SOCIO-CULTURAL PERCEPTIONS OF INDOOR AIR POLLUTION AMONG RURAL MIGRANT HOUSEHOLDS IN ADO EKITI, NIGERIA

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Abstract

Many households in developing countries rely on biomass (wood, charcoal, agricultural wastes, sawdust, and animal dung) and coal to meet their energy needs. The burning of these fuels in open fires creates environmental problems one of which is indoor air pollution (IAP). For effective reduction of indoor air pollution in sub-Saharan Africa, it is therefore, important to understand factors that determine the choice and uptake of cleaner fuels for household energy use. This research investigates the salient factors influencing households in developing countries in choosing fuel types, using the households in peri-urban areas of Ado Ekiti, Ekiti State, Nigeria as a case study.

This research used holistic approaches to understand energy issues in the study area and used methods such as questionnaires, interviews, and field observation during data collection. Key findings suggest that underlying socio-cultural contexts of households' ethnic groups guided wood-fuel harvesting in the peri-urban areas of Ado Ekiti, Ekiti State, Nigeria. Wood fuel continues to be households' main domestic energy source irrespective of their socio-economic status.

The open burning of wood fuel causes indoor air pollution as the recorded 24-hour particulate matter levels was between 42μg/m^3 – 275μg/m^3 for indoor kitchens and 48μg/m^3 – 648μg/m^3 for outdoor kitchens. The cultural perception of the households that natural aeration blows particulates into buildings hinders them from believing that the open of burning of biomass fuels for domestic activities is the cause of indoor air pollution. Based on the findings of this study, it is argued that the traditional norms and values of the householders, being embedded in their socio-cultural contexts, are vital for understanding energy issues in the global South.

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List of Abbreviations

ALRIs..Acute Lower Respiratory Infections

ARIs...Acute Respiratory Infections

BP...British Petroleum

CO...Carbon monoxide

COPD...Chronic Obstructive Pulmonary Disease

ETS..Environmental Tobacco Smoke

GBD..Global Burden of Disease

GTZ..German Technical Cooperation

IAP..Indoor Air Pollution

ICSs...Improved Cookstoves

LPG..Liquefied Petroleum Gas

LRBT...Local Resident Building Type

MDGs...Millennium Development Goals

NGOs...Non-Governmental Organisations

NO_2...Nitrogen dioxide

ORs..Odd Ratios

PM...Particulate Matter

PAHs...Polycyclic Aromatic Hydrocarbons

SO_2...Sulphur dioxide

THBT...Traditional Huts Building Type

UCB..University of Berkeley monitors

VOCs...Volatile Organic Compounds

WHO..World Health Organisation

Chapter One

Introduction

1.1 Overview

Historically, biomass fuels (wood, charcoal, sawdust, animal dung, and agricultural wastes) have been used for cooking, lighting and heating in developing countries. Duflo *et al*. (2008) point out that the use of such fuels as a source of energy has constantly been about 25 percent since 1975. These energy sources, which are relied upon by over 2.4 billion people globally, have continued to raise health and environmental concerns (Perez-Padilla *et al*., 2010; Cairncross *et al*., 2003). It has been estimated that by 2015 and 2030 over 2.6 billion and 2.7 billion people respectively of the world's population will still be dependent on biomass fuels (OECD/IEA, 2011). Therefore, when significant numbers of people in developing countries depend on traditional fuels, the by-product of indoor air pollution (IAP) diminishes the quality of life of these people (World Energy Assessment, 2000). There are also adverse health effects in the short and long term on end-users because of exposure to biomass fuel smoke. As a result, there is growing international concern regarding the access to clean energy and in 2012, the United Nations declared it to be the *International Year for Sustainable Energy for All*. In contrast to international concerns, Nigeria, which appears to have benefitted from oil exports as a result of the oil price boom, has not made notable progress for the provision of accessible clean energy sources for domestic use (OECD/IEA, 2011).

With a high percentage (53 percent) of the Nigerian population (estimated at over 145 million people) living in rural areas, the use of wood fuel is likely to continue as long as infrastructural investment in clean energy technologies is not put in place. Although the country is estimated to have

80 million cubic metres per year of potential wood fuel reserve (International Food Policy Research Institute, 2010), without the provision of strategies for the sustainable use of this resource, it will result in diminishing supplies of fuel wood.

The reliance on biomass fuels to meet domestic energy needs by resource poor households in developing countries has been contributing to high levels of indoor and local air pollution. This universal household fuel, used by around 80 percent of rural households in Sub-Saharan Africa, remains an important source of exposure to a variety of particulates (UNDP, 2009). The inefficient burning of these biomass fuels over open fires or traditional stoves produces high emissions which include, but are not limited to, carbon monoxide, hydrocarbons and particulate matter (Smith, 2000a), all of which contribute to high levels of household, community and global air pollution. A series of studies (see Begum *et al*., 2009; Ezzati, 2008; Fullerton *et al*., 2008; Gordon *et al*., 2004) found high levels of pollution from the burning of biomass fuels in developing countries, which are in most cases above the 25μg/m^3 World Health Organisation (WHO) 24-hour guideline value.

In most of the indoor air pollution studies conducted in developing countries, actual measurements have been taken by comparing indoor and outdoor air pollution levels (Gao *et al*., 2009; Massey *et al*., 2009). Observational studies have also been carried out to investigate linkages between indoor air pollution and health (Bruce *et al*., 2000). Other research has focused on randomized intervention in determining the causal relationship between indoor air pollution and health (Díaz *et al*., 2007) and meta-analysis data on exposure to solid fuel (Kurmi *et al*., 2010). Other studies have accounted for households' behaviour in estimating individual exposure to pollution in order to understand its effects on household members (Jin *et al*., 2006). The various diseases associated with exposure to indoor air pollution have also been widely discussed in the literature (see Ludwinski *et al*., 2011; Barnes *et al*., 2004; Ezzati and Kammen, 2001). However, there is little analysis in these studies to understand the extent to which the socio-cultural context informs the understanding of indoor air pollution during the burning of biomass fuels in developing countries.

1.2 Statement of the Problem

Energy access[1] is increasingly becoming difficult and acute for the rural and peri-urban poor in Sub-Saharan Africa and South Asia. The crucial means of meeting basic domestic needs through the provision of cleaner fuels[2] and improved cooking stoves is often neglected in developing countries (WHO, 2009a). Even in countries where there is improved access to electricity in rural areas (i.e. South Africa, India), most households do not use it for their domestic activities (especially for cooking), but depend on biomass fuels in meeting energy needs. Despite users experiencing detrimental health impacts from exposure to indoor air pollution during the burning of biomass fuels, it is still the preferred fuel amongst rural households of developing countries (see Ezzati and Kammen, 2001; Bruce *et al*., 2000; Smith *et al*., 2000). In relation to this research, it is important to identify what has been responsible for the reluctance to use cleaner fuels in developing countries. There is limited data in Nigeria to ascertain why rural households continue to use and prefer biomass fuels for their domestic activities. Substituting biomass fuels with cleaner fuels will enable greater development and can

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[1] The term 'energy access' has no universally-agreed and universally-adopted definition but has been described in what could be referred to as the provision of cooking facilities that can be used without harm to the health of the users, environmentally sustainable and energy efficient (OECD/IEA, 2011). This description of energy access was adopted for the purpose of this thesis.

[2] The word 'cleaner fuels' is used here in describing clean burning fuel that is less harmful to the environment than traditional fuels (biomass fuels) (Rehfuess *et al*., 2006).

alleviate the pressure on poor households' when trying to access their basic energy needs. However, this cannot be achieved at face value without understanding the various factors that can militate against its uptake.

Despite the several clean energy interventions attempted by experts[3] to improve on the wellbeing of the resource poor in developing countries, ambient air quality remains poor and above WHO guideline values. At different times, the form of IAP interventions for households has focused on improvements in ventilation, stoves and behavioural practices (of taking children away from cooking areas) and providing subsidies (see Clark *et al*., 2010; Barnes *et al*., 2004; Mehta and Shahpar, 2004; Hanbar and Karve, 2002). Others have considered how socio-economic factors influence the use of biomass fuels in households (see Edwards and Langpao, 2012; Yu, 2011; Boy *et al*., 2000). This research was, therefore, undertaken to understand the socio-cultural issues associated with the use of biomass fuels and understand the role of culture in regards to indoor air pollution in Nigeria. With the heterogeneity of cultures in Nigeria, the country provided rich, varied views across different ethnic groups with which to decipher the specific meanings attached to indoor air pollution in relation to the use of biomass fuels.

[3]The word 'experts' is used in describing organisations (international, government and non-governmental) involved in the development and promotion of clean technologies.

1.3 Aim and Objectives

The purpose of this study is to investigate indoor air pollution among migrant farmers residing in the peri-urban area of Ado-Ekiti[4], Ekiti State, Nigeria in order to understand the socio-cultural context of indoor air pollution arising from the use of biomass fuel for cooking and lighting. In order to meet the primary aim of this research, the following objectives have guided this study:

1. To identify the physical (dwelling) characteristics contributing to indoor air pollution in the study area.
2. To measure and compare indoor and outdoor kitchen levels of $PM_{2.5}$ in buildings at the Irasa settlement in Ado Ekiti.
3. To ascertain the socio-economic factors contributing to indoor air pollution in peri-urban areas of Ado Ekiti.
4. To analyse the socio-cultural factors underpinning the use of biomass fuels and perceptions of indoor air pollution by rural migrant farmers in peri-urban areas of Ado Ekiti.
5. To determine how knowledge, information and education about indoor air pollution has the potential to change behaviour in the study area.

The results from this study highlight how the socio-cultural context can impact on the choice of fuel and perceptions of indoor air pollution in Nigeria. By addressing these objectives, this study will bring to light the importance of socio-cultural factors and their implications for the uptake of clean energy in Nigeria.

[4] Detailed description of Ado Ekiti characteristics is provided in Chapter Three.

1.4 Justification for the Study

Energy is central to all aspects of human welfare be it in the provision of water, health care, education or agricultural produce. It influences people's lives as its absence entrenches poverty, damages health, increases vulnerability to climate change and erodes environmental sustainability at the local, community and global levels (WHO, 2009a). Energy needs, therefore, should not be treated as simply satisfying social needs. The basic energy needed for cooking, heating, lighting and storage amongst others is important to end-users to subsist in their environment. It is therefore clear that there is a need to understand how to improve energy access for a high proportion of people in developing countries – with Sub-Saharan Africa accounting for over 80 percent of the proportion of the people dependent on biomass fuels. Also, over 65 percent of the Nigerian population relies on biomass fuels for cooking (OECD/IEA, 2011; Perez-Padilla *et al*., 2010). In Nigeria, the dependence on unclean energy fuels for domestic activities increases energy-related pollution at the household level. As rural households lack access to cleaner fuels, they experience more severe impacts in comparison to their urban counterparts (WHO, 2009a). In addition, there have been few studies that have focused on the socio-cultural context surrounding energy use in developing countries and how this impacts on the continued use of biomass fuels. The socio-cultural context directly relates to household perceptions of indoor air pollution.

Few of the existing discourses on energy sources (more importantly the use of biomass fuels) and indoor air pollution have specifically considered the cultural specifications of resource use among the poor in Nigeria. This research seeks to close this gap somewhat by unravelling some of the complexities underpinning fuel use and energy access in developing countries. As discussed in the succeeding chapters of this thesis, when cultural aspects are not incorporated into understandings of energy issues in developing countries, energy issues amongst the resource poor are likely to remain misunderstood. This research aims to contribute to the literature by emphasising socio-cultural perceptions in regards to indoor air pollution and biomass fuels. At the same time, domestic energy issues in Nigeria have not received significant attention (Anozie *et al*., 2007), and are not well documented in the current literature (Kennedy-Darling *et al*., 2008). This research presents data on the issues that will provide greater insights into energy issues in the country at a deeper cultural level.

