Additional information is available at: https://www.cleancookingalliance.org
Report of the Secretary-General's Advisory Group on Energy and Climate Change	New York, 2010	Sets a target for universal energy access to modern energy services by 2030, by: scaling up renewable energy and other low-emission technologies; increasing funding and investment opportunities for developing countries in order to scale up scale up renewable energy solutions, low-emission, and energy-efficiency technologies; and enable private and public investment in the sector.	AGECC (2010) Document available at: https://www.cbd.int/financial/interdevinno/un-climate-report.pdf

Launch of the Sustainable Energy for All (SEforALL) initiative	New York, 2011	Aims to build partnerships, data, and evidence to inform policy and activities for sustainable energy for all, and a just global energy transition. Moreover, SEforALL focuses on increasing global attention and action on the SDG 7 goals of universal energy access, energy efficiency, and renewable energy. SEforALL was instrumental in the renewed attention on energy, by ensuring that it was part of the 17 UN SDGs.	Additional information is available at: https://www.seforall.org
United Nations General Assembly declares 2012 as the International Year of Sustainable Energy for All	New York, 2012	Recognizes universal modern energy as an essential component for achieving the internationally agreed development goals, including the Millennium Development Goals. Furthermore, the declaration aimed to heighten global attention to and awareness of energy issues.	Additional information is available at: http://seforall.org
Rio+20 conference report, The Future We Want	Rio de Janeiro, Brazil, 2012	Acknowledges insufficient progress and setbacks in the energy sector since the launch of Agenda 21, and commits to increasing access to though support for renewable energy sources , low-emission and efficient technologies, and the sustainable use and management of traditional energy resources.	United Nations (2012: 24–25) Document available at: https://www.un.org

UN Agenda 2030: Sustainable Development Goals (SDGs)	New, York 2015	Dedicates a stand-alone goal on energy, SDG 7, calling for "access to affordable, reliable, sustainable and modern energy for all" by 2030, by ensuring an increase in renewable energy in the global energy mix, improving energy efficiency, fostering international cooperation to support the development of energy research and technologies.	United Nations General Assembly. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development
Paris Agreement on Climate Change	New York, 2015	Acknowledges "the need to promote universal access to sustainable energy in developing countries, in particular in Africa, through the enhanced deployment of renewable energy"	United Nations Framework Convention on Climate Change (2016) Document available at: https://www.un.org

Source: developed by author using available information from respective websites and reports

3.5.Biomass improved cook stoves in Kenya

Kenya was one of the first countries in Sub-Sharan Africa to welcome the innovation and development of ICS. Following the United Nations Conference on New and Renewable Sources of Energy held in Nairobi in 1981, the Kenya Ceramic Jiko (KCJ) become one of the first ICS to be developed in Eastern African, modeled on the Thai bucket stove (Clough, 2012b; Hugh, 1991). In 1982 the Thai bucket stove was redesigned to meet Kenyan needs, funded and spearheaded by the Kenya Renewable Energy Development Project (KREDP) and the United States Agency for International Development (USAID) in partnership with Energy Development International (EDI) and the Kenyan Ministry of Energy (Hugh, 1991). While the KCJ continues to be a popular stove among Kenyan households, other intermediate and advanced improved cookstoves such as the as Maedelo stove (Progress stove), Jiko Kisasa (Modern stove), and the current Jiko Koa and EcoZoom have emerged, although with limited success (Barnes, Openshaw, Smith, Plas, et al., 1994; Barnes, Openshaw, Smith, & Plas, 1994; Jagger & Jumbe, 2016; Ruiz-Mercado, Masera, Zamora, & Smith, 2011; Sutar et al., 2015; The World Bank, 2011).

3.6. Brief overview of the Kenyan Government's efforts to address cooking energy access challenges

Kenya is one of the most vibrant economies in Sub-Sharan Africa. Consequently, access to energy is a high priority on the government's agenda. This is evident in the prominence given to energy matters in the country's Vision 2030 Agenda, where energy is highlighted as one of the main foundational pillars for enabling Kenya become “a globally competitive and prosperous country with a high quality of life by 2030” (Kenya Vision 2030,2008)[24]. The Government's commitment to ensuring energy access for all is also reflected in its pledge to provide a conducive and enabling working environment for international organizations, Public–Private Partnerships (PPP) and researchers, as well as its commitment to work with other nations and partners towards environmental protection and sustainable development goals. For example, Kenya has endorsed or adopted many international and regional agendas geared towards sustainable development and environmental protection, hosted or participated in many

[24] Kenya Vision 2030 is the long-term, ambitious development plan (effective 2007) that aims to improve the quality of life for all Kenyans by 2030. For information, see: https://vision2030.go.ke/

international forums convened to address sustainable energy access processes, and is home to many United Nations and other international organizations that are working towards environment protection and sustainable development more broadly. The government is also credited with the successful ongoing rural electrification processes and its encouragement and support for renewable energy generations and use, especially for rural and urban disadvantaged populations. Notable projects include the Kenya Slum Electrification Program (KSEP) (de Bercegol & Monstadt, 2018) street lighting, rural electrification, and support for renewable energy generation such as solar, wind, and geothermal (Government of Kenya, 2017b). However, while the government acknowledges that the lack of cooking energy access possess enormous challenges for most Kenyans—as well as the risks and burdens posed by the unsustainable production and consumption of biomass and fossil fuels, such as kerosene, for cooking and lighting— there is no evidence that the government's long- term energy policies and commitments are geared toward addressing cooking energy access challenges, a problem that affects a vast majority of Kenyans. Electricity access is also high on the government's agenda compared with access to clean, safe, fuel-efficient, and sustainable cooking energy services. Efforts to address the challenge have only benefited a minority; These include: the Forest (Charcoal) Regulations (2009) rules25; the distribution of LPG to ease the burden of charcoal and other fossil fuels; and taxes increases on kerosene, all of which are poorly implemented and marred by corruption. Electricity access is a step in the right direction, with likely positive welfare improvements for many Kenyans. However, the relative invisibility of challenges posed by lack of clean, reliable, affordable, and efficient cooking energy services represents a serious problem for the Kenyan Government. If appropriate measures are not put in place, many Kenyans are likely to continue to experience adverse effects from the lack of clean cooking energy services, and negative consequences of using dirty and polluting fuels, especially due to growing populations, rural-to-urban migration, and the ever growing challenges of poverty and inequality (UN-Habitat and IHS-Erasmus University Rotterdam, 2018; United Nations Department of Economic and Social Affairs: Population Division, 2017; World Population Review, 2017), especially within low socioeconomic communities such as Kibera. The next section discusses the risks and burdens

[25] The Forest (Charcoal) Regulations (2009) states in Section 7(1) that: "No person shall undertake or engage in any activity relating to commercial charcoal production and transportation without a valid license". https://www.undp.org/content/dam/kenya/docs/energy_and_environment/Charcoal_regulations-1-.pdf

associated with unsustainable production and the use of use of biomass on unsafe and inefficient cooking technologies, at both the local and global levels.

3.7. Justifying the need for ICSs and other clean and effective cooking energy services

There are several justifications for universal access to affordable, efficient, clean, and reliable cooking energy services. These include health, environmental, social, and economic risks and burdens, as presented below.

3.7.1. Health

The major justifications for shifting to ICSs and other clean cooking technologies and fuels include reducing the negative health impacts resulting from exposure to IAP (Clark & Dickson, 2003; E. Eckholm, 1975; Edomah, 2018; Health Effects Institute, 2018; Quinn et al., 2018; Rosenthal et al., 2018). Air pollution—both ambient (outdoor) and household (indoor)—is thought to be the biggest environmental risk to health, responsible for one in every nine deaths annually (Lim et al., 2012). According to Landrigan et al. (2017), air pollution was responsible for an estimated 9 million premature deaths in 2015, accounting for 16% of all deaths worldwide. To put the health challenge into perspective, the study on global burden of disease estimates that household air pollution is the 4th highest risk factor for diseases and death globally; only malnutrition, unsafe sex, and unsafe water are ranked higher (WHO, 2017). More specifically, the production and use of biomass fuels (wood, charcoal, agricultural byproducts, and dung) within households is known to contribute significantly to outdoor air pollution. According to the WHO (2016a: 182-183): "12% of the fine particulate matter ($PM_{2.5}$) is attributed to household use of solid fuels." In 2010, household indoor air pollution was responsible for an estimated 3.9 million premature deaths and about 4.8% of lost healthy life years. In 2012, just two years later, it was responsible for 4.3 million deaths, making it the largest environmental contributor to ill-health and death globally (Lim et al., 2012). The World Health Organization (WHO) estimates that over 2 million premature deaths worldwide are associated with indoor air pollution annually (WHO, 2016b). Of those deaths: in developing countries, 99% resulted from pneumonia, chronic lung disease, and lung cancer. Women and children were the most severely affected (WHO, 2009b, 2009a, 2016b). Moreover, indoor air pollution more than doubles the risk of respiratory disease in children and is associated with pregnancy problems such as low birthrates and stillbirths (WHO, 2009a).[26] A recent report on environmental pollutants underscores the high risks and vulnerability of children by noting: "even extremely low-dose exposures to pollutants during windows of vulnerability in utero and in early infancy can result in disease, disability, and death in childhood and across their lifespan" (Landrigan et al., 2017). Children are thought to be more vulnerable than adults to pollution because of their small physical size, weak immune systems, natural curiosity, and lack of knowledge of such risks and dangers (Programme, UNICEF, & Organization, 2002). Other health burdens associated with lack of access to safe, affordable, reliable, and effective cooking energy services include eye disorders and discomfort, sexual harassment and abuse, physical degeneration, and constant physical pain as a result of walking long distances in hot weather and transporting heavy fuels loads on the head or back.

3.7.2. Environmental

There is overwhelming scientific evidence that the manner in which humans produce and consume energy has adverse effects on the climate and the natural environment (Robert Bailis, Ezzati, & Kammen, 2005; Douglas F Barnes et al., 1994; Intergovernmental Panel on Climate Change, 2014; International Energy Agency, 2014). While the use of fuelwood for cooking is not primarily linked to deforestation (Quinn et al., 2018), the appetite for charcoal in urban areas (J. E. M. Arnold et al., 2006; Girard, 2002b)—especially when produced and consumed in an inefficient, unstainable way and under inappropriate conditions, such as contexts with high degree of ambient air pollution—is associated with many negative effects on people and the environment (Bowe et al., 2018; Mortimer et al., 2016; WHO, 2016b). For example, the incomplete combustion of biomass in traditional cookstoves is known to release gases such as carbon monoxide (CO), nitrous oxide (N_2O), methane (CH_4), polycyclic aromatic hydrocarbons (PAHs), and fine particles composed of elemental carbon or black carbon that are harmful to humans and the environment (Bhattacharya & Abdul Salam, 2002; Panwar, Kaushik, & Kothari, 2011; Smith, 1994). In 2017, it was estimated that energy production and use activities contributed to two-thirds of global greenhouse gas emissions (IRENA and OECD/IEA, 2017). While Africa is thought to contribute a small percentage of CO_2, proportionate to global energy-sector-related emissions the unsustainable production, distribution, and use of charcoal itself is

[26] Cooking and collecting fuel (firewood, etc.) for domestic use is done primarily by women, sometimes with children strapped to their backs or playing close by. Other major groups directly affected by IAP include domestic workers, street food cooks, and institutional (prison, hospital, and school) cooks and kitchen helpers. (Note by author)

known to be harmful to the environment (Mwampamba, Ghilardi, Sander, & Chaix, 2013; Zulu & Richardson, 2013). For example, the hardwood used in charcoal production in Kenya is known to come from village farmlands, drylands, and forests (Iiyama et al., 2014), where it is processed in traditional, inefficient kilns (Wanjiru & Omedo, 2013). Moreover, as is evident from the table 8, the carbonization process has adverse environmental effects by producing greenhouse gases, specifically, CO_2.

Figure 8: Economic and environmental issues related to charcoal production

Some figures regarding economic and environmental issues

Mass yields from a Casamance kiln and a well-managed traditional mound kiln are about 25 percent. In other words, 1 tonne of wood will give 250 kg of charcoal. With poorer techniques, however, yields often do not exceed 15 to 20 percent, in other words about 150 to 200kg from 1tonne of wood. Many charcoal makers, for example, use green wood, and the energy needed to dry it is provided by part of the load, reducing yields to 15 percent.

The carbon content of wood and charcoal is 50 and 90 percent respectively, giving the following carbon equivalents:

- 1000kg of wood → 500kg of carbon;
- 250kg of charcoal → 225kg of carbon;
- 150kg of charcoal → 135 kg of carbon.

When a tonne of wood is carbonized, 365 kg are released into the atmosphere with a poorly managed technique and 275 kg with improved methods. Improved technique thus prevents the emission of 90kg of carbon per tonne of carbonized wood, equivalent to 300kg of carbon or 1.1 tonnes of CO_2 per tonne of charcoal consumed.

For the city of, Abidjan, Côte d'Ivoire, which consumes about 300000 tonnes of charcoal per year, the annual savings amount to:

- 330000 tonnes of CO_2 emission avoided;
- 800 000 tonnes of wood not consumed as a result of the increased yield.

Source: (Girard, 2002: 33)

Moreover, unsustainable wood harvesting for charcoal production is known to have negative effects on forests, farm lands, and water catchment areas (Iiyama et al., 2014). This could lead to deforestation, desertification, destruction of water resources, loss of biodiversity, and poor soil quality (FAO, 2011; Lal, 2006; A. Wood & van Halsema, 2008). These examples underscore the nexus between poverty and energy production, distribution, and consumption, as well as the achievement of other important human needs such as food and water supply.

3.7.3. Social–cultural risks and burdens

There are also a number of social burdens associated with the chronic lack of sustained and sustainable access and effective use of cooking energy services. The amount of time spent collecting and preparing biomass fuels is known to have significant effects on women's and girls' education and skill development. In most African countries, women and children (especially girls) are responsible for gathering firewood, preparing and attending to biomass cookstoves, and cooking. This puts them at a disadvantage because less time is devoted to personal and educational development for girls and productive work for women (Amegah & Jaakkola, 2016). Biomass cookstoves and open fires are less efficient than other cooking technologies such as ICSs, electric cookers, and LPG gas, and are therefore labor-intensive and time-consuming.

A previous study found that in a village in Burkina Faso, people spent up to 3.5 hours collecting wood fuels in scorching heat, while in Tanzania families needed to dedicate 200–300 hours of labor per year to gather firewood (D. Wood, 1996). Moreover, the lack of access to equitable and just energy services could result in social inequalities and instability (Robert Chambers, 1986), especially when communities compete for scarce resources to secure livelihoods and address basic needs. Lastly, the failure to provide energy solutions that enable end-users to address their social–cultural needs could impose enormous burdens on households. This is especially the case for households that are keen to preserve social–cultural values and norms without compromising their economic, health, and environmental conditions and general wellbeing. Social–cultural activities are especially important for households because they enhance societal cohesion and relationships, both of which are important aspects of healthy societies and individual wellbeing (Bourdieu, 1986; Coleman, 1988).

3.7.4. Economic

In the rural context the large amount of time devoted to collecting firewood, time-consuming biomass cooking, and the cost of biomass fuels impose significant economic burdens on households (McKinsey Global Institute, 2015; D. Wood, 1996). In the urban context, households in low socioeconomic communities are thought to allocate a significant proportion of their income to cooking fuels, especially charcoal (Rysankova et al., 2014). Unregulated charcoal production and sale is thought to present major economic challenges and burdens for households. This has mainly been attributed to the high bribes paid to facilitate the transportation of illegal charcoal from rural to urban areas, which are later transferred to consumers, making the price of charcoal extremely high for many households (Mwampamba et al., 2013; Sander, Gros, & Peter, 2013; Zulu & Richardson, 2013). Less efficient technologies also lead to increased costs. It is estimated that most people in developing countries, especially in sub-Saharan Africa (over 40% of the population) live on less than US$2 per day (World Bank, 2014). Some households without land/forest ownership rely on purchasing biomass fuels such as firewood and charcoal, leading to pressure on already meager family incomes. This is known to be the case in both urban and rural households with low socioeconomic conditions (IEA, 2017; OECD/IEA, 2016).

There are also negative economic implications associated with health impacts and loss of human productivity. As previously highlighted in the health section, atmospheric pollution imposes enormous economic burdens on health systems and households due to the cost of health care or economic losses resulting from the death of a household breadwinner. These can also have significant negative effects on the wellbeing of household members, the community, and the country as a whole. For example, current exanimates show that "[p]ollution-related diseases cause productivity losses that reduce gross domestic product (GDP) in low-income to middle-income countries by up to 2% per year. Pollution-related disease also results in health-care costs that are responsible for 1·7% of annual health spending in high-income countries, and up to 7% of health spending in middle-income countries that are heavily polluted and rapidly developing. Welfare losses due to pollution are estimated to amount to US$4·6 trillion per year: 6·2% of global economic output" (Landrigan et al., 2017). Therefore, if not sustainably managed, these risks and burdens could continue to threaten the wellbeing of humans and the environment in both the short and long terms. One ongoing effort to mitigate these risks and burdens has been to encourage households to shift from traditional biomass cookstoves to biomass improved cookstoves (ICSs). The next section reviews the state of these efforts in the last 40 years.

3.8.The state of ICSs interventions

There is unprecedented consensus that ICSs have failed to significantly disrupt the use of traditional cooking practices in most parts of the developing world (Kumar & Igdalsky, 2019; Quinn et al., 2018; Rosenthal et al., 2018; The World Bank, 2015; Venkata Ramana et al., 2015). Signs of policy and technological failure among efforts to introduce and popularize ICSs were recognized earlier on in the intervention process. A World Bank review of ICS progress reported discouraging results, noting that 90% of attempts to promote more efficient cooking stoves had failed over a period of two years, and those that had been distributed were either used irregularly or no longer in use (Manibog, 1984). While progress has been reported in China and Indonesia (Hou et al., 2017; IEA, 2017), poor ICS take-up has continued in others parts of the world, especially in Sub-Saharan Africa. The most recent review by leading ICS implementers notes that only 14% of implemented programs have achieved their distribution and adoption targets

(Venkata Ramana et al., 2015). In Kenya, for example, the government estimated that only 11.9 % of the population had access to clean fuels and technologies in 2014 (Government of Kenya, 2017b). However, this number could be much lower because many households known to use clean cooking energy services also engage with dirty cooking energy services due to lack of secure and reliable supply of clean cooking energy services or because cooking energy services are incompatible with households' diverse individual and social–cultural cooking energy needs (Ezzati, & Kammen, 2003; Masera et al., 2000).

3.9.Identified challenges to ICSs implementation

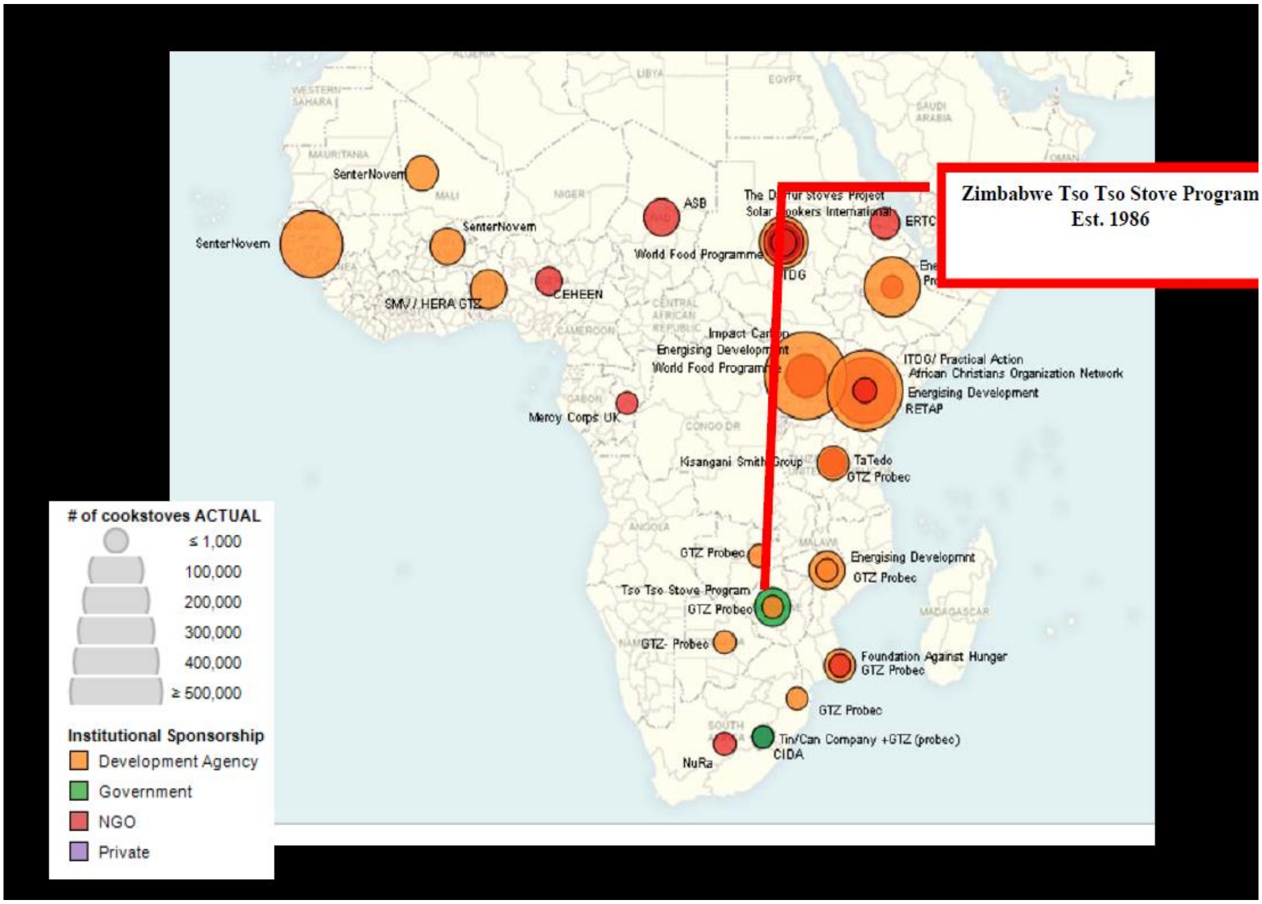
There are multiple factors holding back the sustainable transition from traditional biomass cooking technologies to intermediate and advanced biomass cooking technologies. Responsibility has been laid at the door of misaligned program formulation and implementation processes, technical and quality-related concerns, affordability, and sociocultural factors, that is, the failure to take into account regional differences in the cooking habits and food needs of diverse end-users (households)[27] (Douglas F Barnes et al., 1994; Ferrer, 2018; OECD/IEA, 2017; Practical Action, 2017). Addressing the issue of technological and market-focused approaches, Levine et al. report that "[s]ome of the factors restraining market acceptance result from the limitations of the technologies themselves or are inartistic to the environment in which the technology is applied. Other factors are the result of market failure, such as lack of information, lack of capital…and energy prices that exclude environmental and social externalities" (Levine, Koomey, Price, Geller, & Nadel, 1995: p.48). On the availability of information, the authors highlight the importance of enabling end-users to clearly assess the costs and benefits of a new technology analysis based on the information available to them (Levine et al., 1995). Rejection and abandonment is also associated with use complication, especially as it relates to the size of fuel, lighting processes, and compatibility with available household utensils, and unfamiliarity with the new device (Douglas F Barnes et al., 1994). Also crucial among the main barriers identified in the literature is unreliable supply and affordability of advanced and intermediate cooking technologies and lack of spare parts and repair services (M. Arnold et al., 2003). Unlike KCJs that are locally produced and distributed, intermediate and advanced cookstoves are either

[27] There are various end-users of ICS, including but not limited to: households, commercial, public, and industrial users. In this project, end-users refer only to households, and hence the terms end-user and household are used interchangeably (note by Author).

designed and produced abroad and only assembled in Kenya, or are imported to Kenya as finished products. This makes them more expensive because users bear the costs of transportation and import taxation. However, while affordability is mentioned in several reports and research papers as the main barrier to the adoption of ICSs, affordability remains a major barrier to sustained access of ICSs today. There is also evidence that in programs where stoves were offered at no cost, the acceptability rate was extremely low (Douglas F Barnes et al., 1994; Mobarak et al., 2012). Elsewhere, research shows that even with an improved cook stove and other cooking technologies and energy sources, TCS are widely used in households as backups (Masera et al., 2015a).

Lack of institutional inclusivity has also been associated with hampering ICSs and other energy access processes, especially in the developing world (Gifford, 2010; Kshirsagar & Kalamkar, 2014). As shown in Figure 9, ICSs interventions have been limited to certain institutional structures and sponsorship, mainly: development agencies, national and international NGOs, NGOs/private partnerships, international development agencies/private partnerships, and commercial private companies (Kshirsagar & Kalamkar, 2014). This limited focus has been associated with excluding important actors such local governments, local power players (de Bercegol & Monstadt, 2018) change agents/local leadership, and social organizations (Moses & MacCarty, 2019; Rehfuess, Puzzolo, Stanistreet, Pope, & Bruce, 2014), all of which are associated with facilitating individual and community acceptance (Wüstenhagen, Wolsink, & Bürer, 2007).

Figure 9: Institutional sponsorship of ICSs programs



Source: (Gifford, 2010)

3.10. Identified enablers

Some of the major ICSs access enablers are associated with a clear demand for alternative cooking energy services to address fuel shortages, secure availability of technologies and fuels, and affordable prices as evident the cases of China and Indonesia (IEA, 2017; Kshirsagar & Kalamkar, 2014; Urmee & Gyamfi, 2014b). The involvement of local actors and national governments is also associated with the success of ICSs intervention processes. The involvement of local actors has been credited with enhanced awareness campaigns that have helped to shift the dominant traditional cooking energy practices to cleaner and more fuel-efficient cooking practices, cooking practices, providing enabling access and user conditions through the use of supportive policies and initiatives, local research and technological development, and enabling market and financing conditions (Hou et al., 2017; Smith, Shuhua, Kun, & Daxiong, 1993;

Venkata Ramana et al., 2015). For example, local government could play an important role in the areas of: licensing, regulation, certification, and quality control, after-sale support and services, monitoring and evaluation, and in financing research and development, etc. The Chinese National Improved Stoves Programs (NISP) is especially highlighted as a unique success case by several recent studies because of the limited government role in direct end-user subsidies (IEA, 2017; Kshirsagar & Kalamkar, 2014; Venkata Ramana et al., 2015). Instead, the government's support and financial contribution concentrated on training, administration, communication and promotion of the program opportunities and services (Venkata Ramana et al., 2015), and developing local economic capabilities. Secure purchasing capacity is also cited as enabling both these successful projects in Indonesia and China (IEA, 2017; Kshirsagar & Kalamkar, 2014). More specifically, China's NISP biomass program is associated with high local financial abilities and purchasing capacities. Moreover, the availability of financial instruments in the form of loans and micro-finance opportunities is also associated with the affordability of ICSs and other renewable energy services (Hewitt, Ray, Jewitt, & Clifford, 2018; Kshirsagar & Kalamkar, 2014). Lastly, development of local ownership and participation through the involvement of respected community members, change agents or local champions, and locally initiated and managed institutions such as local kin and social networks, have been associated with successful ICSs and other cleaner cooking energy services (Kumar & Igdalsky, 2019; Ramirez, Dwivedi, Ghilardi, & Bailis, 2014). Such channels have been highlighted as possible pathways, especially for creating awareness and developing a new discourse on the value of sustainable and clean cooking energy production and consumption practices. The emphasis by governments and development agencies has been on providing the most technically advanced improved cook stove at the lowest price feasible to people in need. Henceforth, a number of studies assessing the success or failure of ICS strategies have focused largely on stove programs and technological development (Douglas F Barnes et al., 1994; Global Alliance For Clean Cookstoves, 2013; Silk et al., 2012; The World Bank, 2011; Wickramagamage, 1991; D. Wood, 1996). The complexities associated with sustained acceptance, access, and effective use of a new technology or innovation, such as ICSs are grossly ignored by policy makers, implementers of cooking energy access strategies and approaches, and researchers, especially in socioeconomically disadvantaged communities in urban areas.

3.11. Summary

This chapter provided a review of the literature on the challenges and opportunities associated with cooking energy access; and policies, initiatives and strategies employed to address the growing need for clean, safe, fuel-efficient, and sustainable cooking energy services as highlighted in SDG 7. The literature review shows that there has been substantial interest in ICSs because of their potential to improve access to cleaner cooking energy services for the majority of households that predominantly rely on traditional biomass cookstoves. Moreover, ICS access and use has remained a major focus of international aid organizations and donors, because of their potential to mitigate the health, social, economic, and environmental risks and burdens associated with unsustainable production and use of biomass fuel and inefficient and dirty traditional cooking technologies. However despite the dominance of ICSs in the energy access policy and implementation processes, there is an unquestionable consensus that they have failed to replicate the role played by traditional cookstoves within households, especially in the Global South.

This timid success has persisted despite technological advances and continued financial investment in the sector for the last 40 years, coupled with a clear scientific consensus on the link between current cooking energy production and consumption practices. This leaves more than 3 billion people without access to clean, safe, and fuel-efficient cooking energy services, and polices and solutions unable to cope with the growing demand as a result of growing population and change in demand dynamics resulting from changes in human living environments. These challenges are likely to continue presenting risks and burdens to human livelihoods, individual and community health and general wellbeing and global sustainability unless approaches that match the magnitude of these challenges are designed and implemented. Therefore, there is a clear need to understand in greater depth and detail other factors that influence the acceptance, sustained, and sustainable access and the effective use of ICSs, beyond the technological and economic factors that have dominated cooking energy access initiatives in the Global south. This warrants a new kind of thinking on how user needs are understood and addressed. The next chapter introduces the conceptual framework employed in this thesis to evaluate and analysis the factors that could be influencing acceptance, sustained and sustainable access and effective use of cooking energy services, mainly ICSs, within households in the informal settlement of Kibera.

4. Conceptual Framework

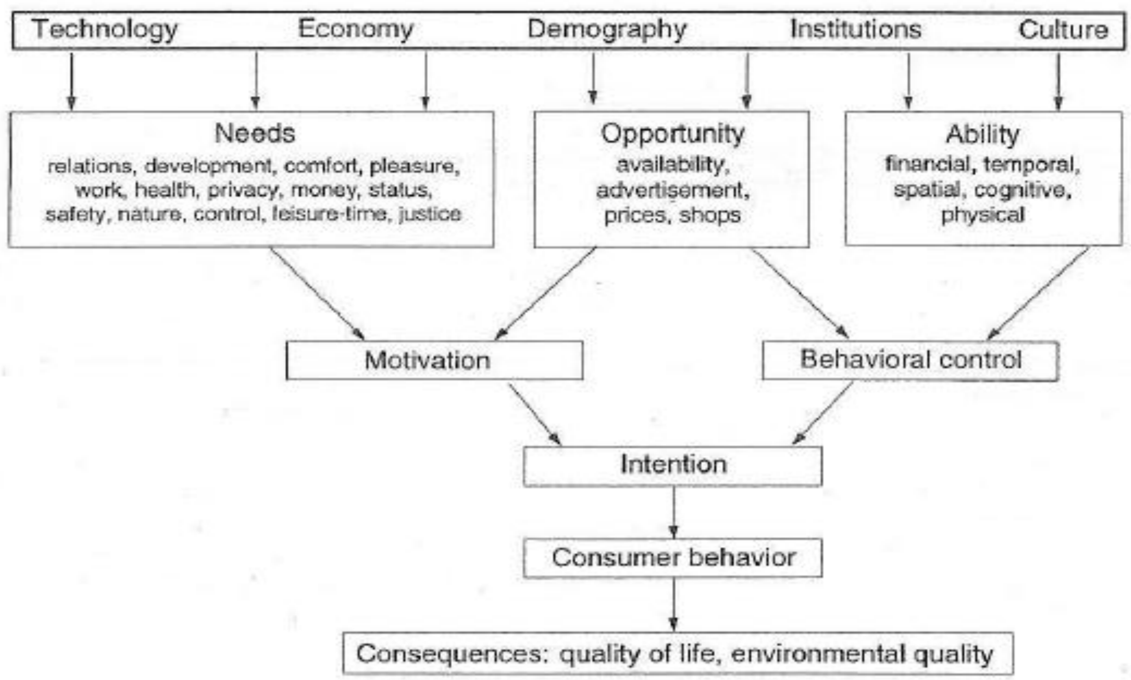
This thesis has two objectives. The first is to explore the cooking-energy-related needs of households in Kibera and how these intersect with factors driving the acceptance, access, and effectiveness of cooking energy services. The second is to identify and contextualize the factors that hinder or enable sustainable access to appropriate cooking energy services and how effectively theses services meet user needs. To achieve these objectives, two conceptual frameworks were considered: the Needs–Opportunities–Abilities (NOA) model (Gatersleben & Vlek, 1997, 1998), and the theory of diffusion of innovations, first developed by Everest Rogers in 1967. The NOA model was developed and used to study the determinants of consumer behavior in Dutch households, while diffusion of innovation seeks to understand and explain how new innovations or ideas become widely adopted or rejected (Rogers, 2003). However, although diffusion of innovations provides important concepts and arguments that show how innovations or new ideas become known, accepted, adopted, and used, the NOA model emerged as the best fitting and most appropriate model for use in this thesis. This chapter introduces the NOA model, its underlying assumptions, core concepts, and its contributions to the body of research. The case is made for employing the NOA model rather than diffusion of innovations in this line of work.

4.1. The Needs–Opportunities–Abilities (NOA) model

Birgitta Gatersleben & Charles Vlek developed the NOA model in 1997 to explore factors that determined consumer behavior in Dutch households in 1998. The NOA model defines consumer behavior as "a process in which consumer goods are selected, acquired, used and disposed of" (Gatersleben & Vlek, 1997: 146). The study focused specifically on consumer household goods intended for the tasks of cooking and home heating. It found that consumer behavior was determined by user needs, opportunities, and abilities, influenced by conditions at both the micro and macro levels.

For example, major changes were noted with the ownership of cooking equipment in the period between 1947 and 1987, when oil stoves and wood furnaces where replaced with gas cookers, a change that was triggered partly by the discovery of gas in the Netherlands at the time. However, while the study focused on households, the authors concluded that it was impossible to understand actions taken at the household (micro) level without considering conditions at the structural (macro) level because of interdependencies and interactions among factors at both levels. Hence, the overall message was that consumption of consumer goods and services is crucially influenced by the needs, opportunities, and abilities of end-users (households), which play out in the broader societal context.

Figure 10: The Needs–Opportunity–Ability model of consumer behavior



Source: (Gatersleben & Vlek, 1998:146)

4.2.Underlying assumptions of the NOA model

Page: 71

In Figure 10, the upper level shows the structural factors that are thought to set the context that influences individual needs, opportunities, and abilities. The second level shows individual factors. The subsequent sections show how factors at the macro and micro levels influence consumer actions and outcomes. As the model suggests, for a certain consumer behavior to emerge, an individual (or household) requires both the motivation (needs and opportunities) and the behavioral control (opportunities and abilities) denoted as the micro level/individual factors. Needs and opportunities are thought to motivate demand, while opportunities and abilities are thought to limit or enable action. From this relationship, the model makes it clear that the motivation to fulfil a certain need in a specific way is not a sufficient determinant for action. In addition to motivation, consumers require relevant opportunities (for example, the commodity, e.g., technology) and abilities (for example, finances) in order to take the desired action. These are thought to depend on the macro/structural factors within the societal context in which individuals (or households in the present thesis) are embedded. Macro-level factors in the NOA model include: technology, economy, demography, institutions, and culture. In the absence of fitting opportunities and abilities, the model assumes that consumers seek alternative means to meet needs or else fail to meet their needs altogether.

Additionally, it is also assumed that consumers seek, acquire, and use commodities for the valued ends/functions that they generate, and not for their own sake[28]. These valued ends are thought to be what is sought when a consumer takes a certain consumer action. For example, the purchase of a technology such as a cookstove can be said to be sought as a means of enabling the consumer to utilize energy to cook a meal and to enjoy the comfort of a warm living space, etc. This line of argument is also presented in the Means–End Chain Model (Gutman, 1982) where commodities are seen as means that facilitate the fulfillment of certain desired ends.

In the NOA model, the interdependences between the micro and macro levels are also thought to be fundamental in understanding consumer behavior. As noted by Gatersleben and Vlek (1997), the micro and macro level factors are discussed separately, together they are mutually interdependent. Due to these interdependencies, actions taken by actors at both the micro and macro (national or regional or international) levels are deemed important in not only determining conditions necessary for consumer behavior, but also in influencing the make-up of factors at both levels of society, which make it impossible to consider one level without the consideration of the other. These interdependencies, while not demonstrated in the original NOA model, are included in subsequent revision of the model by Lucas et al. (2008). The following section outlines the core concepts of the NOA model.

[28] It is important to note that while some people might acquire cooking technologies for their status value, the focus of the NOA model and of this thesis is on the functional value of household goods. That is, values or outcomes that result from using household commodities. In the context of this thesis, it this is the functional value of ICSs and other cooking technologies. Such functional value includes, but is not limited to, the preparation of food. Other sought ends in the case of cooking technologies and fuels could include: comfort, time savings, cooked meals, warm living space, health benefits, and preservation of cultural values, etc. Therefore, when people look to purchase a product, they consider how it would contribute to their sought ends (Author's note).

4.3.Core concepts of the NOA model

The NOA model builds on concepts at two levels of society, the micro and macro levels, as introduced below. I begin by introducing the factors driving consumer behavior at the micro level.

4.3.1 The micro-level factors driving consumer behavior

4.3.1.1. Needs

Needs are presented in the NOA model as aims pursued by individuals in order to maintain or improve their "quality of life" or "wellbeing" (Gatersleben & Vlek, 1998:146). Elsewhere, in the theory of human motivation, needs are defined as goals or forces that drive individual actions (A. H. Maslow, 1943). In the NOA model, the value provided by household goods is derived from their contributions in satisfying "certain needs or quality of life expectations"(Gatersleben & Vlek, 1998: 151). Commodities such as technologies are said to be instrumental in meeting such needs. These functions are thought to facilitate the maintenance or improvement in quality of life and general wellbeing.

4.3.1.2. Opportunities

According to Birgitta Gatersleben & Charles Vlek (1997 &1998), opportunities are external facilitating or limiting factors that make consumer goods and services available or unavailable. In their study on Dutch households, Birgitta Gatersleben & Charles Vlek concluded that increased opportunities involving consumer goods and purchasing methods allowed people to satisfy their needs. These opportunities include: existence of goods; proximity to shops; cost, knowledge, and awareness (advertisement); availability of goods and services; and payment methods, for example cash, credit, and instalment payment plans, etc. Opportunities to access one good over another is also said to influence the choices that consumers make. Birgitta Gatersleben & Charles Vlek (1997 &1998), also argue that opportunities can evoke motivation, which can result in the acquisition of consumer goods. In the context of this thesis, such opportunities may include, free donations, subsidies, and gifts.

4.3.1.3. Abilities

Abilities are described as the set of personal resources or capabilities and skills that enable an individual or household to take advantage of available opportunities. According to Gatersleben and Vlek (1997), abilities include financial, temporal, spatial, cognitive and physical and skills. These different abilities are briefly outlined below.

1. **Financial** abilities in the NOA model refer to the income a consumer or a household enjoys. It is assumed that the higher the income, the greater the ability to facilitate consumer behavior and vice versa. Income is mainly thought to be a resource generated from work[29]. Other supportive financial opportunities, such as credit, loans, and installments payment plans, are also thought to enable consumer behavior, and were associated with increased consumption in the study of Dutch households(Gatersleben & Vlek, 1998).

2. **Temporal** abilities refer to the time available for consumption. For example, a household might require a commodity to fulfil a certain need, but might decide against it due to the lack of time needed to procure and use that commodity.

3. **Spatial** abilities refer to the amount of space available to store goods, and the distance from the household to the location where goods and services can be accessed.

4. **Cognitive**[30] abilities refer to the consumer's knowledge, awareness, and exposure to available goods and services; how they function; as well as their perceived and known advantages and disadvantages. Cognitive abilities are thought to influence one's ability to understand the outcomes associated with the consumption of certain goods and services in comparison with others. Cognitive abilities can also trigger interest in the identification and use of available opportunities. For instance, in the context of this thesis, it might be likely that people with knowledge and awareness of certain risks and burdens associated with the use of dirty, unsafe, and inefficient cooking technologies and fuels might be more open to trying alternative technologies and fuels to prepare their meals. On the

[29] In the context of the case study applied in thesis, (see chapter 2), it is clear that not all people who work (for example, domestic work mainly undertaken by women) can earn an income, and neither do all people who seek work obtain work or generate living incomes despite the number of hours and effort invested, especially in the informal sector. Therefore, to a certain extent, income is also influenced by other micro- and macro-level factors, but also the meso level factors examined later, in the Discussion chapter and not accounted for in the NOA model (Author’s note).

30 The term cognitive abilities is often used to refer to intellectual abilities(Carroll, 1993; Oechssler, Roider, & Schmitz, 2009) . However, the term is used in the NOA model and in this thesis to refer to knowledge and information available and access to the consumer, in this context the household or individuals within a household.

other hand, it could be assumed that people without such knowledge and information have no motivation or reason to change their current consumer practices because their limited knowledge prevents awareness of potential alternatives.

5. **Physical abilities and skill** includes the health conditions, body fitness, and strength of the consumer; the possession of necessary permits and licenses to use certain opportunities and access certain resources; as well as the necessary skills (e.g., educational achievements or driver's license) to acquire, use, and maintain a commodity. For instance, an individual may own a vehicle but be unable to afford the long-distance travel costs of accessing commodities that are not available locally. Consumers might also possess certain goods but be unable to use them as initially desired (e.g., due to poor health, physical disability, or lack of skills to operate them). Others might fail to fully utilize the potential of a community or the benefits accrued from their use, due to lack of skills to use, maintain, or repair it.

4.3.2. The macro-level factors driving consumer behavior

Macro-level factors are considered external influences on consumer behavior. According to the NOA model, consumers are engaged in larger social structures that shape and influence their needs, opportunities, and abilities, as introduced and described in the following sections.

4.3.2.1 Technology development

This is the development of a technical production processes that make goods and services available for consumption. In both developed and developing countries, more goods and services are available now than 40 years ago. This provides households with more opportunities to access a wide variety of affordable, reliable, and high-quality household goods and services. On the other hand, high-quality technological development is thought to reduce the frequency of purchasing goods and services. This may enable savings that could be invested elsewhere or used towards other economic activities or personal development. In the context of access to sustainable and effective cooking energy services, the development of other technological infrastructures such as transportation and mobility infrastructure, electricity distribution services, gas storage tanks and distribution pipes can also be said to directly or indirectly influence household consumer behavior. However, it is important to caution that the mere presence of such supporting technological development does not necessarily guarantee access to certain desired goods and services. For example, a powerline passing through a village does not automatically guarantee electricity connection to all village households and business. Neither does the presence of a power connection to all households and business in such a village result in access to electricity or reliable access for that matter. This is because, while the infrastructure might exist, some households or business might lack the financial capacity to purchase a connection, or those connected might lack the financial capacity to pay their consumption fees. In other cases, poor grid management and maintenance, overload, planned rationing, or illegal grid-tapping activities could result in unreliable supply or lack of access altogether for needy households (de Bercegol & Monstadt, 2018). Hence, these kinds of technological advancements can only be seen as opportunities. Sustainable and reliable access, in this example, can happen when the consumer experiences certain needs, such as the need for a lighted space, and also has the abilities needed to take advantage of the available technological infrastructure.