1.5 Scope of the Study

The case study used in this research is limited to peri-urban areas of Ado Ekiti, Nigeria. Households inhabiting settlements in the study location are comprised of various ethnic backgrounds, which provide a rich cultural context for understanding the use of biomass fuels and perspectives about indoor air pollution in Ado Ekiti.

The proposed measurement of ambient air quality in buildings will assist in obtaining reliable data that will help build a database of pollution levels in the study area. Air quality conditions in households will be used as a guide to describe particulate matter levels for buildings in the area irrespective of whether cooking is done indoors or outdoors.

1.6 Organisation of the Thesis

This thesis comprises eight chapters. Chapter Two reviews literature on indoor air pollution and energy needs in developing countries. An overview of how the burning of biomass fuels relates to indoor air pollution is discussed in Section 2.2. Acceptable guideline values for air quality in buildings are examined in Section 2.2.1. The discussions on exposure pathways in Section 2.3 provide an understanding of risks associated with indoor air pollution and the health implications of having measured values above standard limits. In Section 2.4, efforts are made to identify the factors determining energy choice in developing countries. Section 2.5 elaborates on energy policies in developing countries. Section 2.5.1 evaluates 'hardware' versus 'software' approaches in resolving indoor air pollution problems. The barriers to the use of cleaner fuels are discussed in Section 2.6. An overview of energy issues in Nigeria and interventions to alleviate problems associated with indoor air pollution is provided in Section 2.7. The chapter goes on to identify specific constraints peculiar to the Nigerian environment in terms of the uptake of cleaner fuels in Section 2.7.1.

Chapter Three details the methodological approach employed in the research. Sections 3.2 and 3.3 elaborate on the theoretical underpinnings adopted in social research, which leads to an explanation of the qualitative and quantitative approaches adopted for this research. The methods used are discussed in Section 3.3.1. Section 3.4 provides background information on the study location (Ado Ekiti). Section 3.5 examines the context of migrant farmers and the physical environment, livelihoods, and infrastructural challenges in the study area. Sections 3.6, 3.7, 3.8, and 3.9 discuss data collection, data analysis, and methodological issues respectively.

In Chapter Four, using measurements of particulate matter in buildings, Section 4.2 compares analyses of ambient air quality between indoor and outdoor kitchens in the Irasa community in Ado Ekiti. It reveals the impacts of household and community levels of pollution in the study area. The results of the data gathered on householders' dwelling characteristics are presented and analysed from Sections 4.3 to 4.5. Section 4.6 evaluates the strategic importance of ventilation and kitchen locations during the burning of biomass fuels. The health impacts of exposure to wood smoke are also examined in Section 4.7 by relying on the survey analysis.

Chapter Five considers biomass fuels in relation to indoor air pollution and socio-economic factors. Section 5.2 highlights types of fuel used in homes for domestic activities. Section 5.3 examines the socio-economic conditions of householders. Further analysis of the relationship between fuel types and socio-economic characteristics is discussed in Section 5.4.

Chapter Six focuses on the socio-cultural issues surrounding biomass fuels from householders and stakeholders' perspectives. The interview analysis explicitly articulates cultural influence on energy choice (Section 6.2) and how perceptions of indoor air pollution are shaped through a greater understanding of traditional norms around biomass fuels (Section 6.3). Sections 6.4 and 6.5 examine beliefs surrounding sources of biomass fuels and cultural taboos associated with cooking practices.

Chapter Seven discusses knowledge dissemination with respect to indoor air pollution. Section 7.2 highlights the means of sourcing information about indoor air pollution amongst householders. The section also identifies householders' environmental problems in the study area and how they have been prioritised. Section 7.3 examines stakeholders' perspectives on the problem of indoor air pollution in the study area. Section 7.4 evaluates, in the light of cultural context, what needs to be considered when introducing cleaner energy and technologies to householders. The results highlight one key culturally contextualised issue that needs to be addressed when introducing energy technologies and what experts needs to consider when integrating them in an everyday, communal environment. These findings will allow experts and communities to develop solutions specific to local environments.

Chapter Eight of the thesis discusses the findings and conclusions of the research. In Section 8.2, major conclusions are drawn from the findings of the study as it relates to energy issues in developing countries from a socio-cultural perspective. Insights from this research indicate that cultural norms guide householders on the type of wood fuel to harvest for domestic activities (Sections 8.3 and 8.4). The other pertinent aspect of culture relates to behaviours guiding cooking activities within the hearth. It is noteworthy that cultural complexities shape acceptance of cleaner energy interventions in the area. Evidence suggests that household and neighbourhood pollution levels affect ambient air quality in buildings regardless of kitchen location. Areas identified for further research are highlighted in Section 8.5 of the chapter.

Chapter Two

Review of Literature

2.1 Introduction

This chapter reviews literature on energy and health as it relates to the global South[5] and is central to understanding the underlying economic, social, and environmental situation of the energy poor populations in the global South. Energy needs in the global South cannot be neglected as they create local, regional, and global environmental problems. Although poor access to cleaner fuels can limit households to the use of unclean fuels in meeting domestic energy needs, there are a range of factors (social, economic, and cultural) contributing to fuel choices (World Energy Assessment, 2000).

Section 2.2 details the sources of indoor air pollution and the various types of indoor air pollutants. There is also discussion of particulate levels for studies conducted in the global South in relation to acceptable limits recommended by the World Health Organisation for household buildings. Studies on indoor air pollution in the global South are also reviewed in Section 2.2.1. Section 2.3 examines exposure pathways and risks associated with exposure to indoor air pollution, which are felt at the household level and community level. The section also highlights the various health impacts of inhaling wood smoke through the burning of biomass fuels. In Section 2.4, linkages are drawn between indoor air pollution and resource poor

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[5] The term 'global South' is used interchangeably with 'developing countries' emerging economies and developing economies like China, India, Brazil and South Africa (Tomlinson, 2003)

households of developing countries. Factors determining energy choice amongst householders are examined in Section 2.4.1.

In Section 2.5, I explain how energy policy in developing countries has evolved. The discussion in Section 2.5.1 sheds light on strategies deployed to address indoor air pollution in the global South. Specific barriers to the uptake of cleaner fuels in developing countries are explained in Section 2.6. Section 2.7 discusses energy issues in Nigeria and interventions to combat the problem of indoor air pollution. In Section 2.7.1, I discuss problems in Nigeria that can prevent the use of cleaner fuels.

2.2 Sources of Indoor Air Pollution

Indoor air pollution in developing countries results from a variety of smoke sources such as neighbours' hearths, the burning of wood, charcoal, crop residue, animal dung, and the use of kerosene lamps (Nweke and Sanders, 2009; Bruce *et al*., 2000; MaCracken and Smith, 1998; Gold, 1992). Incomplete combustion of biomass fuels causes the emission of pollutants from cooking stoves which include but are not limited to carbon monoxide (CO), particulate matter (PM), NO_2, sulphur dioxide (SO_2) aldehydes, chlorinated dioxins, VOCs (volatile organic compounds), and PAHs (Polycyclic Aromatic Hydrocarbons) (Black *et al*., 2011). This contributes to poor air quality, especially when there is inadequate ventilation in buildings (Smith *et al*., 2000a). Wood smoke also contains PAHs which are carcinogenic and are potentially genotoxic and harmful to health when used in preserving (smoking) products (Stolyhwo and Sikorski, 2005). Studies conducted in various parts of the global South (Colbeck *et al*., 2010; Begum *et al*., 2009; Fullerton *et al*., 2009; Dasgupta *et al*., 2009; Siddiqui *et al*., 2009; Balakrishnan *et al*., 2002; Ezzati and Kammen, 2001a; Smith, 2000a) indicate that indoor air concentrations of PM, CO and NO_2 often increase beyond World Health Organisation (WHO) guideline levels (as discussed in Section 2.2.1). Other sources of poor air quality include the presence of biological particles (i.e. house dust, moulds and microorganisms) and environmental tobacco smoke (ETS) which should not be overlooked as a source of pollution (Bruce *et al*., 2000; Jones, 1999; Lewis *et al*., 1994).

2.2.1 Pollutants Indicators and Types of Indoor Air Pollutants

In measuring pollution concentrations in homes, Table 2.1 indicates WHO air quality guidelines for buildings.

Table 2.1: WHO guideline values for indoor air quality

Pollutant	WHO guideline values		
	Annual mean	Average 24 hour	
$PM_{2.5}$	10μg/m^3	25μg/m^3	
PM_{10}	20μg/m^3	50μg/m^3	
SO_2		20μg/m^3	500μg/m^3 (10-minute mean)
NO_2	40μg/m^3		200μg/m^3 (1-hour mean)
CO		7mg/m^3	100mg/m^3 (15-minute mean) 35mg/m^3 (1-hour mean) 10mg/m^3 (8-hour mean)

Source: WHO, 2010; WHO, 2006a

In those developing countries which have been studied, the 24-hour level for PM_{10} ranges from 500μg/m^3 to 3000μg/m^3 during cooking when households use biomass fuels (Ezzati, 2008; Gordon *et al*., 2004; Balakrishnan *et al*., 2002), and air quality often fails to meet WHO guidelines (see Colbeck *et al*., 2010; Begum *et al*., 2009; Fullerton *et al*., 2009). There are frequently wide gaps between guidelines and the real air quality in buildings in the global south.

In rural areas of China, biomass fuel users average PM_{10} levels of exposure to indoor air pollution ranges between 680μg/m^3 and 750μg/m^3 (Mestl *et al*., 2007). Massey *et al*. (2009) compare the 24-hour indoor and outdoor concentrations of $PM_{2.5}$ in rural areas of Agra, India. Their analysis showed that indoor particulates range between 143.36μg/m^3 and 198.38μg/m^3 in the buildings, while 127.86μg/m^3 to 182.05μg/m3 was recorded for outdoor areas. Although their study shows that average concentrations of particulates indoors were high, the outdoor concentrations were also high.

Gao *et al.*'s (2009) study compares $PM_{2.5}$ concentration levels in indoor microenvironments (kitchen, living room, bedroom) in rural areas of Tibet, China. The estimate of the daily 24-hour averages for kitchens, living rooms, and bedrooms was put at 134.91μg/m^3, 103.61μg/m^3 and 76.13μg/m^3 respectively. The outdoor air concentrations were estimated at 78.33μg/m^3. Their results show variation in $PM_{2.5}$ levels in different microenvironments, and the kitchen area had the highest pollution level compared to other areas in the building. The main source of indoor air pollution in the area is from cooking activities, as kitchen designs ensure the heat retention of buildings by reducing indoor/outdoor air exchange.

In contrast to Gao *et al*. (2009), a study carried out by Dasgupta *et al*. (2006a) in peri-urban and rural areas of Narshingdi, Bangladesh, estimated the 24-hour concentration of PM_{10} as 260μg/m^3 for cooking areas and 210μg/m^3 for living areas, whilst the average outdoor concentration levels in the area ranged between 36μg/m^3 and 62μg/m^3. During cooking periods, 1-hour concentration levels peaked at 845μg/m^3 in the cooking areas and 683μg/m^3 in the living areas. The living areas were polluted because cooking smoke generated in the cooking areas diffused almost immediately into the living areas. As a result, pollution in buildings wafts around in response to fuel combustion used for cooking in the areas. Dasgupta *et al*. (2006a) also noted that pollution levels always peaked during the morning and evening cooking times, and at this period it was 3 times above the daily average level. Indoor pollution also has an impact on the outdoor ambient air quality as many houses emit cooking smoke, leading to poor outdoor air quality. Huboyo *et al*. (2009) further emphasise that indoor cooking is believed to increase the indoor/outdoor pollutant ratio in buildings.

With a focus on fuel use, cooking locations, structural materials, ventilation practices (household specific factors) and other potential sources of IAP, a further study was conducted by Dasgupta *et al*. (2006b) in Dhaka and Narayangi areas of Bangladesh to measure the level of PM_{10} concentrations in households' kitchen and living areas. 24-hour monitoring in the area shows that concentration levels are between 68μg/m^3 and 4864μg/m^3, in buildings. Findings from this study indicate that household specific factors had more influence than fuel choice on PM_{10} levels in buildings in the area. Seasonality was also an important factor determining the interaction between indoor and outdoor air pollution.