4.3.2.2. Economic development

In the NOA model, economic development includes the development of conditions that provide a basis for production and purchasing power. In the NOA model, technological development and economic development are said to complement each other. For example, increased production of goods is said to lead to greater competition, thereby lowering prices and providing people with sufficient choices to meet their needs. Additionally, economic prosperity may lead to an increase in wages or incomes, which could result in financial abilities that enable long-term access and use of needed households goods and services.

4.3.2.3. Demographic development

In the NOA model, demographic development is seen as a multiplier, because more people need more goods and services to meet their needs. However, different demographic groups can be said to have different needs, abilities, and opportunities. For example, the populations of some African and Asian countries are increasing exponentially(UN-DESA Population Division, 2017), and settling more in urban areas (UN-Habitat and IHS-Erasmus University Rotterdam, 2018). However, the demand and consumption of goods and services is still higher in the developed countries where economic and technological development is more advanced, longer established, and better governed. Hence, while demographic development is an important factor that can contribute to the understating of consumer behavior its influence ought to be placed in appropriate context, for example the population's social–economic realities and conditions.

4.3.2.4. Institutions

In this context, institutions refer to the way in which society is organized. According to the NOA model, institutional development is thought to influence economic and technological development, in turn influencing consumer behavior. This includes the development of markets, financial institutions, governance and regulatory structures, as well as enforcement and implementation capacity. Moreover, the state and nature of institutional development can also influence consumer behavior towards already available commodities.

4.3.2.5. Culture

In the NOA model, culture refers to societal norms and values that influence consumer choices and actions. For example, in traditional societies, most domestic activities, including cooking, and looking after children, the elderly and the sick, are typically associated with and carried out by women (Farioli & Dafrallah, 2012). It is estimated that 70% of the 1.3 billion people living in poverty are women, mostly in female-headed households (Clancy, Skutsch, & Batchelor, 2003). These kinds of gendered patterns can influence the consumer behavior of men and women in households and the dynamics between them, as well as the amount of income available to meet various household needs. In most cases in traditional societies, men work outside the home and therefore earn the household income, while women work within the domestic sphere. This dynamic can tip the decision-making power in favor of men, leaving women powerless and fully dependent on men for financial abilities. For example, because women are culturally tasked with taking care of vulnerable members of the society, some with little or no support could be trapped within the domestic sphere, leaving them little or no time for personal development. Moreover, individuals with developed capabilities are known to be more motivated to participate social and economic engagement and activities than those with limited capabilities (M. C. Nussbaum, 2011; Sen, 2003). Hence, societal norms and values could positively or negatively influence consumer choices and actions.

4.4 Contribution made by the model

The NOA model makes a convincing case that consumer behavior is a complex and non-linear process influenced by factors at both micro and macro levels. Due to this complexity and nonlinearity, factors at both levels of society influence not just the consumer behavior itself, but also the make-up of factors at both levels. External factors are thought to influence abilities and opportunities available to the consumer, while abilities and opportunities available to them can also alter the state of the economy. For example, economic development can influence the number and variety of cooking technologies in the market, thereby trigging competition, which in turn might result in lower prices. Skilled consumers could also participate in the development of such technologies. With employment comes financial ability, which could enable individuals to purchase goods and services, in this case cooking energy services. This is particularly important because it shows that the uptake of technologies or other consumer goods and services does not occur in a vacuum, but within social contexts that include many influencing and competing factors beyond the technology itself.

As a result, the NOA model centers its arguments on consumer needs (ends) and not on the commodity (means). Commodities and services facilitate identified needs. In the case of cooking technologies, biomass ICS is a means to meet the need for food and beverage preparation, while also mitigating health, social, economic, and environmental risks and burdens associated with other biomass cooking technologies such as open fires. Therefore, the NOA model emphasizes that it is not technologies per se that people are seeking, but the function(s) they derive from use of those technologies in order to meet desired needs.

This contribution is particularly important and relevant for this study because the model sets itself apart from other models that predominately focus on the technology in evaluating the success or failure of certain technological interventions. The model goes a step further in pointing out that having a certain need and being motivated to fulfil it does not necessarily mean that such a need can be fulfilled in the most desired manner, or indeed at all. To have a need and then be able to fulfil that need in the most desired way requires the presence of enabling conditions (opportunities and abilities). These conditions, it is argued, are determined both at the individual level (micro) and the societal (macro) levels in which end-users (households) are embedded.

Lastly, in the NOA model, consumers are thought to play a central role in deciding whether consumer behavior is initiated and/or sustained. Henceforth, they are valued for their decision and consumption powers that determine the fate of technological interventions, but also for their contributions as members of the society to the outcomes of factors at both the micro and macro levels. In the NOA model, this is emphasized in the importance assigned to understanding the relationships and interdependencies of factors at the individual and structural levels.

4.5 Suitability of the NOA model to this thesis

The NOA model was considered suitable for this particular line of research in preference to the theory of diffusion of innovation for three major reasons. Firstly, the NOA model highlights the importance of understanding end-user needs in order facilitate the development of acceptable and enabling goods and services. Secondly, it shifts the responsibility of access or lack thereof from the end-user (household) alone, to the end-user together with the structural conditions and societal contexts in which they are embedded. Thirdly, it provides an alternative to the technological and economic theories and approaches that are predominantly used to explain technological diffusion, and provides a fitting framework to explore and understand the diverse factors that hinder or enable access to acceptable and enabling cooking energy services in the context of households in the Kibera study area.

Unlike the NOA model, diffusion of innovation, although a widely applied theory, was deemed unsuitable for this project for three main reasons. Firstly, it does not explicitly incorporate the independent and interdependent roles played by micro- and macro-level factors in the initial adoption, use, and long- term access. Rogers (2003, p. 5) defines diffusion as the "process in which an innovation is communicated through certain channels over time among the members of a social system" with the objective to "persuade a client to adopt an innovation" (ibid., p. 6). The decision process is said to involve several stages, including: 1. The *knowledge stage:* information about the existence of an innovation and how it functions; 2. The *persuasion stage*: the state where end-users develop a favorable or unfavorable attitude towards a new idea or technology; 3. The *decision stage*: where a choice is made to adopt or reject a technology; 4. The *implementation stage*: where the new innovation is put into use; and 5. The *confirmation stage*: where the consumer makes the decision to incorporate the new innovation into their day-to-day practices or to discontinue its use altogether (ibid., p. 169-192). The process is linear and is thought to result in several phases of adoption, including: innovators, early adopters, early majority, late majority, and laggards (ibid., p. 410). However, this thesis is not only interested in the adoption of a technology, but there is also an interest in understanding whether adopted or available technologies can be accessed over the long- term and used to sufficiently and sustainably meet end-users' desired needs. Hence, it was important to consider a conceptual model that also has a focus on understanding end-users' needs. The NOA model places significant importance on understanding end-users' needs that they seek to meet through technologies or commodities.

Secondly, the diffusion of innovation model was not considered for this line of research because access to cooking energy services entails more than just the adoption of a technology. In order to achieve the objectives set out in this thesis, it was important to consider a conceptual framework that looks at consumer behavior in a wider context. Unlike diffusion of innovation, the NOA model presents an approach that is suitable for considering access to cooking energy services in a broader context, beyond the availability and accessibility of technologies. While the adoption of a technology, for example an ICSs, is necessary precondition for ensuring access to cooking energy services, one time adoption of technology does not guarantee long term access and sustainable and effective use. For example, assuming that the technology adopted is the one sought by end-users: in addition to the technology itself, other supporting conditions are also needed to enable its use and the attainment of desired ends. For instance, to deliver the ends sought from cooking technologies (i.e., harnessing energy to cook food), it is necessary to actually use the technology. To use an ICS, and to achieve the desired ends (cooked food) and other desired co-benefits such as clean air and environmental protection, etc., other appropriate supporting items and conditions are needed. These include, for example, desired technological properties, accompanying fuel, physical and environmental conditions of use, appropriate weather and environmental conditions, and good management and sustainable use of fuel resources, etc. Thus, even with a desired technology, if a household is trapped in a set of individual and/or structural circumstances that hinder sustained access to these supporting items and conditions, that household can also be said to be lacking access to cooking energy services, just like households that lack a technology and those that own a technology but do not use it.

Thirdly, the case study area is an informal settlement within a large urban area. There are many dynamics at play in the community and surrounding environment that not only influence access to cooking energy services, but also their effectiveness in meeting needs (see chapter two). While some of these dynamics have already been highlighted or will be discussed later, at this point it is important to underscore the role played by the informal nature of the social, economic, and political activities as well as the day-to-day human activities within the case study context, in influencing the selection of a conceptual framework that is appropriate to this project. Both the

NOA and diffusion of innovation models originate in the developed world and are applied to study phenomena in contexts that enjoy formal conditions. However, unlike the theory of diffusion, the NOA model provides a suitable foundation to explore the potential roles of informality in influencing households' access to desired cooking energy services.

4.6 Summary

Two conceptual frameworks, the NOA model and the theory of diffusion of innovation, were considered for use in this thesis. The NOA model emerged as being best suited to the research objectives because it provides a rich basis and appropriate guidelines for assessing household cooking energy needs as well as exploring and analyzing the factors that allow or hinder access to such needs in an informal urban settlement in the context of a developing country. The overall approach of the NOA model is to consider both individual and structural factors in order to ensure a holistic assessment and understanding of consumer needs as well as the factors that allow or hinder sustained and effective access to household commodities. This makes it the most suitable model to guide and enable the objectives set out in this thesis.

5. Methodology

This chapter describes the methodology used in the field study. This thesis has two objectives: The first is to explore the cooking-energy-related needs of households in Kibera and how these needs intersect with factors driving the acceptance, access, and effectiveness of cooking energy services. The second is to identify and contextualize the factors that hinder or enable sustained and sustainable access as well as effective use of cooking energy services. To achieve this objective, qualitative research with a case study approach was adopted as the main method. Semi-structured interviews and observations were used as the main tools for data collection. The following sections describe the data collection methods, where and with whom the empirical research was conducted, and how the data were documented and analyzed.

5.1 Qualitative research

This research employed a qualitative research approach. According to Silverman (2013) the most important methodological consideration is what method is suitable for the research challenge at hand. This study seeks to understand the factors that enable or hinder sustainable access to—and the effectiveness use of—cooking energy services in meeting sought needs and other goals (mainly social, economic, health, and environmental and climate protection). Moreover, central to this research is the need not only to understand the factors driving initial adoption, but also whether such a cooking service can be accessed and used in a sustained and effective manner. While the goal of quantitative research is to isolate cause and effect, to measure and quantity a phenomenon under controlled conditions, qualitative research approaches focus on subjects in real-life conditions (Flick, 2009; Robert K Yin, 2009). Quantitative data are already available on the state of ICSs interventions, which have predominantly focused on technological and economic aspects as well as cookstove programs. This knowledge is important because it provides a sense of the scale of the challenge. However, little is known about the stories behind these numbers, because little attention has been accorded to the needs of the main users of cooking services (households), or the role of social and structural elements in influencing the success or failure of technological and economic approaches. Guided by the NOA model presented in the previous chapter, this thesis seeks to address this gap by understanding the factors driving the acceptance, access, and effectiveness of cooking energy services from the household perspective, and the social contexts in which they are embedded. Due to the fundamental interconnectedness between individual households, the social and structural spheres, and cooking energy production and consumption processes, a qualitative approach was deemed most suitable because it provides an opportunity to understand these interactions in real-life conditions in order to uncover the details underling the meager success to date of cooking technologies such ICSs, the focus of this thesis.

5.2 Case study approach

A case study approach was adopted to facilitate the data collection. The diversity and complexity of factors enabling or hindering access to cooking energy services, and the nature of the selected case study area, called for the use of a case study approach. While other approaches can also be used to collect qualitative data, including historical and ethnographic approaches (Robert K Yin, 2009), a case study approach was deemed the most appropriate for this line of research because it is best suited to understanding phenomena under real-life conditions (Robert K Yin, 2009). Moreover, a case study approach, unlike the other two highlighted approaches, allows for a broader choice of data collection tools, as summarized in Table 2. This was particularly useful in this study because it enabled the verification of information obtained from different sources. Most businesses and activities conducted in Kibera are either in the informal or illegal sectors. Hence, much commercial activity is characterized by great secrecy and lack of trust, especially for outsiders. Moreover, Kibera is rife with diverse and often conflicting information, perpetrated by actors with competing and diverse interests both within and outside Kibera. Hence, to ensure that accurate data were being obtained, the use of multiple tools and sources of information was paramount. This kind depth and context-dependent knowledge is important for understanding and addressing often complex and diverse urban challenges (Parnell & Pieterse, 2014), especially within informal urban settlements in developing country contexts, such as Kibera. A case study approach, unlike the historic and ethnographic research strategies mentioned previously, allows for this kind of assessment of real-life situations.

Table 2. Summary: Characteristics of case study, historical, and ethnographic approaches

Methodological approach	Time of phenomenon	Type of data	Data sources
Historic	Past	Quantitative, qualitative, or both	Documents and artefacts

Ethnographic	Contemporary	Mostly qualitative	Interviews and observations
Case study	Contemporary	Quantitative, qualitative, or both	Interviews, observations (direct observations and participant observations), artefacts, documents, and archival records

Source: summarized by author based on (Robert K Yin, 1994, 2009)

5.3 Scope of the study

While there was potential to examine many different case studies for this research, it was deemed important to select a single case study rather than several, because this can facilitate much more detailed examination of the research questions. A focus on a single case also enables adequate breadth and depth (Gerring, 2006; Robert K Yin, 2009), especially in identifying contextual factors. Focusing on Kibera is an attempt to enable the identification of contextual and structural variables, in addition to household conditions and circumstances that influence the sustained and sustainable access and the effective use of ICS by concentrating on a highly heterogeneous group of people. Given the magnitude of disadvantages facing the residents of Kibera, the success in reaching such populations to develop a sustainable path to clean, affordable, efficient and sustainable energy access would have immediate and lifesaving impacts on the current and future generations, as well as the environment.

5.4 Unit of analysis

The unit of analysis in this thesis is households. For the purposes of this study, a household consists of a person or group of persons living together under the same roof or in the same compound, but preparing their meals under the same roof or in a communal kitchen. This definition is embraced to account for the Nubian, the natives of Kibera who live in large compounds as an extended family, made up of different nuclear families. According to Robert K Yin, (2009), the unit of analysis in a case study describes the core of the case study and therefore what the research is about. The objective of this thesis is to understand and contextualize the factors that enable or hinder household access to desired and appropriate cooking energy services, as well as the factors influencing the sustained and sustainable access, and effective use of energy services. Households are the main consumers, and stand to benefit or lose the most from sustained and sustainable access or lack to effective cooking energy services. Therefore, the core focus of this study is households.

The choice of households as the main unit of analysis represents one important principle employed in this thesis, that is, households are the main 'experts' concerning their needs and the struggle and opportunities available to achieve them. Therefore, a truly holistic understanding of the factors that allow or hinder access to ICSs could only be accurately captured and understood by focusing on the people most directly involved and affected by unsustainable and interrupted access of cooking energy services. Moreover, it was also important to focus on households in an informal settlement like Kibera, because their views on what enables or hinders sustainable access and the effectives of cooking energy services have seldom been the focus of research into cooking energy access and technological development, because of the predominate focus on rural households. This previous lack of attention to urban households is a missed opportunity, because decisions and factors at the household sphere play a decisive role in determining what technologies are accepted, adopted, and used in a persistent way. For example, Lucas et al., (2008) and Stern (2000) both note, that seeking to understand the situation from the actor's perspective, especially when dealing with interventions directed towards change in environmentally destructive behavior, is crucial because it increases the chances for evidence-based interventions. Moreover, the need to understand the situation from the household perspective is an effort to highlight that the intended beneficiaries of cooking energy services are active participants in change processes, and not passive recipients of interventions. Therefore, if success is to be achieved and sustained in the cooking energy sector and in development processes more broadly, the ways in which policy and interventions are designed and implemented must be revised to focus on and involve the intended beneficiaries.

However, while households are the main focus of this study, research has highlighted the complexities of cooking energy access processes as well as the quality of expected impacts beyond the presence, adoption, and use of high-quality cooking technologies, such as ICSs by households (Kumar & Igdalsky, 2019; Mortimer et al., 2017; Quinn et al., 2018). Therefore, it was important to consider external factors that lie beyond the control of households. This was enabled by the use of extensive direct observation of the case study site, resident observation, and formal interviews (R.K. Yin, 1994) with opinion-leaders involved in cooking energy access processes within and beyond Kibera. A secondary objective of this study was to establish whether the end-users and external actors are aligned in their assessments of the need for improved cook stove as well as the challenges and opportunities that exist in Kibera and beyond. This understanding could provide useful information, especially with regard to knowledge gaps and the alignment of goals and visions for the sustained achievement of clean cooking solutions. Moreover, consideration of the interplay between household cooking-energy needs, access conditions, and external conditions (micro, meso, and macro) was also important in this study. This wider view enabled a holistic understanding of the factors that enable or hinder sustainable access to and effectiveness of cooking energy services, both within the household and beyond. An added advantage of such an approach is that it allows for generalization of the results beyond Kibera, because in many respects the societal and contextual conditions in Kibera are similar to the situation in other informal settlements within Nairobi and beyond (UN-Habitat, 2014; UN-Habitat and IHS-Erasmus University Rotterdam, 2018; UN Habitat, 2007b, 2007a). Ultimately, the goal of this thesis is to understand and highlight the forces that influence end-users' choices surrounding cooking energy from all levels of society, because unless households are willing and able to respond to positive developments in the policy, technological, and market spheres the achievement of SDG 7, other SDGs, and the Paris Agreement will remain elusive.

5.5 Data Collection tools

The field work mainly employed interviews and observational data-collection methods. In addition, photographs were taken with the prior consent of the individual(s) involved. In the absence of human subjects, photographs were taken when this was deemed appropriate. The combination of interviews and observations in the context of this thesis allowed for a robust and accurate assessment of the challenges that need to be addressed and the potential opportunities to support the uptake and sustained access to sustainable and effective cooking energy solutions within households in informal settlements like Kibera. The use of photography complemented the interviews and observations in three ways. It captured people's lived situations and struggles to access appropriate and clean cooking energy; it depicted their surrounding environments in detail; and it served as a control for disparities between their accounts and what appeared to be the reality. The use of multiple data-collection tools and sources of information was important in this study because it allowed for triangulation and data cross-validation, which increases credibility (Robert K Yin, 2009). Moreover, the use of multiple data sources is known to facilitate a detailed and in-depth assessment of the contextual and environmental conditions and circumstances that directly or indirectly influence the study subject or the unit of analysis (Gerring, 2006). The use of interviews and observations is explained in greater detail in the following sections.

5.5.1 Observations

There are two main kinds of observation in case study approaches: direct and participant observation (R.K. Yin, 1994). Direct observation involves field visiting the case study area, while participant observation involves both passive and active engagement with the study subject and individuals. In site observation or non-participant observations, the researcher is an independent observer and is unlikely to influence the situation being observed. On the other hand, in the participant observation approach the researcher is activity involved and could influence the situation being observed (Flick, 2009; Robert K Yin, 2009). Both kinds of observations were utilized in this research. Direct observation took place during the pilot study and throughout the fieldwork period, including in parallel with interviews. On the other hand, participant observations were applied during informal conversations with business agents engaged in cooking energy services in Kibera, social group meetings, and social events within Kibera to obtain an in-depth understanding of the factors influencing access (or lack of) to desired, appropriate, and effective cooking energy services, beyond ICSs. Such observations also enabled the understanding of everyday activities in Kibera, especially as these related to access and use of various cooking energy services. This involved taking part in scheduled local events on invitation, such weddings and community and social group meetings, and directly engaging with participates. Probing questions and follow-up questions (especially concerning access to and use of cooking energy services) were used whenever the provided information was not clear or obvious; in order to gather additional information or to check the accuracy of previously received information. More specifically, informal discussions about access to and use of cooking technologies were conducted with three self-help groups (a youth group, a women's group, and a mixed group comprising men and women. On two occasions, I conducted observations with groups of local residents, both men and women, who had been invited to the Kibera Town Centre (KTC)[31] for a "green technologies"[32] awareness-creation meeting. On four occasions I was invited to observe the Nubian cooking traditions and practices in the context of two households and two wedding ceremonies. My long-term presence in Kibera allowed me to build trust that later developed into friendships. The invitation to the Nubian wedding was a direct result of these friendships. This kind of access would otherwise have been impossible for an outsider (as I was initially considered).

There was great value in these observations for my research. They allowed for in-depth assessment of cooking-energy-related activities, involving different parts of Kibera and individuals engaging in their day-to-day activities, beyond those taking place in the household context. As noted by Rappaport, Swift,and Hess (1984:132) " residents are the "experts" on their neighborhood and that a truly accurate understanding of any community requires a combination of formal data and informal knowledge of the community". The formal and informal observations served several functions: They provided a rich contextual understanding of the day-to-day life in Kibera as well as the social, economic, and cultural value and importance of cooking activities within households and the broader community. Moreover, through general observation, data were gathered on environmental conditions and the effects on people and the surrounding environment of using certain cooking energy services. Observations were also of practical importance for this study because, due to lack of trust, information gathered from observations was instrumental in counter-checking the accuracy of information provided by different participants. Observations were also conducted in parallel with formal interviews, to complement and cross-check the accuracy of the information provided during interviews. Lastly,

[31] The Kibera Town Centre is non-profit organization with local and international partnerships within the umbrella organization of the Human Needs Project. The first center was opened in Kibera in 2014. The center adopts a holistic approach to human needs by providing various opportunities in the areas of education; water and sanitation services, including safe drinking water, modern toilets, and shower facilities; education and sale of improved and cleaner cooking energy services, including ICSs and briquettes; household goods and services; meeting areas; and a restaurant, among others. These services make the KTC one of the most visited public places in Kibera. Their vision is to "build physical infrastructure for clean water and sanitation, and social infrastructure with capacity building: information, skills training, access to credit and computers, and community ownership" with the goal of empowering people to transform their communities. For more information about the Kibera Town Centre, see: http://www.humanneedsproject.org/tags/kibera-town-centre

[32] "Green technologies" is the term used within KTC to refer to cleaner cooking technologies, including ICSs, as well as solar-powered technologies including light bulbs, solar Latinas, and radios that are partly or entirely powered by solar energy.

the use of both formal and informal observation was a necessary strategy to enable accurate understanding of the factors that enable or hinder persistent and sustainable access and effective use of ICSs, and clean cooking energy services more generally. Kibera is an informal settlement, and therefore most of the activities are informal and occur somewhat spontaneously. There is also considerable illegal activity, for example the sale of illegal charcoal and the collection and sale of firewood from the Ngong Forest, which previously covered the Kibera area and parts of Nairobi before being cleared for human settlements. These illegal activities are often conducted in secrecy to avoid the long reach of the formal government.

5.5.2 Interviews

Interviews are essential sources of case study information, especially in one involving human subjects and their affairs (R.K. Yin, 1994). Moreover, interviews are unique in that they provide the researcher with a deep understanding of these subjects' lived experiences that could only be sufficiently captured through face-to-face interactions in real-life situations (Marshall & Rossman, 2006). The interviews used a semi-structured format. This was chosen because the open questions provide an opportunity for respondents to make meaning of their own situations without feeling limited by closed-ended questions (Creswell, 2003). Additionally semi-structured interview questions were chosen because they provided flexibility while at the same time ensuring focus on the research topic (Flick, 2009). The open-ended nature of the questions provided interviewees with the freedom to state their own opinions during the interview processes, and for the interviewer to pose more detailed follow-up questions to obtain additional information or clarification.

Interviews were conducted with representatives of twenty households (18 women and 2 men) from eight of the fourteen villages in Kibera. These interviewees were the main cooks in their respective households. Interviews ranged in duration from 20 minutes to one hour. All interviews were conducted face-to-face. Interviews with household representatives were conducted within their dwelling in close proximity to their living areas. It was my intention, where applicable, to interview and make observations in closest proximity to where the households prepared their meals and spend most of their free time (i.e., within the household and its immediate surroundings). This was important in order to capture the real context within which decisions about access to ICSs were made and implemented.

To capture this kind of knowledge in detail, it was also important to interview opinion leaders within Kibera and beyond. Hence, additional interviews were also conducted with 6 opinion leaders (3 women and 3 men) working on issues related to energy access from within and outside Kibera. The opinion leaders came from diverse backgrounds, thereby helping to capture the factors that enable or hinder access to cooking energy services, especially ICSs, in a comprehensive way. The opinion leaders comprised: a retiree from the Ministry of Energy who is presently an advocate for clean energy access; a researcher and professor from the University of Nairobi; the head of a non-governmental organization in Kibera; a cooking stove distributor in Kibera; a church minister; a women's group representative; and a maker and seller of fuel briquettes. When interviewing opinion leaders, each one was conducted at a convenient location that was chosen together with the interviewee. The information gathered from these interviews allows the cooking energy access challenges and opportunities to be placed in a broader context, not only those contexts influenced by household-level conditions or by the presence of astute technologies. This was important not only to complement the information from the household representatives, but also to enable a deeper understanding of the contexts in which users make their cooking energy decisions. Interview data were corroborated with information from observations and relevant documents. The use of multiple sources of data in qualitative research is important because it helps mitigate possible shortcoming in the data collection processes that could compromise the validity, reliably and generalizability of results (R.K. Yin, 1994). By focusing on a small interview sample and complementing the research with informal and formal observations with relevant stokeholds, a good understanding of the overall situation can be achieved (Gerring, 2006).

5.6 Interview and observation procedures

Three different interview guides where developed and used to collect data. They included two separate household interview guides and one opinion leaders' guide. An additional observation guide was developed to inform observations made during the time spent in the case study site and during interviews. The three interview guides and observation guide were important in shaping the data collection activities and maintaining focus on the subject matter.

5.6.1 Household interview guides

The two household interview guides were developed for interviews with the two main households selected for this study, which will be described in detail during the sampling phase. These comprised: 1. The constrained category: Households predominantly using traditional biomass cooking energy services and fossil-fueled stoves (mainly kerosene), and; 2. The transitional category: Households using a combination of traditional biomass cooking energy services, fossil-fueled stoves (mainly kerosene) in addition to other modern cooking energy services such as LPG. As emphasized in the work of (Karekezi et al., 2008), Kibera is a highly diverse and heterogeneous community, such that households could be categorized using wide-ranging criteria. However, to maintain focus on the subject matter, the main selection criteria for household interviews concerned their ownership and use of various cooking energy services, as defined by the constrained and transitional categories. More information on the sampling process is provided in the sampling section later in this chapter. It was important to understand the different conditions and circumstances that households were experiencing, despite their ostensibly similar contextual and environmental conditions concerning their cooking energy ownership and user patterns. Moreover, it was important to understand these factors from the household perspective, because while households are the 'experts' in their individual and community challenges and opportunities, such expertise is often not sought or used in development solutions. However, a truly accurate assessment and understanding of these issues can only be obtained from the people directly involved. Moreover, while technologies such as ICSs are designed and intended for household use, there is always the tendency to homogenize households' needs, abilities, and opportunities. However, in the interest of not leaving anyone behind, it was important to acknowledge that what is considered practical and accessible may differ between households.

5.6.2 Opinion leader interview guides

A separate interview guide was developed for interviews with opinion leaders. To understand the link between households' choices and various contextual and structural conditions, it was important to develop a separate interview guide to assess and understand the external and structural conditions under which households' cooking energy decisions are sought and made, as seen from the perspectives of relevant societal opinion leaders. . Overall, all the interview guides consisted of four main parts: The introduction and purpose of the study, including seeking consent from the interviewee; the main subject questions; personal questions; and a final debriefing section. All interview guides and the observation guide are provided in the Appendix.

5.7 Pilot phase

Yin (2003) recommends pilot testing before beginning interviews and observations, as this helps the researcher to make needed adjustments during the early stages of the study. Therefore, a pilot test was conducted at the beginning of the site observations and before the interview process. In the context of this study, the pilot study served several purposes:

1. Identification of a suitable host institution and research guide, which was crucial for the successful completion of the field work. For more about the use of host institution and research guide, see the later section titled, use of a host institution and research guide.
2. Allowed for a better understanding and familiarization with the context, the people, as well as the structure of everyday life activities, especially as these related to access, use, and effectiveness of cooking energy services.
3. Served as an exploratory phase for the villages and potential interviewees. Subsequently, it was much easier to contact the people who I had already met during this pilot phase, and to request an interview. In some cases, household representatives volunteered to be interviewed after hearing about the purpose of my visit to Kibera, during observation and interview pilots.
4. The process also helped in building trust with individuals within the households and the broader community.
5. The pilot interviews yielded important information, which led to the adjustment of some interview questions. For example, the pilot interviews informed the reframing and use of language in the household interview guides, thereby enabling better understanding of the questions and communication by the interviewee. It was also clear that people were not always comfortable with being recorded, and when recording was allowed, the quality was very poor due to constant human interference and noise pollution. This ensured that I was always prepared to take notes to complement the recordings whenever I was allowed to record, or as the main source of data recording when permission to record was denied.
6. Lastly, the pilot phase was important for mastering some practical and safety considerations that enabled for a smooth and successful data collection process. For example, Kibera is a high-risk area, especially in certain areas or at particular times of day. Theft, violence, and especially gender-based violence is rife (Swart, 2012). This kind of violence often snowballs into a massive security challenge. In Kibera, where

official security details are either not permitted or are strategically absent, residents take matters into their own hands by the use of mob justice. Such scenes can be dangerous for people without knowledge of how to react or behave in order to protect themselves.

5.8 Sampling

With the help of an research guide, a purposeful and convenient sampling method was used to identify both household and opinion leaders interviewees (Miles & Huberman, 1994). This was to ensure a just representation of the villages in Kibera and the two types of households selected for this study, as defined earlier. Contact with potential interviewees was made during the early days of the site observation phase which took place one month before the formal interview process. The basics of the research project were explained to each potential interviewee and then they were asked about their interest in participating in a future interview. If the individual was willing to participate, preliminary information about their ownership and use of cooking energy services was sought. If the respondent met the set criteria described previously, and was willing to participate in an interview, a date and time were scheduled. This prior selection was especially important because it ensured a fair balance between the two kinds of household sought for this study. While there is a wide diversity of households in Kibera, household representatives sought for this study fell into one of the two major social economic strata: either socioeconomically disadvantaged or transitional-class households[33]. The main criterion for selecting households was their ownership and use of cooking energy services. For the purposes of this study, this was defined as: Those households dependent primarily dependent on high-carbon fuels burnt on traditional cookstoves (or high-carbon technologies, such as basic improved cook stoves, open fires, and kerosene stoves) to meet their cooking energy needs were categorized as socioeconomically disadvantaged households. On the other hand, those households dependent on a mixture of high carbon and fuel inefficient technologies and fuels such as such: as basic improved cook stoves, open fires, and kerosene stoves together with low-carbon and energy-

[33] The term "transitional households" is used in this study for households living in informal settlements, which retain hope that when their socioeconomic conditions improve, they will move to more formal housing and living environments, or else join loved ones back in their rural homes. Generally, members of this class of households were worried about their security and the general wellbeing of their children. Most where worried about their children's futures and the effects of peer and environmental influences (drugs, alcohol abuse, sexual and physical harassment) on their children. The constrained households defined Kibera as home and, due to their socioeconomic realities, expressed no desire or hope to move out. Most were concerned about the health and wellbeing of their children, but saw it as fate; and expressed hopeless and inability to change their current situation.

efficient cooking technologies and fuels (such as LPG, bioethanol stoves, and biomass) to meet their cooking needs are defined here as transitional-class households. The main defining characteristic of the household representative was their level of involvement in the choice and use of the cooking fuels and technologies used in the household. From a cultural perspective, it was likely that the person making the decisions about access to cooking energy services was not the person using these services. For instance, men bought most of the biomass ICSs sold at the KTC, whereas the main users of biomass cooking services are predominantly women and children. Therefore, women were over-represented in the household sample. Women and children are also known to suffer most from the negative effects of lack of access to clean, safe, affordable and reliable cooking services as well as inappropriate user conditions (Health Effects Institute, 2018; Landrigan et al., 2017). Therefore, in the context of this study, it was important to understand their circumstances and realities. Opinion leaders where mostly recommended by the research guide and by KTC employees. On two occasions, an interviewee was recommended by a previous participant. Earlier, I laid out the need for both internal and external inputs in identifying the challenges and highlighting available opportunities for a path towards sustainable and effective access to cooking energy services. It was also a secondary objective of this study to establish whether end-users and external actors were aligned in their assessments of the need for improved cookstoves, and the obstacles and enabling factors for the transition from traditional to ICSs. However, efforts were made to ensure that all points of views were reflected in the study, through follow-up questions, participant observation, and interviews with opinion leaders. As noted by Gerring (2006), by focusing on a small interview sample, and complementing the data with observations, a better understanding of the whole can be achieved. Because the study sample was small, the numbers are illustrative.

5.9 Interview procedure

The day before an interview was scheduled, a phone call was made to confirm the availably and willingness of the interviewee to participate. The interview was framed by a briefing and debriefing after the completion of the interview (Kvale, 2011). The briefing included researcher introduction, the purpose of the interview; duration, data handling, and protection of the interviewee, including their right to refuse to answer any question or to halt the interview at any time. Verbal consent was then obtained from the interviewee, after which the main questions were presented. It was important to develop free and safe interview environment for the interviews because, as noted in the work of Knox and Burkard (2009), a good relationship between interviewees and the research not only enables the collection of good data, but the quality of the researcher/interviewee relationship could also affect the depth of information provided about personal experiences and information about the subject matter. The briefing section proved extremely valuable for this research because it helped create understanding and, more importantly, friendliness between the researcher and interviewee. This kind of initial connection was especially important because it put the interviewee at ease and facilitated the smooth flow of the interview processes. The interview ended with a debriefing, which included a summary of what was learned from the interview; and offered the interviewee the opportunity to respond, provide additional information and feedback, or to ask additional questions. All interviews were conducted by the researcher, who for security and navigation purposes was always accompanied by a research guide from the KTC.

5.10 Data documentation and analysis

The data collected for this study are based on the case study approach. The data collection tools included interviews and observations, complemented by pictures and available recorded information from within Kibera, such as sales data from the KTC Green Shop. While the researcher always attempted to make audio recordings, such attempts were often unsuccessful due to noise pollution, human interference, and denied permission. In most cases, respondents felt uncomfortable with the recording device, in which case a decision was made to avoid it altogether and to instead take written notes. While this was not the most convenient way to record information, such situations were expected after the pilot study process. Hence, I was always prepared to take written notes at all times. As noted by Yin (1994:86), while recorded interview notes provide more accurate recollections of interviewees' information than other forms of documentation, a tape recorder should be avoided, for among other reasons, when “an interviewee refuses permission or appears uncomfortable in its presence”. On two occasions, consent was denied. The situations involved the collection and sale of firewood, and a charcoal storage unit. Preliminary data analysis was conducted following the pilot and initial observations, which then informed adjustments to the interview guides and subsequent observations. The main data analysis was conducted at the end of the field work phase. The interviews were manually transcripted and all relevant notes typed and grouped into different themes based on the research questions.

5.11 Use of a local host institution and research guide

My acceptance in Kibera and ability to collect data would have been virtually impossible without the presence of a local research guide. This acceptance and trust enhanced my access to high-quality and often inaccessible information concerning cooking energy access and the situation of energy access more generally, and their interconnectedness to people's livelihoods, survival, and day-to-day social and economic activities in Kibera and beyond. The information communicated by the local research guide was also central to my safety and wellbeing throughout the field work. As corroborated by Karekezi et al. (2008), it is difficult to conduct research in Kibera under fear of intimidation or physical harm. This can especially be dangerous if certain factions with various vested interests feel threatened by the information sought and provided, or feel insecure due to the mere presence of an outsider.

While the initial plan was to only identify a host institution rather than a personal research guide, after my initial time in Kibera I realized that it would be virtually impossible to gain access to information, build trust, or to navigate through Kibera without a personal guide or informant from the community, because of the security risks that this could have posed. Therefore, the successful completion of the field work necessitated identifying a host institution and personal guide within Kibera. This was especially important given my lack of firsthand experience of Kibera. According to Yin 1994:84) research guides "not only provide the case study investigator with insights into a matter but also can suggest sources of corroboratory evidence—and initiate the access to other sources." After a desktop exploratory phase and discussions with people familiar with the Kibera contexts, I visited the KTC[34] to informally introduce my study interests and proposed timeline of the field work to the then manager of the Centre and her employees. Following their interest in my work and field study, I was allowed to use the Centre as a host institution and assigned a volunteer guide for the duration of the field work. While there were many institutions in Kibera, mostly run by local and international NGOs, KTC was a fitting institution because of its central location in Kibera. It is also the gateway to one of the poorest villages, Gatwekera. Moreover, the KTC is located next to Kibera's main public square (*Kamukunji grounds*) where people gather for public meetings, and social and economic activities. More specific to research subject, the KTC houses one of the only non-profit outlets,

[34] For more information about the Kibera Town Centre, see: http://www.humanneedsproject.org/tags/kibera-town-centre

the "*Green Shop*" that promotes and sells cleaner and safer cooking energy technologies and fuels, mainly biomass ICSs and other renewable energy powered technologies. The data from this shop also provided crucial insights concerning the state of access to biomass ICSs, interested buyers, the mode of payment (cash, credit, or instalment payments), and the actual state of access to and use of such services within Kibera, as presented in the Results chapter.

The volunteer guide was also instrumental in the data collection process. My guide was a young, vibrant woman who had been born and raised in Kibera. Her work at the KTC and vast awareness of Kibera had earned her respect and credibility within the community. People knew her, trusted her, and related to her. This cleared the way for me to feel safe and comfortable, especially during my early days at the settlement. It also provided me with a firm base to build trust and to interact directly with local residents. The volunteer guide was especially helpful in guiding me through the villages in Kibera and introducing me to potential interviewees.

5.12 Language used

Multiple languages are used in Kenya. These include, English, Kiswahili, as well as multiple ethnic languages and dialects. At the beginning of an interview, I asked respondents about their preferred use of language. Most respondents choose Kiswahili. However, in the end, all respondents used a mixture of English and Kiswahili. Occasionally some people used slang words only used within Kibera to better express themselves. In that case, a follow-up question was posed, or the respondent was asked to show or provide an example. Words like *pungunza* (a fuel made by mixing charcoal dust and soil with water) and *Skode* (the name given to Kenya Ceramic Jiko within Kibera) are unique to the slum context. All translations were done by the author and notes were taken only in English.

5.13 Research authorization and informed consent

Authorization to conduct research in Kenya and in Kibera more specifically was sought at the beginning of the study and obtained from the Kenya National Commission for Science Technology and Innovation, and approved by the Ministry of Education State Department of Basic Education in Nairobi. Additionally, verbal informed consent was obtained for all interviews, observations, and photo documentation. To maintain confidentiality, individual respondents are anonymized.

5.14 Challenges experienced during the field study

Several challenges experienced during the fieldwork are worth highlighting. First was the extreme difficulty experienced in developing a working rapport and trust with the local community. While this is a common experience, sometimes attributed to respondent fatigue (Karekezi et al., 2008) or mistrust of all outsider influences (de Bercegol & Monstadt, 2018), difficulties in gaining access, despite my status as a Kenyan and woman seeking information about cooking energy services, resulted from my lack of knowledge and experience with the slum subculture. The use of a host institution and local research guide enabled me to build trust with the local community and made access to information much less difficult.

Secondly, noise pollution and human interference were common during interviews. This was mainly as a result of lack of zoning, congestion, and poor building standards. For example, people lived side by side with various loud businesses such as pubs, grain millers, etc. The houses in Kibera are also designed to maximize space use, such that there was no privacy or noise protection from one owner/tenant to the other.

Thirdly, the existing literature provides only limited coverage of the factors that enable or hinder sustained and sustainable access as well the effective use of cooking energy services in informal settlements. There are also limited studies about social dimensions and dynamics concerning the broader theme of energy accessibility and effectiveness. This made it extremely difficult to cross-check the limited number of existing data sources for their accuracy and consistency. Moreover, despite the great interest in Kibera shown by national and international NGOs, the lack of accurate data about all aspects of life in Kibera, and especially the presence of contradictory and competing data sources concerning the demographic composition and distribution of Kibera, acted as a barrier in the sampling and interviewee selection phase. The accessibility and accuracy of data collected during the field work was also compromised by the slum residents' mistrust of the outside world. These limitations were minimized by the quality and quantity of time I spent in Kibera to access the situation firsthand, as well as the use of multiple data collection tools and sources of information.

Fourthly, the physical accessibly of Kibera is limited by lack of marked roads, environmental pollution, congestion, and substandard housing. This made it extremely difficult to locate a household within a multitude of similar shacks, even after multiple visits. The willingness and kindness of respondents to share their mobile phone numbers with me made the process of connecting with them much easier. KTC was also centrally located, and most people I worked with knew about the Centre and had used its services at some point. Often, I used the KTC as the main meeting point. However, since the intention was to understand enabling factors and barriers in respondents' immediate living contexts, interviews and observation were mainly carried out within or in close proximity to their shacks. This was especially important to ensure that this research process did not interfere with the respondents' livelihood activities because they engaged with all of the research activities purely on a voluntary basis.

Lastly, despite the suitability of a case study approach, and the choice of one case to ensure in-depth assessment of relevant factors, case study approaches have been shown to have certain shortcomings. The most cited shortcomings of case study approaches concerns a lack of rigor and poor generalizability of study results (Robert K Yin, 2009). In this thesis, the use of multiple data -collection tools helped mitigate this shortcoming.

5.15 Summary

This chapter provided details of the research methodology employed, including data collection methods and tools, and the analysis strategy employed. A qualitative research method was used with semi-structured interviews, direct observations, and photo documentation as tools for data collection. Qualitative research was deemed suitable for addressing the research question because it allowed assessment of factors that enable or hinder sustainable access to cooking energy services in real-life situations and settings. The case study approach was chosen because it enabled a focus on one specific location, thereby facilitating in-depth assessment of enabling and inhibitory factors at all levels of society (micro, meso, and, macro). The focus on multiple data tools and data sources and contemporary phenomena, enabled by case study approaches, was also suitable for addressing the diversity and complexity of these enabling and inhibitory factors. The depth needed to understand the factors enabling or hindering sustained and sustainable access as well as the effective use of ICSs and other clean cooking energy services called for a qualitative and case study approach, because this allowed the use of multiple data collection tools and sources of information. Being an informal settlement, the accessibility and accuracy of data were not always guaranteed. Hence, the use of multiple data collection tools and information sources was paramount in triangulating and cross-checking data to ensure its reliability and validity. Moreover, the use of multiple data sources provided a detailed, in-depth assessment of the contextual conditions and factors that influence decisions regarding access to ICSs as well as the sustainable and effective transition from open fires and basic improved cookstoves to sustained and effective use of alternatives such as improved cook stoves. Overall, the methodology employed here is unique among available studies. The next chapter presents the results of the study.

6 Results

This chapter presents the findings of field work conducted within the case study area of Kibera during February–May 2017. These derive from semi-structured interviews with household representatives and opinion leaders working on energy-related issues within and beyond Kibera; structured observations; and informal discussions with social group members and residents of Kibera. The main focus of these activities was to identify and contextualize the factors that hinder or support the sustainable access and effective use of clean, efficient, and affordable cooking energy services, with a specific focus on improved cook stoves.

The chapter is organized into five sections. The first section begins by highlighting the unique and diverse characteristics of the households included in the interview sample. This includes assessments of the structure of everyday life, the state of cooking practices, eating cultures, and energy uses within households and in Kibera more broadly. The objective is to place household needs and cooking energy requirements within the context of the study respondents' lived realities and circumstances. The second section presents households' cooking energy needs and the kinds of abilities and opportunities they seek in addressing those needs. The third section examines current access and usage patterns surrounding cooking energy, as well the factors influencing household decision-making and access processes. The fourth section focuses on the state of the art concerning sustainable adoption and use of ICSs. Lastly, section five addresses the level of awareness, specifically concerning the risks and burdens associated with the use of dirty, polluting fuels and energy-inefficient technologies (health, environmental, social, and economic), and highlights possible pathways toward sustainable access, use, and effectiveness from the perspectives of household representatives and opinion leaders. The chapter concludes with a brief summary of the main results.

6.1 Household characteristics

Kenya's ethnic diversity provides for a vibrant food culture and cooking practices. This was reflected in the heterogeneity of households in Kibera, and was also evident in the diversity of ethnicities, family types and sizes, lifestyles, energy consumption patterns, and social–economic activities that fuel livelihoods. However, this study focuses on two types of households. Those predominantly relying on traditional high-carbon cooking energy services: biomass traditional cookstoves, including basic biomass improved cookstoves such as the Kenya Ceramic Jiko (KCJ) and kerosene stoves); and those relying on a mix of traditional high-carbon cooking services and improved biomass cookstoves (intermediate and advanced) combined with modern cooking energy services such as bioethanol powered stoves and liquefied petroleum gas (LPG). For simplicity, these are referred to as constrained (represented by letter A) and transitional (represented by letter B) later in this thesis.[35] The term "transitional households" is used in this thesis to connote a narrative of hope, desire, and attempts for change and transition to cleaner and low-carbon cooking energy services outside Kibera. The term "constrained households" is used to connote a lack of control and hope by households, to change the use of polluting cooking services (basic cookstoves and kerosene stoves) and to improve their life condition more generally. Moreover, households in these groups depicted several different socioeconomic characteristics that directly influenced how cooking energy services were acquired. For example, house size, use of household space, family type (single female headed with children; single male; traditional two-adult (woman and man) household; shared: two or more single men; etc.), nature of electricity access (legal, illegal, or both), prized household possessions, income generating activities / employment status, and household size (members living in the household). The focus on these two household types enabled identification of the conditions under which some households manage to access cleaner and safer cooking energy services while others do not. The identified household distinctions are summarized in Table 3.

Table 3: Summary of major household characteristics

Characteristics	Constrained household (A)	Transitional household (B)
House size and type	One-roomed-houses, Type: Mud, rattle, cardboard; with recycled iron, tin or sheet roof; a dirt floor with a door as the only opening. For privacy, some spaces are dividing in half	Two roomed houses, Type: A combination of mud, stone, wood, and cement with an iron-sheet roof, often with a cement floor, a small window opening, and a door.

[35] It is important to note that households in Kibera can be grouped into additional categories to depict their unique characteristic (which are numerous). However, the categorization chosen and used in this study relates directly to the theme of cooking energy access, the focus of this study. These narrowly defined categories are only used to aid in the understanding of the conditions and circumstances that allow or hinder households to sustainable access and use cleaner cooking energy services, especially improved cookstoves and are no way a holistic representation of the diversity, heterogeneity, and social and cultural richness, and resilience of the people of Kibera. (author's note)

	with a curtain.	
Use of household space	All household activities take place within the single space, including: cooking, hygiene activity, bathing, washing clothes, and cleaning kitchen items, leisure time, children's homework, sleeping, and economic activity. Some households organized or sometimes ran their business from the living area.	There are two distinct rooms divided by a strong wall. One is the living and cooking space; the other is the bedroom and storage area, often used by the adults (mainly parents). Children sleep in the living and cooking area. Some households organized or sometimes ran their business from the living area.
Electricity access and use	Illegally connected to electricity, commonly known in Kibera as ‘electricity of the slums’ (*Stima za mtaani*).	Households had either a legal connection or a combination of legal and illegal connections.
Prized household possession	A radio, small television, cell phone(s), and basic metal/wood sofa that doubles as a bed	Flat-screen television, cell phone(s), microwave, refrigerator, stereo, and modern sofa that doubles as a bed
Household size (members living in the household)	An average of 6–8 people (two adults: male and female). In single-mother households (4–5members with the women being the only adult). Single two-man households	An average of 4–5 people including adults. (Nubians live in extended family homesteads that total to 10 to 20 people, each comprising various small, nuclear households).
Income-generating	Most adults were dependent on small self-employed businesses	Either one or both adults were in formal or informal employment with a regular and

activities / employment status	for women (cooking on the streets, dress making, hair dressing, housekeeping, vegetable sales etc. Men depend on day-labor jobs in the market place or on construction sites	reliable income (This also includes income-generating activities operated in stable/ permeant structures such as retail shops, electronic shops, transportation business, etc.
Environmental and physical living conditions	Households in this category located in low economic status villages such as Gatwekera, Laini Saba, Kisumu Ndogo Soweto East lack access to physical infrastructure such as paved roads, etc.	Located in more developed/developing locations with clear improvement in physical infrastructure such as roads. With better business and residential housing, and transportation opportunities (e.g., Lindi, Makina, Olyphic,and Karanja)
Present Cooking fuels and technologies	Kerosene stove and basic improved biomass stoves using mainly charcoal and pungunza[36] as their primary cooking fuels. In some households, the Safi bioethanol stove was present, but unused due to lack of fuel	Most had more than three cooking technologies, namely, 6 kg LPG *Meko*[37], kerosene stove, and basic improved biomass stoves or a Safi bioethanol gel stove. In two cases intermediate improved ICS were also present. Some Nubian households had additional 2- or 3-stone fireplaces within their compounds.

6.2.Structure of everyday life

With a few exceptions, access to and use of cooking energy services can be said to be highly influenced by the structure of everyday life of members of the households. Based on my observations and reports by households representatives, certain cooking technologies such as

[36] Pungunza is a Swahili word which means to reduce in English. In the context of cooking fuels it is a kind of cooking fuel locally made in Kibera by mixing charcoal dust and soil with water. It enables households to reduce the cost of charcoal by using it as the only fuel or mixing it with high quality, but high cost charcoal.

[37] The Meko is the term used in Kenya to refer to a portable liquefied gas cylinder which is accompanied by a burner and a removable cooking pot/pan support.

kerosene stoves, bioethanol stoves, and LPG were used in the morning when simple meals such tea and porridge were prepared in the rush to send children to school, and for the adults to engage in their daily social and economic activities. On the other hand, biomass stoves of all kinds (basic stoves, ICSs, and open fires) were mostly used during the evening and weekends when there was more time available. Therefore, to understand the factors that enable or hinder households from accessing and using technologies such as ICSs in a context like Kibera, it was important to understand the structure of everyday life.

The structure of life can differ substantially from one day to another in Kibera. This can be largely attributed to the informality of everyday social and economic activities and life in general. The structure and outcome of the day for most people was not predetermined, which differs from those engaged in formal structures of life. The only activities that come close to formality were the school schedules, which provide families who sent children to school with a point of departure to structure their day-to-day activities. However, despite these uncertainties, a clear pattern of how an average day was structured emerged from the accounts of household respondents. Normally, the day began between 5 and 6 am for most households. Children left for school at 7 am, where most remained until 4 pm. Adults, mainly men, left for their day jobs or in search for work. Women normally engaged in multiple activities: cooking, homekeeping, caregiving (for children, the elderly, and the sick) as well as in small-scale goods and service income-generating activities within the domestic sphere in Kibera or in neighboring upscale residential areas. Women in demanding informal or formal economic activities hired a residential or daily housemaid[38] (often a female) who took up caregiving and homekeeping activities. However, among most women interviewed for this study, their lives revolve around Kibera.

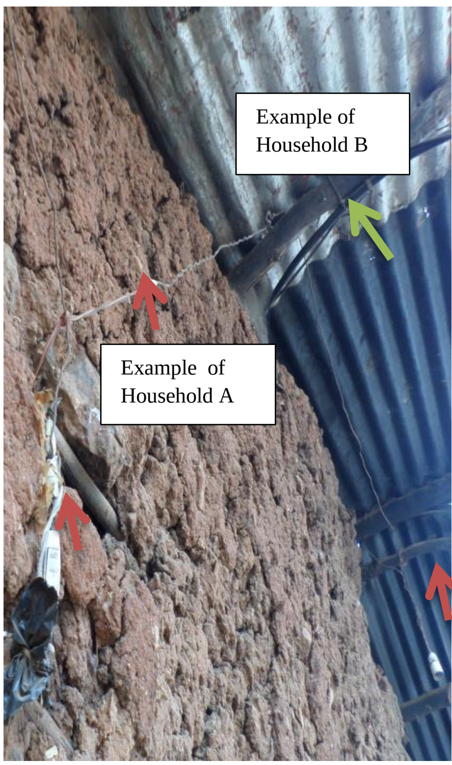
6.3. General household energy use in Kibera

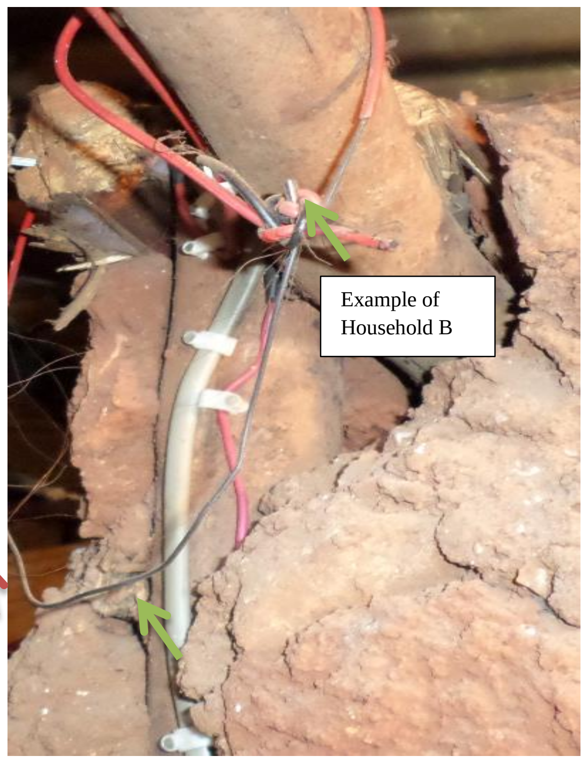
The four main household energy uses in Kibera included cooking; lighting; powering of basic household electric appliances (refrigerators and microwaves for households in category B), and

[38] It is common for Kenyan households to employ a residential or daily housemaid, especially among wealthy and middle-class households in both rural and urban areas. However, this practice is rare in Kibera, and was only observed in households where the woman with young children was engaged in formal employment or time-demanding economic activities outside of the household sphere. Although not a focus of this thesis, these types of household dynamics are highly relevant to the topic of access to clean, safe, and efficient technologies, and touch on, for example how such dynamics influence the choices of cooking energy services; who uses what kind of energy service; and who is impacted, positively or negatively, by household cooking energy choices within the household (author's note).

information communication technologies (ICT) such as mobile phones, television and radio for households in both categories (A and B); and small-scale productive uses, which take place in both categories (A and B). Households relied predominantly on charcoal and kerosene for cooking energy. Other sources of cooking energy included pungunza, LPG, firewood, and bioethanol gel. However, while Kibera is one of the few informal settlements with electricity infrastructure in Kenya, none of household representatives observed or interviewed for this study reported cooking a meal using electricity. However, water heaters were commonly used for boiling water, especially in category-B households. Some of the reasons given both by household representatives and opinion leaders for low electricity use included: the high cost of appliances such as electric cookers, unreliable power supply, power outages due to overload, poor safety standards due to lack of proper wiring, and restrictions from landlords due to the frequency of fires.

Note: All the pictures below were taken by the author in Kibera during the field study.





The two pictures above show electrical connections within two households in Kibera. The green arrows show the legal electric connection, while the red arrows show the illegal connections. Most households in category B had both legal and illegal connection and often illegally sold electricity to their neighbors. Others were illegally connected by cartels that provided electricity tapped directly from the main transformer, as shown directly above. Most houses in group A were fitted with one bulb for lighting and a socket to connect to a television and charge a mobile phone, while households in group B used extension cables, and in some cases power guards, to protect electronic appliances such as refrigerators and television sets from damage during power interruptions. When available, electricity was also used within the household and in the broader community for economic and productive activities such as hair dressing, woodwork, lighting retail shops, welding, food processing, and refrigeration of soft drinks (water, milk, alcoholic drinks). Candles, kerosene, and solar lamps were common among all households, and acted as backups during power blackouts.

6.4.Cooking practices and eating cultures

Based on observations, apart from fruits and some vegetables, almost all other food items eaten in Kibera and in most households in Africa are cooked. However, cooking practices and eating cultures vary between households, as do the kinds of cooking energy services engaged. For example, respondents with children in Kibera reported cooking more than those without children, with more cooking for all households reported on weekends, school holidays, and days off work. Respondents with children reported preparing two warm meals per day: breakfast and supper/dinner, with the exception of weekends and school holidays, where many reported cooking three times, including lunch. Children had lunch at school during school days, while the adults depended on street food, leftovers, or went without lunch altogether due to lack of money and/or time.

However, while cooking patterns and eating cultures described above were typical of households with children in both category-A and -B households, respondents in all-male households in both categories A and B, and some other types of respondents in category A, reported different cooking patterns and eating cultures. For example, male-only households met their food needs mostly by purchasing all their meals on the street or from food kiosks. Those who reported cooking did so only during days off work. Additionally, to save on money used on fuels and food items, it was common practice for households to purchase either a part of their meal on the street and to prepare the other part at home, or to purchase ready-made food and then modify it at home by adding certain vegetables, meats, and spices. This practice was said to be convenient and to require less cooking fuel and time. Portions of ready-made food also cost less than uncooked food items that are sometimes only available in bulk. In contrast to bulk purchases, ready-made food allows respondents to buy food portions according to the money at hand, a survival tactic that people in Kibera have come to embrace due to lack of financial security. These findings are consistent with a report by the Economist[39] about life in Kibera, in which one

[39] For the full article see: Boomtown slum: A day in the economic life of Africa's biggest shanty-town. Dec 22nd 2012. Available at: https://www.economist.com/news/christmas/21568592-day-economic-life-africas-biggest-shanty-town-boomtown-slum

male responded noted: "In Kibera everyone eats out…home-cooking is a luxury. The poor have no capital and cannot buy food in bulk. A single portion of charcoal to cook a meal costs at least 20 shillings" [23 Euro cents]. Despite such trends, cooking within the household remained a highly valued social–cultural activity in Kibera, but these evolving cooking and eating patterns represent a shift in lifestyle, cooking practices, and eating cultures, influenced partly by lack of access to affordable cooking energy services and food items. These trends also represent a contextual survival tactic unique to households in urban low socioeconomic living environments, where people are forced to create new means of meeting their basic needs, such as food, despite limited abilities and opportunities, and where fellow residents organize to meet such needs in the most fitting and realistic ways possible.

6.5.Household members involved in cooking activities

The household respondents interviewed were the primary cooks within their respective households. While this could present a bias due to the over-representation of women in the interview sample (as noted earlier) women tend to be involved in cooking and household activities more than other household members. However, other household members were also observed and reported to be engaged in cooking activities within the household, including men. For example, children, especially teenage girls, were observed supporting their mothers during cooking preparations and the cooking activity itself. In most cases, it was their task to buy charcoal and prepare the stove for cooking. Children were also observed and reported to be more involve in cooking and housework generally in single-mother households than in households where two parents were present. Single mothers, unlike mothers with partners, stayed away to earn the family income in most cases, in the early morning or in the evening when most of the household cooking took place[40].

Men were also reported to be involved in cooking activities in traditional households (male and female partnership) and in men-only households, but only when a liquefied petroleum gas stove (LPG) or kerosene stove was involved. These accounts and observations were confirmed in an interview with a male opinion leader who noted, "LPG is gender-neutral, while cooking with charcoal and firewood is seen by many men and boys as women's work." If there is an LPG

[40] Early morning, late evening, and nighttime are the busiest times for street business in Kenyan cities. This is done to capitalize on customers commuting to/from work in the morning and evening, and from entertainment venues later in the day. These also happen to be the times when the main meals are prepared within the household, and when those not cooking instead seek to buy street food.

stove, men cook; otherwise, cooking becomes a woman's job." This underscores the connection between gender inequality and access to affordable, reliable, sustainable, and modern cooking energy services highlighted earlier in the Literature Review chapter (see the section on social–cultural risks and burdens).

6.6.Cooking practices in wider Kibera

Commercial (small and large scale) food and drink preparation and sale are prominent business activities in Kibera. Food and drinks for commercial purposes were either cooked inside the shacks during the night and then warmed and sold on the streets during the next day, or else cooked on the streets, and at makeshifts kiosks, illegal beer breweries, and in institutions such as schools and churches all located within household living environments and residential areas. Communal cooking for social and cultural events (weddings and funerals, etc.) was also observed and reported in Kibera. Makeshift kitchens were erected in public areas or in people's compounds, particularly among Nubians, to accommodate such events. For example, the pictures below show communal cooking in preparation for a Nubian wedding and street food preparation within Kibera.


Source: author

Note: people on streets preparing and selling food in Kibera

Source: author

Note: food preparation in makeshift kitchens for a Nubian wedding celebration in Kibera

As shown in these images, women were also the main cooks observed on the streets and during communal cooking for social–cultural activities, whereas men where were the main cooks in food kiosks, illegal beer breweries, and in social institutions such as hospitals and schools. The main technologies used were 2- and 3-stone fireplaces, locally made metallic stoves, and modified basic ICS stoves, while firewood and charcoal were the main fuels used during such cooking activities.

6.7. Other uses of cooking energy

In addition to cooking, open fires and basic improved cook stoves are also used for space heating and drying household spaces and items. Nairobi and many other parts of Kenya experience spells of cold weather during May–August. Heating technologies are uncommon for purchase in Kenya, even for wealthy households. Therefore, people turn to fireplaces and charcoal fueled stoves to keep warm and dry. Additionally, while open fires are commonly used as a source of lighting in rural households due to low electricity penetration, the practice is also common in low socioeconomic urban areas like Kibera. On some occasions, especially, during power blackouts—and in the absence of other lighting alternatives such as candles, paraffin lamps, and solar lamps—fires serve multiple functions: cooking, heating, and lighting. The heat and smoke generated by biomass cooking and lighting technologies and fuels is also said to deter insects such as mosquitos, flies, cockroaches, and rodents.

6.8 Cooking energy demand and preferences

Category-A and -B households showed similar demand and preference for cooking technologies. Overall, the most preferred technology combination cited by all household representatives was a charcoal-burning stove and LPG stove. As one respondent from a category-A household noted, "I want real change, moving from one charcoal stove to the other is not change for me; I want to buy an LPG stove when I get the money." LPG was also most preferred for meeting essential, but not all, cooking needs in category-B households. Owning an LPG stove was also associated with higher class and social status. All household respondents reported being satisfied with the basic improved biomass stove and saw it as an indispensable part of their cooking technology mix. Henceforth, the negative self-reported experiences with smoke and smells were associated overwhelmingly with kerosene stoves but not with the basic charcoal burning stoves. The smoke, smell, and fire risks of the charcoal burning stove were associated with the quality of the fuel, i.e., charcoal, but not with the technology itself. On the other hand, the risks associated with the kerosene stove were attributed to both the quality of the technology and the fuel. However, as earlier outlined, households in category A had different combinations of cooking technologies and fuels than those in category B, which implies a gap between desires/preferences and reality. In a previous study these trends were also evident in South Africa, where a survey of energy-related behavior and perception in the residential sector found that low socioeconomic groups had limited choices, irrespective of their preferences or the presence of energy technologies and infrastructure (Human Sciences Research Council, 2013). Therefore, in such contexts, the question is not whether the technologies exist, but whether households are both aware of the opportunity and whether such opportunities can be accessed and used in a sustained way. The next section presents the main factors that drive current cooking energy technology ownership and use patterns in category-A and -B households in Kibera.

6.8 Desired characteristics for cooking technologies and fuels

In order to understand and appropriately address household cooking energy needs, it was necessary to understand the desired characteristics for cooking technologies and fuels by end-users[41]. The following sections summarize some of the major characteristics identified by respondents as being important for their preferred technologies and fuels. The order in which they appear does not imply ranking.

[41] The term end-user(s) is used in this thesis to refer to household(s).

6.7.1. Convenience and rapid cooking

This refers to the speed and ease with which the user can get the fire ready to begin the cooking process, and how quickly the food can be ready for consumption. Different fuels and technologies require different amounts of time for such preparations. For example, it only requires a strike of matchstick to make the LPG, Safi bioethanol, and kerosene stoves ready to begin cooking. On the other hand, it takes an average of 30–40 minutes to prepare a fire in a 2- or 3-stone fireplace or a charcoal stove. Depending on the time required to cook a meal, more time is needed to tend to the fire and to refill the fuel (charcoal, firewood, etc.). Additionally, the speed at which a stove cooks the food depends on the range and intensity of the energy output. As evident in Kibera and most other African contexts, most cooking practices involve first boiling and then simmering for an extend period of time (rice, corn, beans, lentils, porridge, *Ugali (*corn cake), etc.). Boiling requires a high power output while simmering requires low temperatures (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981). Due to fuel efficiency properties, most ICSs produce energy output in narrow ranges for an extended period of time. This is ideal for someone intending to cook slowly over an extended period, but not for people with less time or in need of rapid cooking.

6.7.2. Flexibility and compatibility with cooking practices

Compatibility and flexibility were also characteristics desired of technologies and their accompanying fuels. Compatibility is defined by Rogers (2003) in his book on *Diffusion of Innovations*, as "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 2003:15) . Flexibility is used in this thesis to mean the degree to which a technology or fuel can be adjusted to meet the cooking needs of a household at a given time.

6.7.3. Safety

Respondents were also interested in safety characteristics because of the burdens and risks associated with cooking technologies and fuels in Kibera. These issues were reported by both household respondents and opinion leaders as being experienced in Kibera in four major ways:

1) Fire: Fires were reported to be caused by poor handling of technologies, poor quality fuels and technology/infrastructure, and negligence (e.g., leaving fires and electrical appliances such as water heaters/boilers unattended).

2) Fuel ingestion: Kerosene and bioethanol gel were the two main fuels mention as the most frequently abused. Bioethanol gel was a source of substance abuse among adults and youths, while kerosene could be accidently consumed by curious children who confused it for a soft drink, or by genuinely thirsty children who mistook it for water. Small quantities of kerosene are resold in common soda or soft drink bottles. The ingestion of kerosene is known to have major health consequences that can result in death or long-term health complications(Chilcott, 2006).

3) Physical burns: Burns were mainly reported by both opinion leaders and household representatives to result from contact with the outer surface of charcoal or firewood stoves, fire sparks, hot biomass, or flame; tipping pots with hot content; and from exploding cookers (most often cited as kerosene stoves and LPG). Children were at greatest at risk because they were often responsible for preparing and tending to biomass cook stoves and also (in some cases) cooking. The playful nature of children also puts them at greater risk.

4) **Theft:** Low-value cooking technologies and fuels were more desirable in Kibera than high-value cooking technologies because of the possibility of theft. Single men or family men living alone in Kibera were particularly cautious about investing in a high monetary value cooking technologies and fuels for use in Kibera. These men spent little time at home and were afraid that having such technologies and fuels would attract attention and cause their homes to be targeted by thieves, leading to the loss of not only the technology and fuels, but also other valuable items in the house. Such investments (bioethanol gel stove, LPG or biomass ICS) were reserved for use in rural households. As noted previously: In Kibera, they relied on cheap kerosene stoves or bought ready-made food from street vendors or food kiosks.

6.9.5. Cleanliness

There was a great desire among household respondents for clean cooking appliances and utensils, as well as a space free from soot and smoke. Henceforth, the desire for cooking technologies and fuels that produced less or no soot and smoke. Kerosene stoves as well as poor-quality charcoal were associated with excessive production of soot left on cooking pots and household possessions. The desire to limit the dirt on cooking pots and other household appliances was also often linked to the lack of water. Access to water is a major challenge in Nairobi and more so in Kibera. When available, it comes at a high cost. Since most people use one space for all or most of their personal and household activities (cooking, work, leisure, hygiene, etc.), the presence of odors and black soot was reported to be a cause of embarrassment. Two opinion leaders mentioned smell and smoke on clothes as a major disadvantage of the use of biomass cook stoves in general, but more specifically the 2- and 3-stone fires and kerosene stoves. They attributed this discomfort to the lack of confidence expressed by women when asked to engage in community-level activities or civic events. **Others:** esthetic appeal and space-heating properties were also often mentioned as desired characteristics of cooking technologies and fuels. The next section summarizes the advantages and disadvantages of technologies used in Kibera households, as self-reported by both household representatives and opinion leaders.

6.8.Patterns of cooking technology and fuel ownership

Multiple cooking technologies and fuels where reported and observed in the participating households, with the exception of the two male respondents who only owned kerosene stoves. These results are consistent with other studies that reported households in the Global South relied on multiple technologies and fuels to meet day-to-day cooking needs (Akolgo et al., 2018; Bonan et al., 2017). This practice is referred to as stacking the ownership of multiple technologies and fuels (Akolgo et al., 2018; Bonan et al., 2017; Masera & Navia, 1997; Masera et al., 2000; Yonemitsu, Njenga, Iiyama, & Matsushita, 2014). In Kibera, the combination of cooking technologies and fuels differed between the two household categories. The patterns of ownership also varied within these two groups, and were influenced, for example, by the type of household, (single parent (woman) household or two adults (man and woman)), the presence of children, gender, and the age of the main cook. For example, young couples without children reported solely using LPG, with a kerosene stove retained only as a backup. In contrast, young couples with children reported using a charcoal stove in addition to LPG, and using a kerosene stove as their backup. Table 4 shows the main technology and fuel ownership patterns observed and reported by household representatives.

Table 4: The main technology and fuel ownership patterns within interviewed households

Combination of technologies	Fuels used	Type of household
Basic improved biomass cook stove (KCJ) and kerosene stove	Charcoal and kerosene	A (one- or two-adult household with

		children)
Basic improved biomass cook stove (KCJ), kerosene stoves, and Meko (6 kg LPG)	Charcoal , kerosene, and LPG	B (one- or two-adult household with children)
Basic improved biomass cook stove (KCJ) kerosene stoves, and Safi Jiko (one or two burners)	Charcoal, kerosene, and bioethanol	A (one- or two-adult household with children)
Basic improved biomass cook stove (KCJ), kerosene stove, and Meko (6 kg LPG), intermediate improved cook stoves such as the Jiko Koa	Charcoal, kerosene, and LPG	B (two-adult household with children)
Basic improved biomass cook stove (KCJ) and kerosene stove; Meko (6 kg LPG and 2- and 3-stone open fires	Firewood, charcoal, kerosene, and LPG	B (mostly of Nubian origin)
LPG stove and/or Kerosene stove	LPG and/or kerosene	B (young couples without children; single men)

Source: constructed by author

As Table 4 shows, there was no tangible transition from high-carbon technologies to low-carbon technologies reported or observed. Whenever a household had information about a technology, and had extra finances, they simply purchased the desired technology. However, the purchase of an advanced technology or any other cooking technology did not mean that other existing technologies were abandoned or discarded, unless they were in a state that could not be used or repaired. Moreover, such a purchase did not mean that the now additional technology was used on a regular basis, or at all. The next section outlines the patterns of use of available technologies and fuels by households in the interview sample.

6.9.Motivation for purchasing cooking technologies and fuels

As noted previously, households typically own two or more cooking technologies at a time. However, while there were differing ownership patterns between households in categories A and B, the determinants influencing such decisions largely remained consistent across the two household categories. The most often cited determinants are outlined below, including brief explanations:

6.12.1 Availability and reliability

The availability and reliability of technologies and fuels within a convenient distance from the household were major determinants of the kinds of technologies and fuels available and used within households. For example, the basic ICS and kerosene stoves were widely available in a variety of sizes in Kibera. Repairs and maintenance could be done by users themselves and, when necessary, repair centers were widely available within convenient walking distances. Charcoal and kerosene were also readily available, conveniently portioned, and priced. Their visibility, availability, accessibility, and affordability can perhaps explain why they are the most widely used fuels in households in Kibera despite their overall cumulative cost. More details on the cumulative costs of fuels are given later in this chapter.

6.12.2. Cost

A one-time lump sum investment is needed to purchase a technology, with the exception of constructing traditional 2- or 3-stone fires. The cost of other cooking technologies depends on the type, size, quality, location of purchase, and method of payment (e.g., cash versus instalment payments). The frequency of such purchases depends on the lifespan of a technology, which is influenced by their quality, frequency of use, and the level of care and maintenance. Most biomass improved cook stoves, including ICS, were reported to have a lifespan of 6 months to 3 years. In addition to the cost of the technology, on-demand financial investment is required for fuel, maintenance, and replacement of worn out parts. While some households, especially those in category B, reported making monthly fuel purchases, all representatives in category-A households reported making day-to-day fuel purchases based on daily income and prioritizing immediate needs. As noted earlier, some households purchased ready-made food in order to bypass the costs of fuels and raw food products when the money at hand could not meet both needs.

There was no evidence of price control or regulation in Kibera. Instead, retailers priced and sold energy products based on procurement prices, the political mood in the settlement and/or the country, availability of the products, the weather, retail prices in other parts of Kibera, and demand. None of the households interviewed or engaged in informal conversations had documented how much they spent on cooking energy per month or had spent the previous week. This lack of record-keeping could be attributed to: the nature of fuel purchases (either day-to-day or on-demand), unstable prices, and inability to plan due to lack of stable and regular incomes. What was obvious, however, is that people in Kibera were paying more for energy services and other basic needs than those living in Nairobi's formal settlements. The United Nations also found that households within socioeconomically disadvantaged communities tend to pay more for energy services than wealthier citizens, in part because of poor infrastructure and high up-front costs (UN Habitat, 2009). Poor infrastructure is common in many developing countries. Lack of transport infrastructure is especially problematic and can result in high costs of charcoal, which is transported from rural to urban areas. Charcoal vendors reported higher during the rainy seasons because: 1) charcoal is produced in traditional mud kilns, which are easily destroyed by heavy rains, and 2) most rural roads are unsurfaced, which makes the bulk movement of charcoal to main roads for transportation into urban areas virtually impossible. A general overview of fuel and technology costs in Kibera is provided on table 5 below. These costs were assessed by asking interviewees how much they had spent on their owned cooking technologies, or how much they had spent or were planning to spend on that particular day on fuel. These reports were supplemented by price observations from retail shops and street vendors as well as by accounts provided by opinion leaders directly involved in the sale of cooking technologies and fuels in Kibera. Henceforth, the figures provided here are only average prices and only represent the period from February to May 2017, when these data were collected.

- **Technology costs**

Unlike fuels such as charcoal, LPG, ethanol, and kerosene, whose prices varied by day, by time of day, or between villages, technology prices remained relatively stable at the time of the field work. For example, most ICS in the market were priced within the range 3000–4500 Kenyan shillings (Ksh) while basic ICS were priced at 200–600 Ksh on average. The Safi bioethanol stove sold at 2500–4700 Ksh on average. Most ICS and Safi stoves were sold through instalment payments[42]. This was done in the context of organizations such as self-help groups, NGOs, and church-based organizations. LPG (meko) stoves typically cost 4500–6000 Ksh for the stove, fuel cylinder, the initial gas. Table 5 summarizes the average costs and determining factors of the various stove and fuel types.

Table 5: Average stove & fuel costs and determining factors

Technology	Cost range (KSh)**)**	Determining factors
Basic ICS (KCJ)	300–600	Stove size; purchase location
Intermediate ICS (Jiko Koa; EcoZoom)	3000–4500	Brand name; size; purchase location; mode of payment (cash or instalment payment)
Safi stove	2500–4700	Number of burners (1 or 2); mode of payment; purchase location
Kerosene stove	500–1500	Stove size and quality; purchase location
Empty LPG cylinder (6 kg)	3500–4000	Brand name; mode of payment; purchase location

Source: author

Fuel costs

Respondents were asked to estimate how much money (daily average) their household spent on cooking energy. Those predominately using kerosene reported paying 30 KSh per day to prepare breakfast and cook other light meals. Households with the Safi stove reported using 1 liter of bioethanol gel per 3 days to prepare breakfast and cook other light meals, at an average cost of KSh 100. Households with LPG gas reported that a 6 kg cylinder of gas lasted 6 weeks at an average cost of 900 KSh. Both charcoal and kerosene fuels could be accessed in Kibera at any time even without immediate cash, out of trust that the payment would be made at a later time. This trust was based on kinship and social connections, because the sellers of these fuels were

[42] Instalment payment method: Payment towards the purchase of a technology in small amounts until the purchase price is reached. In Kibera, the buyer receives the item the agreed upon installments had been completed.

often immediate neighbors or relatives. Their availability in small qualities, as shown below, also made these fuels more accessible.

Source: author

Note: Small-scale sales of charcoal (left) and kerosene (right) in Kibera

All households with basic ICSs reported spending KSh 70 on average for charcoal per day. The two interviewees using ICS reported consuming less charcoal in their ICS than with their previous stove (i.e., basic ICS) but none had attempted to record how much less charcoal was needed. Therefore, due to limited data, these data do not reflect fuel savings from using an ICS. However, the advertisement poster shown below, which was obtained in a supermarket outside Kibera, shows a 50% fuel savings from shifting from the KCJ to the ICS models shown. Additionally, firewood was used only in some Nubian households but no figures were provided by the household representatives interviewed. Therefore, the cost is also omitted from table 6 below, which shows monthly average household fuels costs.

Source: author

Note: an advertisement poster on Jiko Koa)

Table 6: Average monthly cost of selected fuels

Fuel	Average monthly (30 days) in Ksh
Charcoal	2100
Kerosene	900
Bioethanol	1000
LPG gas	600

Source: author

6.12.3. Education and exposure

Respondents with a higher level of education (post primary) or those who had a partner or child with a higher level of education or exposure were more likely to have cleaner and more efficient cooking technologies and fuels (LPG or bioethanol gel stove and ICSs) in addition to other biomass stoves and fuels. In comparison, those with only primary-level education predominantly relied on kerosene stoves, together with solid fuels and associated technologies. Studies conducted elsewhere (Ethiopia and Guatemala) have also reported a strong relationship between education level and the prominence of cleaner, safer, and more efficient cooking technologies such as LPG in household technology mix (Heltberg, 2005; Mekonnen & Köhlin, 2008). This can perhaps be as result of exposure to the use and benefits of cleaner technologies and fuels in different contexts, as well as information about availability, and of access opportunities and abilities. These kinds of exposure and information are unlikely to be available to people experiencing one kind of living environment and pattern of cooking energy consumption. It also follows that people with higher levels of education are more likely to find more stable and financially rewarding employment opportunities. The value of regular and reliable income as one determinant of technology and fuel choices and use is outlined in the following section.

6.12.4. Household size and age structure

There was a higher likelihood for younger people, including young couples with small families (1–2 children), to own and frequently use LPG than their older counterparts. This was evident in a meeting with 15 members of a young socioeconomic group aged 20–30, who reported using LPG gas for most of their cooking. This was in sharp contrast to cooking practices described during a meeting with older women in a social–economic group, most of whom reported owning a bioethanol gel fueled stove but using the basic ICS as their primary cooking technology. Members of both groups reported acquiring their technologies through arrangements with their respective groups. This leads to the final determinant of peer influence / group pressure.

6.12.5. Peer influence and social connections

Peer-to-peer influence and/or membership to social and economic networks were a major factor influencing the ownership of cooking technologies. Household members self-organized into self-help groups (Chamas) to support and enhance each other's wellbeing. Such groups were organized around economic and social welfare support themes. Membership was based on gender, age, ethnicity, social needs, economic activity, geographical proximity, social and economic standing, and religious affiliation. Some groups were homogenous (men, women, youths; or specific economic activity, around ethnicity or rural origins, etc.). Others were heterogeneous (men and women; involving many ethnic communities; or people of varying socioeconomic status or age, etc.). The main group activities involved weekly/monthly contributions of an agreed amount to a common pool. This money was subsequently loaned to group members or outsiders for a profit, or redistributed to members as a lamp sum for personal or business development projects. Involvement in business ventures included the sale of cooking technologies and fuels, housing construction, rental services, and management of lavatory services. Moreover, members were also involved in peer-to-peer support and mentorship, and the communication of available social-economic opportunities and risks within and outside the community.

On the other hand, social support groups involved weekly/ monthly contributions of an agreed amount to a common pool, or impromptu contribution to a member in case of emergency, as specified in the group's constitution, such as medical bills or the death of a loved one. Other welfare groups were organized around a specific social issue, for example funeral expenses, hospital bills, weddings, etc. Membership of such groups not only provided individuals with a pool of necessary abilities and opportunities, but also acted as a guarantee whenever one needed to borrow money to enhance social or economic wellbeing, within the group or beyond. Groups had close-knit memberships and well-outlined rules of action, specifically including stiff penalties that were said to minimize the risk of loan non-repayment. Moreover, unlike traditional loan banking services where large capital was required as collateral, one's membership served as the security. These activities and support systems were particularly important for members because Kibera lacks formal banking systems and lending mechanisms due to the perceived risks of doing business in the settlement.

In adaption, social–economic groups were also observed to have been particularly important in the awareness- and knowledge-creation processes, because of the peer-to-peer learning environments they provided. Individuals in self-organized networks had the opportunity to share and exchange information about available cooking energy services, their advantages and disadvantages, and other related opportunities from trusted peers. The ownership of certain energy services by group members also served as motivating factors and a source of observation for others, a function that is thought to be important in the diffusion of technologies (Rogers, 2003) .

6.10. Factors influencing the use of available cooking technologies

While most studies on access to ICSs focus on the initial adoption of a technology, it was important in this thesis to distinguish between the ownership and use of a technology, because technologies such as ICSs only derive functional value from use, and not by their mere presence in the household. The focus of this thesis is functional value (rather than synthetic value such as status) together with the main factors driving the campaign for cleaner and sustainable cooking energy services (see the section on justification of ICSs in the Literature Review chapter). This section highlights the factors that influenced the use of available technologies among the interviewees.

6.10.1. Cost of fuel

While households with an educated member and/or a member exposed to broader society (either physically or through mass media and the Internet) were more likely to possess cleaner and more efficient cooking technologies, the frequency of use, especially of LPG or bioethanol gel stoves, was determined by the nature of income generated within the household itself. Household respondents who had (or whose partner had) a regular and reliable income were more likely to use LPG or bioethanol gel stoves on a regular basis than those who depended on irregular and unreliable incomes. This shows that while possession of a technology (adoption) is the primary precondition for its use, access to accompanying fuels is an important determinant for whether or not a cooking technology is used. This example also shows that while gifts, donations, or subsidies are well intended and might facilitate adoption, subsidies and donations in the absence of appropriate enabling conditions might hinder initial use, subsequent use, or derail the sustained access assess and use of a technology.

6.10.2. Number of people for whom the food is intended

The number of people to be fed determines the size of the pot used and the number of food courses to be prepared. While open fires can be adjusted to fit any pot and multiple pots at a time, portable improved cook stoves cannot be manually modified to serve this purpose. This consideration was mostly raised by representatives of the Nubian ethnic group, who lived in extended family compounds and cooked in communal kitchens for an average of 10 to 20 people depending on the family size. Other households preferred the basic improved cook stoves to ICSs because they are available in various sizes to fit the family's needs, whereas most available ICSs only come in small sizes that fit a small pot. Communal cooking and eating during social and cultural events is also common, and involves more people than the typical household size. In this case, households cook various meals within the household, or provide their cooking technologies and utensils communally.

6.10.3. Food type

The type of food available and the desired end product also determined the technology and fuel chosen at a particular time. Most typical foods eaten in Africa require boiling and later simmering for a short time such as 15–30 minutes (e.g., rice) or for as long as 3–5 hours (e.g., beans and corn). Boling demands high energy output, whereas simmering needs lower energy outputs. Hence, stove energy output is a major consideration by households when choosing how to prepare various foods. Charcoal and firewood are especially favored for this kind of cooking, because they initially produce very high energy output that subsequently subsides as the charcoal and firewood turn to ash. Biomass-fueled technologies are also often used for roasting vegetables and roots.

6.10.4. Time of day and day of the week

Time and the day of the week were serious considerations for households when determining the choice of cooking technologies and fuels. Unlike technologies that use non-solid fuels (such as gas and electricity), solid-fueled technologies such 2- or 3-stone fireplaces, basic ICSs, and ICS require longer preparation time. Household representatives reported choosing less time consuming cooking technologies such as kerosene, bioethanol Safi, and LPG stoves to prepare breakfast and light meals, whereas time-intensive) technologies and fuels were used to prepare evening meals and all weekend meals (including breakfast) because there was more time available. Household representatives reported that it takes an average of 30–40 minutes for a charcoal stove to be ready for cooking. The process is often influenced by the quality of the charcoal, draft/wind direction, the size of stove openings, the condition of the stove, the material used to light the charcoal, and by personal experience.

6.10.5. Gender of the cook

Cooking remains predominantly a task for females in most African households. Men are known to cook either in the absence of a female or in the presence of cleaner and less labor- and time-intensive cooking technologies and fuels. All household respondents who participated in the formal, semi-structured interviews were the primary cooks in their respective households. Eighteen were females, and two were men living alone. The two single-male respondents reported using a kerosene stove during the few occasions that they cooked. Other households used a combination of solid-fuel and non-solid cooking technologies (a combination of LPG and kerosene stove; or Safi bioethanol gel stove and kerosene). This dominance of women as the primary household cooks supports the arguments that energy access is also a gender issue because, for example, women would benefit the most from time saved by the use of less time-and labor-intensive fuels and technologies (Köhlin, Sills, Pattanayak, & Wilfong, 2011; Oparaocha & Dutta, 2011).

6.10.6. Cultural considerations

The taste and appearance of the final food product was also an important determinant of cooking technologies and fuels chosen. Some cultures have specific ways of preparing and cooking certain foods. One example, given by a respondent from the Luyha ethnic community, is the cultural consideration needed to prepare and cook a chicken. Chicken is one of the most valued food items in the Luhya community, and hence, there are strict cultural prescriptions on how best to prepare and cook it. According to the respondent, the chicken preparation process alone requires the use of dry heat from an open fire or a charcoal-burning stove. This is needed to get rid of the small hairs remaining on the chicken skin after the major feathers are plucked off. Then, depending on the desired final product (backed, roasted, stewed, or boiled) and the available technologies and fuels, a cooking technology and fuel is chosen. Other cultural considerations that determine the choice of cooking technologies and fuels include: the people the food is intended for and the occasion. For example, food served to one's future husband or parents-in-law is prepared with utmost consideration of cultural needs and prescriptions (as observed during a visit to a cooking/catering event for a Nubian wedding), whereas food intended for one's friends or immediate family members is prepared with fewer cultural considerations or prescriptions.