Dasgupta *et al.*'s (2009) study in Bangladesh captured seasonal variations during the high-dust season (spanning from November to March when humidity is low and rainfall is rare) and low-dust season (between April and June, and also in October during which pre-monsoon thunderstorms and post-monsoon rainfall occurs). The average 24-hour PM_{10} concentration during the low-dust season was estimated at 55μg/m^3 and 150μg/m^3 during the high-dust season. The seasonal difference in the concentration levels of ambient air quality at these two seasonal periods also contributes to household level indoor air pollution in the area.

The 8-hour average of $PM_{2.5}$ measured in Honduran communities was 1002.3μg/m^3 with a peak of 4835.4μg/m^3 amongst traditional stove users (Clark *et al*., 2010), whereas, in Rehri Goth, Pakistan, a value of 274μg/m^3 was recorded in the area for the 8-hour period (Dasgupta *et al*., 2009). One intriguing observation about the contrasting results in these locations was that most of the Honduran households kept their cooking fire burning for up to 12.7 hours daily, indicating long periods of exposure to indoor air pollution in buildings even when they are not cooking, which was not the case in Pakistan.

Pennise *et al*. (2009) compare indoor air quality impacts of an improved wood stove in Ghana and an ethanol stove in Ethiopia by measuring concentrations of $PM_{2.5}$ and CO before and after intervention with improved stoves. In Ghana, the average 24-hour $PM_{2.5}$ and CO decreased from 650μg/m^3 for the traditional clay wood stove to 320μg/m^3 for the Gyapa wood stove and from 15.2mg/m^3 to 9.13mg/m^3 respectively before and after stove intervention, whilst in Ethiopia $PM_{2.5}$ decreased from 1250μg/m^3 for traditional stoves to 200μg/m^3 for the cleancook ethanol stoves, and CO concentrations reduced from 48mg/m^3 to 11.3mg/m^3. Despite stove interventions in these areas, $PM_{2.5}$ concentration levels are above the 24-hour WHO guideline values. Therefore, in bringing the $PM_{2.5}$ concentrations to levels not considered harmful to health, Pennise *et al*. (2009) suggest households make changes to their stove, fuel type, and fuel-mixing pattern in the area. Similarly $PM_{2.5}$ measured in Comachuén, Mexico pre and post-stove intervention for households using a traditional open fire to cook showed concentration levels ranging between 94μg/m^3 and 693μg/m^3 (pre *Patsari* stove installation) to between 110μg/m^3 and 246μg/m^3 (post *Patsari* stove installation) in the area (Zuk, *et al*., 2006).

The study by Clark *et al*. (2010) in Santa Lucia and Suyapa in Honduran communities show that CO levels for an average 1-hour period were estimated at 17.6mg/m^3 in houses using traditional stoves in comparison to 2.22mg/m^3 in homes with improved stoves. In rural South African villages, measurements from 24-hour CO levels in kitchens ranged between

0.44mg/m^3 to 25.84mg/m^3 in un-electrified dwellings in the area (Röllin *et al*., 2004).

The study in Malawi on biomass fuel use and indoor air pollution in homes carried out by Fullerton *et al*. (2009) further reveals that the CO level was >370mg/m^3 when cooking with wood. In many of the rural areas, rooms are partitioned in such a way that cooking smoke did not reach the ceiling, and with no specific kitchen area or entrance, this allows air circulation of the pollutants within the building (Fullerton *et al*., 2009). Furthermore, comparative analysis of indoor levels of suspended particulates and nitrogen dioxide in Nigeria carried out by Ukpebor *et al*. (2007) indicate that average 8 hour measurement of suspended particulate matter were estimated at 25833μg/m^3 and <180μg/m^3 for nitrogen dioxide. A lower level of suspended particulate matter (352.9μg/m^3) however, was recorded amongst households using biomass fuels in rural areas of India (Padhi and Pady, 2008). These results suggest that there is a high health risk associated with the use of fuel wood for cooking, heating and lighting in the global South.

In the study conducted by Kumie *et al*. (2009) in Butajira district Ethiopia, with specific reference to NO_2, the mean level for a 24-hour period was estimated at 97μg/m^3 (WHO, 2006a). Furthermore, the results point to a seasonal variation in NO_2 concentration, with the wet season in comparison to dry season recording higher concentrations of indoor air pollution during cooking, because biomass takes a longer time to burn during this period. However, rainy conditions meant residents cook and stay longer indoors with the belief that keeping smoke indoors maintains warmth.

The investigation of exposure to indoor air pollution in Mexico by Pruneda-Álvarez *et al*. (2012) makes specific reference to PAHs and VOCs in the area by analysing urine samples of householders. The results show that those exposed to biomass fuels smoke have high levels of 1-hydroxyprene (1-OHP), trans (t), trans-muconic acid and hippuric acid (HA) in their urine samples. As 1-OHP is a pyrene metabolic and pyrene is present in the mixture of PAHs, households are at risk of diseases (see Table 2.2) associated with indoor air pollution. The fact that many studies show that WHO guidelines are being exceeded (see Stanek *et al*., 2011; Clark *et al*., 2010; Gao *et al*., 2009; Massey *et al*., 2009; Mestl *et al*., 2007; Dasgupta *et al*., 2006b) indicates that the use of biomass fuels contributes significantly to poor ambient air quality in developing countries. Household air quality sometimes does not improve when stove interventions are provided (see Pennise *et al*., 2009). It is when fuel type changes that air quality levels in buildings improve. However, it is not only fuel types that contribute to poor ambient air quality; household specific factors (cooking locations, structural materials, ventilation practices) also influence air quality in buildings (see Dasgupta *et al*., 2006b). If changes are not made to fuel type and household specific factors, therefore, the magnitude of health risks associated with indoor air pollution are likely to increase in developing countries.

2.3 Exposure Pathways to Indoor Air Pollution and Risks

The burden of ill health caused by environmental risks (such as indoor air pollution) has attracted significant attention by international organisations particularly in developing countries. With different levels of socio-economic development in developing countries, there are variations in how to assess the impacts of environmental risks, which are strongly associated with poverty (WHO, 2009b). With air quality exceeding WHO guidelines (Section 2.2.1), prompt intervention is needed to combat the problem. Since the majority of households in the global South rely on biomass fuel for cooking and lighting, exposure risk to IAP is responsible for about 2 million excess deaths per year, and accounts for 4 percent of the global burden of disease (GBD) in developing countries and 3.8 percent of Nigeria's GBD (see WHO, 2009b, 2007). As the burden of diseases is used in assessing the health of the population, it is, therefore, necessary to understand the causes of GBD in relation to selected risk factors, diseases, and injuries, which affect regions and populations (Murray *et al*., 2007).

2.3.1 Varying Perspectives on Indoor Air Pollution Risks

According to Cox and Tait (1991), risk refers to the likelihood of a particular hazard causing harm to the exposed individuals and the severity or consequences of the harm. Nevertheless, strategies to reduce the risks, the extent of the threat posed by different risk factors, availability of cost-effective interventions, and, social values and preferences (WHO, 2002) are important factors that must further be considered for reducing risk impact among people. Local perceptions in defining risks reflect the social, economic, political, and cultural factors prevailing in an environment (WHO, 2002). The prioritisation of risks among poor households in developing countries often means that urgent physiological needs (food, shelter and water) are 'foregrounded', compared to less immediate risks like indoor air pollution (Jewitt and Baker, 2012).

However, since humans are social beings, it is important to consider the social context of their risk perception, which is socially or culturally constructed. The complexity in understanding spatial risks by the resource poor often makes it difficult for them to understand the relationships between cause (burning biomass fuels) and effect of exposure to risk (indoor air pollution), because there is a time lag before health impacts occur (Jewitt and Baker, 2012). In a situation like this, the immediate signs of illness and symptoms requiring referral treatment determine the evaluation of the perceived risk. Any absence of this means less attention may be focused on the situation.

Regardless of the social and/or cultural perception of risks, however, Bruce *et al*. (2000) argue that indoor air pollution affects people's health either through the substances in the smoke (i.e. carcinogens and toxins) or as pathway for bacterial infections which damage respiratory systems. When energy based aspects of the risk transition[6] model (Smith, 2002), (which is based on the premise that absolute risks decline as traditional (biomass) fuels are replaced with cleaner fuels) are considered there could be less impact of the risk of exposure to indoor air pollution. However, the relative risk trend is unclear as "changes in diseases might come quickly before changes in the risk factor" and/or "the shift in risk factor may come years or decades before the change in disease" (Smith and Ezzati, 2005:294). Many of the solutions provided to address household indoor air pollution (chimneys, hoods) tend to shift the environmental problem from the household level to the community and global levels (Smith and Akbar, 2003). Consequently, community level pollution re-enters buildings thereby re-creating household level pollution, which often defeats the aim of interventions provided to improve air quality (Zhang and Smith, 2003). Potentially, the lag from exposure to air pollution at the household and community levels creates health impacts to householders in the area (Smith and Ezzati, 2005). Contrary to the anticipated trajectory of the risk transition model, clustered settlements in the global South often display no decline in

[6] The risk transition in relation to energy is the process "in which the traditional risks of household fuel subside and modern risks from building materials emerge" (Zhang and Smith, 2003:221)

levels of IAP. Smith (1997:55) argues further that the pace of the "risk transition has changed such that traditional risks persist while modern risks start earlier in development".

2.3.2 Health Impacts Associated with Indoor Air Pollution

There is evidence from previous studies in developing countries indicating biomass fuels (used for cooking and heating) as one of the main causes of acute respiratory infections in children, chronic obstructive pulmonary disease, cataract, and asthma (see Balakrishnan *et al*. 2004; Schel *et al*. 2004; Bruce *et al*. 2000; Schwela, 2002; Ezzati and Kammen, 2001; Smith *et al*. 2000a). Indoor air pollution from the combustion of biomass fuels has a significant influence on some health problems (see Table 2.2) in developing countries (Begum *et al*., 2009). That is why in determining the health effects of pollution, time spent breathing polluted air, and the "concentration of pollution in the immediate environment during a specified period of time" are all factors that are used in calculating exposure levels of individuals (Bruce *et al*., 2000:1079). Individuals susceptible to this risk must have been exposed to pollutants over a relatively long period of time or on repeated occasions (Briggs, 2003). The inherent health risks further depend on where the pollution occurs and who occupies those locations at such a time. When biomass fuels are burnt indoors on open fires or poorly designed stoves without flues or hoods (which can take smoke out of the living area), it exposes householders to high concentration levels of CO, SO_2, NO_2 and toxic compounds i.e. benzene, bezo[a]pyrene and formaldehyde (Begum *et al*., 2009; Fullerton *et al*., 2008; Ezzati *et al*., 2005; Bruce *et al*, 2000).

Table 2.2: Air pollutants and potential health effects

Pollutant	Potential Health Effects
Particulate matter: Particles >10 μg and >2.5 μg	Wheezing, exacerbation of asthma, respiratory infections, chronic bronchitis etc.
Biomass smoke	Cataract, acute lower respiratory infections, COPD (chronic obstructive pulmonary disease) etc.
Carbon monoxide	Low birth weight, increase in perinatal deaths, asphyxiation etc.
Nitrogen dioxide	Wheezing and exacerbation of asthma, respiratory infections, reduced lung functions in children etc.
Sulphur dioxide	Wheezing and exacerbation of asthma, COPD etc.
PAHs	Lung cancer, cancer of the mouth, nasopharynax and larynax, increased susceptibility to infections

Source: Akunne *et al*., 2006; Smith *et al*., 2000a

In children, a link has been established between indoor pollutants and acute respiratory infection (see Dasgupta *et al*., 2009; Akunne *et al*., 2006; Kilabuko and Nakai, 2007; Khalequzzaman *et al*., 2007; Zhang and Smith, 2007; Smith *et al*., 2000a). During the cooking process, children below the age of 5 years are often strapped to their mothers' backs in developing countries including Nigeria (see Kraai *et al*., 2013; Mishra, 2003; Bruce *et al*., 2000), inhaling smoke for long periods each day. The process may make children more susceptible to asthma attacks during the cooking process, especially where open fires are used (Schel *et al*. 2004). Rehfuess *et al*. (2009), for example, found that exposing children under the age of 5 to solid fuel smoke increases their risk of having acute lower respiratory infections (ALRIs) of which cough, convulsion, chest in-drawing (the inward movement of the whole lower chest wall when the child breathes in) or severe pneumonia, and fast breathing are key symptoms (see Murray *et al*., 2012; Barnes *et al*., 2004; Moya *et al*., 2004; Gouveia and Fletcher, 2000). In adults, cumulative exposure to biomass smoke increases the prevalence of respiratory symptoms attributed to COPD and decline in lung function (see Kurmi *et al*., 2010; Salvi and Barnes, 2009; Akhtar *et al*., 2007; Liu *et al*., 2007; Bruce *et al*., 2000). It also affects the central nervous system thereby impacting on mood and behaviour (Banerjee *et al*., 2012). Carbon monoxide interferes with the development and functioning of the central nervous system, a situation that causes memory impairment, learning disability, and affects concentration. Comorbidity (psychiatric or physical illness), migraines, headaches, shortness of breath, wheezing or whistling chest, and throat pain have also been associated with exposure to ambient air pollution (see Szyskowicz *et al*., 2010; Massey *et al*., 2009; Teneja *et al*., 2008).

Studies have revealed (see Khalequzzaman *et al*., 2007; Díaz *et al*., 2007; Porkhrel *et al*., 2005; Zodpey and Ughade, 1999; Mishra *et al*., 1999; Ellegård, 1996a) that tears coming out from the eye, eye discomfort and sore eyes, redness and itching of the eye, eye irritation, muscle weakness, fatigue, sleeping problems, stomach pains, dry mouth, and blindness linked to cataracts, trachoma, and conjunctivitis are further indications of indoor air pollution within buildings, which exposes affected people to greater health impairment. Intrauterine growth retardation in foetuses, birth defects, low birth weight and nutritional deficiencies (anaemia and stunted growth), still birth, mortality, placenta dysfunction and adverse reproductive outcomes have also been observed among young children and women that are exposed to indoor air pollution (see Kadir *et al*., 2010; Pope *et al*., 2010; Tielsch *et al*., 2009; Fullerton *et al*., 2008; Gosh *et al*., 2007). The long-term health effects of exposure to biomass fuels in the global South include but are not limited to lung, nasopharyngeal and laryngeal cancer. Although tobacco smoke has been the primary cause of lung cancer, Dalegado *et al*.'s (2005) study in Mexico also found an association between wood smoke and lung cancer.

The constant and continual exposure to smoke from biomass fuel thus poses both long and short-term health threats to people because of the amount of time spent indoors and the high levels of pollutant concentration encountered in these microenvironments and in the community. This risk from indoor air pollution applies to the substance (pollutant), source (fuel type), environment, target group, effect (health impacts/risks) and pathway (ventilation).

Hence, it could be suggested that there is a strong association between the use of biomass fuel and health risks since there is a source, pathway, and receptor.

2.4 Indoor Air Pollution and Resource Poor Households in the Global South

Resource poor households in urban, rural or peri-urban areas in the global South frequently make use of biomass fuel for cooking and lighting (Dasgupta *et al*., 2006a). Their adverse economic situations further impact on their health and also on indoor air quality. Better knowledge of the complex linkages between wood smoke and cultural beliefs can improve understandings of why householders continue to use biomass fuels (Jin *et al*., 2006) but these factors have received limited focus in previous studies (Kowsari and Zerriffi, 2011; Miah *et al*., 2011; Tsephel *et al*., 2009; Boadi and Kuitunen, 2006; Röllin *et al*., 2004). There have been studies focusing on IAP in rural areas (Fullerton *et al*., 2009; Ezzati and Kammen, 2002b), but there is limited emphasis on predominately peri-urban areas in the literature (Dasgupta *et al*., 2009; Smith, 2002). The purpose of this thesis address this gap by focusing specifically on IAP in peri-urban areas. Parikh (1995) in his study of energy choice argues that each community has its own reasons for preferring a particular type of biomass fuel and if the wider cultural context is not properly identified, adequate solutions cannot be provided to target the problem of indoor air pollution. In poor households where fuel for cooking is inadequate, food is prepared in larger quantities than is needed and is stored (by using fermentation and/or smoking methods) for other meals of the day (Ehiri and Prowse, 1999). Ehiri and Prowse (1999:6) define fermentation as "a process where growth and survival of microorganisms are regulated by high acidity." Although food-borne diseases have been associated with fermented foods when the technology is applied inappropriately, smoking continues to be a means of preserving food among rural people when they cannot afford to spend more on cooking fuel. The smoking method is such that foods are placed over open fires directly or on wire gauze while smoke from the fire preserves the food, thus, exposing the food to carcinogens. This practice is common among rural poor in the global South, as they do often lack access to electricity (UNDP, 2009) and they cannot afford fuels that generate less indoor air pollution let alone having refrigerating infrastructure in their homes. According to Mishra (2003), most rural households are unlikely to be able to afford cleaner fuel because of poverty. Poor infrastructural facilities also hinder the supply of cleaner fuels to most homes in rural areas of developing countries.

Quagraine and Boschi (2008) assert that cultural practices contribute to indoor air pollution in Ghana. The study compares two housing types- the traditional huts building type (THBT) and the local residential building type (LRBT). The THBT is located in rural communities (mostly occupied by poor farmers and fishermen). Buildings are constructed with earth-soil, wood, and thatch, while the LRBT is constructed with concrete blocks and mortar, predominately found in urban areas. In both buildings, natural ventilation is relied upon for cooling even though kerosene lamps and candles are burnt for lighting, mosquito coils are burnt indoors, thus, increasing the concentration of carbon monoxide, nitrogen dioxide, and particulate matter.

However, most of the residents in Kumasi, Ghana did not link the effect of poor ventilation and overcrowding to health problems arising from indoor pollution.

The study by Mestl *et al*. (2006) in China with households having stoves with a vented chimney estimates that 70 percent of the rural population use either coal or biomass for cooking and heating, thus, exposing them to indoor air pollution. Though rural populations often have cleaner outdoor air than urban populations, their exposure to indoor air pollution is often higher, due to the use of biomass fuels for cooking and for heating purposes indoors. In addition, Fullerton *et al.* (2009) further attribute poor air quality to 'the rural environment being significantly dustier' because of the simple methods used when constructing homes.

In China, both men and women in rural areas had similar exposure experiences, though the kitchen area where cooking is carried out by women is more polluted than the living area where men spend more time. However, the average exposure is not significantly affected. Mestl *et al*. (2007) argue further, that all household members using coal for cooking are susceptible to indoor air pollution exposure burdens that cause impairment to their health. Nevertheless, the study indicates that the WHO underestimates the health impacts of indoor air pollution especially for men compared to women and children. It is generally believed that women have a higher risk since they are exposed to particulate matter during cooking alongside children who are normally around them. However, when different average levels were used in estimating the exposure, the risk is reduced for population groups that are not cooking (Mestl *et al*., 2007).

Pollution levels may be higher at the fireplace or cooking place than elsewhere indoors, but in order to protect the people living in such environments, measures are necessary to bring pollution levels below WHO guideline values (Section 2.2.1; WHO, 2006a). Dasgupta *et al*. (2009) argue that fuel types combined with construction materials, space configuration, cooking locations and household ventilation are important determinants of indoor air pollution among poor families in South Asia and Africa. The most economical way of reducing indoor pollution however, might be to re-design the kitchen and increase ventilation of the living room. Their findings in Bangladesh show that pollution from cooking areas is transported to other living spaces in the building. Nonetheless, seasonal conditions seem to influence the severity of pollution from wood and other biomass fuels. The authors conclude that, if cooking with clean fuels is not possible, the kitchen must be constructed with permeable materials and a well-designed stove with proper ventilation to achieve a healthy environment.

It has been suggested that indoor air pollution is one of the key "enemies of health and allies of poverty" (WHO, 2002:8). Case studies in the current literature have highlighted a plethora of health risks and concerns as a result of indoor air pollution associated with the use biomass fuels for domestic activities.

2.4.1 Factors Determining Choice of Fuel in the Global South

Understanding the factors that expose the rural poor in the global South to indoor air pollution would allow for more appropriate interventions – hardware (using pollution-reducing products and technology to solve IAP problems) or software (considering and incorporating social and cultural contexts in providing IAP interventions) in the area. The complex interactions between technology, economy, behaviour, and infrastructure have often been neglected in the past (Jin *et al*., 2006). Interventions regarding indoor air pollution have shifted from ideal operating conditions, to stove monitoring performance under actual usage, bearing in mind social behavioural and physical factors that would limit optimal performance of the stove (Jin *et al*., 2006). However, energy choices and behaviours have complex linkages to household economy and infrastructure. Therefore, characterising these determinants is important in designing and delivering solutions to indoor air pollution in diverse environmental and socio-cultural conditions in developing countries (Jin *et al*., 2006). Several factors such as high cost and accessibility of other cleaner fuel (e.g. LPG and electricity) influencing the use of biomass fuel should not be overlooked. In addition, cooking techniques, number of meals cooked per day and meal ingredients have a major influence on the choice of energy sources made by householders in carrying out their domestic activities (Kowsari and Zerriffi, 2011).

Röllin *et al.*'s (2004) study compares indoor air quality in electrified and un-electrified (without electricity supply) dwellings in South Africa. The climatic conditions, socio-economic status, housing quality, and household density are contributory factors to indoor air pollution in the area. Similarly, household socio-economic status and educational level are found to be important determining factors for energy choice in Ghana (Boadi and Kuitunen, 2006). Higher levels of education can improve awareness of the health risks associated with the use of biomass fuels.

According to Miah *et al*. (2011) socio-economic factors such as income, family size, gender, age, occupation and frequency of cooking determines household energy preferences in Naokhali, Bangladesh. Whereas, in Guatemala, the inability of households to afford clean energy because of their low-income is one factor determining fuel choice in the area (Heltberg, 2005). On the contrary, Kowsari and Zerriffi (2011) aver that the amount of energy consumed within a household is influenced by family size, because larger households have higher total energy consumption. Energy use in large families alters income and resource availability as well as the finance spent on domestic energy demands.

In contrast, Bailis (2004) suggests that the extent of industrialization in a country determines the fuel choice by residents. Households in industrialized countries rely on modern fuels, in contrast to less industrialized countries that tend to use more biomass fuels in meeting their energy demand. He outlined other factors, which included government development policies, prevalent energy technologies in the area and the gender of the main household decision maker that contributes to household fuel choice in an environment. On the contrary, in China the restrictions on traditional biofuel consumption caused people to shift to coal as the main energy source. Likewise, the rationing of energy sources in Hyderabad discouraged people from choosing kerosene as their main energy source because rations and distribution services are not sufficient and reliable (Kowsari and Zerriffi, 2011).

Inadequate information, education, and social learning are additional factors that determine energy choice amongst householders. Most often householders are not aware of the benefits associated with using clean fuels (Kowsari and Zerriffi, 2011).

Tsephel *et al*. (2009) argue that aside from socio-economic factors (i.e. income, age, gender, education etc.), product specific factors (materials used in production) in terms of safety, indoor smoke, usage cost, stove price, and fuel characteristics are important to households when using clean fuels in developing countries. The relevant characteristics of each type of fuel influences decisions about energy sources used and the use of each fuel along the energy ladder corresponds to accessibility, acceptability, availability and affordability (current cost and the expected distribution of future cost) (Wickramasinghe, 2011; Zerriffi, 2011; World Energy Assessment, 2000). The energy ladder concept implies moving from biomass fuels to more convenient and efficient forms of fuel (cleaner and/or commercial fuels) for domestic activities. It is the framework used in examining trends and impacts of household fuel usage (World Energy Assessment, 2000). However, in reality 'multiple fuel' or 'fuel stacking' depicts energy transitions in rural areas rather than the linear progression demonstrated in the energy ladder (Masera *et al*., 2000). Moreover, if one and/or all the characteristics failed to influence householders' energy choices, it creates barriers as discussed in Section 2.6 in shifting to cleaner fuels. However, there have been several interventions used over the years to combat the problem of indoor air pollution in developing countries.