Table 7: Summary of identified advantages and disadvantages of technologies owned and used in Kibera households

Stove, physical characteristics, and fuel(s)	Advantages	Disadvantages

Basic and traditional biomass cook stoves	-Affordable and easily available -Easy to light and use -Provides space heating during cold seasons -Locally produced and repaired Large fuel-surface area, allowing greater airflow and hotter combustion, and therefore faster cookingPage: 127	-Not fitted with a hood or chimney -Non-insulated, leading to loss of energy -Not fuel-efficient (more heat escapes from the pot or pan) -Emitted heat is unbearable during the hot season -Black soot deposited on pots, pans, and household items -Relies on charcoal that is not available sustainably in Kibera
Paraffin/ kerosene stove	-Affordable -Easily available -Easy to light and use -Locally produced and repaired -Fuel is affordable and readily available throughout Kibera in different proportions and small quantities	-Not fitted with a hood or chimney -The burning cloth and fuel produces black soot and strong smell during cooking (permeates the food or drink) -Does not provide room heating during cold seasons -Black soot deposited on pots, pans, and household items -Responsible for frequent explosions and fires due to poor quality of fuel and stoves -Relies on fossil fuels
Two and three stone arrangements	-Costs nothing -Easily available in Kibera -Easy to light and use (quickly reaches operating temperature) -Provides lighting and space	-Not fitted with a hood or chimney -Non-insulated, leading to loss of energy -Not fuel-efficient (more heat escapes from the pot or pan) -Emitted heat is unbearable during the hot

	heating during cold seasons -Convenient to use -Large fuel-surface area, allowing greater airflow and faster combustion	season -Black soot deposited on pots, pans, and household items
LPG gas 6 kg (Meko)	-Available in Kibera -Easy to light and use -Can be turned on and off as needed -Produces minimal soot and smoke during cooking -Does not deposit soot on cooking utensils or house interior -Convenient to use	-Very high initial cost -Accompanying fuel is expensive -Does not provide room heating during cold seasons -During cooking, stove can turn off without warning if the gas canister is depleted -Risky to use in Kibera due to frequent fires and risk of gas explosions
Safi stove (bioethanol)	-Easy to light and use -Produces minimal smell, smoke, and soot -The upper hardware is strong and durable -Can be turned on and off as needed	-Unaffordable for many residents -Accompanying fuel is expensive and not readily available -Does not provide room heating during cold seasons -Fuel canisters wear out fast and need to be replaced every 2–6 months depending on frequency of use -Not easily repaired in Kibera

Intermediate and advanced biomass Improved cook stove (ICS)	-Saves fuel compared to other biomass burning technologies and basic ICS -Insulated outer surface protects users against burns -Produces less heat in the house -Lasts longer than the basic ICS -Available in attractive designs and colors	-Not fitted with a hood or chimney -Does not provide space heating during cold seasons -Black soot deposited on pots, pans, and household items -Takes much longer to light due to its small opening that allows little space for the draft -Unaffordable -Not readily available in Kibera -Not easily repaired in Kibera

Source: constructed by author

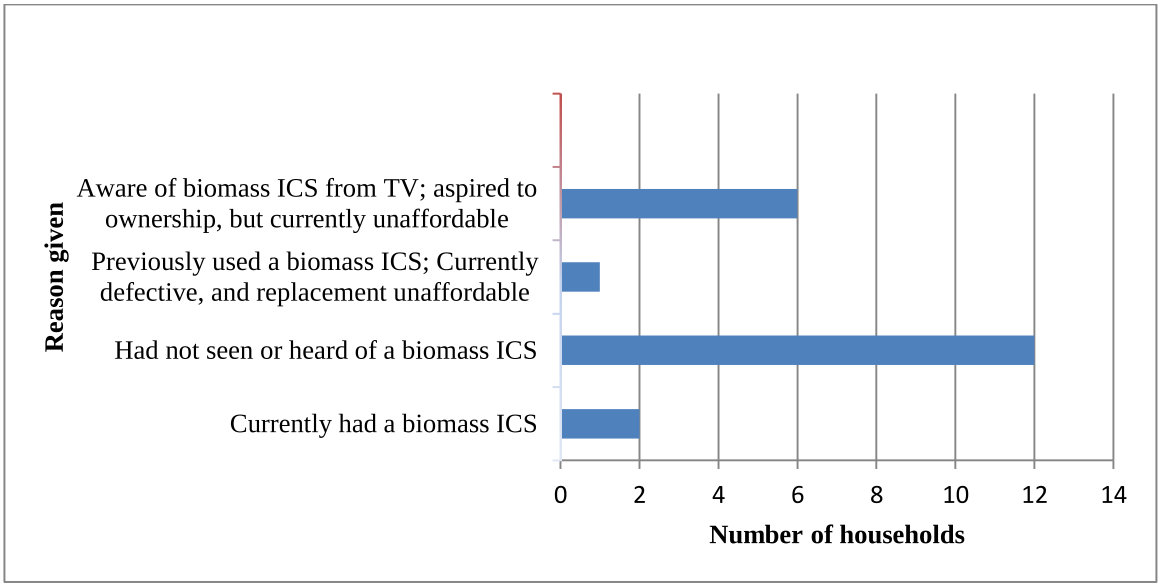
6.11. State of the art concerning adoption of biomass ICS

The adoption of ICS was low within the household interview sample. Out of the twenty household respondents, only two owned and reported using an ICS on a regular basis (at least once per day). It is also important to note that the two households with an ICS also owned a basic improved cook stove[43] or the Kenya Ceramic Jiko. Both respondents reported using the basic improved cook stove when cooking for large groups, when an additional stove was needed to prepare family meals, and during cold seasons for heating the home. Poor affordability, and lack of awareness of alternative technologies, and fuels to meet cooking needs were some of the most commonly cited factors constraining a shift from overreliance on inefficient and unsafe technologies and polluting fossil fuels and biomass fuels (the basic biomass ICS cook stove, 2- and 3-stone fires, and kerosene stove) to ICSs and other cleaner cooking energy services such as electricity and LPG. These accounts by household respondents were supported by accounts by opinion leaders and social group members, most of whom reported not being aware of the presence of biomass ICSs but instead having seen or owned either an LPG or bioethanol stove.

[43] Basic improved cookstoves refer to the Kenya Ceramic Jiko, which is more advanced and energy-efficient than metallic and open fires but more basic than improved cookstoves.

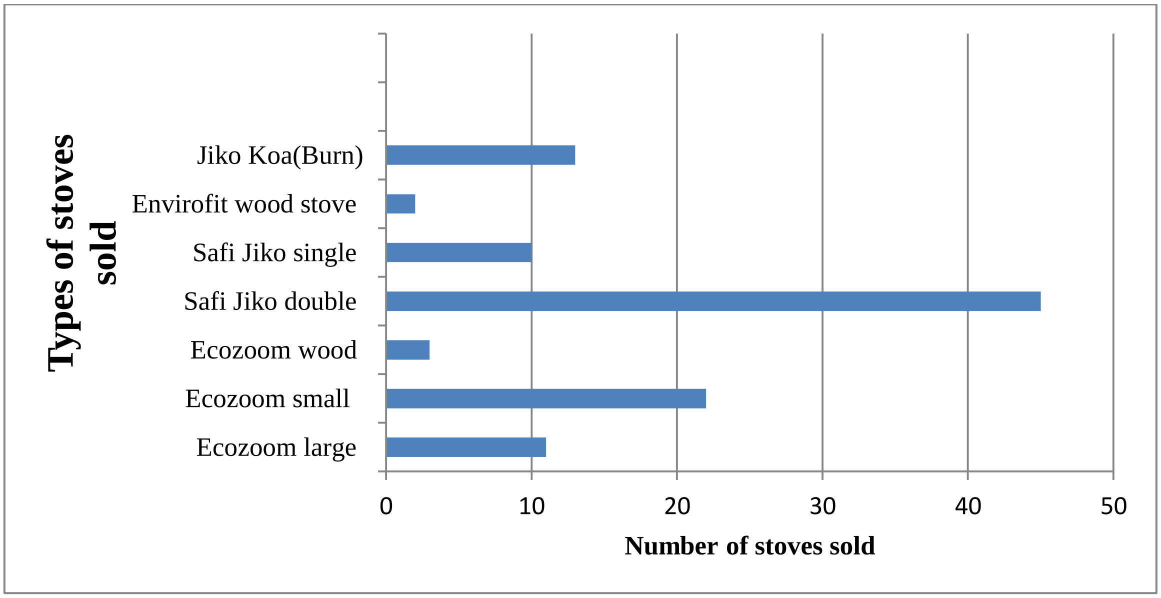
The remainder had either not heard of the ICS, or else had heard about it but lacked the financial means to purchase or replace a broken ICS, as shown on Table 11 below. For example, one respondent had owned and used an ICS prior to the interview, but was struggling to replace it after it had broken. The respondent attributed the delayed replacement to the high up-front cost of a new ICS. At the time of the interview, the respondent was using a basic biomass ICS

Figure 11: Adoption and use of biomass ICS among household representatives



Source: author

Figure 12: Wider adoption of ICSs throughout Kibera



Source: author based on sales data for the period 1 July 2014 to 20 March 2015 (provided by KTC)[44]

Table 12 shows sales records for ICSs and bioethanol in Kibera for the period 1 July 2014 to 20 March 2017. The KTC kiosk were this data was obtained also sells hygiene products and solar-powered lighting products, but did not stock or sell LPG gas stoves at the time these data were provided. These data are relevant because they help provide a broader overview of the adoption of biomass ICSs in Kibera, given the limitations of the interview sample. However while this information sheds light on the adoption of ICSs and other clean cooking-energy services such bioethanol stoves, it is limited in that it does not track the usage or continued presence of such stoves within Kibera households. However, the data show that more men than women (3:2 ratio of men to women) bought ICSs and other cleaner cooking energy services. The majority of the stoves (80%) where paid on instalment over an average period of 3–6 months. The remaining 20% were cash payments, mostly to male customers. The high ratio of men to women was unexpected, but the sales manager confirmed that the majority of stoves dispatched from the shop were indeed sold to men. She further explained that most stoves bought in Kibera were not used within Kibera but were instead transported for use in other villages. Men working in Kibera, away from their partners and family, bought the stove for use in their village home, whereas while working in Kibera they continued to rely on a kerosene stove for their occasional cooking.

6.12. Awareness of the advantages associated with biomass ICS and other affordable, reliable, sustainable and modern cooking technologies and fuels

Household representatives in the interview sample displayed low awareness of the potential risks and burdens associated with the use of high-carbon technologies and fuels (basic ICS, kerosene

[44] The KTC is the only station throughout Kibera that sells a variety of biomass ICSs. It is also the most visible and most frequented place in Kibera because it provides residents with a variety of other social and economic services such as free clean and safe drinking water; social and economic development services such as group training, social meeting room, sit-in and takeaway food and drink services, savings credit unions, and sanitation services, among others. The center also provides installment payment options for all its improved and clean cooking technologies as well as solar-powered technologies at no additional cost to the customer. Consequently, people who take up to 6 months to make advance payments for a cooker or fuel pay the same amount as those who are able to make a single, up-front payment for the same item. This is a unique characteristic of the KTC because improved biomass cooking technologies sold either though loans or on credit—models adopted by banks, credit unions, and social–economic groups—charge high fees for their services. For example, Equity Bank Limited offers members and employees a service to purchase a Jiko Koa, one of the most common ICSs in Kenya. The cost of a small Jiko Koa is KSh 3000 (30 Euro) in retail stores and at the KTC. Bank members can obtain the stove from selected Equity Banks at an overall cost of KSh 6500 (65 Euros) paid over a period of not more than one year. The bank employee who provided this information noted that bank employees can obtain the stove for only KSh 2800(28 Euros). This is less than the market price and less than half the total the price paid by a bank member obtaining the product though a loan and making payments on an instalment basis.

stove, 2-and 3-stone fires) and the potential opportunities presented by low-carbon technologies and fuels (e.g., ICS, LPG, bioethanol, biogas, electricity-powered technologies). Of the four risks and burdens (health, environmental, social, and economic) outlined in the Introduction and Literature review chapters, health-related concerns were identified most often and attributed to the decision to use and/or aspire to low-carbon cooking technologies and fuels by households in both categories A and B. The most commonly cited health burdens and risks included: eye irritation, burns from charcoal sparks and fires, suffocation (especially for young children), unpleasant odors from burning kerosene, coughing and choking from black carbon and soot. Household representatives were also aware of economic burdens resulting from the high cost of technologies and fuels, while social burdens were associated with the time needed to prepare biomass cooking technologies for cooking activity. However, none of the household respondents deduced connections or made explicit statements regarding relationships between households' choices of cooking technologies and fuels, and the state of the external environment.

Unlike the household respondents, opinion leaders expressed strong awareness of the social, economic, health, and environmental risks and burdens, with the latter two (health and environmental) being associated the most with the use of unsafe and inefficient cooking technologies and fuels. However, it is important to note that there were also differing levels of awareness among opinion leaders. Those opinion leaders who lived outside of Kibera, or who had a higher level of education (university diploma and above) expressed greater awareness of the risks and burdens, as well as the opportunities associated with the use of low-carbon technologies and fuels, compared to the less educated individuals (high school diploma or less) and those spending most of their time in Kibera. This lack of awareness on the part of household respondents and some opinion leaders could be attributed to the lack of knowledge and information about such risks and burdens, as well as the marginal availability and use of ICSs and other advanced technologies and fuels in their immediate contexts. This opportunity for exposure is referred to by Rogers (2003) as ‘observability,’ defined as “the degree to which the results of an innovation were visible to others” (p. 16). Unlike other parts of Nairobi, where one can find ICS and other affordable, reliable, sustainable, and modern cooking technologies and fuels in supermarkets and displayed in retail shops, the few stations that sold ICSs in Kibera kept them hidden and locked up, mostly for security reasons. As a result, people do not naturally see them, become aware of their availability, or inquire about their cost, use, and benefits.

There were fundamentally differing perceptions among opinion leaders living outside Kibera and opinion leaders living within Kibera and the household representatives, about the risks and burdens associated with the use of inefficient and polluting technologies. Nevertheless, all interviewees valued the role of biomass cookstoves, especially in enabling the preservation and maintenance of social–cultural values. However, while household representative were keen on the affordability and short-term benefits of their preferred and owned cooking services (such as convenience, and eliminating the discomforts of kerosene- or charcoal-fueled stoves), the opinion leaders expressed more comprehensive understanding of the interconnectedness between cooking energy production and consumer practices in relation to human health and general wellbeing and the environment. Generally, both categories of households and opinion leaders the external actors saw the solutions as lying in better communication and greater awareness, more economic and employment opportunities for end-users, and better availability of reliable, affordable, and sociocultural compatible technologies, as well as fair and just mechanisms for financial payments.

6.13. Household representative and opinion leader attitudes to challenges and the path forward

There was agreement between household representatives and opinion leaders on the need to access ICSs and other affordable, reliable, sustainable, and modern cooking technologies and fuels, and also on the barriers facing households in informal settlements like Kibera. Thus, both opinion leaders and household representatives expressed the need for enabling conditions to allow households to access other cleaner and more efficient cooking technologies. As one opinion leader noted: “Kibera is not a disadvantaged community, but a place that lacks and needs opportunities.” This is in line with what household representatives cited as barriers to access to their preferred cooking technologies and fuels, namely: lack of employment opportunities, unavailability of technologies at fair prices, lack of credit opportunities and instalments payments, poor-quality fuels resulting in fire risks, and poor value for money spent on technologies and fuels.

However, while both groups agreed that change was essential, there was no clear agreement on what that change meant, what it might look like, or the approach that such change should take. For example, most household representatives expressed satisfaction with the basic ICS, that is, a KCJ because it met most of their cooking needs. Therefore, it was not in their immediate interest to invest in an ICS because it was not perceived as real change. Instead, the focus was on LPG gas to replace kerosene stoves, which was the most disliked cooking technology in Kibera. On the other hand, opinion leaders were unsatisfied with the health, environmental, social, and economic performance of the basic ICS, the kerosene stove, and also the current ICS models on the market. Opinion leaders also critiqued current energy policies and implementation strategies as being out of touch with the real challenges facing people in urban areas, especially in informal settlements. Some of the reasons given included: lack of understating of the needs and preferences of end-users, lack of end-user involvement in understanding and addressing their energy access challenges, unstainable nature of the fuel sources and use, the sub-standard nature of the technologies on the market, overemphasis on rural areas, as well as poor governance and a lack of the institutional capacity necessary to regulate and manage the production, distribution, sale and user conditions of biomass and fossil-fuel technologies and fuels. On the other hand, household representatives blamed the government for their socioeconomic conditions and lack of opportunities in Kibera. Overall, information and awareness-creation; availability of appropriate technologies and fuels; local community involvement in decision and implementation processes; the need for local industries to produce high-quality technologies and fuels at fair prices; regulatory mechanisms (strong governance and institutions); and social–economic opportunities such as education, training, skill development, and employment opportunities were cited by household respondents and opinion leaders as the factors most essential for initiating and facilitating access to sustainable cooking energy services in Kibera.

6.14. Summary of results

State of the art: Sustainable access and use of ICSs was extremely low in Kibera. Moreover, the envisioned transition from dirty, unsafe, and inefficient cooking technologies to ICS and other affordable, reliable, sustainable, and modern cooking technologies and fuels, as underscored in SDG 7, was not reported or observed in Kibera. Instead, stacking was the norm (i.e., the ownership of multiple technologies and fuels at one time), with most households owning a mix of two or more high-carbon and low-carbon cooking technologies and fuels at a time.

Ownership of technologies and fuels: The most common household cooking appliances included: basic kerosene stoves, improved ICSs and intermediate biomass ICSs, LPG stoves, 2- and 3-stone fires, and the Safi stove, with their accompanying fuels: kerosene, charcoal, LPG, pungunza, firewood, and bioethanol gel.

Use patterns: The decision to use a technology and its accompanying fuel was mainly influenced by the availability of a stable and reliable income, time available, fuel availability and affordability, the number of people being cooked for, the time of day and day of the week, the type of food and desired outcomes, as well as the gender of the cook.

Needs and energy service preferences: There were no differences needs and preferences for technologies and fuels to facilitate the achievement of such needs between household categories A and B. However, the technologies and fuels that a household ultimately owned and used (i.e., the outcomes) were influenced by the opportunities and abilities available to each household, and hence the differing ownership and use patterns observed between households in categories A and B.

Costs: Households spend a significant proportion of their income to access cooking technologies and fuels.

Gender disparities: The issue of gender disparities in the context of access and use of cooking technologies and fuels as well as cooking practices was dominant in Kibera. These gender disparities where reinforced by social and cultural norms, but also by the social and economic standing of women in society.

Barriers: The major barriers to the access and sustainable use of technologies and fuels concerned the lack of: appropriate technologies to meet households' needs; information about the availability, uses, and benefits of alternative cooking technologies and fuels; up-front capital to access technologies and/or accompanying fuels; compatible, fair, and just payment methods or credit opportunities; the near absence of clean cooking technologies and fuels in Kibera; and safety fears.

Enablers: Major enabling conditions for access and sustainable use of ICS involved improved availability of: technologies and fuels; regular and reliable household income; exposure to areas outside of Kibera; sense of self-worth and need for social status; and education and general awareness of the availability and benefits of alternative cooking technologies.

Desire for change: The ownership and use of ICSs and other affordable, reliable, sustainable, and modern cooking technologies and fuels was a common desire among all respondents in this study. The strongest desire was to shift from kerosene stoves to LPG or bioethanol gel, rather than a shift from basic ICSs or open fires to an improved biomass ICS.

7. Discussion

The objective of this study was to investigate and contextualize the factors that enable or hinder sustained and sustainable access to and effectiveness of clean and safe cooking energy services, with the focus on biomass improved cook stoves (ICSs). To achieve this objective, a case study approach was adopted. The main data collection tool consisted of semi-structured interviews with household representatives and opinion leaders, structured observations, and informal discussions with social group members and residents of Kibera.

The results show that while there was sporadic access to and use of ICSs within households, sustained access to sustainable cooking energy service, and use, including of ICSs, were not the norm. The results also show that while the conventional approaches to dealing with clean cooking energy access challenges remain predominately focused on technological development, the presence of improved cooking technologies alone does not mean acceptance, adoption, and sustained and effective use. Instead, the results suggest that non-technological household and societal factors carry more weight in determining whether or not a technology is accepted, adopted, and used in a long-term and effective way. These non-technological factors relate to why a technology is needed and sought in the first place (needs) and the conditions that enable or hinder access to and use of the service(s) sought (abilities and opportunities). In respect of needs, the results reveal that people no not select a technology per se, but instead the set of advantages that such technological innovations provide: These advantages enable users to meet their needs, which are diverse and inextricably intertwined. In Kibera, for example, households sought to meet the basic needs of food, safe drinking water, and warm living space; to maintain and strengthen social–cultural values, norms, as well as individual and social cohesion within the community. In the absence of these advantages, technological innovations were rejected or abandoned.

The results also reveal the acceptance, adoption, and sustained access to and effectiveness use of technological innovations by households to be dependent in complex ways on human realities and circumstances, and on the social–cultural, political, structural, and environmental conditions inherent in their immediate living environment and beyond. Therefore, the success or failure of technological developments cannot be assessed or fully understood in isolation from these contexts. Overall, while technological solutions offer an important set of opportunities to enable sustained access to sustainable and effective cooking energy services, these alone do not always motivate consumers, influence consumer action, or enable desired outcomes and impacts, unless they are compatible with user needs and are implemented and used within appropriate and enabling conditions.

In this chapter, and based on my findings, I argue that because households are the main target for biomass ICSs, then the needs of such households ought to be the core focus of technological design and development efforts. Moreover, because households are embedded in social contexts, conditions within and beyond their lived environment must be assessed and taken into account when implementing technological solutions. As this study has shown, local and structural factors, some beyond the control of households, influence needs, and the state of abilities and opportunities available and accessible to them. Therefore, the challenges surrounding access to cooking energy can only be fully understood and addressed from the perspectives of end-users, and within the broader societal and environmental contexts as discussed in this chapter. The remainder of this chapter is organized as follows:

In light of the results presented in the previous chapter, I address the NOA model's shortcomings in accounting for the diverse factors that enable or hinder sustained access to sustainable and effective use of ICSs in Kibera. This culminates in a new conceptual framework, which is briefly introduced and used as a means to analyze these factors. I begin by analyzing households' cooking-energy-related needs. This is followed by analyzing the state of current opportunities and abilities, and how these influence sustainable access to ICSs in relation to traditional cooking energy services and other cleaner cooking energy services. Lastly, I address the role of societal factors in influencing sustainable and effective access to appropriate and effective cooking energy services as underscored in SDG 7. The chapter concludes with a brief summary, discussion of the study limitations, and potential avenues for further research.

7.1 The shortcomings of the NOA model in light of the results

The Needs–Opportunities–Abilities (NOA) model (Gatersleben & Vlek, 1997, 1998), introduced in Chapter 4, was adopted to guide the empirical research in this thesis. There were three main advantages that led to the choice of the NOA model over the Diffusion of Innovation Theory (Rogers, 2003) which was also considered as a candidate theoretical framework. Firstly, the NOA model underscores the importance of understanding end-user needs and societal conditions in order to facilitate the development of and access to acceptable consumer goods and services. Secondly, it shifts the responsibility of access, or lack thereof, from the consumers (households) alone to consumers together with the societal context in which they are embedded. Thirdly, it provides an alternative to the technological and economic theories and approaches that are predominantly used to explain technology diffusion and energy transitions in the current literature. This wide scope allowed the present study to focus not only on consumers (households), but also to consider other factors that could be enabling or hindering their access to cooking energy services such as ICSs. That approach was particularly useful because it provided the depth necessary for understanding and addressing the challenges associated with long-term access to sustainable and effective cooking energy services in the context of the informal settlement that formed the research case study. However, while the NOA model provided a useful frame for understanding certain factors that enabled or hindered sustained access to ICSs and other clean cooking energy services, as the results demonstrate, it was insufficient for capturing all the factors in a context such as Kibera. This next section highlights the role of local-level forces and other additional factors at the micro and macro levels (not captured by the NOA model) that played decisive roles in facilitating or hindering the acceptance, sustained access and effective use of ICSs.

7.1.1. Micro-level forces

The importance of end-user needs as underlying factors in consumer behavior is emphasized in the NOA model. Consequently, understanding end-user needs and the conditions that enable or hinder the achievements of such needs (i.e., abilities and opportunities) form the core elements of the model. However, the model focuses on assessing these factors in relation to the macro-level underlying mechanisms or driving forces (Gatersleben & Vlek, 1997). Based on this approach, the contributions of the consumer are thought to be on two levels: 1) in actions taken to procure goods and services based on the opportunities and abilities available at the macro level; and 2) the consumer contribution to improving the macro-level factors by taking an active role in their development. However, the NOA model has its origin in a developed country context and is used to study determinants of consumer behavior within households that enjoys high socioeconomic advantages. For example, the Netherlands, where the Model was developed and applied enjoys formalized and developed socioeconomic conditions, strong governance and institutional capacity, and political stability. The same cannot be said for the case study area of the present thesis. As highlighted in chapter two, Kibera is an informal settlement that experiences many socioeconomic disadvantages. Hence, households were actively involved in generating their own abilities and opportunities, whenever these were unavailable at the macro level or else beyond their reach. For example, this is demonstrated by the self-production of biomass briquettes, commonly referred to as pungunza (reduced price) in Kibera. Therefore, contrary to the portrayal of households as passive consumers and indirect contributors to the state of the macro-level forces, households in Kibera were directly and actively involved in generating their own abilities and opportunities.

Equally important was the role played by households as ambassadors or adversaries of proposed energy solutions, depending on their experiences with their use and the value added to their lives and general wellbeing. As was evident in Kibera and highlighted elsewhere (Ramirez et al., 2014; Rogers, 2003), the most common way in which users come to know about new innovation is through peer-to-peer exchanges. This is important , especially in a context like Kibera where trust and community acceptance play a crucial role in determining the success or failure of energy access interventions and other development projects more broadly (de Bercegol & Monstadt, 2018; Myers, 2015). These roles position households as important forces that cannot be ignored or valued only for their consumption of available goods and services, passive implementers of energy policies, or recipients of charitable deeds. Instead, as this study has shown, household are valuable and important actors in the processes of cooking energy access because their abilities and choices ultimately decide whether energy solutions such as ICSs are successful and sustainable.

7.1.2. Meso-level forces

The societal context in which consumers are embedded is given significant consideration in the NOA model, where it is thought to play an important role in influencing individual needs, opportunities, and abilities (Gatersleben & Vlek, 1997, 1998). However, while the context considered in the NOA model is a formal one, where its influences on consumer behavior are rather well defined and often predictable and governed by the rule of law, the present findings reveal a more complex and chaotic picture of the case study area. In Kibera, consumers are entrenched in diverse societal conditions, with formal and informal forces exacting competing influences on needs, abilities, and opportunities. For instance, the NOA model emphasizes formal macro-level factors that motivate consumers, such as credit access, market competition, sufficient goods and services, price control mechanisms, all of which are either absent or poorly implemented in Kibera. Therefore, besides the macro- and micro-level factors that are also relevant for understanding the factors that determine consumer behavior in any context, there are some unique local factors inherent in Kibera that are also important to consider. These intermediate-level connections are referred to in this thesis as the meso-level forces. While the meso level is not included in the NOA model, the results show that, in a context like Kibera, the forces at this level could hold the key to the success or failure of any clean cooking energy solutions.

The meso level is presented in the economic literature as a rule system that provides a path for understanding "the micro process and the macro consequences they involve" (Dopfer, Foster, & Potts, 2004:263). In the context of this thesis, the meso level is used to refer to local intermediaries—mainly value chain networks, local governance structures, and supportive organizations (NGOs, social and economic groups, religious and charitable organizations)—that are embedded in the local context of the case study and which are applied in a manner that influences households' access to cooking energy services and the fulfilment of needs. In Kibera, these local forces influence households' choices, their sustained access to sustainable cooking energy services, and the fulfilment of sought needs in an effective way by exerting control over needs, abilities, and opportunities. For example, the charcoal and firewood supplied and sold in Kibera is controlled by a tight and closely guarded networks of producers, distributors, and government enablers, making it extremely difficult to change the status quo, enforce existing laws, or introduce cleaner and sustainable alternatives without encountering opposition or sabotage or endangering one's life (de Bercegol & Monstadt, 2018).

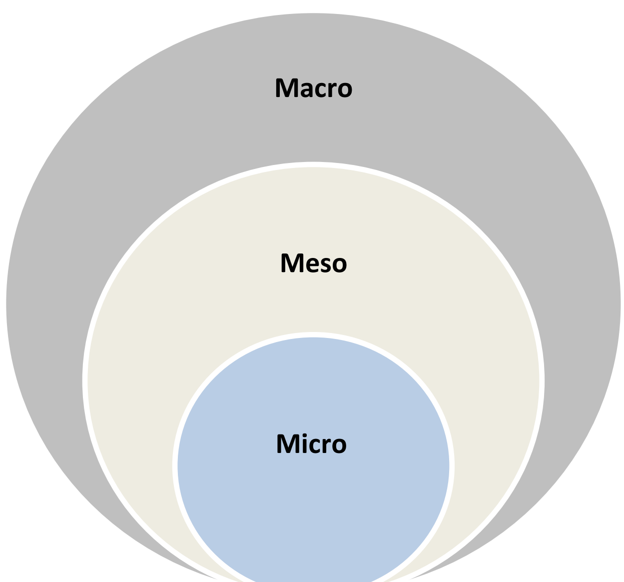
The importance of including the meso level in the analytical framework is demonstrated in the work of Dopfer & Potts (2004) who argue that change occurs at the micro-, meso-, and macro scales simultaneously and is irreducible to any of these levels alone. They note "to reduce [economic evolution] to a story about agent adoption, as in innovation–diffusion studies or to treat it entirely in a representative- agent macro - model, as in endogenous growth theory would be to make theories that are not so much simple, but rather simplistic" (p. 200). The value and importance of an intermediary level between the micro and macro levels in generating opportunities and abilities for households in Kibera is also underscored by also underscored by de Bercegol and Monstadt (2018), who conclude that localized coordination and organizational structures formed over decades control day-to-day operations of the slum as the de facto authority.

In the context of access to cooking energy services, such organizations wield significant power and influence within Kibera. For example, despite their exploitative prices, retailers provide cooking fuels such as charcoal and kerosene that are tailored to people's needs and financial realities. These kinds of services have proven very attractive for households in disadvantaged socioeconomic situations. The providers are also held in high regard in the community because of their ability to provide goods and services in a convenient and a timely manner, against all odds. From the household perspective, especially those experiencing poor social and economic conditions, such actors act in their best self-interest because they enable them to meet their needs. This subculture is enhanced by the culture of secrecy and the informal nature of day-to-day life and social–economic activities that are a hallmark of Kibera. On the other hand, attempts by the formal government to streamline basic social services, including energy services, has faced stiff resistance. This was especially evident following the government's attempt to provide safe and regulated electricity supply to households by introducing prepaid electricity meters through the state-owned Kenya Power and Lighting Company (de Bercegol & Monstadt, 2018). This case provides a compelling and unique example of the powerful role of meso-levels factors in Kibera. However, as de Bercegol and Monstadt (2018) eloquently analyze in their work: Once the project was completed, the people involved became the main adversaries of the project, and not the project supporters that this kind of inclusion had hoped for. The knowledge acquired during the implementation process was used to steal and sell electricity to local residences or to manipulate installed meters to reduce the payment required of local residents. By so doing, they continued to earn an income following termination of their employment upon completion of the KPLC installation project. These examples demonstrate the importance of accounting for meso-level forces alongside micro- and macro-level forces, because while macro-level efforts are important, the case of Kibera has shown that individuals ultimately identify with and support processes that generate value at the local level, especially when livelihoods depend on them. The meso level is therefore an important analytical level, alongside the micro and macro levels.

7.1.3. Macro-level forces

In order to understand the scope and depth of the challenges involved in the long- term access to sustainable cooking energy services, and the potential effectiveness of these services, it was also important to consider other macro-level elements that are relevant to the subject addressed in this study, but not captured by the NOA model. The most relevant elements include natural environments (geographical location, natural resources, and climatic conditions) as well as conditions in the built-in environment. The state of these factors not only influenced the needs and functions sought, but also the abilities and opportunities available and accessible to households. The role of these forces in influencing sustained and sustainable access and effective use of ICSs is discussed in greater detail later in this chapter. Overall, these additional elements underline that the forces that determine households' sustainable access to cooking energy services are complex and multidimensional and cannot be reduced to only technological development or forces at the macro and micro levels of society. Furthermore, these forces are intrinsically interconnected and influential upon each other, making it impossible to understand the factors that enable or hinder sustained access to sustainable to cooking energy without considering them together. Hence, unlike in the NOA model where only the micro and macro analytical levels are considered, the findings from Kibera indicate that the meso level plays a significant role in user needs and the kinds of abilities and opportunities available and accessible to households. In the context of this context, this warrants consideration of a multilayered analytical framework at the three levels of society (micro, meso, and macro levels), in order to holistically understand the factors enabling or hindering sustainable and effective cooking energy services in a context like Kibera.

Figure 13: Illustration of the three multi-layered analytical scales



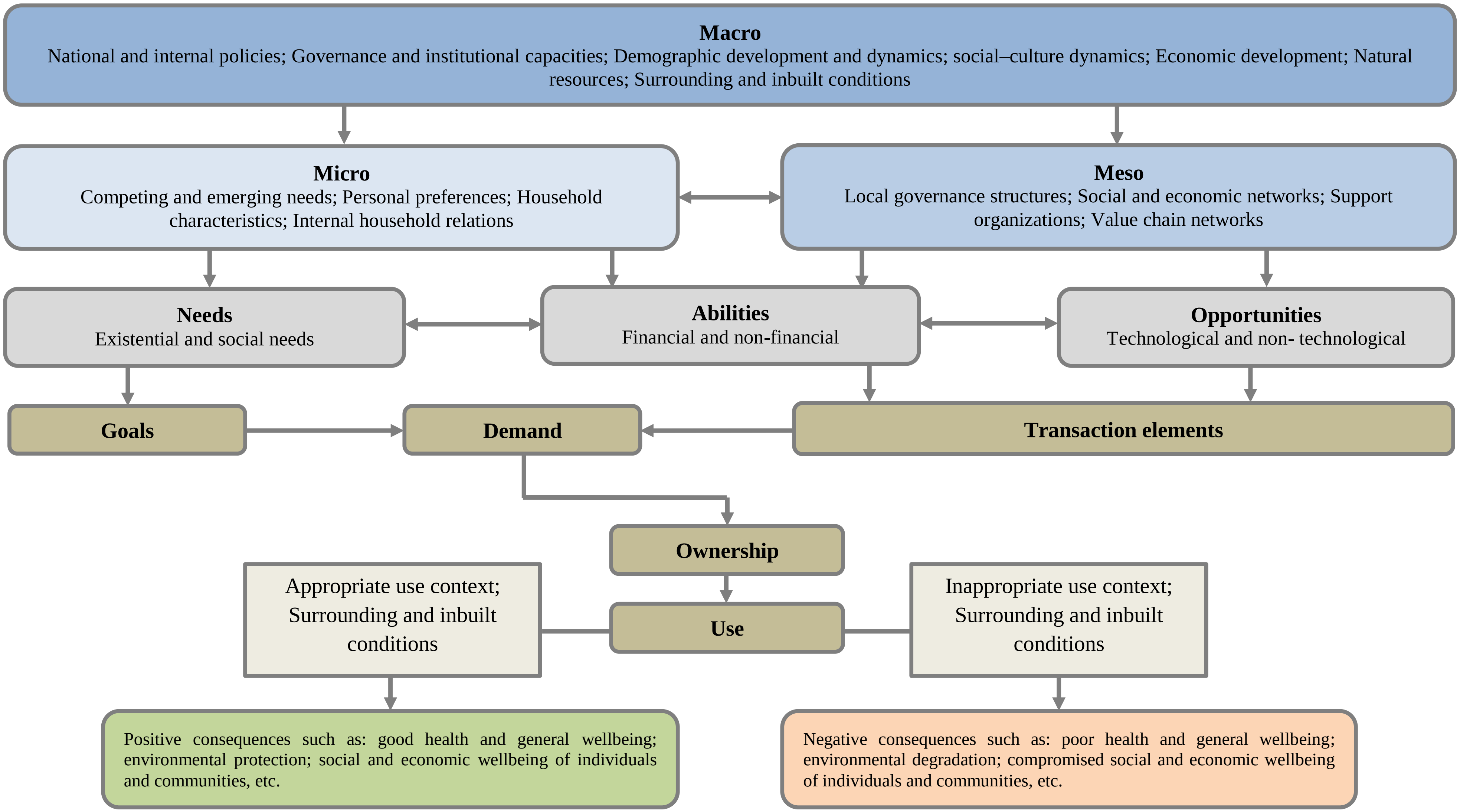
Source: illustration by author

7.2 Introduction of the new conceptual framework

Based on the NOA model and the additional elements introduced above, it is clear that the forces that enable or hinder sustained access to sustainable and access and the effective use of proposed cooking energy solutions, such as ICSs, are bound up in complex ways with the socioeconomic, social–cultural, social–political, and contextual realties of end-users. Hence, a major outcome of this research was the development of a conceptual framework that captures this complexity. This framework, henceforth referred to as the Cooking Energy Access Landscape, captures the direct determinants of sustained access and effective uses of cooking energy services (needs, abilities, and opportunities) and their interdependences on and interconnectedness with other aspects of social and economic dynamics at the individual household level (micro), the local (meso), and broader societal contexts (macro) level.

The multilayered analytical framework, introduced below, underscores that cooking energy access processes and uses are embedded in the social–cultural, societal, and environmental contexts, and hence, cannot be understood or addressed only in the isolated context of technological innovations and adoption processes or implemented within narrowly defined landscapes of formal structures and sectors. This contribution is particularly important because this new framework sets itself apart from other approaches that focus on technologies and households to evaluate the success or failure of ICSs. While this study has shown that technological developments and economic forces remain an important part of the opportunities and abilities needed to ensure sustainable access to clean and safe cooking energy services, the results also reveal that technologies and economic incentives alone do not always motivate consumers or determine consumer action, unless technologies feature characteristics sought by end-users and are introduced into societal contexts that contain a suitable enabling environment and supportive conditions. The strength of looking at access to cooking energy services in the broader context is that it enables the assessment of possible enablers and barrier and their influences on each other. This kind of assessment, while time consuming and demanding, presents the most comprehensive and holistic approach for assessing and understanding possible barriers and enablers, which might allow efforts toward accessing clean cooking energy to move forward in a sustained and effective way. This is approach is especially enhanced by taking into account factors at the meso level in addition to the micro and macro levels, as illustrated in Figure 14 .

Figure 14: The Cooking Energy Access Landscape



Source: developed by author, with inspiration from the NOA Model (Gatersleben & Vlek, 1998)

Guided by the Cooking Energy Access Landscape, the rest of this chapter analyzes and discusses the factors that enable or hinder sustainable access to and effectiveness of cooking energy services, specifically of ICSs, by focusing on households' needs from their perspective, and the state of available and accessible opportunities and abilities at all three levels of society. The discussion begins with needs.

7.2.Needs

Needs are defined in the NOA model and elsewhere (A. H. Maslow, 1943) as underlying forces that drive consumer behavior and actions. While fuel-efficient and environmentally friendly cooking technologies dominate the cooking energy discourse at the macro level (Elizabeth Shove & Walker, 2014; Van Der Kroon et al., 2013), this study has shown that households do not simply adopt or use a technology for those reasons, but rather to enable them to meet certain needs or, as noted by Shove and Walker (2014), the "outcomes of what energy is for" (p. 54). Seen in this light, technologies are instruments or means whose actual value is in their contributions towards the achievements of user needs. In the context of this thesis, needs are the precursor to goals that can fulfill the needs, given requisite abilities and opportunities. Thus, needs and goals generate demand for technologies such as ICSs.

7.3.1. Understanding households needs from their perspective

The findings demonstrate that the needs associated with household cooking energy are not only about a cooked meal, energy efficiency, or environmental protection as highlighted in energy policies and the technologies rolled out to implement such policies. Instead, as it is emphasized in the work of Shove & Walker (2014) and Der Kroon et al.(2013) cooking energy related needs are multi-dimensional, complex, and influenced by a variety of externalities, often extending beyond the simple availability of modern technologies and fuels (Elizabeth Shove & Walker, 2014; Van Der Kroon et al., 2013). In Kibera, cooking energy services are used for a wide variety of purposes within the household and to meet multiple goals, often simultaneously, such as cooking and space heating. Moreover, cooking practices are also about the enhancement of individual and societal values and general wellbeing (Groves, Henwood, Shirani, Thomas, & Pidgeon, 2017; Kumar & Igdalsky, 2019; Miller, Iles, & Jones, 2013; E Shove, Pantzar, & Watson, 2012; P. C. Stern, 2000) which are deeply woven into people's social–cultural practices and day-to-day activities (Groves et al., 2017; E Shove et al., 2012). As a result, cooking energy decisions are also fundamentally about the choice to preserve valued social–cultural norms and identities, individual livelihoods, and community cohesion.

The needs that households seek to address through cooking energy services are also directly or indirectly influenced by individual local realities, including geographic location, weather conditions, support infrastructure such as good transportation network, and people's livelihoods and availability of fuel resources Such decisions also derive from social circumstances such as peer pressure (Kumar & Igdalsky, 2019) as well as local power dynamics (de Bercegol & Monstadt, 2018), and the endowment of natural resources, which often shape the kinds of goods and services available and visible opportunities from which end-users can choose. For example, the success of ICSs in China was partly attributed to the growing scarcity and cost of fuel resources (Kshirsagar & Kalamkar, 2014), while poor acceptance and use of ICSs in rural contexts endowed with biomass, is partly attributed to a lack of motivation to save biomass (IEA, 2017). In Kibera, households sought cooking energy services in order to:

- Meet the immediate and basic life requirements of food and safe drinking water.
- Provide practical functions, such as space heating and lighting; improved quality of life and general wellbeing through increased comfort; convenience; time saving for self-development, leisure, productive work, and personal care; clean and safe living environments, including clean air.
- Preserve and enrich social and cultural norms and values, for example food preparation procedures; enhance food taste; participate in communal cooking and eating rituals or social gatherings such as wedding, funeral, etc.; strengthening social relations and cohesion.

As indicated by the list, households choose new technologies yet also maintained older ones that were deemed instrumental in achieving the outlined needs, and the enhancement or maintenance of sought individual and societal norms and values. As Groves et al. (2017) note "uses of energy emerges through the connection it sustains to people, but also things, to practices, and above all to valued ways of living and being" (p. 19). This can be demonstrated by the desire of households in Kibera to feed their loved ones, or to participate in preserving valued social and cultural norms, even when the choice of cooking energy services prove harmful in the short term and/or compromise their long-term well-being. This can perhaps explain why some households in Kibera maintained three-stone fireplaces and Kenya Ceramic Jikos despite the acquisition of ICSs and other cleaner cooking energy services such as LPG and bioethanol stoves. Therefore, just because household had diverse cooking energy-related needs, it did not mean that all needs were accorded the same importance. Instead, needs were negotiated and prioritized based on their immediate nature and importance to the survival of household members, and weighted against available abilities and opportunities, as discussed in the following section.

7.3.2. Household cooking-energy-related needs: value assessment and prioritization

The results imply that Kibera households' value assessment and prioritization of their needs was a reflection of their determination to meet immediate survival needs first, over non-survival needs, especially in the absence of viable abilities and opportunities, as opposed to an attempt to deliberately rank needs. On this basis, cooking-energy-related needs are grouped into two categories: immediate and non-immediate, as summarized in Table 8.