2.5 The Context of Energy Policy Interventions in Developing Countries

There are various energy policies and interventions with respect to indoor air pollution problems in developing countries. These differ according to country context and the relative priority of energy issues *vis-à-vis* national agendas. This meant that the emphasis of research on household energy in developing countries initially tended to focus on the environmental impacts (deforestation and desertification) of biomass use (see Karekeizi, 1994; Manibog, 1984). However, by the mid-1990s there were challenges to the assumption that fuelwood demand was a driver of deforestation (see Simon, 2010; Hanbar and Karve, 2002; United Nations 2000). As a result, emphasis shifted to providing cleaner stoves for households that are biomass dependent in developing countries.

Improved stoves, therefore, have been promoted as energy-efficient stoves in the domestic sector. In comparison to traditional open fireplaces, improved cookstoves can save up to 20 – 67 percent of fuel (Smith *et al*., 2007). Two of the earliest programmes to introduce improved cookstoves to developing countries in the 1980s are the Indian National Programme for Improved Chulhas (NPIC) and Chinese National Improved Stove Programme (NISP).

Under the NPIC programme, the Indian government aimed at increasing fuel efficiency, creating income-generating opportunities, reducing the time spent collecting wood and reducing indoor air pollution through the use of chimneys (Venkataraman *et al*., 2010; Hanbar and Karve, 2002). In disseminating improved cookstoves, the government provided subsidies to all households purchasing the improved stoves. On the one hand, this created awareness among householders for the need to use improved stoves, however, as many of the stove designs were not user friendly, many households reverted to the use of traditional biomass fuels (Sinha, 2002). At the end of the NPIC programme, it was realised that indoor air pollution reduction in buildings was not a key driver in the effective dissemination of improved stoves. Attempts were, therefore, made to incorporate cooking smoke reduction accessories into already installed ICSs. This created non-user friendly stoves, which made the stoves inappropriate for householders' daily cooking activities (Sinha, 2002). Kishore and Ramana (2002), argue that the installation of ICSs into existing buildings often allowed cracks to develop in buildings walls, thereby allowing cooking smoke to infiltrate into buildings. So, rather than improve air quality, these contributed to poor ambient air indoors. Other drawbacks of using ICSs include misinformation and ambiguity about the life cycle of stoves, which were often presented as a one-off installation. Although there is a corresponding cost benefit of using

ICSs, the rebuilding and redecorating of Chulhas during special occasions and yearly may be a drawback in using them. The low durability and usage of the improved stoves as a result of conflict with cultural norms, strengthens the critique of the use of 'hardware' dominated approaches in stove dissemination initiatives.

In contrast, to the failure of the NPIC programme, the NISP was able to successfully promote ICSs among households in China. One of the strategies employed under the NISP was to train locally based technical personnel who were responsible for implementing the programme in relation to regional conditions. Recognising that regions have differing energy demands, local fuel structures and environmental protection goals, ICSs were disseminated with this in mind. Stove designs were also modified to fit local conditions, which made them suitable for local cooking (Sinton *et al*., 2004). In addition, the high efficiency of the ICSs also encouraged their use, but to an extent the claims for high usage may have been somewhat overstated. As part of the NISP programme, households paid for the stove installation, whereas the NPIC was subsidy driven. It probably shows that the 'cost' attached to ICSs perhaps did not favour their use among the resource poor. Considering that the NISP programme combines 'hardware' and 'software' approaches in disseminating ICSs, it appeared to meet the energy demands of the householders. Key differences between these two programmes were that one was subsidy driven with government support, while the other was publicly financed. The latter highlights that although users could access the stoves, users who tended to be wealthier individuals could afford them. Overall, the initial stages of ICSs promotion ran into challenges surrounding diffusion, dissemination, and implementation. When potential users have not tested a technology, they are reluctant to invest or maintain it. Because users do not know much about the technology, they will not value it despite it having associated benefits (Lewis and Pattanayak, 2012). All of these have shown that user needs must first be identified before introducing ICSs.

More recently, energy policies have emphasised improving the health status of the user of biomass fuels and the reduction of greenhouse gases. In particular, from the 1990s energy policy has aimed at reducing indoor air pollution for biomass dependent households (World Bank, 2011). As a result, international organisations (e.g. WHO, Partnership for Clean Indoor Air (PCIA), Shell), foundations (e.g. Morgan Stanley), NGOs (e.g. Aprovecho) and international coalitions and initiatives (e.g. Global Alliance for Clean Cookstoves – GACC) have been involved in providing financial and policy support to alleviate the problem of indoor air pollution in developing countries. Wilson *et al*. (2012), however, argue that alleviating indoor air pollution should not only focus on providing ICSs; rather there should be an evaluation of the impacts of improved stoves on end-users' health. In view of this, for the long-term viability of ICSs that improves air quality, there should be a better understanding of the socio-cultural contexts prevalent in target countries and communities. As Wilson *et al*. (2012) observe, community cohesion and cultural preferences (cooking methods) influence the adoption of clean fuels and should be considered central to the delivery of energy services. In other words, it is crucial to take into account certain differing aspects of a community or country as it is likely to have a bearing on the replicability of ICSs in other environments (Pachauri *et al*., 2013).

In addition, it is important to clearly understand the respective roles of government, NGOs, and the private sectors in programmes advocating the use of cleaner stoves and fuels in developing countries (World Bank, 2011). On the other hand, Bruce *et al*. (2011) argue that if national policies do not encourage IAP interventions, there will be less impact overall even when there are local initiatives to promote cleaner fuels and stoves. As a result, there is a need for national governments to define their own energy targets, strategies, and minimum level of energy access appropriate to their country situation when promoting cleaner fuels. At the same time, acknowledging the importance of political will in the promotion of cleaner fuels, particularly when it involves government, is also vital. It is therefore imperative to match ICS types and cooking preferences and, to consider the effectiveness of credit, information campaigns, local institutions, and the supply chain when introducing the stoves to users (Lewis and Pattanayak, 2012).

2.5.1 'Hardware versus Software' Approaches to Addressing Indoor Air Pollution Problems in the Global South

In providing, 'holistic' approaches (interventions) to the problem of indoor air pollution, several reviews have focused on epidemiological studies, toxicological studies and controlled human exposure studies (Rohr and Wyzga, 2012). However, this generic view of a 'holistic' approach often focuses on the 'hardware', without incorporating the 'software' into it.

The 'hardware' approach to reducing the impact of IAP often focuses on adoption of pollution-reducing products and technology by end-users. Interventions of this nature take two main approaches: (1) access to cleaner fuels and (2) access to improved ventilation (Mehta and Shahpar, 2004). The 'software' approach by contrast, draws attention to the consideration and incorporation of wider social and cultural contexts when providing interventions to reduce IAP and encourage the adoption of clean energy technologies. As an integral aspect of energy intervention, a 'software' approach is concerned with institutional frameworks that create options for users through effective fostering that ultimately enhances community acceptance (Mallett, 2007; Wüstenhagen *et al*., 2007). Precautions are required to guard against problems linked to a lack of community acceptance of new energy technologies. When decisions are made to benefit some sections of the community at the perceived expense of others, such decisions can damage relationships, divide communities, and create favouritism and unfairness (Wüstenhagen *et al*., 2007). Although community acceptance is important, Troncoso *et al*. (2007) stress that it is also through 'software' approaches that individual differences to technologies are easily recognised, pointing to customer segmentation strategies in understanding factors involved when users choose among different energy technologies. Previous policy interventions seeking to combat IAP in developing countries rarely reflect the realities of environmental risk in these countries, and, therefore, are not able to address the priorities of the people (Smith, 2000b). Many policy interventions have emphasised improved stoves, better housing, cleaner fuels and behavioural changes (Bruce *et al*., 2000), but, in an ideal intervention "efficacy, cost and time taken to attain adequate intervention coverage" needs to be considered (Metha and Shahpar, 2004:53).

As experts made efforts to provide clean energy technologies for households in the global South, householders are often apprehensive about switching to technologies because of cost, accessibility and other factors (see Balanchadra, 2011; Wickramasinghe, 2011; Kaygusuz, 2010). At other times, if there is an absence of knowledge/information about IAP, it can create setbacks in efforts made to promote the adoption of clean energy and/or stoves (see García-Frapolli *et al*. 2010; Schlag and Zuarte, 2008; Adegbulugbe, 1991). However, in areas where interventions using the 'software' approach have been successful, attention has often been paid to the nature of existing hearths, living environments, and user behaviour. For example in China, upgrading to cleaner and standard stoves in rural areas reduced indoor air pollution (Mestl *et al*., 2006) because locally trained personnel implemented the programme according to regional needs under the NISP as earlier discussed. Clark *et al.* (2010:12) argue that, "designing kitchens with proper ventilation structures could lead to improved indoor environment." According to Jin *et al*. (2006), one of the problems confronting experts in the field of improved cookstoves (ICSs) in developing countries is not being able to develop integrated programmes that target the solving of environmental problems associated with the burning of biomass fuel.

The improvement of cleaner stoves by incorporating chimneys into the design significantly reduces human exposure to smoke particulates (Li *et al*., 2011), but Zhang and Smith (2007) observe that it only diverts a fraction of the particulates from inside households to the outside, thereby, worsening neighbourhood and local air quality.

The general approach for reducing exposure to IAP in Kenya was 'hardware' oriented and emphasised a variety of changes. It encouraged change in fuel from wood to charcoal, a shift from traditional open fires to improved (ceramic) woodstoves, and a change in cooking location from inside to outside of the house using an improved stove. The substitution of three stone hearths with cleaner stoves has reduced health impacts of IAP among cattle herders in Mpala Ranch, Kenya (Ezzati and Kammen, 2002a). The emphasis on cleaner stoves that partially or totally reduces IAP in Kenyan homes was crucial to the provision of energy technology interventions such as the introduction of LPG stoves, solar cookers, fireless cookers, *upesi* stoves[7] and smoke hoods (Malla *et al*., 2011). All of these interventions

[7] *Upesi* stove is made of clay fired in a kiln and designed to burn on agricultural wastes, wood and sugar cane wastes. The stove halved the amount of fuel wood used for cooking in comparison to traditional three stone stove (http://practicalaction.org/docs/energy/EnergyBooklet3.pdf accessed 15/11/2012).

provided a range of benefits including health benefits, fuel savings and cooking time reduction amongst the householders.

In Bushenyi district, Uganda, the Rocket Lorena stoves[8] are specially designed and insulated to minimize heat loss, thereby maximizing the temperature of combustion in the chamber (Komuhangi, 2006). The adoption of the improved stove was successful in Uganda, as the government, with support from German Technical Cooperation (GTZ) collaborated with a variety of community based Non-Governmental Organisations (NGOs) in the area. In forming the NGOs, a 'pyramid' strategy was used to incorporate stakeholders and beneficiaries and was designed with coordinators (proven artisan) at the top and stove builders at the bottom of the pyramid (Komuhangi, 2006). The NGOs are further divided into various districts within the sub-counties for administration and technical management purposes. Also, integration of non-commercial incentives (positive image of the community), voluntary contributions, local construction 'skill' and affordability by poor rural households has made the programme successful in Uganda. Similarly, the satisfaction derived from users, coupled with the ability to transfer technical construction knowledge about the stove has helped make it a sustainable programme (Komuhangi, 2006).