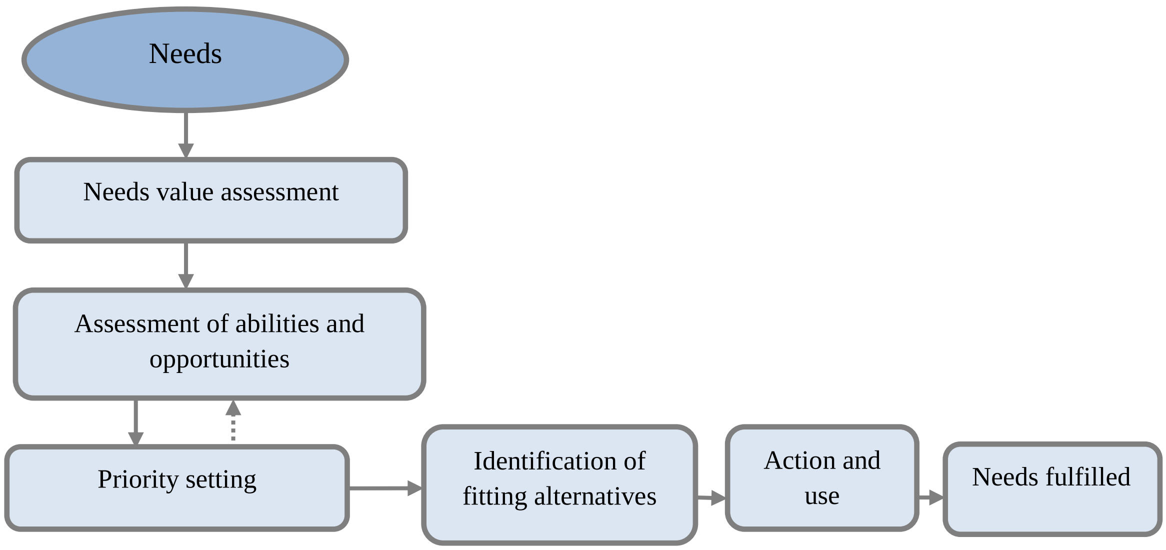
Table: 8 Categorization of cooking energy needs from the household representative perspective

Types	Examples
Immediate	Cooked food, safe drinking water, and warm living space
Non-immediate needs	Comfort; health; safety; time saving for self-development, leisure, productive work, personal care, and growth; maintenance of social and cultural norms and values; social relations; clean and safe living environments; expression of identity and status; convenience; security of access; freedom; identity or sense of belonging; self esteem

Source: constructed by author

In this categorization, the immediate needs are the necessary requirements for survival, quality of life, and general wellbeing, while non-immediate needs are desired but not urgent for immediate survival. Households in Kibera prioritized[45] immediate needs such as food over non-immediate needs such as the need to protect the environment. Against this background, needs prioritization is viewed in this work as a reflection of the kinds of opportunities and abilities available and accessible to the households at a given point and time, as illustrated in Figure 15.

Figure 15: Process of prioritizing household needs



Source: constructed by author

These realities are demonstrated in the differing cooking energy access and user patterns between category-A and -B households, despite their similar cooking energy service preferences. Hence, while both category-A and -B households lived in the same societal context, they experienced parallel realties, and hence took different paths in choosing their cooking energy services. These findings imply that if policy making fails to include socioeconomic heterogeneities, then the needs and preferences of disadvantaged and vulnerable households could be overlooked.

[45] Prioritization of needs is used in this thesis to reflect the categorization of needs provided above, where the immediate need for food was prioritized over the non-immediate need for clean and safe living environments, especially among people struggling to meet the survival need for food.

7.3.3. Understanding household demand for cooking energy services

The needs associated with cooking energy do not exist in a vacuum. Therefore, questions about how households choose certain technologies and fuels also concern their contextual realities and circumstances. These circumstances and realities determine demand and—depending on one's abilities and opportunities—the kinds of cooking energy services sought and used. The circumstances and realities in Kibera that were identified as influencing household cooking energy demand and choices included:

1) Competing and emerging needs,
2) Household characteristics,
3) Gender dynamics and power relations,
4) Habits and routines,
5) Personal preferences

7.3.3.1. Competing and emerging needs

The relationship between poverty in general and energy poverty in the developing and developed countries is well documented (Bazilian, Nakhooda, & Van De Graaf, 2014; González-Eguino, 2015; Daniel M. Kammen & Kirubi, 2008; Khandker, Barnes, & Samad, 2012; Practical Action, 2009; Sadath & Acharya, 2017). This level of urban poverty is confirmed in a recent report on the state of African cities, which notes that "rapid urbanization in Africa often results in the urbanization of poverty and manifests itself in mushrooming urban informal settlements (slums) (UN-Habitat and IHS-Erasmus University Rotterdam 2018 : 31). As the case of Kibera has shown, households in informal settlements experience both poverty in a broader sense and energy poverty specifically. As a result, raising money to purchase an ICS or LPG stove is difficult under the social and economic conditions in Kibera, and what comes from this day-to-day struggle is prioritized to meet the most immediate needs, such food, rent, and education. As one respondent noted, "Although I would like to have an LPG, I still can cook without it; For now, I have to worry about where the food will come from and how I will pay the rent." In the interim, households continued to cook with BCSs or kerosene stoves. This resulted in need value assessment and prioritization, especially for households with limited opportunities and abilities, as demonstrated above. As described by Gatersleben and Vlek (1997: 160) the "discrepancy between the ‘we, here and now’ needs of individuals and long-term, distant needs for collective welfare and a livable environment” makes the short-term positive consequences of individual choices more visible than the collective long-term and distant negative consequences of their actions and behaviors. For example, the effects of charcoal production, transportation, and unsustainable consumption are minimized when compared with the more visible and immediate fulfilment of needs for food and warm living space. Therefore, it is unsurprising that households did not mention the need to protect the environment as a reason for aspiring to cooking technologies such as LPG. Instead, visible and immediate effects such as cooking smoke and bad odors, especially from the use of kerosene stoves, were more visible and hence were mentioned by all household representatives as motivations for aspiring to or already having shifted from kerosene stoves to LPG. On the other hand, opinion leaders, including those living in Kibera, were more aware and concerned about the environmental effects of fuel-inefficient technologies and polluting fuels such as charcoal and kerosene. This could be as result of their exposure to knowledge and information in comparison to the household representatives, or the fact that their “here and now” needs were already being securely met, thereby allowing them space to think about the “we” or the collective needs of environmental protection and sustainably.

These findings are consistent with Maslow's 1943 seminal theory of human motivation and the hierarchy of needs, which posits that people are motivated to fulfill their fundamental survival needs first, before considering other, higher, levels of need. Against this background, it is clear that energy-related needs can only be understood and addressed within the broader context of social–economic development, because as this study has shown, secure access to basic needs is an essential precondition for ensuring initial and sustainable access to advocated energy solutions such as ICSs.

7.3.3.2. Household characteristics

Household characteristics influenced the kinds of cooking technologies chosen and used within Kibera households. Differing household characteristics result in different patterns of need (e.g., a single-person households has different needs than a 10-person household. Moreover, household characteristics can influence the kinds of abilities and opportunities available to a certain household. In Kibera, for example, households headed by single women had lower abilities and fewer opportunities. This not only influenced everyday life activities, but was also shown to influence the kinds of technologies acquired and used. For example, kerosene stoves were used in category-A households, while LPG and bioethanol stoves were used in category-B households to prepare breakfast and quick meals. Both ICSs and BCS were less preferred for use during these times because of their tedious and time-consuming preparation requirements, but were used during weekends and holidays when time was not at a premium. Moreover, households headed by single women only reported allowing their children to prepare and cook with biomass cook stoves, as opposed to LPG and kerosene stoves, in the parent's absence.[46] Both LPG and kerosene stoves were associated with fire risk, particularly for children due to their lack of knowledge on how to handle the stove or react in case of explosion or fire. These examples highlight the social dimensions of energy demand and use, which are often invisible or overlooked in approaches focused solely on technology.

7.3.3.3. Gender dynamics and power relations

The term gender is used in this thesis to refer to different socially learned and constructed roles, relations, behaviors, and expectations in relation to men and women (Danielsen, 2012). According to the World Bank, unequal gender-power relations can help define, enhance, and create values and norms in social systems, institutions, and daily realities that influence the ability to access resources (World Bank, 2001). In Kibera, such gender and power imbalances were evident in the roles assumed by men and women within the household and the broader societal sphere. For example, women were often tasked with household responsibilities such as cooking, cleaning, and taking care of children, the sick, and the elderly, while men were involved in paid work within the community and beyond, and earned the larger share of household income. The income earned by men was reserved for 'capital-intensive' household projects such as building a house in the village, purchasing family land, paying school fees, etc. Women, on the other hand, were expected to run households, ensuring the survival and general wellbeing of its members without secure financial abilities or other necessary abilities and opportunities. While these jobs are time- and energy-intensive, they offer no economic gains. These kinds of jobs also tied women to the domestic sphere, often depriving them of the opportunity for self-development,

[46] Children in households headed by single women were more likely to engage in cooking activities than those in traditional male–female households. This was because woman in such households acted as the full-time breadwinner, housemaker, and caregiver combined. To relive their mothers of these burdens, older children, especially girls, helped in preparing the fire or taking care of the younger children. This was observed particularly during the morning and evening, when most women went to the street to attend to their street-food business. Early morning and late evening were times when food was mostly prepared and needed in the household and on the streets, as people left in the morning for work (or in search of work) and returned to their homes in the evening.

income-generating activities, or exposure to the outside world, which, as discussed previously, could help develop and enhance knowledge and awareness of available abilities and opportunities abilities. These inequalities and dynamics can perhaps explain why many households were either dependent on cheaply available technologies and fuels; on naturally occurring stones and fuel sources such as wood and biomass byproducts; or on self-made fuels from recycled materials and charcoal dust (pungunza). This analysis shows that while addressing gender inequalities is often highlighted as one of the justification for ensuring sustainable access to cooking energy services, including ICSs, such challenges cannot be addressed unless there are sufficient and equitable abilities and opportunities afforded to men and women, within the domestic and public spheres.

7.3.3.4. Habits and routines

Habits and routines were also key factors influencing demand for cooking energy services. The social psychology literature has demonstrated that attachment to routines and habits are thought to hinder environmentally significant behavioral change (Dahlstrand & Biel, 1997). In the context of cooking energy services, the change from one cooking service to another demands a change in habits and routines, user operating knowledge and standard routines, time allocation, and sometimes the cooking equipment used (type and size of fuel), etc. In Kibera, efforts are necessary to break current habits and routines related to the size and type of fuel required for use with ICSs as well as the time devoted to cooking. These inconveniences were mentioned by opinion leaders and household representatives as major barriers to the uptake and use of ICSs in Kibera and rural contexts. For example, the picture below shows unused firewood ICSs next to a traditional 2-stone fire in a Kenyan household[47].

[47] While the rural context is not the focus of this study, such example demonstrated that the challenges facing the acceptance and sustainable use of ICSs is not only limited to urban contexts, but is also prevalent in rural areas where ICSs have been implemented for over 40 years.

Source: author

7.3.3.5. Personal preferences

While most interventions for access to clean cooking energy services tend to focus on ICSs, the findings in Kibera showed that LPG was the most preferred cooking technology. Apart from their modern appearance and potential to save on fuel, ICSs where not perceived by end-users as offering any superior services to those offered by the BCSs. Moreover, the ownership of ICSs was not associated with real change because it did not fill any immediate, visible/felt gap and neither did it provide any unique functional value that was not already provided by BCSs. This was also evident by the continued use of BCSs within households where ICSs where present. On the other hand, the ownership and use of LPG signified higher social status while also enabling convenient, clean, and fast cooking—characteristics that were sought and prioritized by households. LPG and bioethanol stoves were also liked for their ability to reduce discomfort and health issues associated with indoor air pollution. It is also worth noting that the presence of LPG and bioethanol was reported by both opinion leaders and household representative to encourage men in traditional households to cook, while the presence of ICSs was not associated with the same effects. The dirty and tedious work of preparing biomass cook stoves is primarily undertaken by women and girls. Men in Kibera cooked only using kerosene stoves when alone in the household, or when clean cooking technologies and fuels were present in traditional households (headed by an adult woman and man). Hence, men's involvement in cooking activities can be said to be a particularly valuable impact of LPG and bioethanol stoves because it can lessen the burden on women, who are primarily the cooks in traditional households.

Moreover, ICSs were rejected on the basis of one of their major advocated properties, that of energy efficiency. Energy efficient stoves are designed to minimize the amount of heat lost into the surrounding environments. However, for households in Kibera this denied them the ability to address their needs for space heating. These examples show that this measure of progress from the perspective of policy makers and implementers actually contrasts sharply with what is sought by the end-user. The analysis paints a situation where the advocates, designers, and implementers of household energy solutions seem to be operating without regard to end-users (households) needs, resulting in a push for cooking energy services that are at odds with user preferences and needs. These results imply that while cooking energy policies and implementation strategies are designed and implemented with good intentions, progress in the sector will remain elusive unless informed by the needs, preferences, social, cultural and economic realities of end users.

7.3. Determinants of sustainable access, use, and effectiveness of cooking energy services

Abilities and opportunities are referenced in this thesis as transactional elements or the determinants of sustained access to sustainable and effectiveness of cooking energy services. For the purposes of this discussion, transactional elements are seen as the central conditions necessary for households to acquire and use cooking energy services in a sustained, sustainable and effective way. The results imply that the secure presence of both transactional elements, at the same time, motivated and enabled households to acquire and use cooking energy services in sustained ways, while the absence of one or both elements discouraged or constrained such action. The next section discusses the role of available opportunities in enabling or hindering household choices and actions in Kibera, with the focus on ICSs. Subsequently, the role of abilities is discussed.

7.3.1. Opportunities

While needs drive households' desires for certain cooking energy services, the kinds of choices made depend on the opportunities available to the user. In the NOA model, opportunities are referred to as a set of external facilitating conditions that motivate and enable consumer action (Gatersleben & Vlek, 1998). In the context of this thesis, opportunities are categorized as technological or non-technological. Technological opportunities refer to the physical features of cooking stoves which enable households to fulfil certain desired needs, while non-technological opportunities refer to the enabling elements needed to allow access and use of desired cooking energy whenever needed. This section highlights the technological and non-technological opportunities sought by households in Kibera, and discusses how their current state enables or hinders the long- term and sustainable access and use of ICSs, and other clean cooking solutions more broadly.

7.3.1.1. Technological opportunities

While the presence of technological opportunities is important for achieving energy access for all, the nature and quality of a technology have tremendous effects on the ability of the user to fulfil their sought needs and to the achievement of other human and environmental goals. Hence, for households in Kibera it was not only important to have a technology, but such technologies had to fit the function for which they were sought or purchased, otherwise they were abandoned or rejected. Based on the current technological ownership patterns outlined in the Results chapter, the four technological characteristics most valued by Kibera households were: the four technological characteristics most valued by Kibera households were: multi-functionality; individual, social, and economic advantages; quality, reliability, and durability; and compatibility with households' social contexts, preferences, and lifestyles[48] as outlined and discussed below.

Multi-functionality

Households in Kibera sought cooking technologies from which they could draw the most value to fulfil their diverse needs. Consequently, one of the desired physical characteristics was multi-functionality, i.e., the ability of a technology to provide multiple functions whenever needed. For example, the two main immediate needs sought from cooking technologies were food and warmth. Unlike ICSs, open fires and BCSs featured characteristic that enabled households to meet both these main needs simultaneously. ICSs have fuel-efficiency and safety features that limit thermodynamic losses to the outer surface of the stove and the surrounding environments, both slowing the cooking process and limiting the ability to warm the living environment (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Gill, 1987). In this regard, BCSs and two- or three-stone fires were most preferred because of their intense energy release and their added benefits of space heating. This implies that for ICSs to be acceptable and embraced as a household's main cooking technology; their designs would need to incorporate characteristics and functions desired by end-users, beyond their fuel-efficient attributes.

[48] Lifestyle is defined as "outcomes of choices people make according to their values, needs and the social contexts " (Stephenson et al., 2010:6121).

Moreover, the use of cooking technologies was not limited to cooking within households alone. Households were also the main participants in social and communal cooking events, such as weddings. These events are highly valued in Kibera and the African context because they enable the preservation of social–cultural norms and the enhancement of social wellbeing among the community and its members. To meet these needs, BCSs and two- and three-stone fires were most preferred and used because of their suitable sizes and/or adjustable physical properties. These examples illustrate why technologies such as BCSs and open fires still continue to play an important role in African households' cooking energy mix despite the presence of ICSs and other cooking solutions such as biogas, LPG, and bioethanol stoves on the market, as well as improved social economic conditions. Indeed, as shown by the pictures below, which were taken in a household in Kibera, cleaner and energy-efficient cooking energy services remain unused despite their presence in households.

Source: author

The pictures above show an unused two-burner bioethanol gas stove, commonly known in Kibera as a *Safi*[49] and a KCJ that is being used to prepare a traditional meal (a mix of beans and corn, often prepared in a traditional pot). On a cold day in Kibera, this design provides users with the opportunity to prepare their meals in a culturally acceptable way while at the same time enjoying a warm living environment in a relatively inexpensive manner. On the other hand, while the *Safi* bioethanol-powered stove is liked for being clean and convenient, the fuel is expensive and not legally available in Kibera. Moreover, its characteristics and functions are incompatible with the traditional cooking practices and space heating that is enabled by the KCJ. This suggests that technological development does not always have a positive influence on consumer behavior unless they provide the characteristics sought by end-users. Moreover, the fact that most households in Kibera and in other parts of Kenya and the continent have limited financial abilities to amass different cooking energy services highlights the importance of multifunctional characteristics in cooking technologies.

Relative social and economic advantages

Consumers invest in technologies in the hope of getting the most value from their use, especially in comparison to their current technologies and in relation to the investment made. Potential advantages motivate households to desire or choose certain technologies over others or to transition from their current cooking technologies to another. Households in Kibera were interested in high-quality and durable technologies, and a shift to technologies that presented greater relative advantages than their current technologies. In that context, a shift from kerosene stoves to LPG was most desired. Unlike kerosene stoves, the use of LPG was said to be clean, and free from smoke and odors. On the contrary, the shift from BCSs to ICSs was not a priority because it was not associated with real change or any substantial added advantages. Unfortunately, while some of these ICS shortcomings were flagged early on in their design and development (Gill, 1987; Manibog, 1984), they nevertheless persist in current ICS designs, including those available and used in Kibera and in Kenya more broadly. However, as the present findings suggest, the emphasis on characteristics such as fuel efficiency—at the expense of need-satisfying characteristics valued and prioritized by households—is failing to motivate households. Therefore, unless technologies such as ICSs are equipped with characteristics that

[49] Safi is a Swahili word, which means clean in English.

enable households to meet their needs in a reliable and sustainable way, households will continue to act in their best interests and within their means to meet their most valued needs. This could mean a continued rejection of advanced technologies such as ICSs, in favor of less advanced technologies such as BCSs and open fires.

Quality, reliability, and durability

The need for high-quality products is emphasized in the work of Allwood et al. (2013: 2), who note that, “in addition to pursuing energy efficiency and recycling, we could also reduce our total demand for material by pursuing the idea of ‘material efficiency’ — which is to continue to provide the services delivered by materials, with a reduction in total production of new materials.” While ICSs were said to last longer than BCSs, they were relatively expensive and unreliable, due to their near absence, and lack of spare parts and after-sales services in Kibera. Unreliable, poor-quality, and short-lived technologies, combined with the lack of repair services, presented several negative implications for sustained and sustainable access and effective use of cooking energy services. From the household perspective, poor-quality technologies had far-reaching implications for their ability to fulfil desired needs, as they experience frequent service interruptions. Moreover, from a cost–benefit perspective, investing in poor-quality technologies made little economic sense, especially for households struggling to meet other urgent and immediate needs. From a human health, environmental and climate change perspective, poor-quality and unrepairable technologies presented many pollution risks that are known to compromise human health (Landrigan et al., 2017), environmental goals, and sustainable development efforts (Cooper, 2010). The magnitude of this quality problem is illustrated in the pictures below, which show the poor condition of a Jiko Koa stove (one of the most commonly available ICSs in Kibera and throughout Kenya) after one year of use (approximately once daily).

Examples of new and used (one year old) Jiko Koa ICSs in Kibera

New Jiko Koa stove	Two stoves after one year of regular household use (approximately once daily)
	 

Source: author

The pictures above show a new ICS (Jiko model; left panel) photographed at the KTC Green shop, and two used stoves (right panel) from two separate households in Kibera. According to the respective owners (both part of the interview sample), the stoves had been in use only for one year. However, as shown in the photos, the charcoal and inner insulation compartments are severely damaged, making the stoves unusable and unsafe. The owners of these stoves had bought their stoves through their social–economic networks, but were unable to repair or replace the stoves. Therefore, poor-quality technologies not only demotivate users and hinder fulfilment of their needs, but their production and presence in the market acts against envisioned climatic and environmental protection goals, because such appliances have short lifespans, are unrepairable, and are therefore soon discarded, hence exacerbating problems of waste and pollution.

Compatibility with household social contexts, preferences, and lifestyles

While the design, testing, and production of technologies take place in industrial facilities, their dissemination and use take place in social contexts (Kumar & Igdalsky, 2019; Ramirez et al., 2014). Hence, beyond technological improvements, various other factors also come into play: individual and social elements, such as personal preferences and lifestyle changes, households' characteristics and social–cultural demands, changes in living environments, increased knowledge and awareness, sense of self-worth and value, higher education attainment, and the demands of everyday life. In Kibera these forces motivated—and sometimes compelled—households, to choose certain technologies over others, and to retain the use of certain energy services such as open fires. For example, landlords did not allow the use of firewood because of fire risks. Moreover, both household representatives and opinion leaders expressed greater preference for a shift from kerosene stoves to cleaner and safer technologies such LPG and bioethanol stoves, rather than ICSs, because of the perceived advantages of such cooking technologies over biomass ICSs. This represents a positive outlook for access to clean cooking energy for several reasons. Firstly, unlike most biomass ICSs, the use of LPG for cooking meets WHO targets for reducing IAP (IEA, 2017; Quinn et al., 2018; Rosenthal et al., 2018). Secondly, LPG and bioethanol stoves, are known to be safer than kerosene and any biomass stoves (Khandelwal et al., 2017). Thirdly, in addition to meeting IAP targets, the use of LPG was reported by both opinion leaders and household representatives to encourage men to participate in household cooking activities, hence allowing women some free time to focus on personal care and self-development, a benefit that was not associated with ICSs. LPG cooking services thereby make a powerful contribution to lessening the gender burdens highlighted in the Introduction and Review of the Literature chapters. This is important, because, as highlighted in the literature (Drèze & Sen, 2002; Martha Craven Nussbaum, 2011; Sen, 1999) affording women greater free time and freedom of choice is essential for unlocking opportunities, which have the potential for personal development and the development of the wider society.

With respect to health and environmental improvements, the effectiveness of ICSs has been challenged when using charcoal in unsuitable user and environmental conditions (Bowe et al., 2018; Health Effects Institute, 2018; Quinn et al., 2018; Rosenthal, Quinn, Mortimer et al., 2017, Grieshop, Pillarisetti, & Glass, 2018). Moreover, ICSs achieve positive scores in laboratory tests for reducing indoor air pollution, but these results are said to differ from users' real-life experiences (Ezzati & Baumgartner, 2017; Wathore et al., 2017). This is more strongly stated in the latest Energy Access Outlook (Chapter 3: Access to clean cooking), where it is noted that improvements, mainly on the pollutants from ICSs, are overstated. More specifically, the reports notes that: “Virtually no biomass cookstove currently on the market meets World Health Organization (WHO) standards for exposure to household air pollution”(IEA, 2017: 65). Based on these examples, it can be concluded that the failure to prioritize households' needs, preferences, and priorities could be acting as a barrier to the success of ICSs. Moreover, the exaggerated focus on energy access interventions within lower socioeconomic rural areas could also be obscuring or distracting from essential knowledge needed to design context-relevant policy agendas for households for households in informal urban settlements. This failure is not only reflected in the growing challenges of cooking energy access (OECD/IEA, 2016) and the poor performance of advocated technologies such as ICSs (Kumar & Igdalsky, 2019; Quinn et al., 2018), but is also evident in the continued use of BCSs and open fires within households where ICSs and other clean, modern technologies and fuels already exist (Masera, Saatkamp, & Kammen, 2000). Overall, this analysis portrays a situation in which the designers and implementers of household energy access policies seem to be operating in isolation from the needs and preferences of households, as well as the social and environmental realities of their living conditions. Indeed, while appliances such as ICSs feature characteristics that could prove valuable to households, their rejection partly stems from the failure of their designs to incorporate features that match those of existing technologies such as BCSs and open fires, which are valued by households. Nevertheless, this could also be seen as an opportunity, given the advantages associated with LPG. The overwhelming preference for LPG expressed by Kibera households could be harnessed to facilitate access to acceptable, affordable, and reliable cooking energy services. Unfortunately, such opportunities are often missed or their effects understated, due to the absence of processes to track: consumer needs and demands, emerging dynamics and disparities in different communities, as well as the non-technological determinants of the success or failure of advocated technologies.

7.3.1.2. Non-technological opportunities

While technological opportunities are a necessary precondition for users to acquire and use energy services, technological opportunities alone do not guarantee access to and use of that technology, or the fulfilment of needs. In addition to technological opportunities, non-technological opportunities are needed. Hence, considering the state of non-technological opportunities is also important to fully understand the factors enabling or hindering acceptance, sustained and sustainable access to technologies such as ICS. Non-technological opportunities are referred to in this thesis as the conditions that enable access to and use of technological opportunities, as discussed in the following sections.

Availability

Availability is described in the work of (Sovacool & Dworkin(2015) as the most basic element of energy justice, and "involves the ability of an economy, market or system to guarantee sufficient resources when needed" (p. 439). In the literature on diffusion of innovation, availability of technologies is thought to enhance awareness by providing potential buyers with the knowledge and information that is essential for informed decision-making processes (Rogers, 2003). In Kibera, the unavailability of technologies hindered access to clean cooking energy services in two ways:

1) People who sought particular cooking appliances and accompanying fuels could not access these in a timely and convenient manner, or possibly at all;
2) Their near absence from homes and shops (and intentionally poor visibility in shops, even when available) prevented potential consumers from becoming aware of them and familiar with their usage, or to inquire about their advantages and disadvantages.

For example, the availability (and visibility) of technologies in shops could provide potential users with the opportunity to enquire about their cost, payment opportunities, advantages and disadvantages of their use, and to purchase them when needed and if financial conditions permitted. Additionally, their presence and use within homes could provide potential users with the opportunity to observe their use firsthand, hence enabling them to understand their use, and to internalize the dangers, risks, and benefits to humans and the environment. Therefore, the near absence of ICSs in Kibera acts as a barrier to their adoption, but also compromises the opportunity for potential buyers to learn about them. These observations corroborate the work of Rogers (2003: 16) where observability is thought to "stimulate peer discussions of new ideas, as the friends and neighbors of the adopter often request innovation evaluations information about it." To put the ICSs availability challenge in Kibera into perspective: Beyond the sporadic distribution by NGOs and other charitable organizations, there was only one location that regularly retailed ICS in the entire settlement. However, even at this location, the retailer expressed frustration with irregular supply, which was said to frustrate customers, often resulting in them cancelling their pre-orders for ICSs. Moreover, whenever such technologies were present, they were placed away from the view of the public, to minimize theft.

Affordability

The up-front cost of new technologies is thought to be one of the greatest barriers to accessing modern cooking energy services, including ICSs (IEA, 2017; Jagger & Jumbe, 2016; Jan et al., 2017; Khandelwal et al., 2017; Rogers, 2003). This enduring challenge is also recognized in UN SDG 7, where affordability is highlighted as one of the principles required of energy access processes to ensure that no-one is left behind. Affordability refers to the ability of a consumer to acquire a commodity or service whenever it is needed. However, as Sovacool & Dworkin, (2015 p. 439), caution, that entails not only low prices but also “stable prices (minimal volatility) as well as equitable prices that do not require low-income households to spend disproportionally large shares of their incomes on essential services(p. 439).” However, there is often a failure to recognize that traditional approaches to affordability do not always account for the realities of many households in low socioeconomic contexts like Kibera, where incomes are not guaranteed or sufficient for the household member responsible for purchasing cooking energy services. Moreover, charitable donations and subsidies, while important for enabling one-time adoption of technologies such as ICSs, do not address the underlying structural and socioeconomic challenges that hinder households from enjoying long-term access to sustainable and effective cooking energy services.

Fuels, repair, and maintenance services

Sustained, sustainable, and effective use of cooking energy services also depends on, but is not limited to how cooking fuels are produced, traded, and consumed as well as the availability of repair and maintenance services. In Kibera, for example, the poor availability and affordability of fuels such as LPG and bioethanol were responsible for the lack of sustained use of these respective technologies. The availability and cost of fuels has also been shown to have similar effects in rural settings, where lack of certain fuels such as LPG and the abundance of biomass fuels, mainly firewood, is thought to influence household cooking technology choices (OECD/IEA, 2017). In Kibera, the abundant availability of charcoal and kerosene motivated households to acquire and use related compatible technologies, whereas the poor availability and high cost of LPG and bioethanol fuels demotivated households from acquiring and using related technologies. On the other hand, the lack of ICS spare parts and repair and maintenance services limited their lifespan, resulting in their premature disposal. This section has addressed the opportunities element, whereas the next section addresses abilities.

7.3.2. Abilities

In order to take advantage of the opportunities discussed above, households require certain abilities. Abilities are defined in the NOA model as internal capabilities that enable consumers to purchase and use certain consumer goods and services (Gatersleben & Vlek, 1998). Consequently, this section discusses the role played by the presence or absence of certain abilities within households in Kibera, in enabling or hindering the sustained access and effective use of sustainable cooking energy services, with a focus on ICSs.

7.3.2.1.Financial abilities

There is widespread consensuses in the literature, that lack of financial abilities acts as the main barrier to accessing clean and safe cooking technologies (Gill, 1987; González-Eguino, 2015; Hosier & Dowd, 1987; IEA, 2017; Manibog, 1984). Moreover, in addition to a given technology, households also required additional financial abilities to fund subsequent fuel purchases, repairs, and maintenance and replacement of a technology, whenever necessary. In Kibera, these abilities were hampered, particularly by the lack of secure and well-paying employment opportunities, and other financial instruments such as access to loans and installment payment plans. Furthermore, financial and other livelihood uncertainties are built into every aspect of people's lives in Kibera, making it extremely difficult to plan for the future. For example, the risk of eviction by landlords due to rent default, by the government for redevelopment purposes, or the complete loss of property and income-generating capital as a result of fire, regulators, and law enforcement activities, was observed and self-reported by residents. Moreover, household representatives and opinion leaders alike underscored the burden of uncertainty due to poor or absent employment opportunities, i.e., lack of job security, poor compensation, and poor or non-existent social security and health insurance.

The differences in the quality and nature of income-generating activities also mirror the cooking energy access and user patterns highlighted in the Results chapter for category-A and -B households. For example, while Kibera residents are generally engaged in different kinds of economic activity to secure financial abilities, most households were either struggling to access the most basic cooking energy services (household A), while others were unable to meet their needs sustainably or in their most preferred way (household B). These access and use patterns suggest that not all employment opportunities can generate the required abilities, but that the quality and nature of income-generating opportunities also matter. Viewed from the perspective of illegal and informal suppliers, the danger to uncertain livelihoods, and lack of alternative financial abilities could also be motivating then to focus on the unstainable supply of cooking energy services, especially charcoal and firewood. Uncertainty and threats to livelihoods can, for example, result in resistance to change, thereby creating a barrier to cleaner and sustainable alternative and often desired cooking energy services.

7.3.2.2. Informational abilities

Information and awareness creation is thought to be crucial in motivating consumer behavior and in facilitating informed consumer decision-making processes with regard to technological acceptance, sustained and sustainable access, and use (IEA, 2017b; Jagger & Jumbe, 2016; Rogers, 2003; Sovacool & Dworkin, 2015). While more knowledge and information does not necessarily translate into action, having information and knowledge about the risks and burdens associated with the use of dirty and polluting cooking energy service was shown to influenced households' cooking energy access and user patterns in Kibera. For example, the differing access and user patterns observed between category-A and -B households could be partly attributed to differences in their educational level, awareness, and exposure to the world beyond Kibera. Within Kibera, the motivation for change was trigged by the flow of information between trusted peers, especially in the context of social and economic networks and direct observation of the technology in retail shops, and in use with the household context. The role of social and economic networks in awareness creation and disseminating information about the value of clean cooking has also been liked to successful ICS interventions in Honduras and elsewhere (IEA, 2017; Kumar & Igdalsky, 2019; Ramirez et al., 2014). Therefore, the role of adapters as advertisers, further underscores that they are not necessarily passive recipients of technologies such as ICSs as informer–recipient forms of communication might suggest, but rather are also carriers of important information that they can use to champion or topple certain technologies or energy services. Such a role cannot be underestimated, especially in understating the factors that have led to the poor performance of ICSs. In the case of Kibera it is clear that information and awareness are transmitted and amplified most effectively through end-users and within social and economic networks.

7.4.2.3. Physical means and spatial abilities

Physical means and spatial abilities are considered in this work as the conditions of the cooking area, and the state of the user living and built-in and surrounding environments. This includes the physical characteristics (ventilation, enclosed or opens spaces, and size) of the cooking areas, the state and use of other surrounding spaces, as well as the immediate surroundings and built-in conditions. There is growing evidence that where people live and spend most of their time plays an important role in determining the quality of their life and general wellbeing (Ferrer, 2018; Marmot, 2005; World Health Organization, 2014). There is also growing evidence that the effectiveness of advocated cooking technologies, including ICS, is also dependent on the state of users' living environments, the quality of technologies and fuels (Mortimer et al., 2017; OECD/IEA, 2006). As noted in an IEA report, exposure to indoor air pollution depends on the source of the pollution, in this case, (cooking fuels and cooking technologies), as well as how the pollution is dispensed (quality and the nature of cooking space including ventilation) and how much time household members spend cooking or exposed to indoor air pollution (IEA 2006: 427). The importance of enabling cooking and living environmental conditions was also underscored in a clinical trial that followed a biomass ICS intervention in Malawi (Mortimer et al., (2017), which concluded that the incidents of childhood pneumonia in the study area were partly attributed to adverse surrounding environments and poorly ventilated indoor spaces.

In Kibera, such poor conditions also influenced the acceptance and use of technologies such as ICSs. As one household representative noted, “I didn't think such things are meant for us people in the slums.” in response to a follow- up interview question on whether she would like to shift to other cleaner ways of cooking such as ICSs. This mindset can be interpreted as the internalization of one's self-worth in relation to one's living context. As Wells (2012) notes, “people can internalize the harshness of their circumstances so that they do not desire what they can never expect to achieve”(p. 3). This implies that the development and implementation of clean and efficient cooking energy solutions should also be accompanied by efforts to improve use conditions and user immediate living environments as well as the state of the surrounding environments, in order to motivate the acceptance, usage, and ensure the effectiveness of more sustainable and cleaner cooking technologies.

7.5. Social and contextual influences on household sustained and sustainable access to cooking energy services and effective use.

The previous sections addressed households' needs, internal characteristics, and realities that drive demand for certain cooking energy services, as well as the abilities and opportunities required to sustainably and effectively meet such needs. However, the case of Kibera has shown that households are embedded in societal contexts whose demands and conditions influence needs, abilities, and opportunities, and hence, households' decision-making processes, choices, and outcomes. Therefore, to holistically understand what influences households' needs and the factors that enable or hinder their abilities and opportunities to sustainable access and effective use desired cooking energy services, , it is also necessary to consider the contexts in which such decision are contested and made. The study findings identify these influences at the three levels of society (macro, meso, and micro), as outlined and discussed in the following sections.

7.5.1. Macro-level forces

According to the NOA model, consumers are embedded in larger social structures that shape and influence their needs, opportunities, and abilities. The macro-level factors are considered external influences on consumer behavior. The findings of this study show that macro-level forces influence households' cooking-energy-related needs, abilities, and opportunities by defining societal values and norms, and through the establishment of policies that drive national and international development agendas and implementation processes. The macro-level factors identified in this study include: governance and institutional capacity, demographic development and dynamics, social–culture dynamics, natural environments and living environments, economic development, and national and internal policies, as outlined and discussed below.

7.5.1.1. Governance and institutional capacity

Institutions and government instruments are crucial for constituting and governing human societies. In the context of energy, good governance and institutional capacity have been recognized as essential and integral factors in ensuring access to sustainable and just energy services in developing, emerging, and developed countries (Edomah, Foulds, & Jones, 2016, 2017; Kuzemko, Lockwood, Mitchell, & Hoggett, 2016; Mitchell, Woodman, Kuzemko, & Hoggett, 2015; Smith et al., 1993; Sovacool & Dworkin, 2015). For example, institutions and governments can enable or hinder access to sustainable cooking energy services through their use of policy instruments such as taxation and subsidies, quality controls, consumer protection laws, and enforcement mechanisms (Edomah, 2018; Eni et al., 2016; Mitchell et al., 2015; Sovacool & Dworkin, 2015; The World Bank, 2015). Moreover, targeted and sustained government support has played a positive role in improving energy access rates, including access to clean cooking technologies in Indonesia, India, China, and Nigeria (Edomah, 2018; IEA, 2017; Smith et al., 1993). More specific to this study, the success of the Chinese National Improved Stove Program (CNISP) was largely attributed to targeted policies and the role of the government in providing leadership, coordination, training, and necessary human capacity support (Smith et al., 1993). Overall, the continued roles of institutions and government support in China and Indonesia are credited with the declining proportions of the populations relying on kerosene and biomass fuels between the years 2000 and 2015 (IEA, 2017).

Conversely, the absence of good governance and institutional capacity has been shown to hamper energy access processes in developing countries, especially by demotivating private investment and stifling demand (AFDB, 2013). For example, the lack of good governance and institutional capacity in Kibera has led to the proliferation of illegal and informal businesses (Parsons, 1997), benefiting only a few, often wealthy and well-connected, outsiders and government officials (Joireman and Vanderpoel, 2010). These illicit operations exploit the demand created by high population density and the chronic lack of other affordable and reliable fuel alternatives (de Bercegol & Monstadt, 2018). This tight control of the market is enhanced by the collusion of local government actors[50], who maintain economic and social order in return for monetary gain.

Moreover, the absence of robust formal government and institutions makes it difficult for the government to collect taxes, fees for business permits, to regulate business to protect consumers from exploitation, or to enforce quality and safety standards for goods and services sold in the settlement. For example, while there are policies and regulatory frameworks in place to manage the production, distribution, and sale of charcoal in Kenya (i.e., the Charcoal Regulations of

[50] In Kibera, local government actors included: village elders -*Wazee wa mtaani* or wazee wa vijiji (elders of the slums or elders of villages), who are sought to resolve disputes in the community and serve as mediators between the Chief and the community, youth gangs, who parallel and oppose the rule of the Chief and Assistant Chief (de Bercegol & Monstadt, 2018), and are known for their fierce application of 'law and order' in their organization and management of socioeconomic activity and security details.

2009[51] and the 2015 Energy Bill[52], their enforcement is weak and marred by corruption nationwide and more so in Kibera (Wanjiru & Omedo, 2013). In Kibera, the near absence of formal government and the lack of institutional capacity have resulted in limited regulation and enforcement of the current charcoal regulations, leading to corrupt practices and also high charcoal prices for households[53]. Consequently, there remains over-dependence on charcoal, which continues to overshow these well-formulated policies and well-meaning efforts to implement them, as well as the numerous efforts to steer households towards cleaner and safer cooking alternatives, including: offering free or highly subsidized alternative technologies such as ICSs, free biogas cooking stations, or less polluting and more fuel-efficient alternatives such as biomass briquettes.

7.5.1.2. Demographic development and dynamics

In the NOA model, demographic development is said to be a multiplier because the more people there are, the greater the demand for goods and services (Gatersleben & Vlek, 1997, 1998). However, as the case of Kibera has shown, high population growth can also result in scarcity of resources, or in demand only for low-quality goods and services due lack of abilities and opportunities.

Moreover, changes in the demographic landscape and human living environments can also present enormous barriers to access and the fulfilment of needs. This can be as a result of the increased demand for limited energy services, more broadly, or as a result of lifestyle changes (Ahmad & Puppim De Oliveira, 2015; J. E. M. Arnold et al., 2006). The trends in Kenya appear to be pointing in this direction: By 2014, 50% of Kenya's population was thought to be younger than 18 (UN DESA, 2015), while Kenya's urban population is thought to be increasing by more

---

[51] Charcoal Regulations 2009, under the Forest Act, Ministry of Forestry and Wildlife (2009). *The Forests (Charcoal)*

Regulations, 2009. Adopted under Section 59 of the Forests Act 2005, Nairobi: Available at http://www.undp.org/content/dam/kenya/docs/energy_and_environment/Charcoal_regulations-1-.pdf

[52] Government of Kenya (2015). *The Energy Bill, 2015*. Nairobi. http://energy.go.ke/the-energy-bill-2015/

[53] The bribes paid to allow the transportation of illegal charcoal from rural to urban areas are transferred to consumers, making the retail prices extremely high in urban areas (Mwampamba et al., 2013; Sander et al., 2013; Zulu & Richardson, 2013). The cost is higher for households in informal settlements than in formal areas of Nairobi because of the further bribes paid to the local governance structures (mafia groups) that control its trade and market access in Kibera.

than 5% annually (UN-Habitat, 2014). Most of these new residents are thought to be socially and economically disadvantaged, and to settle in informal settlements such as Kibera (UN-Habitat and IHS-Erasmus University Rotterdam, 2018). A multiplier effect is also likely, as these young people begin new families that will create additional energy demand and present their own diverse needs. Lastly, the lack of accurate demographic data, as exemplified by Kibera, poses a barrier for developers of cooking energy services, policy makers, and other actors who wish to address these challenges currently facing the majority of Kibera residents. It can be extremely difficult to plan for the needs of current and future generations without accurate demographic data or the ability to project future demographic dynamics.

7.5.1.3. Social–culture dynamics

While the role of cultural incompatibility with the poor performance of ICSs is well documented, both in Africa and Asia (Barnes et al., 1994; Bowe et al., 2018; Dasgupta, Huq, Khaliquzzaman, Pandey, & Wheeler, 2006; De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Gill, 1987; Heltberg, 2004; Landrigan et al., 2017; Manibog, 1984; Mortimer et al., 2016; UNDP, The World Bank, & ESMAP, 2003) the role of cultural and socially gendered inequalities and power imbalances in relation to opportunities and abilities, especially in urban slum areas, has not been accorded much attention. However, the results suggest that the differing ways in which society treats and values women and men could result in gender inequality and power imbalances that influence the kinds of abilities and opportunities available to certain members of the household, influencing their ability to take action.