Monetary savings is another aspect considered by García-Frapolli *et al*. (2010). When the economic benefits of improved stoves are presented to people (in terms of income generation, health impacts, environmental conservation, fuelwood savings and reduction in greenhouse emissions),

[8] Rocket Lorena Stove is a 2 pot rest stove that has efficient conversion chamber that requires little fuel wood and allows maximum heat transfer to food being cooked. It consists of firewood chamber, insulation around the chamber and a chimney.

they often consider replacing their traditional stoves. The dissemination of the Patsaris cookstoves in the Purépecha region of Michoaćan in west central Mexico has shown that monetary savings in the household economy and the intervention at government level have provided preventive rather than palliative measures to improve the health status of the people affected by exposure to biomass smoke (García-Frapolli *et al*., 2010). Improved stove interventions can therefore, be a worthwhile investment in the long and short-term and can be associated with economic benefits.

According to Troncoso *et al*. (2011) however, the adoption of clean stoves applies not only to the economic benefits derived by investment, but also to householders' needs. If the technology is not compatible with the needs and resources of the user, uptake at the time of introduction does not mean adoption of the clean technology in the long term. Through diffusion processes, people become familiar with the innovation that is being introduced and so, promoters of the technology must be aware that communication is needed between them and the users. It is important that all promoters of clean technology must share information such as design and implementation with end users. Troncoso *et al*. (2011) assert after García-Frapolli *et al*. (2010) that the improved stoves provided in Michoacan are adopted because of the awareness created by NGOs in the communities in relation to health problems associated with the use of biomass fuels. The satisfaction of having a smoke free kitchen and savings on fuel wood was the motivation for agreeing not to use traditional open fires in the area. Of significance in this intervention was that lessons learnt from the earlier stages of implementation helped in subsequent stages of the programme in directing intervention to specific needs of the users in the area.

Pine *et al*. (2011:177) use the example of five indigenous and rural communities in Mexico where ICSs promoters targeted this population in order to make people aware of "its relative advantage, compatibility, complexity, trialability, and observability" over the traditional open fire. Additional insights from the community indicated that the length of stay of individuals in a community accelerated adoption of ICSs because of a higher degree of connectedness amongst people from similar social systems, which facilitated diffusion of new ideas and practices. The site-specific information on communities ensured that the technology gained a foothold amongst intended end-users, by carefully considering the community and household characteristics of the target population. Careful evaluations of end-users views on the technology were addressed by first receiving feedback from community leaders before mass dissemination of the technology took place in the entire community.

A self-sustaining innovation in energy technology in Ghana has adopted a charcoal heat resistant ceramic improved stove. The technology is driven by an indigenous company – Toyola Energy Limited (Toyola™). The cookstoves have holes that supply airflow and allow ash to fall out, as well as adjustable doors to control airflow and rate of burning (Agbemabiese *et al*., 2012). The stoves are made in different sizes to suit the round-bottomed pots mostly used in Ghana, with domestic sizes ranging between 270mm to 360mm and commercial sizes from 460mm – 510mm. The company used scrap materials for its stove production and relied solely on independent self-employed artisans for the manufacturing, distribution and retailing of the products. On average, the stove is able to reduce the amount of charcoal used for cooking by 40 – 50 percent. Toyola provides employment to the local people and improves household ambient air quality. The company also created a 'moneybox' scheme, which allows households that cannot afford stoves to take loans through the scheme and pay back from the money saved from charcoal savings.

On the other hand, clean energy use by rural people in the global South has encountered several drawbacks despite improvements in the technology of producing clean stoves. 'Software' aspects that contribute to householders' failure to use improved energy technologies (Akinbami *et al*., 2001) include a preference in rural Nigeria for the taste of food cooked using fuel wood. This is one aspect of the many 'software' factors that can influence the adoption of cleaner energy in the global South.

Walker (2010:12), however, notes that, "behavioural change naturally takes place in a community without setting the need for professional intervention." In contrast, Barnes *et al*. (2004) suggest behavioural changes such as keeping children away from the fireplace, having other adults look after them during the period of cooking, and extinguishing fires after cooking (dousing fires with water, or fermented maize, millet or sorghum porridge – known as *pap* in Nigeria) can reduce the impacts of IAP.

Bickerstaff and Walker (2001) also draw attention to the local context of understanding air pollution risk in an environment. If people's intrinsic knowledge of or perceptions about air pollution problem(s) are not properly interpreted, they cannot have a stake in determining measures to combat air pollution problems in their areas. Bickerstaff and Walker (2001) stress that the localisation of people's understanding of air pollution problems within wider physical, social and cultural contexts will help shift personal behaviour to approaches that reduce the associated risk of exposure to air pollution. Similarly, spatial perception is also crucial to social constructions of air pollution problems and their health implications because the environment is a reflection of its prevailing social, economic, political, and cultural factors (WHO, 2002).

In understanding how people learn about air pollution, Bickerstaff (2004) recognised the importance of human senses, whereby the power of vision directs people to the dirt or soot in the home, and sources of smoke and fumes from energy fuels. The human senses often redirect people's minds to associated health impacts of air pollution in their environment, which often invoke horror and fear over being susceptible to diseases. Many people, however, do not connect air pollution with behavioural practices, linking it instead to natural geographical occurrences and attributing negative effects to the immediate environment rather than to the wider social and cultural context. Bickerstaff also notes that the receptivity of information by target populations is shaped by the level of trust they have in the communicator, which in Pine *et al.*'s (2011) view must be through the community leader who should be used in disseminating information to the community. IAP intervention's must understand a community's resistance to change as perceived favouritism and unfairness by individual community members may have overarching effects in the uptake of energy technologies. The cultural realities that influence people's perceptions of IAP have not necessarily been considered and there appears to be a gap in the literature, which this research sets to address. This study is, therefore, relevant in terms of the insights it offers into the importance of specific socio-cultural contexts underpinning biomass fuel use and perception of indoor air pollution in peri-urban areas of Ado Ekiti, Nigeria. As there are differing social environments and cultures in developing countries, the analysis in Chapter Six provides detailed information on the Nigerian context which reflects the socio-economic and cultural synergies of resource poor households in Ado Ekiti.

2.6 Barriers to the Adoption of Cleaner Fuels by Households in the Global South

Energy is an important factor in raising the living standards of people in developing countries, as it has a profound impact on economic, social, and environmental development (Khandker *et al*., 2012; Rehman *et al*., 2010). There are, however, factors influencing the use and uptake of commercial or clean energy in developing countries.

With the different types of interventions and cleaner fuels (see Sections 2.5 and 2.7) available for use in the global South, various reasons (including cost) are given by rural populations for not adopting clean energy (i.e. kerosene, LPG, electricity, solar power). There are also polices that limit access to clean energy in these countries. These include tax on imported clean stoves and appliances, banning of traditional fuels without adequate alternative schemes and uncertainty about product quality due to a lack of standardization (Hailu, 2012). However, this research sets out to understand traditional norms and values relating to the socio-cultural contexts of the rural poor in developing countries that can impede the use of clean energies in these areas. My research sets out to investigate the intertwining socio-cultural contexts based on Nigeria's continued use of biomass fuels and apparent reluctance to use clean technologies for domestic activities.

2.6.1 Issues of Availability and Access to Cleaner Fuels

Accessibility implies physical access to cleaner fuels and markets to purchase the fuels. Access, however, can be considered a function of availability and affordability. Zerriffi (2011) argues that there are challenges in scaling up the adoption of cleaner fuels by rural households in developing countries because of a lack of physical access as communities are located in remote areas with low population density. Accessing these clean fuels, which are not self-collected relies on location of infrastructure such as roads, markets and distribution channels (Kowsari and Zerriffi, 2011). Poor access to these facilities can lead to high delivery costs and creates complications in providing logistics and maintenance of energy to this group of people (Reddy *et al*., 2009). For households to scale up cleaner fuels Balanchadra (2011) suggests that:

> "...energy services should be physically accessible and available to the people, should be of acceptable quality, reliability and preference, should be affordable both in terms of low capital and operating cost in the context of income levels and should be adequate in terms of abundance" (p.5558).

Kowsari and Zerriffi (2011) further argue that the provision of affordable, accessible, reliable, and adequate energy sources is an important factor to be considered in encouraging households to use clean fuels. According to Zerriffi (2011) the majority of people lacking access to clean energy are located in rural areas where infrastructures are not provided, and, where it is available, demand over the years has outstripped availability leaving the vast rural populace reliant on biomass (Kaygusuz, 2010). This can result in "un-affordability due to poverty and inaccessibility due to inadequate infrastructure" (Balachandra, 2011: 5556). Nevertheless, studies in Sri Lanka have shown that though rural households have access to cleaner fuel (electricity) the majority of them prefer using biomass fuels because they can be accessed free of cost (Wickramasinghe, 2011). On the one hand, Haines *et al*. (2007) argue that future fuel wood scarcity might compel rural households in developing countries to use other energy sources – cleaner fuels. On the other hand, erratic and poor supplies of these commercial fuels will continue to make households rely on biomass fuels in meeting their energy needs, an indication that they might not be able to adopt cleaner fuels (Rehman, *et al*., 2010).

Benecke (2008) raises the concern that not all rural people may be able to benefit and guarantee access to clean energy when 'good governance' shies away from the provision of infrastructure that will enable energy problems to be tackled in developing countries. Coupled with the immediate availability of biomass fuel which is collected free of charge in most rural areas, convincing the rural populace to switch to clean energy can be difficult because of the costs attached to it.

2.6.2 Affordability Constraints

The financial constraints of the rural poor do not allow them to invest in new energy technologies that are accessible, thereby creating affordability problems. Similarly, householders' energy consumption patterns make it difficult to recoup capital investments in energy systems as they tend to limit the use of the type of energy provided for them, by inefficiently applying it for a purpose that could have been more efficiently used in meeting domestic energy needs such as, lighting, heating, and cooking (Brew-Hammond, (2010; Sebitosi and Pillay, 2005).

Wickramasinghe (2011) attributes unaffordability of cleaner fuels to the additional financial burden they create in adopting them, because many rural poor already live on limited income and have access to 'no-cost' energy sources. The rural populace, therefore, see expending finance on cleaner fuels as a diversion of their income to fuels that they cannot keep under control in terms of cost. Even when households have the capacity to afford clean fuels, large quantities are often required in the case of LPG, unlike biomass fuels where purchases can be made on daily basis (Kowsari and Zerriffi, 2011). Brew-Hammond (2010) asserts that as per-capita income is not expected to increase to a level that allows scaling up to cleaner fuels in Sub-Saharan Africa, the majority of the rural population will continue to depend on biomass fuels in the short term until the situation changes. The cost factor influences alternative clean energy sources available to the householder and, when the cost is prohibitively high, they usually choose not to scale up to clean energy alternative sources accessible in their area (Reddy and Srinivas, 2009).

The upfront cost of switching where households have to purchase modern stoves and connect to the national network of the clean energy source may often be beyond the capacity of households; standing as a barrier to a shift to cleaner fuels. As Howell *et al*. (2005) found out in their study in Nkweletsheni, South Africa, in instances where there is no financial institution (e.g. micro-finance or credit union facilities) that supports collective savings (for meeting the capital requirements for clean energy and appliances), this potentially acts as a barrier for using clean energy in the area. As long as there is a slow pace of development in many developing countries, adopting clean fuel may be difficult (Bruce *et al*., 2000). Many of the rural poor find it difficult to meet their daily needs as they live 'from hand-to mouth', and hence, they may resent anything that might add to their financial burden.

According to Bruce *et al*. (2000), some of the barriers to adopting cleaner fuel in developing countries among poor farmers are attributed to poverty. The adoption of new energy technology might require changing cooking utensils (i.e. pots, pans) suitable for clean stoves, to which capital and maintenance costs are attached (Dasgupta *et al*., 2009). The emphasis on affordability was not however significant in rural areas of India where there is willingness to pay, but the low quality of energy services due to theft and leakages discourages people from opting for clean fuels that they can afford

(Benecke, 2008). One other constraint that reduces affordability of cleaner energy in rural households is family size, which is usually large amongst the rural poor (Rao and Reddy, 2007). This increases their expenditure on energy. Miah *et al*. (2011) suggest that large households consume more energy for domestic activities, and hence, cannot afford cleaner fuels as incomes are lower in rural areas. In addition, the varying building construction styles in developing countries explain the influence housing has on non-adoption of clean fuels in the area (Jones, 1999).