At the broader societal level, gender and power imbalances were reflected in access to and control of resources, especially financial resources; economic opportunities, and political and social participation. For example, women were often involved in the low-value end of the supply chain as venders, parkers, and transporters of goods and services, whereas men were involved in the high-value end of the supply value chain, in the production, distribution, and wholesale processes. These inequalities were further compounded by the fact that women and children, in addition to lacking abilities and opportunities to improve their access to appropriate and effective cooking energy services, also continued to suffer disproportionally from the use of dirty, polluting, inefficient, and time-consuming cooking energy services because of their direct and prominent involvement with cooking and other domestic activities (Bowe et al., 2018; Health Effects Institute, 2018; Landrigan et al., 2017; Mortimer et al., 2016; World Health Organization, 2016). Some observed scenarios imposed a 'double/multiple burden' of such risks. For example, individuals that cooked at home and also for a living, including domestic workers, street vendors, and commercial cooks; and those accompanied by infants or young children, either strapped on their backs or playing nearby could be said to be experiencing greater risks than those who are just involved with cooking with polluting fuels and ineffective technologies within the household. Therefore, the consideration of gender inequalities and power imbalances within and beyond the household is important for understanding not just why households choose certain technologies, but also why they fail to sustainably access certain desired cooking energy services despite their presence in the market. Moreover, addressing gender and power imbalances could greatly contribute to the equity and effectiveness of proposed solutions because, as the present findings suggest, such programs are unlikely to yield expected results if women (who are tasked with cooking in Kibera and most parts of the developing world) continue to be economically and socially marginalized based on their gender. Part of the solution lies in women's and men's equitable participation in social and economic activities both within the household and in broader societal contexts.

7.5.1.3. Natural living environments and in-built conditions

The challenges associated with access to affordable, reliable, efficient, clean, safe cooking energy services and the fulfilment of sought needs cannot be fully understood or addressed without the consideration of end-users' natural living environments and in-built conditions. As shown in this study and elsewhere, one's living and natural environments can influence needs, abilities, and opportunities to access cooking energy services (IEA, 2017; Stephenson et al., 2010; United Nations Development Programme (UNDP), 2000b) as well as the quality of outcomes (IEA, 2017; Landrigan et al., 2017; Quansah et al., 2017; Stephenson et al., 2010; Tielsch et al., 2016; United Nations Development Programme (UNDP), 2000b; Wathore et al., 2017). For example, the space heating needs of people living in the Kenyan highlands and the Great Rift Valley, which experience comparatively cool temperatures throughout the year, may differ from people living in northern Kenya where high temperatures are experienced throughout the year. People in Kibera enjoy relatively modest temperatures throughout the year; however, space heating is required during colder periods in June and July, especially for households with infants and young children. To fulfil their needs for space heating, households preferred to use basic improved cook stoves and open fires. As noted previously, ICSs were rejected partly because their design denied households the ability to fulfil this need.

The effectiveness of cooking energy services such as ICSs is also influenced by the use space, in-built conditions, and the surrounding environment. In Kibera, the poor state of housing (most of which lacks sufficient ventilation), poor environmental conditions (resulting from poor sanitation and waste management services), and severe ambient air pollution (from commercial, domestic, and industrial activities) as evident in the examples below, counteract any potential health benefits resulting from ICS use.

Environmental conditions in Kibera

Source: author

Highlighting these factors is important because it shows that access to affordable, reliable, efficient, clean, safe, and sustainable cooking technologies and fuels is more complex than simply having the opportunity to possess certain technologies and fuels. Rather, a holistic development approach would be required to take into account the role of non-technological forces in allowing or hindering the acceptance and effectiveness of technological interventions.

7.5.1.4. Economic development

In the NOA model, economic and technological development are mutually influential, and both, in turn, directly and indirectly influence consumer behavior through the availability of opportunities and abilities (Gatersleben & Vlek, 1997, 1998). In Kibera, the lack of a vibrant formal local economy and locally generated and produced clean and advanced, including ICSs cooking energy services was detrimental sustainable access to cooking energy services efforts in Kibera on several fronts:

Firstly, it deprived residents of the opportunity to develop a thriving ICS production industry, and perpetuated dependence on the aid sector and vibrant overseas economies such as China.

Secondly, outsourced goods and services were judged harshly (as being out of touch with people's needs, preferences, and realities) and hence rejected.

Thirdly, the local economic activity, which benefited only a few, hindered the development of a formal and inclusive economy. A counterargument could also be made, that: Informal economies allow local entrepreneurial initiatives, which could generate opportunities and abilities at the local levels, whereas formal economies enrich the already-rich and drain money straight out of local circulation. However, the informal (and often corrupt) sector in Kibera often exploited residents' vulnerabilities to advance personal interests.

Beyond the lack of locally made good and services, or the opportunity to contribute to an enabling economy, poor economic development is associated with lack of income-generating opportunities to support basic livelihoods. In the absence of formal employment in the public and private sectors, Kibera residents had taken matters into their own hands to fend for themselves and their families. Most residents were engaged in the informal sector, commonly known in Kenya as the *jua kali sector* in Swahili (the vicious sun business). While such enterprises are not uncommon in Kenya (according to the World Bank (2016) over 80% of Kenyan employment is in the informal sector), what makes Kibera unique is that most businesses and economic activities are not only informal but are also illegal. Hence, local council officials regularly destroy property and make arrests to deter people from engaging in these activities. This can result in total loss of property and hefty fines. Therefore, the lack of a vibrant and regulated local and national economy is a barrier to the success and effectiveness of technologies such as ICSs, because it greatly affects the nature and flow of secure and reliable household income. As highlighted in the NOA model, and as discussed in the Abilities and Opportunities sections, the potential to take consumer action depends on one's financial abilities and the availability of reasonably priced commodities.

7.5.1.6. National and international policies and energy access initiatives

The overarching goals at the macro level have been to ensure access to clean, modern, and affordable cooking energy for all, as underscored in the SDG 7. In the context of this goal, cooking energy policies, proposed solutions, and implementation strategies, especially in the Global South, have remained narrowly focused on technological development and financing, with a focus on achieving energy efficiency and environmental protection (Van Der Kroon et al., 2013)[54]These processes are supported by specific initiatives at the global level, such as UN SEforALL and GACC, which have mounted campaigns and calls for collective action and partnerships to address the energy challenges facing well over half of the global population, especially in the Global South (OECD/IEA, 2017). For example, GACC, established in 2010, aims to distribute 100 million ICSs by 2020 (Ramirez et al., 2014; Smith, 2010). While such efforts are instrumental in easing the up-front financial burden associated with the use of ICSs, especially for households in low socioeconomic communities, such processes are problematic because:

1) They fail to acknowledge that one-time charitable donations do not help households address the underlying abilities and opportunities challenges (described previously), to thereby enable long-term access, use, and effectiveness;
2) They fail to reveal the underlying reasons why individuals and societies demand and consume particular cooking energy services (Groves et al., 2017; Elizabeth Shove & Walker, 2014) and the realities of their intended beneficiaries.

Hence, as evidence from Kibera has shown, despite good intentions, these energy policies and implementation strategies result in energy solutions that enable certain functions while compromising the achievement of some of the most pressing needs of their intended beneficiaries. However, as Rogers, (2003) notes, "it does not matter so much whether an innovation has a great deal of "objective advantage". What does matter is whether an individual perceives the innovation as advantageous" (p.15). Hence, as was demonstrated previously: What may appear advantageous from the perspectives of ICS developers and implementers, may be a disadvantage from the household perspective. By emphasizing characteristics such as fuel

[54] This discourse is also evident in the focus on policies developed at the nation and international levels and with Kenya's energy investment commitment, as highlighted in the in the Literature Review chapter.

efficiency (which are regarded as important or prioritized by external actors) at the expense of satisfying the needs valued and/or prioritized by households, previous attempts have failed to motivate end-users to desire, acquire, or use ICS services. Therefore, in addition to considering technological performance such as fuel-efficiency, there needs to be social and cultural sensitivity around the reasons why households seek and demand certain characteristics in cooking technologies. This is because, as noted by Chambers (1986:4) "unless poor people, their needs interests and priorities, are put first; the objectives for environment and for development will themselves not be attained." These technologies are intended for end-users, and therefore their success ultimately depends on acceptance by these users, and the presence of appropriate abilities and opportunities that enable them to be accessed and used in sustainable and effective ways.

7.5.2. Meso-level forces

There is considerable attention to the role of macro-levels forces in influencing consumer behavior in both the NOA model and in the current energy access discourse. However, little consideration is given to how consumers in informal settlements like Kibera—where macro-level forces are either absent, underdeveloped, or overwhelmed—manage to meet their survival and basic needs. However, in Kibera, meso-level forces remain the most powerful and influential factors in controlling social and economic abilities and opportunities, including the supply and demand for cooking energy services. This is corroborated by a recent study in Kibera (de Bercegol & Monstadt, 2018), which noted that, "the complex picture of the underlying dynamics and politics shows that urban slums are neither chaotic sites without service provision, nor the underdevelopment spaces that are represented in developing discourse" (p.257). Moreover, previous research into the functioning of low-socioeconomic urban communities shows that individuals self-organize into networks to develop social capital and functioning survival skills that are more robust and sustainable than previously assumed (Sánchez-Jankowski, 2008). The role of kinship support systems and support networks in enhancing social capital has been documented in both developing and developed countries alike (Pitt, 1976; Sánchez-Jankowski, 2008). In the context of this thesis, social capital is defined as capabilities acquired by members of a community, resulting from self-organization enacted at the local level due to weak or non-existent formal institutions or government support at that local level (Bourdieu, 1986; Coleman, 1988), defined earlier in this chapter as the meso-level forces. The meso-level forces identified as influencing household needs, abilities, and opportunities in Kibera were associated with support organizations (NGOs, religious, and charitable organizations), value chain networks, local government actors, and social and economic networks, as highlighted and discussed below.

7.5.2.1. Support organizations

Being an informal settlement, and lacking in many basic human services and infrastructure, Kibera attracts many national and international organizations as well as religious and charitable organization that seek to fill the gaps in basic social services in the areas of education, health care, sanitation services, clean and safe water drinking, and clean cooking energy services. In Kibera, such organizations address needs by distributing and installing alternative energy services such as biogas, and through direct gifts of cooking technologies such as ICSs. They also address opportunities and abilities through providing subsidies and payment methods compatible with the realities of residents' household incomes. While these kinds of activities do not necessarily guarantee acceptance, sustainable use, or secure paths towards sustained access, they are instrumental in alleviating the heavy socioeconomic burdens experienced by Kibera residents as a result of lacking government social services. Moreover, their strong and long-term presence makes them trusted sources of information. The disadvantage is that such practices could perpetuate dependency and hinder local development by saturating the market with goods and services that hinder the growth of the local and national economy, especially if such goods are imported. Nevertheless, such organizations, especially those that are based locally, present an untapped window of opportunity because of their direct connection to residents.

7.5.2.2. Value chain networks

The value chain networks in Kibera are complex and secretive due to their illegal and informal nature and activities. However, their existence is a hallmark of life in Kibera, where relationships between suppliers and their local clients are symbiotic and much valued for the abilities and opportunities they generate. My research findings support the point made by Myers, (2015:333) who notes that most informal settlements in Nairobi have their own rules of operation that are evaluated on two levels of extremes: firstly, as an indicator of self-organization amidst the lack of attention from the formal macro-level mechanisms; and secondly, as a "manifestation of longer-term processes of the production and reproduction of poverty and inequality". This is particularly evident in the charcoal industry, where cartels are known to continually sabotage government efforts to regulate and control the production and distribution of charcoal through the use of corrupt practices and non-compliance with current laws (J. E. M. Arnold et al., 2006; Foster, 2000; Girard, 2002a; Sander et al., 2013; Zulu & Richardson, 2013). These cartels have significant influence and ability to frame and control the slum narratives, and tightly control goods and services entering and leaving Kibera by positioning themselves as an alternative to the government's absence and shortcomings. Moreover, the exclusive power to include or exclude actors within the local social–economic context has left vulnerable residents fully dependent on and loyal to their brands, reinforcing their legitimacy and consumer dependency. As meso-level forces, this implies that residents' reception of clean and more sustainable cooking energy solutions will be strongly influenced by whether the cartels consider them an opportunity or a threat to their own survival. Against this background, it is extremely important to acknowledge and to seek to understand the role played by such actors, in influencing sustained access to advocated cooking energy services.

7.5.2.3. Local governance and institutional systems

A limitation of the current literature and the NOA model, in assessing the role of governance and institutional structures in energy access process, is the tendency to focus only on formal contexts and hence formal governance and institutional structures. This, however, ignores the role of informal governance and institutional structures that predominately wield power and influence within informal contexts such as Kibera (de Bercegol & Monstadt, 2018; Myers, 2015). In the absence of formal governance and institutions, local governing systems and institutions have established order in exchange for sharing existing but scarce local socioeconomic resources, as it is evident in Kibera. These findings support those of a recent study on electrification in Kibera (de Bercegol & Monstadt, 2018), in which youth gangs and economic mafias similarly influenced the presence of and access to electricity services, despite governmental efforts to provide safe electricity to residents. In the present study, these informal actors governed and maintained the flow of illegal charcoal into Kibera, in return for monetary gains, making it extremely difficult to enforce the charcoal regulations established by the government in 2009. As (de Bercegol and Monstadt 2018: p. 249) note, informal energy service providers and cartels in Kibera exact a strong influence in defiance of state attempts to “align the service provision to existing standards, to push back illegal taps, [and to] reduce customer dependence on charcoal and petroleum”. These examples demonstrate the complexities of addressing clean cooking energy challenges, and underscore the inadequacies of narrowly technologically and economically focused strategies. However, despite some possible challenges, such as the strong influence of self-interest, the pre-existence of locally established governing structures presents untapped opportunities. Their awareness of the local context, the needs and aspirations of residents, and the power dynamics that exist within their jurisdictions, could be leveraged as entry points to build partnerships and context-applicable clean cooking energy solutions.

7.5.2.4. Social and economic networks

The role of social and economic networks in enhancing social–economic welfare is not a new phenomenon in either developing or developed countries (Pitt, 1976; Sánchez-Jankowski, 2008). Social and economic networks are known to be an instrumental in the lives of people in lower socioeconomic communities by providing social and economic support, and opportunities that enable households to diversify resources and maneuver for scarce and often rare opportunities and abilities (Parnell & Pieterse, 2014). Their presence in both developed and developing countries has been attributed to the functioning of poor urban communities (Sánchez-Jankowski, 2008). These views are emphasized in the work of Pitt, (1976), who writes of the great value placed on social and personalized group in the Global South, and by Forouzanfar et al. (2016) whose work has focused on the positive social structures and networks in poor urban neighborhoods in developed and emerging countries. Carole Rakodi's chapter titled Religion and social life in African cities (2014) eloquently captures the essence of social organization and economic networks in informal settlements in Africa by noting:

> The extreme view that all African cities are unruly, confliction and socially dysfunctional is a mistake. In practice many urban residents succeed in forging good lives for themselves and their families; families and winder social groups continue to provide social and moral support; and new ways of thinking and doing things result in progressive social change (Parnell and Pieterse 2014: 101)

In Kibera, social and economic networks were crucial in driving initial adaptation of ICSs, but more so the initial adoption of other cleaner cooking technologies such as LPG and bioethanol stoves. For example, membership of one of the many social–economic networks in Kibera was attributed to the direct or indirect ownership of ICSs, LPG, and bioethanol stoves by both opinion leaders and household representatives alike. Similarly, previous studies have shown that social networks played an essential positive role in the success of public health initiatives in Tanzania

(Mohammed, 2001), successful micro-financing and livelihood interventions in India (Bali Swain & Wallentin, 2012; Rangan, Quelch, Herrero, & Barton, 2007), dissemination of rainwater harvesting tanks among households in coastal Bangladesh (Samaddar, Murase, & Okada, 2014), and, more specific to this study, diffusion of non-traditional cook stoves in western Honduras (Ramirez et al., 2014).

However, while such groups provided diverse opportunities and enhanced abilities to access cooking energy services, they could also present a host of unintended negative consequences such as peer pressure and exclusion. One such example was raised by an opinion leader interviewed for this study, who noted that financially weaker members are often driven by group pressure to take up consumer actions that exceed their financial capacity. This can cause personal distress and often compromise their ability to meet other essential basic needs such as food, water, and housing, with negative consequences for the wellbeing of the individuals involved and their dependents. Nevertheless, with appropriate caution, and in the presence of other support mechanisms, such networks provide promising paths to initiate sustainable access to cooking energy services (Kumar & Igdalsky, 2019; Ramirez et al., 2014). It is therefore in the interests of policy makers and implementers of cooking energy solutions to understand how these networks function in Kibera, what drives their choices of action, and how their influence can be leveraged to facilitate positive, sustainable, and effective access to clean cooking energy services within contexts like Kibera, and beyond.

7.5.3. Micro-level forces

As relevant as these macro and meso-level influences are, there is a tendency to overemphasize them (especially the macro-level forces) in current processes relating to cooking energy access. However, the concerted efforts made by households to address their cooking energy needs, despite hardship, deserve considerable attention. In this section, I focus especially on household strategies of fuel stacking, user innovation, and the re-use and recycling of fuel resources. These demonstrate residents' resilience in addressing their needs by self-generating cooking energy opportunities and abilities.

7.5.3.1. Technology and fuel stacking

Stacking is a term used in the literature as ‘fuel stacking’ or ‘technology stacking’ to describe the ownership of multiple fuels and technologies within households, especially in developing country contexts (Heltberg, 2005; Masera et al., 2000; UNDP et al., 2003). As shown in this study and elsewhere in Kenya, Tanzania, Guatemala, Mexico, and India (Foster, 2000; R. H. Hosier & Kipondya, 1993; Masera et al., 2000), stacking of both cooking technologies and fuel is a common practice among both wealth and poor households in the developing world. In Kibera more specifically, households employed stacking to cope with:

1) The insecurities resulting from irregular and insufficient employment opportunities and secure incomes;
2) Price volatility and/or overpriced goods and services;
3) Unreliable supply of technologies, fuels, and support services such as repairs and maintenance services, due to overdependence on outsourced resources—both human and material; and
4) Technological inadequacies, such as lack of warning systems to alert households about depleted fuel levels when using LPG stoves, etc.

In response, households seek to diversify their cooking energy services mix, to guarantee that their needs will be meet in the event that their preferred cooking technologies become unavailable or unaffordable. In Kibera for example, stacking enabled households to use clean and safe cooking energy services whenever abilities and opportunities were available; and when unavailable, reserves were used as backups. Therefore, while such strategies presents some risks to households, the kinds of cooking energy technologies and fuels currently available and used by households could be useful as points of orientation for tailoring solutions that households want.

7.5.3.2. User innovation

Users also used creative ways to manage their fuel use and to address the lack of appropriate cooking technologies. One of the main techniques was the use of shielded fires, mainly within Nubian households, which predominantly use open fires. The technique is said to prevent the loss of thermal heat by directing most of the energy generated to the cooking pot. This technique is also known to protect the cook from burns and excessive heat during the hot seasons (Clark & Dickson, 2003; Kates et al., 2001). Indeed, some have argued that such techniques post better safety and fuel efficiency results than those claimed by some biomass ICSs (De Lepeleire G, Krishna Prasad K, Verhaart P, 1981; Gill, 1987). In Kibera, household representatives from the

Nubian community claimed that these kinds of practices, which also enable the use of less fuel (charcoal and firewood), allowed them to save on fuel and also maintain their traditional cooking practices. Nubian communities are known for their elaborate family, communal ceremonial food preparations that require many hours to prepare. Nubians also believe that slow, rather than fast cooking, enhances the taste of food and drink. Therefore, another advantage of promoting such techniques, especially for communal cooking, is that it would ensure that social–cultural values and norms are respected and preserved while also fulfilling other goals such as fuel efficiency and safety.

7.5.3.3. The re-use and recycling of fuel resources

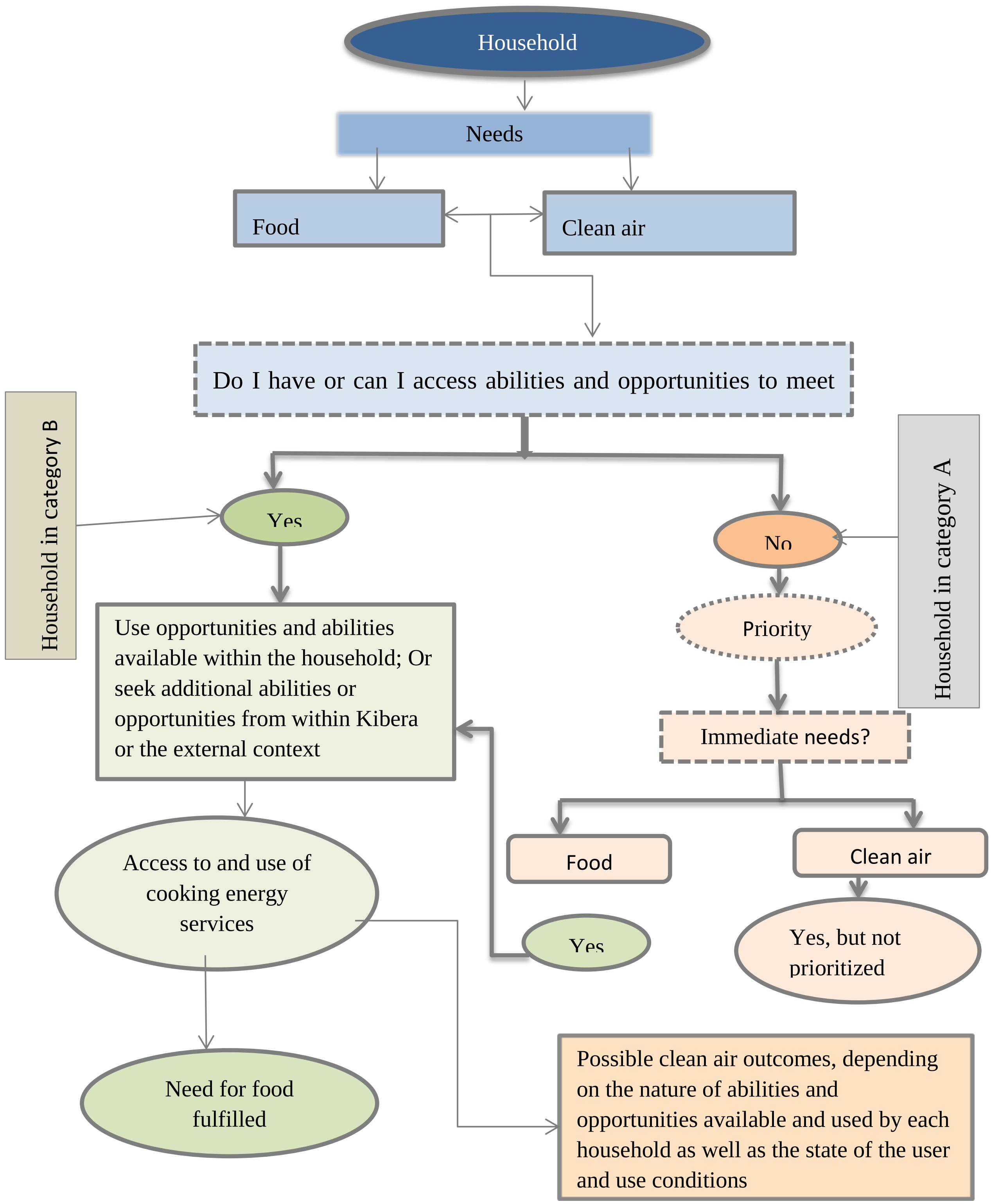
To minimize expenditure on charcoal, women have devised a process of mixing dirt with charcoal dust (often disposed as waste by more affluent families and charcoal retailers) with water in front of or inside their shacks, to make briquettes commonly known as *pungunza* (meaning reduced price). These briquettes are made for personal use, but surplus is sold to other households and street cooks to supplement household income. While their effects on people and the environment are not yet known, the use of charcoal dust is a positive contribution by households in meeting their needs and enhancing sought impacts on two levels. Firstly, it enhances self-reliance and independence. Secondly, such practices have the potential to promote responsible resource use and to reduce the high demand for charcoal, through the use of byproducts that are currently under-utilized or wasted.

Note: This first picture below shows a women making *pungunza,* while the other shows the finished product which requires time to dry prior to use.

Source: author

Based on this analysis, it is clear that households have needs that they can/cannot meet via their abilities and opportunities, as determined by conditions of their internal context (micro level) and the societal context (at the meso and macro levels). The diagram below demonstrates a typical household's decision-making process and outcomes, using the examples of cooked food and clean air, based on the available and accessible abilities and opportunities for household A and B. As shown in diagram below, the primary need for cooked food can be achieved regardless of the means (technology and fuel) used, as long as there are available abilities and opportunities to facilitate ownership of a technology and fuel. However, to achieve the need for clean air, additional abilities and opportunities are necessary. This relates to the quality of the technology and fuels used as well as factors relating to the individual user and conditions of use. For example, households may all use a biomass ICS of the same quality and value, and achieve a similar desire for cooked food, but the air quality might be different depending on the circumstances of use. In this case, a household cooking in a well-ventilated kitchen / cooking space might experience less exposure to harmful particulate matter ($PM_{2.5}$) and enjoy better air quality than a comparable household using the same stove and fuel with poorer ventilation.

Figure 16: Household decision-making process and possible outcomes using the examples of food and clean air needs



Source: developed by author

7.6 Summary

This analysis endeavored to provide a better understanding of the factors that enable or hinder sustainable access to cooking energy services within households in Kibera, with the specific focus on ICSs. This was achieved by employing the Cooking Energy Access Landscape, inspired by the NOA model. More specifically, the integration of meso-level factors into the framework and the deeper assessment of enabling and hindering conditions from the household perspective, by focusing on the two categories of households (constrained and transitional, respectively A and B) facilitated: the identification of disparities between forces at the macro, meso, and micro levels, which strengthen the arguments made in this thesis that while technological solutions are a part of the solution, providing enabling abilities and opportunities for households to access and use them in sustainable ways is also crucially important. In summary, this analysis has shown that:

At present, most actors seek to address the challenges of cooking energy access by primarily focusing on the macro-level forces, whereas in contexts like Kibera meso-level forces wield more influence over households' needs, abilities, and opportunities, and hence the success or failure of macro-level interventions.

In terms of the role of technological solutions such as ICSs, this thesis has shown the necessity of first understanding end-users' diverse needs before designing and developing cooking technologies. This will increase acceptance of such technologies. Once an appropriate technology has been developed, the abilities and opportunities within the household and the immediate societal context (rather than the presence or absence of advanced cooking technologies) become the decisive factors in whether or not a technology can be accessed.

The status of socioeconomic, environmental, and enabling conditions are critical in influencing long-term access and use of sustainable cooking energy services as well as their effectiveness. Hence, contrary to the portrayal of access to clean cooking energy services as being straightforward and influenced by the availability of technologies, the case of Kibera has shown that households' decision-making processes relating to cooking energy are complex and often unpredictable. This unpredictability and apparent chaos results from the complexity of interactions among influences at the three levels of society. Therefore, while households have the final responsibility to adopt and/or sustain the use of low-carbon technologies and fuels, gaps within households and in the wider social systems present end-users with daunting challenges in making informed and sustainable decisions about appropriate and feasible choices regarding cooking technologies and fuels.

However, regardless of contextual conditions in Kibera, some individual households are attempting and achieving steps towards using low-carbon technologies and fuels, supported by clear and well-defined enabling conditions that are often locally generated. Such conditions, however, are fragile and could be lost at any time, thereby compromising the sustainability of access due to lack of social–economic enabling conditions. Therefore, if such barriers are identified and appropriately addressed, and current enabling conditions enhanced and stabilized, there can be huge potential to unlock a widespread household transition to low-carbon technologies, capitalizing on the wishes of end-users and the need that exists within households for alternative, more appropriate, and convenient cooking practices.

Last, but not least, while there is much data available about the risks, burdens, and benefits of transitioning to sustainable and efficient cooking energy services, there is still a lack of structures and processes that allow meaningful integration of decision-making, policy processes, and the users (households) who seek to inform their decision making.

Therefore, rather than a lack of household interest in accessing and using available cleaner, safer and more modern cooking energy services, this thesis concludes that it is the failure to understand and account for households' diverse needs and preferences that results in the rejection or abandonment of available solutions such as ICSs. In the event that appropriate technologies are developed, households encounter a multitude of factors at the household, local, and broader societal levels, which act as barriers to sustained access, use, and effectiveness. Hence, biomass ICS intervention strategies need to be nested within broader approaches to systemic change. As stand-alone processes, their envisioned positive impacts for people and the environment are limited, especially in contexts like Kibera.

7.7 Study limitation

While I took utmost care to ensure methodological and theoretical soundness in conducting this research, I encountered several limitations. Firstly, the use of a single case study limited the scope of information collected, which might otherwise have permitted assessing the situation in other informal settlements and complemented the data from Kibera. Therefore, there are grounds for questioning the generalizability of the results beyond the context of Kibera. However, the assessment of the factors that enable or hinder sustainable access to and effectiveness of ICSs and other cleaner cooking energy services at the structural level go beyond Kibera, providing a strong basis for the generalization.

Moreover, the use of interviews presented some constraints because there were tendencies, especially at the pilot level, for household representatives to over- or under-report the kinds of cooking technologies present and used within the household. I sought to minimize this issue by conducting interviews within cooking and living contexts, thereby enabling direct observations. The use of observations and photography enabled the triangulation of interview data. Moreover, multiple visits to a household, enabled by the trust developed at the pilot study phase, were instrumental in the free flow of information. This was particularly important in navigating the culture of secrecy that is part of the reality of life in Kibera.

Another limitation was a lack of data and accurate information on Kibera, such as demographic data. There are several differing figures quoted in the gray literature, reports from international organizations, local and international media, and the government, which differ greatly from local reports. This was compounded by the lack of scientific data on the issue of access to sustainable and effective cooking energy services, and more specifically on ICSs, in socioeconomically disadvantaged urban contexts, due to overemphasis on rural contexts within the literature. This made it extremely difficult to cross-check the accuracy of the information I was receiving on the ground. However, while such lack of information was challenging, it provided me with an opportunity to provide new insights into the state of the art concerning cooking energy access, and to highlight some barriers that would need to be addressed and also some opportunities that could be leveraged to make progress in the sector. For example, the use of a multi-level assessment approach sets itself apart from the predominantly technological and economic theories and approaches that are most commonly used to explain technology diffusion, thereby providing a rare avenue to capture the nested factors that influence household decision-making processes on cooking energy, beyond the presence of technologies such as ICSs.

8. Recommendations for strengthening sustainable and effective access to cooking energy services

This thesis showed that cooking-energy-related needs, and the factors that enable or hinder sustained access to sustainable and effective cooking energy services, are nested in households' everyday functions and the contexts in which they are embedded. Moreover, while households experience firsthand the negative or positive effects of energy production and consumption practices, they will—regardless of wealth or location—be exposed to the consequences of unsustainable production and consumption of dirty and polluting cooking energy services. As an example, air pollution or climate change does not respect borders. Therefore, what is at stake is more than questions concerning household access to appropriate, effective, and sustainable cooking energy services or the achievement of SDG 7 by the year 2030. Instead, it is a question of survival and whether humans can live together sustainably on this planet in the long term. This is why the short- and long-term production and consumption of cooking energy services in low-socioeconomic urban communities such as Kibera should matter to local governments and the international community alike. Moreover, it is why new thinking and approaches are needed to leverage the already positive work happening on the ground, and to rethink how the current challenges can be turned into opportunities for current and future generations. Against this background, and based on the findings from Kibera, this chapter provides recommendations for how identified opportunities can be leveraged, and how challenges can be addressed, to enable long- term access to sustainable and effective cooking energy services for current and future generations in Kibera and beyond. Challenges imply factors that hinder access to appropriate, effective, and sustainable cooking energy services. Opportunities, in this context, imply factors that do or could enable households to address their cooking-energy-related needs. The recommendations are not presented in any particular order, but touch on all three analytical levels of society (micro, meso, and macro) applied in this thesis, and address the general conceptual structure of needs, opportunities, and abilities.

8.1. Recommendations for improving acceptance of clean and efficient cooking energy services

8.1.1. Understand household needs and account for these in energy services

Policy framing and implementation, concerning access to cooking energy, currently center around environmental and climate protection, mostly ignoring the vital role of cooking energy services as facilitators of user needs and preservation of sociocultural values and norms. While aligning cooking energy production and consumption activities with climate commitments reflects the changing realities of energy demand dynamics and the roles that energy production and consumption play in sustainable development processes and climate protection efforts, the failure to account for users' needs risks the rejection or abandonment of available solutions. However, if universal clean, affordable, reliable, and sustainable energy access is the goal, then user-centered solutions must be the guiding principle. The first step would be to understand and incorporate user needs into cooking energy policy and solutions.

8.1.2. Get the entire household and the broader community on board

While there are clear justifications for targeting women when promoting access to clean cooking interventions, the failure to include men and the entire community is a missed opportunity. Although women are commonly responsible for household cooking and face immediate risks from using polluting fuels and inefficient technologies, they often lack the necessary abilities and opportunities to change or sustain their efforts to use cleaner and fuel-efficient cooking energy services. On the other hand, it is presumed that men are disinterested in issues of cooking energy access and use within the household. However, to make progress and to address the gender inequality that is perpetuated by focusing only on women, shared responsibilities between women and men should be encouraged. This inclusion of men is especially important in contexts like Kibera, where the percentages of men are higher in some villages than those of single women or women in traditional partnerships (Desgroppes & Taupin, 2011). The present findings also showed that men, more than women, were responsible for the purchase of ICSs at the KTC (see the Result chapter. Moreover, in general, men were more closely involved than women in the cooking energy service value chains. Therefore, the inclusion of men needs to be approached in a gender-sensitive way, so that it does not re-center men as key informants or decision makers.

8.1.3. Leverage user-readiness, visions, and efforts

While the disadvantages encountered by households in Kibera cannot be discounted, there is a tendency to overemphasize this aspect of the cooking energy discourse. However, as the case study made clear, households are the experts in their own needs, and manage to meet such needs with or without international aid. Hence, there is value in leveraging such efforts and visions in order to drive change. An important example of a vision expressed by Kibera households is the overwhelming preference for LPG as the primary cooking fuel. This can be leveraged to institute appropriate opportunities and abilities to address the up-front cost, high prices, and unsafe and irregular supply of LPG that presently impede households' efforts. Universal and sustainable access to LPG in Kibera would be a game charger, especially in combination with electricity as a complementary source of cooking energy, because both household representatives and opinion leaders stated that the presence of LPG in the household encouraged men to participate in cooking activities. Moreover, social and economic networks play a crucial role in enhancing livelihoods and access to cooking energy services. Their position as change agents can be leveraged to spread information about possible solutions in a rapid and inexpensive way. Furthermore, their access to local people; good working knowledge of local contexts in addition to political and social arrangements and functioning; as well as their understanding of the diverse needs and challenges facing households, uniquely position these networks as an entry point for instituting change in the cooking energy sector and beyond.

8.1.4. Support for alternative livelihoods

The transformations required to meet universal, sustainable, and effective cooking energy and climate goals would have real social and economic losers. Therefore, it would be necessary to develop alternative livelihoods, especially for the people who currently depend on the sale of biomass and fossil fuels as their main livelihoods, both in urban and rural areas. The iShack project[55] in the Enkanini settlement of Cape Town, South Africa could provide inspiration for such processes in Kibera. Through participatory identification of needs, abilities, opportunities,

[55] The iShack project is a public–private partnership whose focus is to provide renewable energy services to underserved communities in Cape Town. It also supports and trains local residents to development their abilities and opportunities, including employment opportunities, to ensure acceptance, long-term access and productive use and sustainability, and individual and community wellbeing. For more information, see: https://www.ishackproject.co.za

and strategizing (involving residents, researchers, policy makers, activists, and civil society organizations, etc.), acceptable long-term strategies could be developed to introduce cooking energy services that replace charcoal, firewood, and kerosene; effectively meet the needs of users (households, street-food vendors, institutional cooking); and provide livelihood opportunities for people who currently rely on the sale of illegal electricity, charcoal, firewood, and kerosene.

8.2.Recommendations for strengthening access to opportunities

8.2.1Increase the ambition of energy access solutions by promoting a mixed cooking-energy portfolio

A dominant narrative in the cooking energy access discourse has elevated ICSs as the main solution to the cooking energy challenges faced by households in low socioeconomic communities, especially in Sub-Saharan Africa. Consequently, for the last 40 years, the adoption of ICSs has been the dominant standard against which progress on access to cleaner and energy-efficient cooking energy services has been measured. However, ICSs as stand-alone interventions are not suited to fulfilling diverse household needs; nor (as the analysis has shown) to address current and future demand, health, and environmental challenges. These trends can present both opportunities and challenges, depending on how the phenomena are understood and approached. The outcomes (i.e., opportunities or challenges) will depend on the speed and nature of actions taken at all levels of society (micro, meso, and macro). One possible solution is to abandon the singular focus on technological interventions, in favor of a mixed cooking-energy portfolio. However, to be acceptable, sustainable, and effective, such solutions would need to take into account household needs, abilities, and opportunities in different contexts, as well as the need to protect the environment. Such an approach is consistent with the realities of cooking practices within households that have secure abilities and opportunities, in both developing and developing countries. Diverse cooking-energy portfolios therefore have the potential to significantly scale back on the use of biomass and fossil fuels, especially in urban contexts, as households become aware and experience the benefits of alternative cooking energy services. Hence, holistic, context-specific approaches are needed to address the structural conditions that undermine sustained access and use and enjoyment of associated co-benefits in parallel to the strategic introduction of technologies and fuels and livelihood support initiatives (see Recommendation 1).

8.2.1. Support innovative and non-exploitative financial mechanisms that are allied with households' economic realities

Financing mechanisms, in support of access to cooking energy services, have mainly taken conventional and traditional approaches in which bank loans, subsidies, and free gifts in the form of aid, are prioritized over local social and economic empowerment and development strategies. However, in contexts like Kibera, such strategies, while well intended, are ineffective because they are often hijacked to benefit well-connected households or certain actors in the supply chain, for whom they were not intended. In other cases, formal institutions such as banks are absent or reluctant to deal with households in lower socioeconomic communities because of financial risks.

However, alternatives to conventional financing approaches are available. These include: opportunities presented by social and economic networks and organizations such as the KTC, micro lending, instalment payments, mobile banking and payment services, and other innovative payment methods such as pay-as-you-go (PAYG). Such processes should be supported and encouraged, especially to addresses the barrier of high up-front costs of cleaner cooking energy services such as LPG, and to mitigate the burdens associated with the high interest rates typically charged (by both conventional banks and informal lenders) to the poorest borrowers.

8.3.Recommendations for strengthening abilities

8.3.1. Invest in human development

End-users must be sought and included as co-creators rather than just observers and passive consumers of finished products. People need to know, through learning processes: what needs to be changed, why such change is needed, and what opportunities are available to facilitate and sustain change processes. In *Limits to Growth* (Meadows et al., 2004: 280), learning is defined as the "willingness to slowly try things out, and to collect information about the effect of action (or non-action) including the crucial but not always welcome information that the action is not working." Learning processes also present opportunities to envision different conditions. Meadows et al. (2004) highlight visioning as an important tool for the transition to sustainability. They note: "Visioning means imagining, at first generally and then with increasing specificity, what you really want. That is, what you really want, and not what you have learned to be willing to settle for" (Meadows et al., 2004: p. 272). Learning processes could provide an environment for envisioning new and alternative cooking processes, which could inspire long-term and sustainable change.

8.3.2. Support localized and meaningful information sharing

There is considerable information and sound research on the need for clean, efficient, and sustainable cooking energy production and consumption practices, as demonstrated in chapter three. However, evidence from Kibera showed that there is very little awareness of the advantages and disadvantage of clean and fuel-efficient cooking energy services because very little information reaches the people responsible for household cooking practices, especially in low socioeconomic communities and the wider public. Consequently, there is an urgent need to develop and promote locally tailored and focused knowledge-sharing and awareness-creation processes, or as one opinion leader noted, “localization of knowledge and information”. Existing local social and economic networks, schools, and religious organizations are particularly suited to these tasks. These institutions are well respected and trusted, have direct access to their members and the wider public, and could facilitate the spread of information in a language and in terms that people in local communities can understand and relate to. Moreover, inclusive information-sharing and awareness-raising activities, involving both men and women, could present the best approach to tackling taboos, while acknowledging the reality that culturally and gender-biased attitudes and roles are deeply entrenched at every level of society.

8.3.3. Encourage and support household bookkeeping

Most households in Kibera were not aware of the amount they spent on technologies or fuels, because of the nature of purchases (on a need basis, and when money allowed) and the lack of receipts or monthly bills. However, by recording how much is spent (per month/week/day), individuals can quantify the real value and cost of their cooking fuel and technologies, compare them with other available options, and make informed decisions. These efforts could be reinforced by price-control and consumer-protection mechanisms, to mitigate exploitative prices and unregulated price fluctuation, which are the norm in Kibera. Moreover, the ‘mobile money’ revolution in Kenya also presents an opportunity, because people using mobile payments could benefit from recording their cumulative expenditures.

8.4.Recommendations for improving sustained access to sustainable cooking energy services

8.4.1. Strengthen leadership and institutions at the local and national levels

As is clear from Figure 9 in the Literature Review, international aid institutions, and nongovernmental and charitable organizations dominate the cooking energy access space. However, while these organizations and institutions can play an important role in enabling energy access processes, the role of local government and local institutions cannot be overlooked. As emphasized by Lucas et al. (2008), policies are more effective if implemented by local actors. This was evident in Kibera, where meso-level forces wield substantial power and influence over macro-level forces. Institutions and governance structures at the local level are more in touch with local needs and challenges, and from a political point of view, are more directly accountable to their electorate or the people they govern. Therefore, while international financial institutions and other charitable organizations play valuable roles in this sector, national and local governments are in a unique position to steer the nation and local comminutes towards a clear vision and goal. Equally important is their role in ensuring secure environments that enable external support to flourish; supporting local economic development, skill development, and training; enforcement of existing laws and regulations; as well as providing social services that complement and support users, to enjoy the full benefits offered by clean and efficient cooking energy services. These opportunities could translate into secure and regular incomes; reliable and secure supply of cooking energy services; and employment and skills-development opportunities for local consumers, enabling them to sustainably access clean and fuel-efficient cooking energy services. Therefore, care should be taken when designing and implementing cooking energy access policies and solutions to ensure meaningful collaboration with local governments and institutions. In other words, international aid institutions and nongovernmental and charitable organizations should aim to support local governments' efforts, and refrain from acting as substitutes to their efforts or lack thereof. Such an approach is critical for strengthening partnerships, acceptance, ownership, and sustainability of cooking energy access policies and implementation processes. Aim for long-term strategic planning.

The full scale of energy access challenges has not yet emerged, given the lack of sufficient and accurate data (e.g., demographic data in the case of Kibera) and the scale of needs presented by growing populations; changing demographics, settlements dynamics, and lifestyles; and reduced natural resources resulting from climate change. However, on the basis of reliable demographic data, combined with the kinds of partnerships and collaborations proposed in Recommendation 1 and 4.1 above, local governments their international partners could take advantage of available data and trends to put forward long-term plans and thereby adapt early to these challenges. Moreover, the development and dissemination of sustainable and effective cooking energy services, and more specifically of ICSs, will require ongoing holistic and deep understanding and consideration of human, societal, and environmental factors and conditions in order to remain relevant in effectively addressing the ever-changing needs of households.

8.4.2 Introduction and enforce existing rules on biomass production and consumption

The reality is that the development and implementation of cleaner and fuel-efficient energy services is a slow and complex process. Therefore, even with the introduction of alternative energy services, the use of biomass will remain a substantial source of cooking fuel for households in low socioeconomic communities in both urban and rural areas. Moreover, current trends and realities show that despite the acquisition of cleaner cooking energy services, households still retain their biomass cooking services to address social–cultural needs and as backups (see the section on technology and fuel stacking in the Discussion chapter). Hence, regardless of which energy mix emerges as the most appropriate and effective, biomass is likely to continue to feature to some degree in the energy mix. Therefore, the goals should be to achieve sustainable production and consumption management of biomass in parallel with the introduction of other cleaner, safer, and fuel-efficient cooking energy alternatives. It is encouraging that the Kenyan Government has introduced policy measures to regulate the production and consumption of wood fuels, mainly charcoal. However, to be effective, enforcement should be strengthened at all levels of the value chain.

8.5.Recommendations for improving the effectiveness of cooking energy services

8.5.1. Aim for collective approaches

If the goal is to achieve sustainable and effective access, then individual and social acceptance (Wüstenhagen et al., 2007) must be sought rather than one-time adoptions of technology by individual households. The need for collective acceptance and access to clean cooking energy services is also underscored in the work of Jagger and Jumbe, (2016) where it is concluded that ensuring general societal acceptance and access to cleaner and more fuel-efficient cooking energy services could be one of the most effective strategies for ensuring speedy achievement of the clean cooking agenda. In Kibera, targeting single households is ineffective because:

- High population density and poor housing conditions make it highly unlikely that households using clean cooking energy services would enjoy the envisioned benefits (e.g., example improved air quality) if their neighbors continued using polluting cooking solutions.
- Processes surrounding cooking energy access are tightly nested within people's livelihoods, and might face rejection if proposed shifts are not collectively accepted.

8.5.2. Address the trend of over-consumption

To deal with the challenges of sustainability and climate change, overconsumption needs to be addressed. In the context of sustained access to sustainable cooking energy services, it means less production and consumption of unsustainable cooking energy technologies and fuels. One way this can be achieved is by the production of high-quality, durable, acceptable, technologies and fuels (Allwood et al., 2013). Moreover, repair services must be made available and accessible whenever needed. Local skills-development, making spare parts available a requirement of new technologies, and strengthening consumer protection laws and enforcement mechanisms, must be encouraged and explored rather than promoting greater production and consumption.

8.5.3. Promote energy-saving practices; improve use conditions, surrounding environment, and built- in- conditions

In the long-term, energy access processes should aim to achieve structural transformation, but some more immediate, less costly and complementary investments could be leveraged to improve the effectiveness of current cooking energy services, including:

1. Improved air quality in cooking environments, by fitting chimneys and improving air circulation to enable complete biomass combustion.
2. Encourage the use of grates on open fires, to improve air intake and enhance fuel combustion and performance (Gordon, Mackay, & Rehfuess, 2004).

3. Encourage energy-saving cooking practices such as covering cooking pots, or soaking grains in water for several hours to soften them prior to cooking. This can reduce the amount of time and fuel required for cooking.
4. Highlight useful cooking aids, such as use of boiled water over cold water for cooking: a service that could be provided by renewable energy, for example solar water heaters, etc.
5. Improvements in immediate living environments can improve the effectiveness of clean cooking energy services, especially in Kibera, which lack zoning laws, and where human, domestic, commercial, and industrial waste are poorly disposed and managed.

8.6. Recommendations for policy and implementation processes

8.6.1. Provide a new narrative and vision for cooking energy access

There is a growing body of knowledge showing that the potential for energy services to support intended activities and functions in a sustainable and effective manner depends on how energy needs are understood and addressed (Groves et al., 2017; Elizabeth Shove & Walker, 2014; Sovacool & Dworkin, 2015). Moreover, the effectiveness of energy services is closely linked to how energy services are produced, implemented, and consumed (IRENA, 2019; Khandelwal et al., 2017; Kumar & Igdalsky, 2019; Quansah et al., 2017; Quinn et al., 2018). However, the challenges of cooking energy access are often simplified as women carrying heavy loads of firewood and cooking on open smoky fires, often surrounded by young children. While this is a legitimate concern that necessities immediate attention, the narrative does not represent the realities of all households, especially households in urban low socioeconomic communities like Kibera that predominantly rely on charcoal and kerosene. Against this background, it is important to revisit the framing and narratives around cooking energy needs, challenges, and opportunities, especially in light of the need to address emerging and growing demands, the urgency presented by climate change, and growing social inequalities, especially in urban areas (UN-Habitat and IHS-Erasmus University Rotterdam, 2018). To be effective, such a narrative and framing must address the needs, values, and aspirations of intended beneficiaries and seek to reconcile the artificial differences perpetuated by the biased narrative towards environmental protection and health benefits over the needs and values of end-users. Moreover, cooking energy solutions must focus on why cooking energy is sought in the first place (needs), and what and who households actually care about, value, and trust. As this study has demonstrated, households seek and aspire for healthy lives, clean living environments, and sustainable livelihoods, but currently lack sufficient abilities and appropriate opportunities to do so.

8.6.2. Acknowledge and manage diverse viewpoints and interests

This thesis highlights many different vested interests in the realms of cooking energy access. For example, households are motivated by the drive to fulfil their individual and societal needs; Policy makers and charitable organizations are motivated by specific goals such as climate protection and sustainable development. On the other hand, producers, distributors, and retailers focus on profit margins and securing livelihoods. These interests and viewpoints can be contentious and, depending on how they are approached and managed, could make or break energy access processes despite the presence of well-meaning policies and innovative technological solutions. In Kibera, for example, it is necessary to consider and understand how informal settlements are actually governed and managed in order to access the most appropriate avenues for instituting and managing cooking energy access processes. The aim of working at the three levels of society (micro, meso, and macro) should not be to find consensus on all aspects of energy access processes, but to seek points of agreement that could be leveraged to inform just, equitable, and sustainable cooking energy solutions.

8.6.3. Consider not just the implementation of cooking energy services, but also their implications

The justification for ICSs and other cleaner and efficient cooking services relies heavily on supposed health, environmental, economic, and social benefits. However, it is often unclear whether current energy access solutions are effective in addressing these challenges in a sustainable way, due to lack of robust research and reliable data in the sector. Therefore, monitoring and evaluation at the user and community levels, as well as fuel and technology lifecycle assessments (Nilsson and Costanza, 2015) should be considered to understand the impacts of cooking energy services production, transportation, consumption, and disposal practices on humans and the environment and to inform the development of future solutions.

8.6.4 Nurture cross-sectoral cooperation

Universal energy access or the achievement of SDG 7 (i.e., access to affordable, reliable, sustainable, and modern energy for all), is often elevated to the level of the nuclei of the SDGs, because of its unique influence on the outcomes of multiple other SDGs, including: SDG 1: no poverty; SDG 2: zero hunger; SDG 3: good health and wellbeing; SDG 5: gender equality; and SDG 13: climate action. However, the benefits that clean cooking energy service can bring to bear could only be possible if energy access efforts occur in parallel with efforts from other sectors such as health and education, as well as broader structural transformations at all levels of society. For example, the realities of cooking practice in Kibera suggest that, in addition to addressing households' cooking needs, it would also be necessary to address commercial, and industrial cooking and heating needs. Moreover, housing and the state of immediate living environments would all need to be improved if clean cooking solutions are expected to be effective. In other words, the role that cooking energy solutions, such as ICSs, can play is limited, unless nested in other change-oriented and transformational processes.

8.6.5 Support research, documentation, and education processes

Research and documentation are crucial for providing data and analysis of the economic, social–cultural, geographical, and contextual realities and impacts of ongoing interventions in order to shape, reshape, and support decision-making process and intervention strategies. The Kenyan Government recently undertook encouraging steps towards providing information and data that are critical for promoting the acceptance and use of clean cooking solutions. The Energy Ministry, in collaboration with the Clean Cooking Association, conducted its first household survey on energy use in the cooking sector. This exercise provides firsthand insights on the state of access to clean cooking energy services, and for the first time includes national-scale quantitative data concerning deaths from the effects of polluting cooking energy services in Kenya[56]. Further collaborations and research efforts should be encouraged and supported, because such information is essential for long-term planning and providing appropriate cooking energy solutions. Research can also be instrumental in examining past and present shortcomings, and opportunities to inform future access processes. Greater emphasis is also needed at all levels of the education system, concerning the benefits of sustainable energy production and

[56] For more information, see Reuters (5 November 2019): "*Kenya vows to cut emissions as dirty stoves and fuels kill 21,500 a year*". Available at: https://www.dailymaverick.co.za/article/2019-11-05-kenya-vows-to-cut-emissions-as-dirty-stoves-and-fuels-kill-21500-a-year/

consumption practices, as well as the risks and burdens of business-as-usual lifestyles to humans and the planet.

8.7. Recommendations for effective development co-operation and collaboration

The present state of the energy sector in Africa provides a unique opportunity to develop sustainable energy infrastructure and engage in successful development co-operation and collaborations between developed and developing countries. It is clear that, even with their numerous energy resources, African countries will require financial, advisory, and technological support. However, even with these kinds of assistance, no sustainable outcomes should be expected without the full inclusion and participation of beneficiaries. Given the financial and operational costs involved in developing successful and sustainable energy projects, and the financial and environmental risks associated with stranded assets, a strategic transformational approach focused on inclusion, understanding people's needs, demand dynamics, reducing inequality, promoting an informed and skilled population, and improving quality of life, must be at the forefront of energy policy and development co-operation and collaborations.

This could be achieved through investment in knowledge exchange, technological collaboration, and capacity building, as well as governance and institutional development processes that are aligned with community circumstances and needs. For example, the integration of the best local resources and knowledge with the best external resources and knowledge, to create context-specific solutions and local value, over the distribution of finished products, has the potential to guide and shape the success and sustainability of energy access processes. Moreover, ‘one-size-fits-all’ approaches and the general accounts of technology transfer are too simplistic and general to provide satisfactory explanations, and understate complex and unique contexts that are often outside the formal social, technological, and economic domains, of which Kibera is an example. As a result, energy policies and implementation processes should aim for inclusivity at all three levels of society (micro, meso, and macro) highlighted in this thesis, in their support for developing foundational conditions to enable sustainable access, use, and enjoyment of the positive impacts of energy infrastructure and services. Ultimately, the success or failure of cooking energy access processes and the value of international community investments will not be judged on the amount of money given or earmarked for development aid, but by the effectiveness of such investment in enhancing individual and community value and general wellbeing.

9. Conclusion

9.1 General conclusions

Energy is an enabler of social and economic activities. It also enables functions such as cooking, which sustain human life and general wellbeing. Moreover, how people cook, both within and beyond the household, can shape their sense of place and community.

In Sub-Saharan Africa, while cooking accounts for the highest energy demand in most households, access to affordable, reliable, clean, safe, and sustainable energy services remains a major challenge faced by households in low socioeconomic contexts, such as those in Kibera. To address this challenge, many policies and technological initiatives have sought to mitigate the damaging risks and burdens of current practices surrounding the production and consumption of cooking energy. One such ongoing effort is the development and implementation of biomass ICSs. However, despite 40 years of financial investment and technical development, past and current efforts have failed or been unsustainable, especially in Sub-Saharan Africa, with only a 15% known success rate globally (Practical Action, 2017) and a less than 12% access to clean cooking energy in Kenya (Government of Kenya, 2017b).

Motivated by the need to understand why ICSs have failed to achieve widespread acceptance and sustained access and use, despite the growing need for cleaner biomass cook stoves and the enormous investment directed into the sector over the last 40 years, this thesis examined and contextualized the factors that enable or hinder sustainable access to, and effectiveness of, clean and safe cooking energy services by households in Kibera, an informal settlement in Nairobi, Kenya. In doing so, the work sought to understand and capture the social dimensions and dynamics influencing households' decision-making processes and actions pertaining to energy access, both from their perspective and in relation to their structural and environmental conditions and realities.

To address this overarching objective, a case study approach was adopted. Guided by the Needs–Opportunities–Abilities (NOA) conceptual framework, qualitative data were collected by means of semi-structured interviews, direct and indirect observations, and photo documentation.

9.2. Summary of the key findings

This thesis made the following key findings.

1) Households in Kibera had multiple and diverse individual and social needs and values that they sought to fulfil and maintain through cooking energy services. However, these needs and values are not presently fully understood, appreciated, or taken into account in the design and development of currently available ICSs. Consequently, potential users were not enthusiastic about ICSs, which may partly explain their limited presence within Kibera households.

2) There is considerable information and reliable research supporting the need for clean, efficient, and sustainable cooking energy production and consumption practices. However, evidence from Kibera revealed very little awareness, among household representatives, of this need to shift to cleaner and more energy-efficient cooking energy services, beyond the obvious smoke hazard and eye irritation highlighted by interviewees. This shows that despite the availability of information, very little may reach households and the winder public in contexts like Kibera.

3) Contrary to overly simplistic narratives, access to cooking energy services and the fulfilment of needs and values are actually complex processes, often influenced by multiple factors beyond the mere presence of improved technologies.

4) While technological opportunity is a primary requirement for sustainable and effective cooking energy services, it is not the only opportunity required. Instead, other, non-technological opportunities, such as fuels and financing opportunities that are aligned with socioeconomic realities are also preconditions for enabling access to and sustainable use of available technological opportunities.

5) In addition to opportunities, potential adopters also require the abilities to access and use existing energy services in effective and sustainable ways. In essence, abilities—such as disposable income, appropriate payment methods, loans, and credits facilities—put power in the hands of users, to weigh different options and take desired actions. The absence of such abilities in Kibera limited the pool of technologies and fuels, influenced the availability and affordability of goods and services, and diminished personal abilities to access and use available services in effective and sustainable ways.

6) The findings also showed that, in the context of access to cooking energy services, abilities go beyond the acquisition of a technology and fuel. The level of personal

development and physical condition of the user, the context of use, and the nature of the surrounding environment and built- in conditions also influence sustainable access to and the effectiveness of technologies such as ICSs. Therefore, individual abilities are of core importance in securing sustained access and use of effective cooking energy services.

7) The acceptance, implementation, accessibility, and use of such technologies takes place within social contexts. Hence, their success or failure depends on the support and commitment of local communities and end-users, while their continued access and effective use depends on the presence or absence of long-term abilities and opportunities that are enabled or hindered in these specific contexts. For example, poor structural conditions—such as lack of clean drinking water, sanitation, and sewer services; air pollution from external sources; as well as in-built challenges such as poor housing conditions and living environments—create circumstances that negated or nullified the expected gains of efforts in the area of household clean cooking services in Kibera. Moreover, lack of sustainable livelihoods, and power imbalances and inequalities both within the household and the broader societal context, were shown to influence social and economic realities, the supply and demand for cooking energy services, and hence access to sustainable and effective cooking energy services.

8) Households' decisions about cooking energy services were subject to the influence of factors beyond their control. Hence, solutions and interventions that focused solely on households or formal structures failed to take into account the positive and/or negative power wielded by informal external forces at the meso level. For example, formal governance and institutional structures had limited authority and legitimacy in Kibera. Instead, local structures and institutions were the main points of reference and trusted sources of information, abilities, and opportunities, including cooking energy services. Therefore, technological development does not always motivate consumers, influence consumer action, or create local value; unless such technologies have the characteristics sought by end-users and are introduced into local contexts that provide appropriate enabling environments and supporting conditions.

9) Lastly, social and economic networks were shown to play a central role in enabling access to cooking energy services, by influencing popular acceptance of available technologies and acting as sources of abilities and opportunities. This thesis therefore showed that

challenges do not always impose limitations, but can act as motivators that drive individuals to be proactive and engaged in addressing their needs both individually and collectively. These self-established processes and personal drive could be leveraged to initiate and support processes for cooking energy services which ensure sustainable abilities and opportunities that are aligned with people's needs and realities.

9.3 Significance of this study

These finding are significant because they show that: Technical advances such as ICSs can take us a long way, but not all the way, if we aim for cooking energy solutions that take into account all user needs and values and are effective in enhancing individual and community wellbeing and protecting the environment. Moreover, while technological solutions such as ICSs have a central role to play in ensuring sustainable access to clean and safe cooking energy services, appropriate social contexts are also essential for facilitating individual and social acceptance, implementation, and sustained access and use, as well as the effectiveness of such solutions.

Structural conditions such as poverty and underdevelopment; the negative effects of inequality and marginalization; poor institutional and governance capacity; and disadvantaged environmental and built- in conditions also negatively influence sustainable access to and effectiveness of technologies such as ICS.

The inclusion of the meso level in the analysis framework is also a significant contribution towards understanding the factors that enable or hinder sustainable access to clean cooking energy services in contexts like Kibera. The consideration of the role of meso-level forces underscores the importance of not only focusing on the macro levels of society, but also of taking advantage of the already functional local-level instruments, to initiate and sustain cooking energy access. This is also emphasized in the OECD/IEA *Energy Access Outlook Report* (OECD/IEA, 2017: 108), which notes that: “it is vital that policy-makers engage a wide array of stakeholders, including the private sector, align government policies and objectives with local level policies and dynamics and support capacity-building at the community level to ensure that the energy access solutions delivered are absorbed and maintained long-term.” Hence, while technological developments are critical for long-term access to sustainable cooking energy services, it is also important to encompass the role played by individual, social, and contextual dimensions and dynamics in determining acceptance, sustainable access and use, as well as the quality of outcomes and impacts sought from cooking energy services. Unless such conditions are stable and sufficient, uncertainty about opportunities and abilities will continue to hinder sustainable access to appropriate and effective technologies for cooking energy services. This makes the understanding, acknowledgement, and attention to households' needs, abilities, and opportunities—assessed from their perspective and within the broader framework of their living contexts—prerequisites for guiding policy development and implementation processes of cooking energy access processes.

Due to the limitations of the NOA framework, I developed and applied an alternative conceptual framework entitled the Cooking Energy Access Landscape. This framework makes it clear that the factors which enable or hinder sustainable access to clean and safe cooking energy services are complexly bound to the socioeconomic conditions and contextual realties of end-users. Therefore, this framework underscores that processes of cooking energy access are embedded in the social fabric and societal and environmental contexts, and cannot be understood or addressed only in the isolated context of technological innovations and adoption processes, or implemented within narrowly defined landscapes of formal structures and sectors. Overall, the framework contributes to a deeper understanding of households' decision-making environments, existing and unexploited opportunities, and threats to cooking energy access in the context of a developing country and, more specifically, within an informal settlement. Understanding these factors is important for governments, policy makers, and development agencies seeking to promote the long-term adoption and use of improved cookstoves as a means of mitigating the known human and environmental risks and impacts associated with the use of traditional cookstoves. This knowledge could also be useful to policy makers and development agencies, who might want to reassess the effectiveness of current policies and strategies on cooking technologies and fuels, especially in light of the UN SDGs and the Paris Agreement, and rapidly changing human living environments and dynamics.

9.4 Study contributions

The choice of Kibera as a case study makes a contribution to the literature. This study contributes to understanding the significant mismatch between sustainable development and climate protection goals, and access to clean, efficient, and sustainable cooking energy services. In this regard, the research focuses on an under-examined demographic, that of the low socioeconomic urban communities in Sub-Saharan Africa.

Dominant work and research on access to clean, efficient, and sustainable cooking energy services tend to focus on rural areas. Yet, it is actually urban areas that are experiencing rapid population growth, and where most households in expanding informal settlements rely heavily on charcoal and kerosene to address most of their cooking and heating needs. This invisibility of the plight of households in low socioeconomic urban communities often fails to capture and address user needs and preferences as well as the forces that hinder or enable individual and community acceptance, sustainable access, and effective use of cleaner and effective cooking energy services, beyond ICSs. The plights of people living within such contexts cannot be ignored or continue to be overlooked, especially if sustainable development and climate protection goals are to be achieved.

The methodology used in this thesis is also unique among available studies addressing cooking energy access challenges in the Global South. The case study approach, employing in-depth interviews and observations, allowed for a deeper understanding of people's lifestyle patterns, daily routines, cooking and eating cultures; and the conditions of their lived environments and in-built, social–cultural, and physical conditions. These play crucial roles in households' decision-making processes, their ability and willingness to adopt certain technologies, and the conditions that enable and support sustainable access and sought impacts. This approach also enabled the identification of opportunities that could serve as entry points to co-design and facilitate just and sustainable processes for accessing cooking energy.

This research also adds to the current literature by describing cooking energy challenges through the lens of households, and by analyzing these challenges at the micro, meso, and macro levels. Being able to make sense of the interplay of household realities and broader societal factors is important because, as highlighted in the work of Miller et al. (2013a): “energy systems can only change when and if people make choices, whether these agents are business managers, policy officials, scientists, and engineers, or consumers” (p.136). This broader approach highlighted that processes concerning sustainable and effective access to cooking energy depend on a wide range of factors characterized by tight and highly complex interconnections, making it impossible to consider a single factor in isolation or to propose stand-alone or ‘one-size-fits-all’ solutions. Indeed, while energy needs can vary greatly between households in the same local context, country, or geographical contexts, the presence of secure and reliable abilities, opportunities, social support conditions, and enabling environments can ensure that these differing households have an equitable opportunity to access desired cooking energy services, to succeed, and to sustain such practices. Therefore, in order for cooking energy access processes to follow sustainable and just paths, cooking energy solutions need to be embedded within broader systemic changes and accompanied by individual, social, cultural, political, economic, and environmental transformations at all levels of society. These dimensions present a great level of complexity, and hence care needs to be taken to avoid the temptations of simplification, and short-term solutions and strategies. This suggests that policy makers and implementers need to be more innovative, strategic, and inclusive in designing and implementing policies and solutions concerning access to cooking energy.

9.5 Directions for future research

Despite the contributions made by this research, multiple issues and questions remain unaddressed. For example, while this research sought to understand the factors that enable or hinder sustained access and to sustainable and effectiveness use of cooking energy services at all three levels of society, there is a need for research to provide insights on possible pathways to structure and implement such layered processes. Moreover, knowledge gaps remain in our understanding of the interdependencies and interlinkages between the three levels of society, and how these linkages could hinder—or be leveraged to allow—sustainable and effective access to effective cooking energy services. More specific to this study, it would be instrumental to understand how patterns of equitable and just opportunities and abilities come about and persist in different contexts and at various societal levels.

There are also knowledge gaps in life-cycle impact assessments of technologies such as ICSs. Life-cycle impact assessments could provide instrumental information such as:

1. The effectiveness of proposed technological solutions versus their stated goals in various contexts; and,

2. Assessing changes at the community and household levels, especially with regard to: the dynamics of lifestyles and needs, disparities within user groups, effectiveness of implemented solutions over time, including whether the solutions in place still match current societal and household realities.

References

AFDB. (2013). An Infrastructure Action Plan for Nigeria: Clossing the Infrastructure Gap and Accelerating Economic Transformation. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699. https://doi.org/10.1017/CBO9781107415324.004

Agarwal, B. (1986). Cold hearths and barren slopes: the wood fuel crisis in the Third World. In *Cold hearths and barren slopes: the wood fuel crisis in the Third World*. Retrieved from http://www.cabdirect.org/abstracts/19876703575.html%5Cnhttp://www.cabdirect.org/abstracts/19876703575.html;jsessionid=45393C0DB0682DC54C2615920CB9E6DB%5Cnhttp://www.scopus.com/inward/record.url?eid=2-s2.0-0022854328&partnerID=40&md5=679bba3aa679cab232594fd874

AGECC. (2010). Energy for a Sustainable Future. The Secretary-General's Advisory Group on Energy and Climate Change. In *UNIDO*. https://doi.org/10.1016/j.enbuild.2006.04.011

Ahmad, S., & Puppim De Oliveira, J. A. (2015). Fuel switching in slum and non-slum households in urban India. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2015.01.072

Akolgo, G. A., Essandoh, E. O., Gyamfi, S., Atta-Darkwa, T., Kumi, E. N., & Maia, C. M. B. de F. (2018). The potential of a dual purpose improved cookstove for low income earners in Ghana – Improved cooking methods and biochar production. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2017.09.044

Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2013). Material efficiency: providing material services with less material production. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*, *371*(1986), 20120496. https://doi.org/10.1098/rsta.2012.0496

Amegah, A. K., & Jaakkola, J. J. (2016). Household air pollution and the sustainable development goals. *Bulletin of the World Health Organization*. https://doi.org/10.2471/BLT.15.155812

Anderson, D., & Fishwick, R. (1984). Fuelwood consumption and deforestation in African countries. In *World Bank staff working papers CN - HD9769.F843 A354 1984*.

Arnold, J. E. M., Köhlin, G., & Persson, R. (2006). Woodfuels, livelihoods, and policy interventions: Changing Perspectives. *World Development*, *34*(3), 596–611. https://doi.org/10.1016/j.worlddev.2005.08.008

Arnold, M., Köhlin, G., Persson, R., & Shepherd, G. (2003). Fuelwood Revisited: What Has Changed in the Last Decade? *CIFOR Occasional Paper*, (39), iv–32. https://doi.org/0854-9818

Bailis, Rob, Ezzati, M., & Kammen, D. M. (2003). Greenhouse gas implications of household energy technology in Kenya. *Environmental Science and Technology*. https://doi.org/10.1021/es026058q

Bailis, Rob, Wang, Y., Drigo, R., Ghilardi, A., & Masera, O. (2017). Getting the numbers right: Revisiting woodfuel sustainability in the developing world. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/aa83ed

Bailis, Robert, Ezzati, M., & Kammen, D. M. (2005). Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa. *Science*. https://doi.org/10.1126/science.1106881

Bali Swain, R., & Wallentin, F. Y. (2012). Factors empowering women in Indian self-help group programs. *International Review of Applied Economics*. https://doi.org/10.1080/02692171.2011.595398

Barnes, D F, Openshaw, K., Smith, K. R., & Van der Plas, R. (1994). What makes people cook with improved biomass stoves. In *World Bank Technical Paper* (Vol. 242).

Barnes, Douglas F, Openshaw, K., Smith, K. R., & Plas, R. Van Der. (1994). What Makes People Cook with Improved Biomass Stoves ? A Comperative International Review of Stove Programs. In *World Bank Technical Paper Energy Series*. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1999/08/15/000009265_3970311122727/Rendered/PDF/multi_page.pdf

Bazilian, M., Nakhooda, S., & Van De Graaf, T. (2014). Energy governance and poverty. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2014.03.006

Bhattacharya, S. C., & Abdul Salam, P. (2002). Low greenhouse gas biomass options for cooking in the developing countries. *Biomass and Bioenergy*. https://doi.org/10.1016/S0961-9534(02)00008-9

Bishaw, B. (2001). Deforestation and Land Degredation in the Ethiopian Highlands: A Strategy for Physical Recovery. *Northeast African Studies*. https://doi.org/10.1353/nas.2005.0014

Bonan, J., Pareglio, S., & Tavoni, M. (2017). Access to modern energy: A review of barriers, drivers and impacts. *Environment and Development Economics*, *22*(5), 491–516. https://doi.org/10.1017/S1355770X17000201

Bourdieu, P. (1986). Pierre Bourdieu 1986 - The forms of capital. In *Handbook of Theory and Research for the Sociology of Education*. https://doi.org/10.1002/9780470755679.ch15

Bowe, B., Xie, Y., Li, T., Yan, Y., Xian, H., & Al-Aly, Z. (2018). The 2016 global and national burden of diabetes mellitus attributable to PM 2·5 air pollution. *The Lancet Planetary Health*, *2*(7), e301–e312. https://doi.org/10.1016/S2542-5196(18)30140-2

Carroll, J. B. (1993). Human Cognitive Abilities. In *Human Cognitive Abilities*. https://doi.org/10.1017/cbo9780511571312

Chambers, R. (1987). *Sustainable livelihoods, environment and development: putting poor rural people first*. Retrieved from https://scholar.google.de/scholar?hl=en&q=Chambers%2C+R.+%281987%29+Sustainable+Livelihoods%2C+Environment+and+Development%3A+Putting+Poor+Rural+People+First%2C+IDS+Discussion+Paper+240%2C+Brighton%3A+IDS+&btnG=&as_sdt=1%2C5&as_sdtp=

Chambers, Robert. (1986). Sustainable Livelihood Thinking an Approach to Poverty, Enviroment and Development. *Conservation and Development: Implemening the World Conservation Strategy , Ottawa, Canada*.

Chilcott, R. P. (2006). Health Protection Agency Compendium of Chemical Hazards: Kerosene (Fuel Oil). *Public Health England*.

Clancy, J. S., Skutsch, M., & Batchelor, S. (2003). The gender-energy-poverty nexus: Finding the energy to address gender concerns in development. *DFID Project CNTR998521*. https://doi.org/Project No. CNTR998521

Clark, W. C., & Dickson, N. M. (2003). Sustainability science: the emerging research program. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(14), 8059–8061. https://doi.org/10.1073/pnas.1231333100

Clough, L. (2012a). *The Improved Cookstove Sector in East Africa : Experience from the Developing Energy Enterprise Programme (DEEP)*. Retrieved from www.gvepinternational.org

Clough, L. (2012b). *The Improved Cookstove Sector in East Africa : Experience from the Developing Energy Enterprise Programme (DEEP)*. Retrieved from www.gvepinternational.org

Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology*. https://doi.org/10.1086/228943

Cooper, T. (2010). The Significance of Product Longevity. *Longer Lasting Products: Alternatives to the Throwaway Society*. https://doi.org/10.4324/9781315592930-9

Creswell, J. W. (2003). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. In *Sage* (Vol. 2nd). Retrieved from http://www.amazon.com/dp/0761924426

Cuming, V., Mills, L., Strahan, D., Boyle, R., Stopforth, K., Latimer, S., & Becker, L. (2015). Global Trends in Renewable Energy Investment 2015. In *Frankfurt School of Finance & Mangement*. Retrieved from Frankfurt School of Finance & Management website: http://fs-unep-centre.org/sites/default/files/attachments/key_findings.pdf

Dahlstrand, U., & Biel, A. (1997). Pro-environmental habits: Propensity levels in behavioral change. *Journal of Applied Social Psychology*. https://doi.org/10.1111/j.1559-1816.1997.tb00650.x

Danielsen, K. (2012). *Gender equality, women ' s rights and access to energy services* (pp. 1–45). pp. 1–45. Retrieved from https://www.kit.nl/gender/wp-content/uploads/publications/1975_Gender Rights and Energy Report final.pdf

Dasgupta, S., Huq, M., Khaliquzzaman, M., Pandey, K., & Wheeler, D. (2006, December). Indoor air quality for poor families: new evidence from Bangladesh. https://doi.org/10.1111/j.1600-0668.2006.00436.x

de Bercegol, R., & Monstadt, J. (2018). The Kenya Slum Electrification Program. Local politics of electricity networks in Kibera. *Energy Research and Social Science*, *41*, 249–258. https://doi.org/10.1016/j.erss.2018.04.007

De Lepeleire G, Krishna Prasad K, Verhaart P, V. P. (1981). *A woodstove compendium*. 1–377.

Retrieved from http://repository.tue.nl/175114

Desgroppes, A., & Taupin, S. (2011). Kibera: The Biggest Slum in Africa? *Les Cahiers de l'Afrique de l'Est*.

Dewees, P. A. (1989). The woodfuel crisis reconsidered: Observations on the dynamics of abundance and scarcity. *World Development*, *17*(8), 1159–1172. https://doi.org/10.1016/0305-750X(89)90231-3

Dopfer, K., Foster, J., & Potts, J. (2004). Micro-meso-macro. *Journal of Evolutionary Economics*. https://doi.org/10.1007/s00191-004-0193-0

Dopfer, K., & Potts, J. (2004). Evolutionary realism: a new ontology for economics. *Journal of Economic Methodology*. https://doi.org/10.1080/13501780410001694127

Drèze, J., & Sen, A. K. (2002). *India : development and participation*. Retrieved from https://books.google.de/books/about/India.html?id=UpOl35r8UHQC&redir_esc=y

Eckholm, E. (1975). The other energy crisis: firewood. In *Worldwatch Paper*.

Eckholm, E. P. (1975). *The other energy crisis, firewood*. [Worldwatch Institute].

Edomah, N. (2018). Historical Drivers of Energy Infrastructure Change in Nigeria (1800–2015). In *Energy Management for Sustainable Development*. https://doi.org/10.5772/intechopen.74002

Edomah, N., Foulds, C., & Jones, A. (2016). The role of policy makers and institutions in the energy sector: The case of energy infrastructure governance in Nigeria. *Sustainability (Switzerland)*, *8*(8). https://doi.org/10.3390/su8080829

Edomah, N., Foulds, C., & Jones, A. (2017). Policy making and energy infrastructure change: A Nigerian case study of energy governance in the electricity sector. *Energy Policy*, *102*, 476–485. https://doi.org/10.1016/j.enpol.2016.12.053

Eni, F., Mattei, E., Pareglio, S., & Tavoni, M. (2016). *Access to modern energy: a review of barriers, drivers and impacts*. Retrieved from https://www.econstor.eu/bitstream/10419/149541/1/NDL2016-068.pdf

Ezzati, M., & Baumgartner, J. C. (2017). Household energy and health: where next for research and practice? *The Lancet*. https://doi.org/10.1016/S0140-6736(16)32506-5

Ezzati, M., & Kammen, D. M. (2002). Evaluating the health benefits of transitions in household energy technologies in Kenya. *Energy Policy World Health Organization*, *30*, 815–826.

FAO. (2010). Criteria and indicators for sustainable woodfuels. *FAO Forestry Paper*.

FAO. (2011). The State of the World's land and water resources for Food and Agriculture. Managing systems at risk. In *Food and Agriculture Organization*. https://doi.org/978-1-84971-326-9

Farioli, F., & Dafrallah, T. (2012). Gender issues of biomass production and use in Africa. In *Bioenergy for sustainable development in Africa*. https://doi.org/10.1007/978-94-007-2181-4-28

Ferrer, R. L. (2018). Social determinants of health. In *Chronic Illness Care: Principles and Practice*. https://doi.org/10.1007/978-3-319-71812-5_36

Finighan, J., Schaefer, J., Sembres, T., Schaefer, J., & Forests Philanthropy Action Network (FPAN), 2011. (2011). Protecting and restoring forest carbon in tropical Africa: a guide for donors and funders. *Forest Philanthropy Action Network*, 321. Retrieved from http://files.forestsnetwork.org/FPAN+Africa+report+chapter+1+HR.pdf

Flick, U. (2009). An Introduction To Qualitative Fourth Edition. *SAGE Publications*.

Forouzanfar, M. H., Afshin, A., Alexander, L. T., Biryukov, S., Brauer, M., Cercy, K., … Zhu, J. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, *388*(10053), 1659–1724. https://doi.org/10.1016/S0140-6736(16)31679-8

Foster, V. (2000). Measuring the impact of Energy Reform-Practical Options. *Energy and Development Report*. https://doi.org/10.1016/j.virol.2011.01.029.The

Gatersleben, B., & Vlek, C. (1997). Understanding household metabolism in view of environmental quality and sustainable development. In *Advances in economic psychology* (pp. 145–168). Retrieved from https://www.rug.nl/research/portal/publications/understanding-household-metabolism-in-view-of-environmental-quality-and-sustainable-development(e6ded7c0-4e6b-4ee5-b7b2-4ef29a6058c3)/export.html

Gatersleben, B., & Vlek, C. (1998). Household consumption, quality of life and environmental impacts: a psychological perspective and empirical study. In S. T. Noorman, Klass Jan and Uiterkamp (Ed.), *Green households? Domestic Consumers Environment and Sustainability* (pp. 141–183). Retrieved from https://books.google.de/books?hl=en&lr=&id=niWZAgAAQBAJ&oi=fnd&pg=PP1&dq=Green+households%3F+domestic+consumption+Environment&ots=DMazYQzXkd&sig=7CK62OuB7mx-7Z_g8vc7Yh2ak8k#v=onepage&q=Green households%3F domestic consumption Environment&f=false

Gerring, J. (2006). Case study research: Principles and practices. In *Case Study Research: Principles and Practices*. https://doi.org/10.1017/CBO9780511803123

Gifford, M. L. (2010). *A Global Review of Cookstove Programs*.

Gill, J. (1987). Improved stoves in developing countries. A critique. *Energy Policy*, *15*(2), 135–144. https://doi.org/10.1016/0301-4215(87)90121-2

Girard, P. (2002a). Charcoal production and use in Africa: what future? - ScienceBase-Catalog. *Unasylva*, *53*(4), 30–35. Retrieved from https://www.researchgate.net/publication/283832140_Charcoal_production_and_use_in_Africa_What_future?_iepl%5BgeneralViewId%5D=Tu0zAgbgSsHsqnWYVWfBve8O1USGLwpwJZ86&_iepl%5Bcontexts%5D%5B0%5D=searchReact&_iepl%5BviewId%5D=sGJ4A8wO9kxE52I1FgHFulRmgSopTul5lvZ

Girard, P. (2002b). WOOD ENERGY- Charcoal production and use in Africa: What future? *Unasylva - No. 211*, *53*(53), 30–35. Retrieved from http://www.fao.org/3/a-y4450e/y4450e05.pdf

Global Alliance For Clean Cookstoves. (2013). Global Alliance for Clean Cookstoves Protocol. Retrieved from http://cleancookstoves.org/about/

González-Eguino, M. (2015). Energy poverty: An overview. *Renewable and Sustainable Energy Reviews*, *47*, 377–385. https://doi.org/10.1016/J.RSER.2015.03.013

Gordon, B., Mackay, R., & Rehfuess, E. (2004). Inheriting the world: the atlas of children's health and the environment. In *WHO* (Vol. 64). Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&NEWS=N&PAGE=fulltext&AN=20043150489

&D=cagh3

Government of Kenya. (2017a). Government of Kenya sustainable development goals voluntary national review 2017. In *High-level Political Forum*. Retrieved from https://sustainabledevelopment.un.org/index.php?page=view&type=30022&nr=372&menu=3170

Government of Kenya. (2017b). Kenya Economic Report 2017. In *Kenya National Bureau of Statistics*. https://doi.org/10.1007/s10842-006-7185-8

Groves, C., Henwood, K., Shirani, F., Thomas, G., & Pidgeon, N. (2017). Why mundane energy use matters: Energy biographies, attachment and identity. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2017.06.016

Gutman, J. (1982). A Means-End Chain Model Based on Consumer Categorization Processes. *Journal of Marketing*, *46*(2), 60. https://doi.org/10.2307/3203341

Health Effects Institute. (2018). State of Global Air 2018: Special Report. *Health Effects Institute*, 24. https://doi.org/Available from: www.stateofglobalair.org. (Accessed [14 August 2017]).

Heltberg, R. (2004). Fuel switching: Evidence from eight developing countries. *Energy Economics*. https://doi.org/10.1016/j.eneco.2004.04.018

Heltberg, R. (2005). Factors determining household fuel choice in Guatemala. *Environment and Development Economics*. https://doi.org/10.1017/S1355770X04001858

Hewitt, J., Ray, C., Jewitt, S., & Clifford, M. (2018). Finance and the improved cookstove sector in East Africa; Barriers and opportunities for value-chain actors. *Energy Policy*. https://doi.org/10.1016/j.enpol.2018.02.044

Hofstad, O.; Köhlin, G.; Namaalwa, J. (2009). How can emissions from woodfuel be reduced? In S. Angelsen, A. with Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. D. and Wertz-Kanounnikoff (Ed.), *Realising REDD+: National strategy and policy options* (pp. 237–248). Center for International Forestry Research.

Hosier, R. H., & Kipondya, W. (1993). Urban household energy use in Tanzania. Prices, substitutes and poverty. *Energy Policy*. https://doi.org/10.1016/0301-4215(93)90035-E

Hosier, Richard H., & Dowd, J. (1987). Household fuel choice in Zimbabwe. An empirical test of the energy ladder hypothesis. *Resources and Energy*, *9*(4), 347–361. https://doi.org/10.1016/0165-0572(87)90003-X

Hou, B. D., Tang, X., Ma, C., Liu, L., Wei, Y. M., & Liao, H. (2017). Cooking fuel choice in rural China: results from microdata. *Journal of Cleaner Production*, *142*. https://doi.org/10.1016/j.jclepro.2016.05.031

Hugh, A. (1991). *The Kenya Ceramic Jiko: A manual for stovemakers*. London: Intermediate Technology Publications.

Human Sciences Research Council. (2013). A survey of energy related behaviour and perceptions in South Africa: the residential sector. *Report Compiled for the Department of Energy of South Africa*.

IEA. (2006). World Energy Outlook 2006. In *Outlook*. https://doi.org/10.1787/weo-2006-en

IEA. (2011). Energy for All: Financing access for the poor (Special early excerpt of the World Energy Outlook 2011). *World Energy Outlook 2011*, (October), 52. Retrieved from http://www.iea.org/media/weowebsite/energydevelopment/weo2011_energy_for_all-1.pdf

IEA. (2017). Energy Access Outlook 2017: From poverty to prosperity. *Energy Procedia*. https://doi.org/10.1787/9789264285569-en

IEA, IRENA, UNSD, WB, & WHO. (2019). *Tracking SDG 7: The Energy Progress Report 2019 Executive Summary*. Retrieved from World Bank website: www.worldbank.org

Iiyama, M., Neufeldt, H., Dobie, P., Njenga, M., Ndegwa, G., & Jamnadass, R. (2014). The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. *Current Opinion in Environmental Sustainability*. https://doi.org/10.1016/j.cosust.2013.12.003

Intergovernmental Panel on Climate Change. (2014). Climate Change 2014 Synthesis Report - IPCC. In *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. https://doi.org/10.1017/CBO9781107415324

International Energy Agency. (2014). Africa Energy Outlook. A focus on the energy prospects in sub-Saharan Africa. In *World Energy Outlook Special Report, International Energy Agency*

Publication. https://doi.org/https://www.iea.org/publications/freepublications/publication/africa-energy-outlook.html

IRENA. (2016). *The true costs of fossil fuels: saving in the externalities of air pollution and climate change*. Abu Dhabi: IRENA.

IRENA. (2019). *Measuring the Socio-Economic Footprint of the Energy Transition: The Role of Supply Chains*. Abu Dhabi: IRENA.

IRENA and OECD/IEA. (2017). *Perspectives for the energy transtion*.

Jagger, P., & Jumbe, C. (2016). Stoves or sugar? Willingness to adopt improved cookstoves in Malawi. *Energy Policy*, *92*, 409–419. https://doi.org/10.1016/j.enpol.2016.02.034

Jan, I., Ullah, S., Akram, W., Khan, N. P., Asim, S. M., Mahmood, Z., … Ahmad, S. S. (2017). Adoption of improved cookstoves in Pakistan: A logit analysis. *Biomass and Bioenergy*, *103*. https://doi.org/10.1016/j.biombioe.2017.05.014

Jeuland, M., Bhojvaid, V., Kar, A., Lewis, J. J., Patange, O. S., Pattanayak, S. K., … Ramanathan, V. (2014). *Preferences for Improved Cook Stoves: Evidence from North Indian Villages*. Retrieved from http://papers.ssrn.com/abstract=2467647

Johnson, M. A., Garland, C. R., Jagoe, K., Edwards, R., Ndemere, J., Weyant, C., … Pennise, D. (2019). In-Home Emissions Performance of Cookstoves in Asia and Africa. *Atmosphere*. https://doi.org/10.3390/atmos10050290

Kammen, D. M. (1995). Cookstoves for the developing world. *Scientific American*. https://doi.org/10.1038/scientificamerican0795-72

Kammen, Daniel M., & Kirubi, C. (2008). Poverty, energy, and resource use in developing countries: Focus on Africa. *Annals of the New York Academy of Sciences*. https://doi.org/10.1196/annals.1425.030

Karekezi, S., Kimani, J., & Onguru, O. (2008). Energy access among the urban poor in Kenya. *Energy for Sustainable Development*. https://doi.org/10.1016/S0973-0826(09)60006-5

Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., … Svedin, U. (2001). Sustainability Science. *Science*, *292*(5517).