2.6.3 Challenges of Acceptability in the Uptake of Cleaner Fuels

Acceptability is an important factor that should also be taken into consideration when scaling households up to clean energy. Ekholm *et al*. (2010) hinge household energy preferences on cultural cooking practices. The ease with which food is prepared with biomass fuels accounts for the lack of acceptance of clean technologies for cooking in some rural areas of developing countries (e.g. Sierra Leone, Ghana, Ethiopia, and Mexico). The inability to perform cooking activities in a householder's desired way by using clean technologies further makes them reluctant to use novel technology (Balachandra, 2011). According to Akpalu *et al*. (2011), households in Ghana draw links between the tastes of cooked food and the energy type used for its preparation. Clean energy stoves widely promoted by Toyola Energy Limited often support the cooking utensils (round-bottom pots) used for preparing the staple food in Ghana (Agbemabiese *et al*., 2012). Apart from cultural preferences, the allotment of space in buildings for cooking areas, especially in shared apartments, inhibits the acceptance of some forms of clean energy (Ouedraogo, 2006). For example, in Ouagadougou, tenants faced limited access to spaces for cooking and fuel storage, which made them reluctant to adopt cleaner forms of energy (Ouedraogo, 2006).

Masera *et al*. (2000) on the other hand identify cultural circumstances as one of the most crucial factors in the choice of fuel type among the rural poor in Mexico. Most homes do not make a complete fuel switch from one technology to another; rather, they combine additional technology without abandoning traditional methods. Through the multiple fuel strategy, households are able to maximise fuel security and receive the benefits of using different fuels. In addition, traditional food (i.e. tortillas) in rural Mexico is better prepared over a hot surface that is provided by a *comal*[9] over a wood fire, where it is possible to cook eight to ten tortillas at a time. Consequently, this cultural perspective is further seen as a tension between the adoption of western values and the maintenance of indigenous Mexican culture. Likewise, the use of LPG stoves is seen as a status symbol and these stoves are often given as gifts from migrants (those staying in the urban areas) to their household to show the progress they are making in their living conditions where they are residing.

Furthermore, when households' energy priorities are not known as found in the study of Reddy and Srinivas (2009) amongst rural households in India, it could act as a barrier to providing clean energy. Often householders perceived that the technology was incompatible and inconvenient for their traditional cooking methods. The menu choice of the households together with budgets, preferences and needs are the basis for choosing energy sources in the area (Heltberg, 2005).

Acceptance of clean energy technologies has been a success in Tibet as it is subsidy driven, while it is government initiated in Botswana. Consumers observe that the technology is long lasting compared to other traditional

[9] *Comal* is a metal or ceramic flat pans fitted on furnace or stove with a metal chimney to prevent smoke leakage (Masera *et al*., 2005)

energy sources they have been using. The identification of an appropriate institutional framework that allows distribution of clean fuel initiated by the government encourages its usage (Pode, 2010). In contrast, Balat (2006) and Jashmuddin *et al*. (2006) state that even if there are other types of energy sources made available, rural households would prefer to use fuel wood.

2.6.4 Government Policies and Uncertainty as Factors Limiting Access to Cleaner Fuels

In other contexts, when governments aim to address challenges faced by the rural poor through the provision of shelter, basic services and civic amenities, rural energy facilities are usually left out of their agenda. This is because they are considered a relatively small part of the energy sector and are often not within the mandate of the package programme designed for people (Srivastava and Rehman, 2006). This may help to explain why householders' build haphazardly without following the basic requirements needed for a building.

Government policies at other times have not met the target population's increasing demand for energy in developing countries; hence, such policies have invariably failed to increase access to and availability of clean energy sources for domestic use. As urban and rural areas have different energy challenges, policies that do not reflect these differences discourage wide usage of clean technologies (Schlag and Zuzarte, 2008). In addition, government policies that control the distribution and production of energy sources (especially in developing countries) affect the choices open to householders. For example in India, government policies have created institutional weakness and limited finance opportunities for private investors, thus impacting on delivery of clean energy available to the rural populace (Benecke, 2008). Indeed, the lack of explicit national government regulations encouraging households subsisting on biomass fuels to shift to clean fuels in developing countries has been highlighted by Reddy and Painuly (2004) as one of the barriers to moving households up the energy ladder. Sebitosi and Pillay (2005) argue that the rural poor are often seen as a liability to national budgets, and policies are merely expressions of intention and not adhered to by the government to responsibly make available clean energy sources for them.

In contrast, government policies have enhanced the distribution of clean energies in South Africa where the government set standards for investors to allow diversity in supplying energy to households. This created markets for them, and provided supporting facilities that allowed users to access energy technology (Winkler, 2005). Where there are energy policies in place, government instability can hinder their implementation especially when there is an upsurge of demand for autonomy by movements criticising government failures to deliver options for clean energy.

The uncertainty of government policies in developing countries creates a lack of confidence and an increase in project costs for experts intending to invest in clean energy technologies. When experts are reluctant to invest in these technologies, households are deprived of the opportunity to access and scale up to clean energy in the area (Painuly, 2001). For instance, a study by Burnham-Slipper (2008) in Eritrea points out that, although the improved magogo stove had been promoted in the country, it was not universally adopted because of political barriers[10]. The project, which focused on installing the stoves at refugee camps, found their way into civilian houses

[10] Political barriers refer to government institutional framework that is not conducive to the design and implementation of rural energy initiatives and policies.

belonging to "government lackeys" through corrupt practices, thus, depriving the resource poor of access to the improved stoves (Burnham-Slipper, 2008:11).

There is also uncertainty in delivering projects aimed at improving access to clean technologies for end users, especially when government initiates such projects. Sagar (2005) argues that because of the time frame needed to develop and deploy energy technology to rural areas, there is often a delay in accessing these technologies either in the short or long term. However, the emphasis laid on local procurement of raw materials for the manufacturing of energy products in Uttam Urja, India, increased prompt delivery of these products to end-users. Improvement in delivery times and the provision of efficient after sales services for energy technology influences the uptake of clean technologies by rural people (Rehman *et al*., 2010). This and other concerns in the context of the Nigerian environment as examined in Section 2.7.1 do act as barriers to the provision and use of clean technologies.

2.7 Overview of Energy Issues in Nigeria

In Nigeria, common sources of cooking fuel include fuel wood, sawdust, wood shavings, agricultural waste and crop residue, kerosene, LPG and electricity. The estimated biomass resource in Nigeria is shown in Table 2.3. In most rural areas of developing countries, the predominant source of cooking fuel is fuel wood, which is inexpensive and readily available, a situation which is similar to the peri-urban areas of Nigeria (Anozie *et al*., 2007). The fuel wood in most cases is free, perhaps the 'free cost' of the domestic energy encourages household to use it for their cooking activities.

Table 2.3: Biomass Resources as Estimated in Nigeria

Resource	Quantity (Million tonnes)	Energy value (MJ)
Fuel wood	39.1	531.0
Agro-waste	11.2	147.7
Sawdust	1.8	31.4

Source: Sambo, 2009

Air pollution in Nigeria co-exists with other health issues such as poor sanitation and malaria (WHO 2006b), but the government has not prioritised these issues until recently. Given that the high incidence of child pneumonia has been attributed to the total reliance on biomass fuel for household use in developing countries (UNDP, 2009), IAP problems need prompt interventions.

Over 80 percent of households in rural areas of Nigeria depend on fuel wood for cooking (UNDP, 2009), with about 80 million cubic metres of fuel wood used annually for cooking and other domestic activities (Sambo, 2005). Both the fuel wood and kerosene wick type of lantern used for lighting, which does not provide good luminosity, contribute greatly to indoor air pollution in Nigeria.

As the problem of IAP is particularly rife in Nigeria (Oguntola, 2013; Oguntoke *et al*., 2013; Obueh, 2006), the Federal Government has recently (starting from 2003) been setting policies to support clean cookstoves,[11]

[11] Namely, the National Policy Guidelines on Renewable Electricity of 2006; National Energy Master Plan of 2006; Renewable Electricity Action Programme of 2006 and Renewable Energy Master Plan of 2006.

however, there is limited implementation capacity, and the frequent changes in government make the process ambiguous for stakeholders. The several cookstove programmes in the country (e.g. methanol stoves, Rocket stoves, and Save 80 wood stoves) are being promoted by NGOs and international organisations. International organisations (Shell Foundations, Envirofit International, C-Quest Capital), Nigerian Alliance for Clean Cookstoves, ACCESS Africa, and NGOs are aiming to install clean cookstoves in the country over the next ten years.[12] In addition, some NGOs (CEHEEN[13], Project Gaia, Developmental Association for Renewable Energies, The Center for Missionary and Community Development) have been piloting various clean cookstoves in the country.

Research undertaken by an international organisation (Dometic AB) to determine the feasibility of adapting alcohol stoves using methanol in developing countries was initiated in 1993. This type of stove was introduced to Nigeria in 2003 through Project Gaia International. The initiators of the project believe that with Nigeria having abundant natural gas that is flared daily, the country should be able to produce inexpensive liquid ethanol for household use. Delta State, which is located within the Niger Delta region, was chosen for a pilot study to determine whether there would be an entry point for the stove. On this premise, Project Gaia Nigeria, conducted pilot studies in 2003 and 2007 (covering a period of 3 months each year) in the Niger Delta area of Nigeria, investigating consumer responses to the affordability, efficiency, safety and limitations of methanol stoves (Obueh, 2006). The outcome of this pilot study indicated that householders were willing to switch over to the new cooking technology (Obueh, 2006).

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[12] http://www.cleancookstoves.org/resources_files/nigeria-market-assessment-mapping.pdf (accessed 20/08/2013)

[13] CEHEEN – Center for Household Energy and Environment

Nevertheless, they were sceptical about the supply and availability of the fuel over time based on their experience of perennial scarcity of kerosene. In addition, there was unrest among local communities over the location of the methanol plant in the area.

Apart from the ethanol stove introduced in the Niger Delta, The Center for Missionary and Community Development (CEMCOD) developed Rocket stoves for households at Mambilla Plateau, Nigeria.[14] Under the 'Appropriate Technology' programme, Rocket stoves were made from mud bricks, river sand, gravel, agricultural wastes, and straw. The straw provided insulation and airways to the bricks (which are about 16 in number) in order to make it light and to allow combustion and heat transfer to take place during cooking. There was initial resistance by local people to adopt the stove because of its small size and scepticism about whether the stove could keep them warm. However, this was overcome through sensitization programmes, and involving community leaders and other relevant groups in disseminating the benefits (minimising smoke emissions) of the stove to the people.

The Developmental Association for Renewable Energies is another NGO in Nigeria promoting energy saving stoves (solar cookers and 'Save 80' wood stoves) in Kaduna. The 'Save 80' wood stoves are made of high quality stainless steel material weighing 4 kg, have a ten year lifespan[15] and only need 250g of wood particles to boil 6 litres of water, saving 80 percent of energy compared to the traditional fireplace. The design of the stove is such that it ensures preheating of the air and complete combustion with no visible smoke. Another device that was used in conjunction with the stove is the

[14] http://www.pciaonline.org/node/981 (accessed 20/08/2013)

[15] http://www.pciaonline.org/node/124 (accessed 20/08/2013)

Wonderbox (a retained heat cooking device). This is made of expanded polypropylene material, which is unbreakable, stackable, and lightweight. After cooking, food is transferred into the box to retain the heat while cooking the 'sauce' (curry) since it has only one burner. However, both the solar and 'Save 80' wood stoves have not been widely accepted for use by the people because of pre-existing traditional cooking methods that are not possible with design of the new stoves. All the same, The Developmental Association for Renewable Energies is proposing pilot studies in some rural areas to act as prototype for adoption by local people. It has been argued however that there is need to move away from piloting projects demonstrating the technology to developing national targets for reducing indoor air pollution in the country (Martinot *et al*., 2002).