Khandelwal, M., Hill, M. E., Greenough, P., Anthony, J., Quill, M., Linderman, M., & Udaykumar, H. S. (2017). Why Have Improved Cook-Stove Initiatives in India Failed? *World Development*, *92*, 13–27. https://doi.org/10.1016/j.worlddev.2016.11.006

Khandker, S. R., Barnes, D. F., & Samad, H. A. (2012). Are the energy poor also income poor? Evidence from India. *Energy Policy*. https://doi.org/10.1016/j.enpol.2012.02.028

Knox, S., & Burkard, A. W. (2009). Qualitative research interviews. *Psychotherapy Research*. https://doi.org/10.1080/10503300802702105

Köhlin, G., Sills, E. O., Pattanayak, S. K., & Wilfong, C. (2011). Energy , Gender and Development. What are the Linkages? Where is the Evidence? In *World Bank Policy Research Working Paper*.

Kshirsagar, M. P., & Kalamkar, V. R. (2014). A comprehensive review on biomass cookstoves and a systematic approach for modern cookstove design. *Renewable and Sustainable Energy Reviews*, Vol. 30, pp. 580–603. https://doi.org/10.1016/j.rser.2013.10.039

Kumar, P., & Igdalsky, L. (2019). Sustained uptake of clean cooking practices in poor communities: Role of social networks. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2018.10.008

Kuzemko, C., Lockwood, M., Mitchell, C., & Hoggett, R. (2016). Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research and Social Science*, *12*, 96–105. https://doi.org/10.1016/j.erss.2015.12.022

Kvale, S. (2011). Doing Interviews. In *Doing Interviews*. https://doi.org/10.4135/9781849208963

Lal, R. (2006). land degradation & development ENHANCING CROP YIELDS IN THE DEVELOPING COUNTRIES THROUGH RESTORATION OF THE SOIL ORGANIC CARBON POOL IN AGRICULTURAL LANDS. *Land Degrad. Develop*, *17*, 197–209. https://doi.org/10.1002/ldr.696

Lall, S. V., Henderson, J. V., Venables, A. J., & Lall, S. V. (2017). Overview: Africa’s Cities: Opening Doors to the World. In *Africa’s Cities: Opening Doors to the World*. https://doi.org/10.1596/978-1-4648-1044-2_ov

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N., … Zhong, M. (2017). The Lancet Commission on pollution and health. *The Lancet*.

https://doi.org/10.1016/S0140-6736(17)32345-0

Levine, M. D., Koomey, J. G., Price, L., Geller, H., & Nadel, S. (1995). Electricity end-use efficiency: Experience with technologies, markets, and policies throughout the world. *Energy*, *20*(1), 37–61. https://doi.org/10.1016/0360-5442(94)00055-8

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., … Memish, Z. A. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet (London, England)*, *380*(9859), 2224–2260. https://doi.org/10.1016/S0140-6736(12)61766-8

Lucas, K., Brooks, M., Darnton, A., & Jones, J. E. (2008). Promoting pro-environmental behaviour: existing evidence and policy implications. *Environmental Science and Policy*, *11*(5), 456–466. https://doi.org/10.1016/j.envsci.2008.03.001

Manibog, F. R. (1984). IMPROVED COOKING STOVES IN DEVELOPING COUNTRIES: Problems and Opportunities. *Ann. Rev. Energy*, *9*, 199–227. Retrieved from http://www.annualreviews.org/doi/pdf/10.1146/annurev.eg.09.110184.001215

Marmot, M. (2005). Social determinants of health inequalities. *Lancet*. https://doi.org/10.1016/S0140-6736(05)71146-6

Marshall, C., & Rossman, G. B. (2006). Designing Qualitative Research. In *Handbook of qualitative research* (Vol. 2). https://doi.org/10.4135/9781849208826

Masera, O. R., Bailis, R., Drigo, R., Ghilardi, A., & Ruiz-Mercado, I. (2015a). Environmental Burden of Traditional Bioenergy Use. *Annual Review of Environment and Resources*, *40*(1), 121–150. https://doi.org/10.1146/annurev-environ-102014-021318

Masera, O. R., Bailis, R., Drigo, R., Ghilardi, A., & Ruiz-Mercado, I. (2015b). *Environmental Burden of Traditional Bioenergy Use*. https://doi.org/10.1146/annurev-environ-102014-021318

Masera, O. R., Bailis, R., Drigo, R., Ghilardi, A., & Ruiz-Mercado, I. (2015c). Environmental Burden of Traditional Bioenergy Use. *Annu. Rev. Environ. Resour*, *40*, 15.15.301. https://doi.org/10.1146/annurev-environ-102014-021318

Masera, O. R., & Navia, J. (1997). Fuel switching or multiple cooking fuels? Understanding inter-fuel substitution patterns in rural Mexican households. *Biomass and Bioenergy*, *12*(5), 347–361. https://doi.org/10.1016/S0961-9534(96)00075-X

Masera, O. R., Saatkamp, B. D., & Kammen, D. M. (2000). From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. *World Development*, *28*(12), 2083–2103. https://doi.org/10.1016/S0305-750X(00)00076-0

Maslow, A. (1943). A Theory of Human Motivation A Theory of Human Motivation. *Psychological Review*. https://doi.org/10.1037/h0054346

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*(4), 370–396. https://doi.org/10.1037/h0054346

McKinsey Global Institute. (2015). The power of parity: how advancing women's equality can add $ 12 trillion to global growth. In *Report*.

Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. (n.d.). The Limits to Growth. In *Chelsea* (Vol. 205). https://doi.org/10.1111/j.1752-1688.1972.tb05230.x

Meadows, D. H., Randers, J., & Meadows, D. L. (2004). *The limits to growth : the 30-year update*. Chelsea Green Publishing Company.

Meier, G. M., & Rauch, J. E. (2005). *Leading issues in economic development*. Retrieved from http://econweb.ucsd.edu/~jrauch/leadingissues/leading.pdf

Mekonnen, A., & Köhlin, G. (2008). Determinants of Household Fuel Choice in Major Cities in Ethiopia. *EfD Discussion Paper*, (August), 23.

Miles, M. B., & Huberman, A. M. (1994). Qualitative Data Analysis. In *An expanded sourcebook* (Vol. 3). https://doi.org/10.1080/0140528790010406

Miller, C. A., Iles, A., & Jones, C. F. (2013). The Social Dimensions of Energy Transitions. *Science as Culture*. https://doi.org/10.1080/09505431.2013.786989

Mitchell, C., Woodman, B., Kuzemko, C., & Hoggett, R. (2015). Public Value Energy Governance: establishing an institutional framework which better fits a sustainable , secure and affordable energy system. In *EPG Working Paper*. Retrieved from http://projects.exeter.ac.uk/igov/wp-content/uploads/2015/03/Public-value-energy-governance.pdf

Mobarak, A. M., Dwivedi, P., Bailis, R., Hildemann, L., & Miller, G. (2012). Low demand for nontraditional cookstove technologies. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(27), 10815–10820. https://doi.org/DOI 10.1073/pnas.1115571109

Mohammed, S. (2001). Personal communication networks and the effects of an entertainment-education radio soap opera in Tanzania. *Journal of Health Communication*. https://doi.org/10.1080/10810730117219

Mortimer, K., Ndamala, C. B., Naunje, A. W., Malava, J., Katundu, C., Weston, W., … Gordon, S. B. (2016). *Articles A cleaner burning biomass-fuelled cookstove intervention to prevent pneumonia in children under 5 years old in rural Malawi (the Cooking and Pneumonia Study): a cluster randomised controlled trial*. https://doi.org/10.1016/S0140-6736(16)32507-7

Mortimer, K., Ndamala, C. B., Naunje, A. W., Malava, J., Katundu, C., Weston, W., … Gordon, S. B. (2017). A cleaner burning biomass-fuelled cookstove intervention to prevent pneumonia in children under 5 years old in rural Malawi (the Cooking and Pneumonia Study): a cluster randomised controlled trial. *The Lancet*. https://doi.org/10.1016/S0140-6736(16)32507-7

Moses, N. D., & MacCarty, N. A. (2019). What makes a cookstove usable? Trials of a usability testing protocol in Uganda, Guatemala, and the United States. *Energy Research & Social Science*, *52*, 221–235. https://doi.org/10.1016/J.ERSS.2019.02.002

Mwampamba, T. H., Ghilardi, A., Sander, K., & Chaix, K. J. (2013). Dispelling common misconceptions to improve attitudes and policy outlook on charcoal in developing countries. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2013.01.001

Myers, G. (2015). A World-Class City-Region? Envisioning the Nairobi of 2030. *American Behavioral Scientist*. https://doi.org/10.1177/0002764214550308

Namuye, S., & Namuye, {SA}. (1989). Survey on dissemination and impact of Kenya Ceramic Jiko of Kenya. *Agris.Fao.Org*. Retrieved from http://agris.fao.org/agris-search/search/display.do?f=./1994/v2004/GB9104670.xml%5CnGB9104670%5Cnpapers2://publication/uuid/FFE57BB1-2820-4CCB-9FE6-CD441F63EBCA%5Cnpapers2://publication/uuid/CFDF5C05-ACBD-46D1-B8A7-

EA220D759D44

Nilsson, M , Costanza, R. (2015). *Review of Targets for the Sustainable Development Goals: The Science Perspective*. https://doi.org/978-0-930357-97-9

Nussbaum, M. C. (2011). *Creating Capabilities : The Human Development Approach*. Harvard University Press.

Nussbaum, Martha Craven. (2011). *Creating capabilities : the human development approach*. Cambridge, Massachusetts: The Havard University Press.

OECD/IEA. (2006). Energy for Cooking in Developing Countries. In *World Energy Outlook*. https://doi.org/10.1787/weo-2006-16-en

OECD/IEA. (2016). Chapter 15 -Energy for Cooking in Developing Countries. *World Energy Outlook 2006 - FOCUS ON KEY TOPICS*. https://doi.org/10.1787/weo-2006-16-en

OECD/IEA. (2017). World Energy Outlook Special Report: From poverty to prosperity. In *Energy Access Outlook*. https://doi.org/10.1787/9789264285569-en

OECD. (2017). Health at a glance 2017: OECD Indicators. In *OECD Publishing*. https://doi.org/10.1787/health_glance-2013-en

Oechssler, J., Roider, A., & Schmitz, P. W. (2009). Cognitive abilities and behavioral biases. *Journal of Economic Behavior and Organization*. https://doi.org/10.1016/j.jebo.2009.04.018

Oparaocha, S., & Dutta, S. (2011). Gender and energy for sustainable development. *Current Opinion in Environmental Sustainability*. https://doi.org/10.1016/j.cosust.2011.07.003

Oxfam GB, & Kenya. (2009). Urban Poverty and Vulnerability In Kenya. In *Growth (Lakeland)*. https://doi.org/10.1016/S0749-596X(03)00071-8

Panek, J., & Sobotova, L. (2015). Community Mapping in Urban Informal Settlements: Examples from Nairobi, Kenya. *The Electronic Journal of Information Systems in Developing Countries*, *68*(0). Retrieved from http://144.214.55.140/Ojs2/index.php/ejisdc/article/view/1411/566

Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2010.11.037

Parnell, S., & Pieterse, E. A. (Edgar A. . (Eds.). (2014). *Africa's urban revolution*. Retrieved from http://www.africabib.org/rec.php?RID=383971101

Parsons, T. (1997). "Kibra is our blood": The Sudanese military legacy in Nairobi's Kibera location, 1902-1968. *International Journal of African Historical Studies*, *30*, 87–122. https://doi.org/10.2307/221547

Perlack, R. D., Stokes, B. J., Eaton, L. M., & Turnhollow, A. F. (2011). US Billion Ton Update: Biomass supply for a bioenergy and bioproducts industry (executive summary). *Industrial Biotechnology*, *7*(5), 375–380. https://doi.org/10.1089/ind.2011.7.375

Pitt, D. C. (1976). *The Social Dynamics of Development.* Retrieved from https://books.google.de/books?hl=en&lr=&id=5k60BQAAQBAJ&oi=fnd&pg=PP1&dq=The+Social+Dynamics+of+Development&ots=ct0OtL9GnC&sig=94OJmi6S87faX0Pj6m8A-00v8Y4#v=onepage&q=The Social Dynamics of Development&f=false

Pope, D., Bruce, N., Dherani, M., Jagoe, K., & Rehfuess, E. (2017, April). Real-life effectiveness of 'improved' stoves and clean fuels in reducing PM 2.5 and CO: Systematic review and meta-analysis. *Environment International*, Vol. 101, pp. 7–18. https://doi.org/10.1016/j.envint.2017.01.012

Practical Action. (2009). Energy Poverty: The hidden energy crisis. *Schumacher Centre for Technology and Development*.

Practical Action. (2017). Poor people's energy outlook 2017. In *Poor people's energy outlook 2017*. https://doi.org/10.3362/9781780446813

Programme, U. N. E., UNICEF, & Organization, W. H. (2002). *Children in the new millennium : environmental impact on health*. 150. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/42506/a75954.pdf;jsessionid=797139CFC1A892155D94F45EDD7B90F0?sequence=1

Quansah, R., Semple, S., Ochieng, C. A., Juvekar, S., Armah, F. A., Luginaah, I., & Emina, J. (2017). Effectiveness of interventions to reduce household air pollution and/or improve health in homes using solid fuel in low-and-middle income countries: A systematic review and meta-analysis. *Environment International*, *103*, 73–90. https://doi.org/10.1016/j.envint.2017.03.010

Quinn, A. K., Bruce, N., Puzzolo, E., Dickinson, K., Sturke, R., Jack, D. W., … Rosenthal, J. P. (2018). An analysis of efforts to scale up clean household energy for cooking around the world. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2018.06.011

Ramirez, S., Dwivedi, P., Ghilardi, A., & Bailis, R. (2014). Diffusion of non-traditional cookstoves across western Honduras: A social network analysis. *Energy Policy*. https://doi.org/10.1016/j.enpol.2013.11.008

Rangan, V. K., Quelch, J. A., Herrero, G., & Barton, B. (2007). Business Solutions for the Global Poor: Creating Social and Economic Value. In *John Wiley & Sons*.

Rappaport, J., Swift, C. F., & Hess, R. (1984). *Studies in empowerment : steps toward understanding and action*. Haworth Press.

Rehfuess, E. A., Puzzolo, E., Stanistreet, D., Pope, D., & Bruce, N. G. (2014). Enablers and barriers to large-scale uptake of improved solid fuel stoves: A systematic review. *Environmental Health Perspectives*, Vol. 122, pp. 120–130. https://doi.org/10.1289/ehp.1306639

Ri0+20 Declaration. (2012). United Nations: Rio+20 - The future we want. *Rio+20 United Nations Conference on Sustainable Development*.

Rogers, E. M. (2003). Diffusion of Innovations Theory. *New York: Free Press*, 5th ed. https://doi.org/10.1111/j.1467-9523.1970.tb00071.x

Rosenthal, J., Quinn, A., Grieshop, A. P., Pillarisetti, A., & Glass, R. I. (2018). Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2017.11.003

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. (2011). Adoption and sustained use of improved cookstoves. *Energy Policy*, *39*(12), 7557–7566. https://doi.org/10.1016/j.enpol.2011.03.028

Rysankova, D., Putti, V. R., Hyseni, B., Kammila, S., & Kappen, J. F. (2014). Clean and improved cooking in sub-Saharan Africa: A landscape report. In *Africa Clean Cooking Energy Solutions Initiative*.

Sadath, A. C., & Acharya, R. H. (2017). Assessing the extent and intensity of energy poverty using Multidimensional Energy Poverty Index: Empirical evidence from households in India. *Energy Policy*, *102*, 540–550. https://doi.org/10.1016/J.ENPOL.2016.12.056

Samaddar, S., Murase, M., & Okada, N. (2014). Information for Disaster Preparedness: A Social Network Approach to Rainwater Harvesting Technology Dissemination. *International Journal of Disaster Risk Science*. https://doi.org/10.1007/s13753-014-0017-2

Sánchez-Jankowski, M. (2008). *Cracks in the pavement : social change and resilience in poor neighborhoods*. Retrieved from https://www.ucpress.edu/book/9780520256750/cracks-in-the-pavement

Sander, K., Gros, C., & Peter, C. (2013). Enabling reforms: Analyzing the political economy of the charcoal sector in Tanzania. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2012.11.005

Sandra Joireman and Rachel Sweet Vanderpoel. (2010). In Search of Order:Property Rights Enforcement in Kibera Settlement, Kenya. *World Bank*, 22. Retrieved from http://siteresources.worldbank.org/EXTARD/Resources/336681-1236436879081/5893311-1271205116054/Joireman.pdf

Sen, A. (1999). Development as Freedom. *Oxford Press*, 1–50. https://doi.org/10.1215/0961754X-9-2-350

Sen, A. (2003). Development as Capability Expansion. *Readings in Human Development: Concepts, Measures and Policies for a Development Paradigm*, 41–58. https://doi.org/10.1093/0198287976.001.0001

Shove, E, Pantzar, M., & Watson, M. (2012). The dynamics of social practice. In *SAGE Publications*. https://doi.org/10.4135/9781446250655.n1

Shove, Elizabeth, & Walker, G. (2014). What Is Energy For? Social Practice and Energy Demand. *Culture & Society*, *31*(5), 41–58. https://doi.org/10.1177/0263276414536746

Silk, B. J., Sadumah, I., Patel, M. K., Were, V., Person, B., Harris, J., … Cohen, A. L. (2012). A Strategy to Increase Adoption of Locally-produced, Ceramic Cookstoves in Rural Kenyan Households. *BMC Public Health*, Vol. 12, p. 359. https://doi.org/10.1186/1471-2458-12-359

Silverman, D. (2013). Silverman, D. (2013) Doing Qualitative Research: A Practical Handbook, SAGE Publications.Doing Qualitative Research: A Practical Handbook. In *SAGE*

Publications.

Smith, K. R. (1994). Health, energy, and greenhouse-gas impacts of biomass combustion in household stoves. *Energy for Sustainable Development*. https://doi.org/10.1016/S0973-0826(08)60067-8

Smith, K. R. (2010). What's Cooking? A Brief Update. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2010.10.002

Smith, K. R., Shuhua, G., Kun, H., & Daxiong, Q. (1993). One hundred million improved cookstoves in China: How was it done? *World Development*, *21*(6), 941–961. https://doi.org/10.1016/0305-750X(93)90053-C

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. *Applied Energy*, *142*, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Specht, M. J., Pinto, S. R. R., Albuqueque, U. P., Tabarelli, M., & Melo, F. P. L. (2015). Burning biodiversity: Fuelwood harvesting causes forest degradation in human-dominated tropical landscapes. *Global Ecology and Conservation*. https://doi.org/10.1016/j.gecco.2014.12.002

Stephenson, J., Barton, B., Carrington, G., Gnoth, D., Lawson, R., & Thorsnes, P. (2010). Energy cultures: A framework for understanding energy behaviours. *Energy Policy*. https://doi.org/10.1016/j.enpol.2010.05.069

Stern, N. (2006). STERN REVIEW: The Economics of Climate Change Executive Summary. *October*, *30*(3), 27. https://doi.org/10.1378/chest.128.5

Stern, P. C. (2000). Toward a Coherent Theory of Environmetally Significant Behavior. *Journal of Social Issues*, *56*(3), 407–424. Retrieved from https://pdfs.semanticscholar.org/af18/c7127c241cafc187d1ad2521b0ba88a5ef32.pdf

Sutar, K. B., Kohli, S., Ravi, M. R., & Ray, A. (2015). Biomass cookstoves: A review of technical aspects. *Renewable and Sustainable Energy Reviews*, *41*, 1128–1166. https://doi.org/10.1016/j.rser.2014.09.003

Swart, E. (2012). Gender-Based Violence in a Kenyan Slum: Creating Local, Woman-Centered Interventions. *Journal of Social Service Research*. https://doi.org/10.1080/01488376.2012.676022

The World Bank. (2011). *Household Cookstoves, Environment, Health, and Climate Change: A New Look at an Old Problem*.

The World Bank. (2015). *State of the clean and improved cooking sector in Africa*. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/21878/96499.pdf

Tielsch, J. M., Katz, J., Khatry, S. K., Shrestha, L., Breysse, P., Zeger, S., … Adhikari, R. (2016). Effect of an improved biomass stove on acute lower respiratory infections in young children in rural Nepal: a cluster-randomised, step-wedge trial. *The Lancet Global Health*, *4*, S19. https://doi.org/10.1016/S2214-109X(16)30024-9

Tubiello, F. N., Salvatore, M., Rossi, S., Ferrara, A., Fitton, N., & Smith, P. (2013). The FAOSTAT database of greenhouse gas emissions from agriculture. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/8/1/015009

UN- Habitat. (2009). *Promoting Energy Access for the urban poor in Africa: Approaches and Challenges in Slum Electrification FINAL REPORT*. Retrieved from http://mirror.unhabitat.org/downloads/docs/8292_16690_GENUS AFRICA.EGM Final Report.pdf

UN-DESA Population Division. (2017). World Population Prospects: The 2017 Revision. In *World Population Prospects: The 2017 Revision*.

Un-Habitat. (2003). The Challenge of Slums - Global Report on Human Settlements. In *Earthscan Publications on behalf of UN-Habitat*. https://doi.org/http://dx.doi.org/10.1108/meq.2004.15.3.337.3

UN-Habitat. (2006a). Nairobi Urban Sector Profile. In *United Nations Human Settlements Programme*.

UN-Habitat. (2006b). Nairobi Urban Sector Profile. In *United Nations Human Settlements Programme*. Retrieved from http://www.unhabitat.org/pmss/getElectronicVersion.aspx?nr=2791&alt=1,

UN-Habitat. (2014). The State of African Cities 2014: Re-Imagining Sustainable Urban Transitions. In *Journal of Asian and African Studies*. https://doi.org/10.1177/0021909614547604

UN-Habitat and IHS-Erasmus University Rotterdam. (2018). The State of African Cities 2018:

The geography of African investment. In *United Nations Human Settlements Programme (UN-Habitat)*. https://doi.org/10.1163/156853010X510807

UN. (2002). Report of the World Summit on Sustainable Development. Johannesburg, South Africa, 26 August-4 September 2002 (A/CONF.199/20). In *Rio +10*. https://doi.org/A/CONF.199/20

UN. (2015). Transforming our world: The 2030 agenda for sustainable development. A/RES/70/1. In *United Nations General Assembly*. https://doi.org/10.1007/s13398-014-0173-7.2

UN DESA. (2015). World population projected to reach 9.7 billion by 2050 | UN DESA | United Nations Department of Economic and Social Affairs. Retrieved from UN Department of Economic and Social Affairs website: http://www.un.org/en/development/desa/news/population/2015-report.html%5Cnhttps://www.un.org/development/desa/en/news/population/2015-report.html

UN Habitat. (2007a). Slums : Some Definitions. *State of the World's Cities 2006/7*.

UN Habitat. (2007b). State of the World Cities 2006/7. In *State of the World's Cities 2006/7*.

UN Habitat. (2009). *Expert Group Meeting - Promoting Energy Access for the urban poor in Africa: Approaches and Challenges in Slum Electrification*. Retrieved from http://mirror.unhabitat.org/downloads/docs/7387_33602_GENUS Africa Aide memoire and Agenda.pdf

UNDP, The World Bank, & ESMAP. (2003). Household Energy Use in Developing Countries A Multicountry Study October 2003. In *Fuel*.

United Nations. (2016). The Millennium Development Goals Report 2015. In *The Millennium Development Goals Report 2015*. https://doi.org/10.18356/6cd11401-en

United Nations Department of Economic and Social Affairs: Population Division. (2017). *World Population Prospects*. Retrieved from https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_KeyFindings.pdf

United Nations Development Programme (UNDP). (2000a). World Energy Assessment. Energy and the challenge of Sustainability. In *Vasa*. Retrieved from https://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/world_energy_assessmentenergyandthechallengeofsustainability.html

United Nations Development Programme (UNDP). (2000b). World Energy Assessment. Energy and the challenge of Sustainability. In *Vasa*.

United Nations Development Programme THE ENERGY ACCESS SITUATION IN DEVELOPING COUNTRIES A Review Focusing on the Least Developed Countries and Sub-Saharan Africa. (n.d.).

United Nations Division for Sustainable Development. (1992). United Nations Conference on Environment & Development Rio de Janerio , Brazil , 3 to 14 June 1992. In *United Nations*. https://doi.org/10.1007/s11671-008-9208-3

United Nations Framework Convention on Climate Change. (2016). The Paris Agreement - main page. https://doi.org/10.1093/cercor/bhv316

Urmee, T., & Gyamfi, S. (2014a). A review of improved Cookstove technologies and programs. *Renewable and Sustainable Energy Reviews*, Vol. 33, pp. 625–635. https://doi.org/10.1016/j.rser.2014.02.019

Urmee, T., & Gyamfi, S. (2014b). A review of improved Cookstove technologies and programs. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2014.02.019

Usmani, F., Steele, J., & Jeuland, M. (2017). Can economic incentives enhance adoption and use of a household energy technology? Evidence from a pilot study in Cambodia. *Environmental Research Letters*, *12*(3). https://doi.org/10.1088/1748-9326/aa6008

Van Der Kroon, B., Brouwer, R., & Van Beukering, P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2012.11.045

Venkata Ramana, P., Michael, T., Sumi, M., & Kammila, S. (2015). The State of the Global Clean and Improved Cooking Sector. In *ESMAP and GACC*. https://doi.org/007/15

Wanjiru, H., & Omedo, G. (2013). *How Kenya can transform the charcoal sector and create new opportunities for low-carbon rural development*. Retrieved from http://resources.wpowerhub.org/how-kenya-can-transform-the-charcoal-sector-and-create-new-opportunities-for-low-carbon-rural-development/

Wathore, R., Mortimer, K., & Grieshop, A. P. (2017). In-Use Emissions and Estimated Impacts of Traditional, Natural- and Forced-Draft Cookstoves in Rural Malawi. *Environmental Science and Technology*. https://doi.org/10.1021/acs.est.6b05557

Wells, T. (2012). Sen's Capability Approach. In *Choice Reviews Online* (Vol. 37, pp. 37-1475-37–1475). https://doi.org/10.5860/CHOICE.37-1475

WHO. (2008). Our cities, our health, our future: Acting on social determinants for health equity in urban settings. *Organization*. https://doi.org/10.1007/978-1-4020-8496-6

WHO. (2009a). Global Health Risks: Mortality and burden of disease attributable to selected major risks. In *Bulletin of the World Health Organization* (Vol. 87). https://doi.org/10.2471/BLT.09.070565

WHO. (2009b). the Energy Access Situation in Developing Countries. In *UNDP WHO New York*. Retrieved from http://www.who.int/indoorair/publications/PowerPoint_Energy_Access_paper-lr.pdf

WHO. (2014). WHO guidelines for indoor air quality: household fuel combustion. In *World Health Organization*. https://doi.org/9789241548878

WHO. (2016a). Global report on urban health: equitable, healthier cities for sustainable development. *World Health Organization*, 242. https://doi.org/10.1017/CBO9781107415324.004

WHO. (2016b). WHO | Household air pollution and health. In *WHO*. Retrieved from World Health Organization website: http://www.who.int/mediacentre/factsheets/fs292/en/

WHO. (2017). Global Burden of Disease Study 2017. *The Lancet*.

Wickramagamage, P. (1991). *Improved Cookstove Programs in East and Central Africa*. Retrieved from https://www.scribd.com/document/154821698/Country-Studies-Improved-Cookstove-Programs-in-East-and-Central-Africa

Wood, A., & van Halsema, G. E. (2008). Scoping agriculture – wetland interactions. In *FAO Water Reports*. https://doi.org/10.1016/j.biocon.2015.04.016

Wood, D. (1996). The fuelwood crisis in africa. *Geoactive*, *7*(137).

World Bank. (2001). Engendering development through gender equality in rights, resources, and voice . In *The World Bank*. https://doi.org/10.2307/3341723

World Bank. (2014). Poverty Overview. Retrieved from Poverty website: http://www.worldbank.org/en/topic/poverty/overview

World Bank. (2015). *The State of the Global Clean and Improved Cooking Sector*. 1–179. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/21878/96499.pdf

World Bank. (2016). *INFORMAL ENTERPRISES IN KENYA*. Retrieved from http://documents.worldbank.org/curated/en/262361468914023771/pdf/106986-WP-P151793-PUBLIC-Box.pdf

World Commission on Environment and Development (WCED). (1987). Brundtland Report: Our Common Future. In *United Nations*.

World Health Organization. (2014). Social determinants of health Key concepts. *WHO Website*. https://doi.org/1 Desember 2013

World Health Organization. (2016). *Ambient air pollution: a global assessment of exposure and burden of disease*.

World Population Review. (2017). Kenya Population (2017). Retrieved from World Population Review website: http://www.worldometers.info/world-population/kenya-population/%0Ahttp://worldpopulationreview.com/countries/kenya-population/

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*. https://doi.org/10.1016/j.enpol.2006.12.001

Yin, R.K. (1994). Case study methodology R.K. Yin (second edition). Case Study Research design and methods. Sage, Thousand Oaks (CA)..pdf. In *Case Study Research: design and methods* (p. 170).

Yin, Robert K. (2009). Case Study Research Design and Methods Fourth Edition. In *Applied Social Research Methods Seiries*.

Yip, F., Christensen, B., Sircar, K., Naeher, L., Bruce, N., Pennise, D., … Kapil, V. (2017).

Assessment of traditional and improved stove use on household air pollution and personal exposures in rural western Kenya. *Environment International*. https://doi.org/10.1016/j.envint.2016.11.015

Yonemitsu, A., Njenga, M., Iiyama, M., & Matsushita, S. (2014). Household Fuel Consumption Based on Multiple Fuel Use Strategies: A Case Study in Kibera Slums. *APCBEE Procedia*, *10*, 331–340. https://doi.org/10.1016/j.apcbee.2014.10.062

Zulu, L. C., & Richardson, R. B. (2013). Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2012.07.007

Certification

I, Grace Kageni Mbungu, declare that this thesis is a product of my own work, unless otherwise referenced or acknowledged. Furthermore, I declare that this thesis has not been and will not be submitted, in whole or in part, to another University for the award of any other degree.

Date: 15.07.2020……………………………………………………………………..

Grace Kageni Mbungu

Appendix

Interview questions for households relying on low-carbon technologies and fuels (improved, safe, and efficient cooking technologies and fuels.

Please talk to me about your life here in Kibera. (*Follow up* -what do you like and what bothers you about living here?)

How do you prepare cook your meals?

Who mainly prepares cooks the meals in this household?

Is there anything you would like to change about how you prepare cook your meals?

Why do you choose to cook your meals the way you do?

In your opinion, what are the advantages/disadvantages of using nontraditional cooking technologies?

When you make decisions about how to prepare your meals, what are the most important things that you consider?

Does it matter to you what cooking technologies and fuels other families use?

If you would need any help or information about how to make the change (s) you mentioned in response to question 4, who would you go to and why?

Are you a member of any group or organization in your community?

I am finished with all the questions. Do you have anything else to add or some questions for me?

<u>Follow up</u>

Would you be willing to talk with me again about these issues or in case I have a follow- up question(s).

<u>Personal information</u>

Name	Gender	Age	Number of people reliant on a	Occupation	Tel. Number

			cooked meal in the household		
Date:	Start time:	End time:			

Thank you! Date ………………………Start time…………………….End time …………..

Interview questions for households relying on high-carbon technologies and fuels (traditional cooking practices)

Please talk to me about your life here in Kibera. (*Follow up* -what do you like and what bothers you about living here?)

How do you prepare your meals?

Who mainly prepares the meals in this household?

How much time do you spend collecting fuel and preparing your meals every day?

Is there anything you would like to change about how you prepare your meals?

Why are you not able to make the changes you desire?

What do you need to be able to prepare your meals the way you would like?

When you make decisions about how to prepare your meals, what are the most important things that you consider?

If you would need any help or information about how to make the change (s) you mentioned in response to question 4, who would you go to and why?

Are you a member of any group or organization in your community?

I am finished with all the questions I had, do you have anything else to add or some questions for me?

<u>Follow up</u>

Would you be willing to talk with me again about these issues or in case I have a follow- up question (s).

<u>Personal information</u>

Name	Gender	Age	Number of people reliant on a cooked meal in the	Occupation	Telephone Number

			household		

Thanks You!

Date ………………………Start time…………………….End time …………..

Interview questions for external actors working with a focus on clean, affordable and efficient cooking technologies

With whom or what part of Kibera do you work and why?

What do you think is the current situation in regards to transitioning from traditional cooking technologies (open fires / 3 stone cooking) to nontraditional cooking technologies and fuels in Kibera?

What do you think inhibits households in Kibera from transitioning from traditional cooking technologies to nontraditional cooking technologies such as the ICS?

What do you think motivates households in Kibera to transition from traditional cooking technologies and fuels to improved cooking technologies such as the improved cook stoves?

What is your opinion about traditional cooking technologies?

What should be done to support households in Kibera to transition from traditional cooking technologies and fuels to improved cooking technologies and fuels?

I am finished with my questions; do you have anything else to add or some questions for me?

Follow up

Would you be willing to talk with me again about these issues or in case I have follow- up questions?

Personal information

Name	Gender	Age	Name of the organization you represent	Focus of your organization	Telephone Number

Thank you!

Date ……………………Start time……………………End time …………..

Self and project introduction-households

Thank you so much for finding time to talk with me.

My name is Grace Mbungu. I am here because I am interested in learning from you and your neighbors about how you prepare your meals. I am working on a research project for my studies. The main aim of my project is to understand how you prepare your meals and how you make decisions on the kind of fuel(s) and stove (s) you use for cooking. I hope with this project to create awareness of the needs, the challenges, and the opportunities in making energy available and affordable to all.

I would be grateful if you would share your experiences with me. This is entirely voluntary and, you may withdraw at any time if you feel the need to so. Our conversation will take around one hour. Would you like to consult or share our conversation with other members of the household? If you like to invite them now or at any time during our conversation please feel free to do so.

The information you give me here today will be treated as confidential.

I would also like to record our conversation so I can remember what we have talked about today. Are you comfortable with me recording it? Yes ………… No………………

Do you have any questions for me at this point?

If you do not have questions for me and if you have understood the reason I am here and you agree to our conversation, I would please like to begin.

Thank you again …..

Interview questions follow.

Self and project introduction-external actors

Thank you so much for finding time to talk with me.

My name is Grace Mbungu. I am here because I am interested in learning about your work on facilitating the transition from traditional cook stoves to improved cook stoves. I am working on a research project for my studies.

The main aim of my project is to understand how people prepare their meals in Kibera. I am particularly interested in learning and understanding the conditions necessary for a sustainable transition from TCS to ICS or other low corban technologies and fuels, what should be done and how it should be approach to ensure that households have access, and can sustain the use of ICS or other low-carbon technologies and fuels for cooking. I hope with this project to create awareness of the needs, the challenges, and the opportunities in making energy available and affordable to all.

I would be grateful if you would share your experiences with me. This is entirely voluntary and, you may withdraw at any time if you feel the need to so. Our conversation will take around one hour. Would you like to consult or share our conversation with your colleagues? If you like to invite them now or at any time during our conversation, please feel free to do so.

The information you give me here today will be treated as confidential.

I would also like to record our conversation so I can remember what we have talked about today. Are you comfortable with me recording it? Yes ………… No………………

Do you have any questions for me at this point?

If you do not have questions for me and if you have understood the reason I am here and you agree to our conversation, I would please like to begin.

Thank you again …..

Interview questions follow.

List of interviewees with short descriptions[57]

Household identifier	H-A - 1
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel
Number of people cooked for within the household	5
Location/village	Gatwekera
Gender	Female
Additional information	Single mother/ main bread winner with no stable job or income generating activity: not member of any social or economic group
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 2
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel
Number of people cooked for within the household	4
Location/village	Gatwekera
Gender	Female
Additional information	Single mother/ main bread winner with collecting and sale of firewood as the main income generating activity. Was a member of both a social or economic group
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 3
Type of cooking technologies and fuels present and used within the household	Kerosene stove, and an electric water heater
Number of people cooked for within the household	1
Location/village	Gatwekera
Gender	Male
Additional information	Single man, sharing the living space with another single man
Form and location of the interview	Face to face, conducted at the house

[57] H-A shows that the interviewee was from household A, defined earlier as the constrained household; H- B shows that the interviewee was from household B defined earlier as the transitional household while O-L shows that the interviewee was an opinion leader. The numbers represents one of the 20 household interviews and 1- 6 represent one of the 6 opinion leaders.

Household identifier	H-B - 4
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) with charcoal as the main fuel, LPG kerosene stove, and electric water heater (Had owned previous ownership of Safi stove, but had sold it to address urgent household needs)
Number of people cooked for within the household	5
Location/village	Kambi Muru
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner / interviewee's occupation dressmaker, stay at home parent and homemaker. Member of both social and economic groups with a leadership role
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 5
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) with charcoal as the main fuel and kerosene stove
Number of people cooked for within the household	3
Location/village	Kambi Muru
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner : interviewee's occupation stay at home parent and homemaker with no membership to a social and economic group
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 6
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS), Improved cookstove (ICSs), with charcoal as the main fuel and and LPG
Number of people cooked for within the	6

household	
Location/village	Karanja
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner interviewee's occupation stay at home parent and homemaker; Member of both social and economic networks
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 7
Type of cooking technologies and fuels present and used within the household	Improved cookstove (ICSs) with charcoal as the main fuel and LPG
Number of people cooked for within the household	5
Location/village	Makina
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner : interviewee's occupation (self-employed as a shop keeper and homemaker with membership to a social and economic groups
Form and location of the interview	Face to face, conducted owner's business)

Household identifier	H-B - 8
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel , kerosene stove, LPG (had owned and used an ICSs but was at the time not able to replace or repair it
Number of people cooked for within the household	5
Location/village	Makina
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner : interviewee's occupation (self-employed as a hair dresser and homemaker with membership to a social and economic groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 9
Type of cooking technologies and fuels present and used within the household	Kerosene stove

Number of people cooked for within the household	1
Location/village	Lindi
Gender	Male
Additional information	Single man living alone, occupation security officer
Form and location of the interview	Face to face, conducted the place of work in an upscale residential housing close to Kibera on Ngong road .Interviewee engaged in social support groups

Household identifier	H-B - 10
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel and LPG
Number of people cooked for within the household	6
Location/village	Lindi
Gender	Female
Additional information	Traditional household (male and female) with the male as the main breadwinner : interviewee's occupation -homemaker with membership to social and economic groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 11
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel and LPG
Number of people cooked for within the household	4
Location/village	Lindi
Gender	Female
Additional information	Traditional household (male and female) with both partners engaged in self-employment activities Interviewee not engaged in social and economic groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 12
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) with charcoal as the main fuel, LPG and a communal firewood 3 stone fire

Number of people cooked for within the household	Varies, to nuclear family meals and communal cooking ranges from 8- 20 members
Location/village	Ayani,
Gender	Female
Additional information	Traditional household (male and female) with both partners engaged in formal employment outside Kibera. Lives in a communal Nubian compound Interviewee not engaged in social and economic groups due to lack of time. Presence of an external stay-in house help
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 13
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel , kerosene stove (back-up) LPG (had owned and used an ICSs but was at the time not able to replace or repair it
Number of people cooked for within the household	4
Location/village	Kianda
Gender	Female
Additional information	Traditional household (male and female) the male involved in formal employment with Kibera the interviewee home maker and self-employed selling groceries
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 14
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel
Number of people cooked for within the household	5
Location/village	Kianda
Gender	Female
Additional information	Traditional household with male as a casual worker and the female as street food vendor.
Form and location of the interview	Face to face, conducted at the place of work on the streets at the footsteps of their living unit. Interviewee engaged in social and economic support groups

Household identifier	H-B - 15
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel and a fireplace within the family compound
Number of people cooked for within the household	8
Location/village	Silanga
Gender	Female
Additional information	A traditional Nubian household with source of income generated from rental units to relatives and other Nubians who occupy small units in one compound. . Interviewee engaged in social support groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 16
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) with charcoal as the main fuel. A common kitchen where occasional family meals are prepared using firewood in a 3 stone fire modified with metal sheets to prevent waste of energy
Number of people cooked for within the household	5 (the adult and grandchildren)
Location/village	Silanga
Gender	Female
Additional information	Elderly woman without a partner, but with grown children living in one compound in separate units with their families. Is the main breadwinner with rental income as the main source of livelihood. Is of the Nubian descent. Interviewee engaged in social and support groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 17
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel and LPG kerosene as back- up
Number of people cooked for within the	3

household	
Location/village	Karanja,
Gender	Female
Additional information	Lives with a male partner and an adult male child. She is the main bread winner with hair dressing as the main source of incomes. Interviewee engaged in social and economic support groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-A - 18
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) with charcoal as the main fuel, LPG, kerosene stove available as a back-up
Number of people cooked for within the household	4
Location/village	Karanja,
Gender	Female
Additional information	Traditional household (male and female) and two young children with both adults running a basic household goods shop within Kibera. Interviewee engaged in social and economic support groups. The household also had an external household helper.
Form and location of the interview	Face to face, conducted at the shop which also doubles as the family house

Household identifier	H-A - 19
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) with charcoal as the main fuel, LPG, kerosene stove available as a back-up
Number of people cooked for within the household	2
Location/village	Kianda
Gender	Female
Additional information	Traditional household (male and female) the male involved in formal employment abroad interviewee home maker and self- employed as a hair dresser. Interviewee engaged in social and economic support groups
Form and location of the interview	Face to face, conducted at the house

Household identifier	H-B - 20
Type of cooking technologies and fuels present and used within the household	Kenya ceramic Jiko (KCJ) also referenced in this thesis as the basic cookstove (BCS) With charcoal as the main fuel and LPG
Number of people cooked for within the household	3
Location/village	Ayani,
Gender	Female
Additional information	Single mother/ main bread winner with rental income as the main source of income. Involved in social and economic groups and is also a community leader as a residential house owner of the Nubian origin
Form and location of the interview	Face to face, conducted at the house

Opinion leader identifier	O-L- 1
Occupation	A retiree of the Ministry of Energy
Gender	Female
Form and location of the interview	Face to face, conducted at a coffee shop along Ngo’ng road in Nairobi
Additional information	Currently a consultant and advocate for clean cooking energy access, such as biogas including for households within informal settlements

Opinion leader identifier	O-L- 2
Occupation	a researcher and professor at the University of Nairobi, Chiromo Campus
Gender	Male
Form and location of the interview	Face to face, conducted at the University of Nairobi Chiromo Campus
Additional information	Involved in testing biomass cookstoves for efficiency and pollution prevention properties

Opinion leader identifier	O-L- 3
Occupation	Managing director of the KTC in Kibera
Gender	Female
Form and location of the interview	Face to face, conducted at the KTC
Additional information	One of the early advocates for the “green shop „which also stocks and sells ICSs as well as other renewable energy household technologies such as Safi stove, solar powered lights and ICTs such Radio mobile

	charges etc

Opinion leader identifier	O-L- 4
Occupation	Manager KTC
Gender	Male
Form and location of the interview	Face to face, conducted at green shop in Kibera
Additional information	Also conducts trainings to locals about the use advantages and use of ICSs

Opinion leader identifier	O-L- 5
Occupation	women's group representative
Gender	Female
Form and location of the interview	Face to face, conducted at the KTC
Additional information	

Opinion leader identifier	O-L- 6
Occupation	church minister; maker and seller of fuel biomass briquettes
Gender	Male
Form and location of the interview	Face to face, conducted at briquettes workshop
Additional information	