As mentioned earlier, international organisations are now seeking to address IAP in Nigeria by introducing improved cookstoves. For example, the Nigerian Alliance for Clean Cookstoves (affiliate of Global Alliance for Clean Cookstoves) a public-private[16] partnership aimed at using partner organisations to disseminate clean cookstoves. In addition, the Shell Foundation, Envirofit International, and C-Quest Capital are proposing to distribute 2 million clean cookstoves over the next seven years to solve the problem of IAP in the country by using 'cutting-edge' stove technology that is affordable for households and institutions. The piloting of clean cookstoves

[16] The Nigeria Alliance (inaugurated in 2011) is seeking to introduce 10 million clean cookstoves in Nigeria by 2020 and supports the reform of clean cooking energy policies both at federal and state levels. Partners include federal government agencies, donors (DFID, USAID, UNDP etc.) financial institutions, the private sector, and NGOs (see http://www.cleancookstoves.org/media-and-events/events/nigeria-stakeholder.html and accessed 20/08/2013).

started in March 2011 in Kano State[17] and there are plans to expand the project to other parts of the country after evaluating users' feedback. The cookstoves are developed to be four times as efficient as open fires thereby reducing fuel usage, emissions and cooking times. The stove design sought to meet users' specific cooking styles and choice of fuel (wood or charcoal). On the other hand, ACCESS Africa in partnership with government, donors (USAID), micro-finance groups, and Oando (an oil company) is promoting a 'Switch to LPG Initiative'. It is expected that over the next five years, 20 million gas cylinders integrated with burners and costing as little as $12 and a monthly refill of $5 will be available for householders in the country.[18]

While past initiatives have targeted specific households and regions in Nigeria and recorded little successful adoption of the stoves, current initiatives seem to have a broader scope that is not targeting specific households and regions in the country. In addition, national policies as used in the NPIC and NISP programme are lacking in Nigeria. The implication of having a broad aim and a less focused national policy on energy issues in the country is that the resource poor who are biomass dependent might be excluded from accessing clean stoves and fuels. Even in parts of the global South where households have been targeted for the dissemination of clean stoves (e.g. India and Kenya), there have been drawbacks with a range of economic, access related, and cultural factors that have prevented people adopting improved stoves (see Sections 2.4.1, 2.5.1 and 2.6).

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17 https://docs.google.com/viewer?a=v&pid=forums&srcid=MTIzNzU5NjYyOTMyMTYwNTE3MjIBMTU1NDk5MjU3MzI2MTkxODI1NDMBWTBObkV0aHFBNjhKATQBAXYy (accessed 20/08/2013).

18 http://www.voanews.com/content/nigeria-to-switch-to-use-clean-cooking-gas/1616606.html (accessed 20/08/2013).

2.7.1 Evaluating Barriers to Transferring to Clean Fuels in Nigeria

The energy sector in Nigeria is inefficient in meeting the demands of the populace (Iwayemi, 2008). The huge investment in the sector (electricity generation and distribution, and grid extension) contrasts greatly with poor levels of supply to industrial and commercial users, who now have to rely on self-generated electricity. The weak structural governance system in the country has not allowed reforms that would have facilitated the sector in recovering from its present poor energy production and distribution (Obioh and Fagbenle, 2009).

The current bio-fuel and ethanol plants being developed in the country are designed to boost electricity generation for industrial use and not for domestic consumption (Sambo, 2005). As at the time of this study, energy infrastructures are solely provided by the government. It is difficult to find support and/or partners to invest in upgrading existing electricity generating plants into new technology that will cope with the expanding energy demand of the populace. In addition, there is often suspicion by Nigerians of initiatives with government backing on the grounds that they might deprive them of access to local environmental resources, thus, there is resentment towards human capacity building that would facilitate technology transfer. Part of the problem is that, when policies are initiated by the ruling government, subsequent governments that come to power do not continue to implement policies that have been made by the previous government.

Other problems in adopting clean stoves include local political will, social and institutional infrastructure support, technology delivery, and sustainability of projects. The energy sector in Nigeria is characterised by corruption, inefficiency, waste and lack of continuity, legislative laws, and foot-dragging in implementing policies on alternative energy (Akinlo, 2009; Obioh and Fagbenle, 2009).

In Nigeria, public awareness about the health risks associated with the continual use of and exposure to biomass fuels (for cooking and lighting), is low in comparison to awareness of malaria, sanitation, and polio eradication. Given that there is a lack of information and awareness about clean energy technologies, householders in Nigeria are hesitant about using it for domestic activities (Adegbulugbe, 1991). The limited knowledge of household energy demand and specific patterns of energy use made it difficult to determine the viability of clean energy in the country (Adegbulugbe, 1991). At the same time, it is unlikely that increasing awareness encourages the willingness to make a change to cleaner fuels (Schlag and Zuzarte, 2008).

In creating alternatives to biomass fuels, conflicts over the use of raw materials could be a barrier to the uptake of clean fuels. For example, the Ekiti state government in Nigeria is collaborating with the Green Energy Society on how to invest in biofuels (bio-ethanol and bio-diesel) from agricultural feedstock. Recently, the Ekiti state government has sought to develop partnerships with British Petroleum (BP) in producing biofuels from cassava (Sulaiman, 2012)[19]. However there is agitation that crops meant for consumption are being proposed for ethanol fuel (Sesan *et al*., 2010), so the adoption of cleancook stoves might be difficult because of these conflicting uses. Despite the difficulties posed for use of clean fuels in Nigeria, international organisations, NGOs, and private sector organisations (as discussed in Section 2.7) are making frantic efforts to make ICSs available

[19] http://www.geson-ng.org/publication/index4.html (accessed 02/03/2010)

to households in some regions of the country in order to reduce indoor air pollution.

2.8 Conclusion

This chapter has provided an overview of the literature in regards to indoor air pollution and energy in the global South. Much of the literature is in agreement that the majority of the rural poor in developing countries use biomass fuels for their domestic activities (see Álvarez *et al*., 2012; Clarke *et al*., 2010; Dasgupta *et al*., 2009; Duflo *et al*., 2009; Fullerton *et al*., 2009; Huboyo *et al*., 2009; Padhi and Pady, 2008; Mestl *et al*., 2007; Smith, 1997). The use of biomass fuels in developing countries has seen measurement of air quality in buildings above the stipulated WHO guideline values (see Colbeck *et al*., 2010; Begum *et al*., 2009; Fullerton *et al*., 2009; Dasgupta *et al*., 2009; Siddiqui *et al*., 2009; Balakrishnan *et al*., 2002; Ezzati and Kammen, 2001a; Smith, 2000a). There are multiple routes of exposure to indoor air pollution mainly through the multiple uses of energy during domestic activities. In spite of various interventions used in improving indoor air quality, it appears community wood smoke levels counter efforts to improve indoor air quality at the household level. Little has been done in this respect to investigate the impact that community pollution has on indoor air quality. This research compares air quality in homes with indoor and outdoor kitchens in a community in Ado Ekiti, Ekiti State, Nigeria to determine the effects of community scale pollution in buildings.

A number of interventions have been previously developed as part of energy policies in an attempt to combat the problem of indoor air pollution. In recent times, emphasis has been on improving the health status of biomass fuel users in developing countries rather than focusing on deforestation. In providing solutions to the problem of indoor air pollution, International organisations and NGOs are now implementing initiatives to promote ICSs in developing countries including Nigeria. Although experts are making efforts to provide clean fuels to developing countries, there have been tensions between its perceived advantages and the priorities of rural people. As many energy interventions focus on a 'hardware' approach, the uptake of clean energy technologies has frequently been slow, especially if 'software' factors are not addressed in the diverse cultural environments of developing countries. This research, therefore, attempts to address this gap in the literature by identifying the socio-cultural factors encouraging the use of biomass fuels, and potentially hindering the use of clean energy technologies in developing countries.

Though free access to biomass fuels for domestic energy encourages its use, a number of factors further influence householders' decisions on the choice of energy type. These include, but are not limited to, socio-economic factors (i.e. income, food types, family size, educational attainment of the principal wage earner etc.); frequency of cooking; dwelling condition; government policies and inadequate provision of information about clean fuel alternatives.

The advantages derived from the use of biomass fuels obscure householders' perceptions of the risk of indoor air pollution (see Oparaocha and Dutta, 2011; Stolyhwo and Sirkorshi, 2005; Akinbami *et al*., 2001; Bruce *et al*., 2000). As incomplete combustion of biomass fuels have household, community and global scale risks, perceptions of activities creating indoor air pollution are often not linked with the associated health impacts on the end-users. Analyses in the literature have found social, economic, and spatial dimensions to the perception of levels of risks (see Jewitt and Baker, 2012; Bruce *et al*., 2000; Smith and Ezzati, 2005; Smith and Akbar, 2003; WHO, 2002) but the underlying cultural context has not been sufficiently explored to better understand perceptions of indoor air pollution in the global South. This research engages with local populations in order to investigate how cultural perceptions shape their understanding of associated risks with indoor air pollution. Examples from peri-urban areas of Ado Ekiti, Ekiti State, Nigeria will be used to highlight this. This research incorporates both ‘hardware’ and ‘software’ aspects to better understand the context of indoor air pollution in the global South.

Chapter Three

Research Methodology and Methods

3.1 Introduction

This chapter explains the methods adopted for data collection in order to achieve the objectives of this study (Section 1.3). The rationale for choosing the approach is considered. The advantages and disadvantages of each of the techniques used are also highlighted.

Section 3.2 discusses the fundamental philosophical framework for the epistemological and ontological approaches to quantitative and qualitative social research. In Section 3.3, I explain the qualitative and quantitative approach adopted for gathering information in the study area. I also highlight the merits and disadvantages of each of the methods implemented. In Section 3.3.1, the rationale for integrating the two approaches in the study is discussed in providing triangulation, completeness, and for ensuring the robustness of the data gathered. Section 3.4 provides background information on the study location. The geographical context of the study area is discussed in Section 3.5. The process of negotiating access into the study area and, the process of selecting participants for data collection is examined in detail in Section 3.6. This section also discusses the specific methods adopted for data collection and general characteristics of participants and individual communities. Section 3.7 discusses how quantitative and qualitative data are analysed. My positionality and its potential impacts on information obtained from respondents is considered in Section 3.8. In Section 3.9, I discuss the ethical issues relating to conducting research in the study area.

3.2 An Epistemological and Ontological consideration for the Research

Methodology approaches used in social research have both philosophical frameworks and fundamental assumptions that guide data collection in order to develop robust datasets during survey (Hesse-Biber and Leavy, 2008: Creswell and Clark, 2007). As such, social research is tied to how reality is studied and examined in our environment, which is usually conducted by observing and describing how the social world operates scientifically (Green and Browne, 2008). However, there should be a consideration of what knowledge is acceptable within the discipline (Bryman, 2004). When the social world is studied according to the principles, procedures and ethos of the natural sciences, this position could be viewed as positivism. According to Bryman (2004:11), "positivism is an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond." It suggests that theoretical terms must be subjected to scientific observation, and with the use of appropriate methods, reality can be understood so changes can be made when structures properly identify the distinctiveness of humans within the social world (Bryman, 2004). Confirmation or refutation is then drawn from the data gathered about such social phenomena, in order to understand and measure the social world (Bryman, 2004).

Social ontology in contrast, refers to the nature of social entities that is objective (a framework for determining the nature of rationality, truth, and reality) and external facts that the researcher cannot influence (Bryman, 2004; May, 2001). With this approach, knowledge gained either through direct observation or experience could be better understood through actual interpretation of the social world in people's own meaning and words (Bryman, 2004). Such interpretations can be gathered through interviews and observation, which "emphasize words rather than quantification in the collection and analysis of data" (Bryman, 2004:266). These methods, either qualitative or quantitative, are flexible and can be adapted for any study in the social sciences with the overall objective of finding specific techniques for studying research problems (Hesse-Biber and Leavy, 2008).

3.3 Qualitative and Quantitative Approach to the Research

In carrying out real world research that involves people, quantitative and qualitative approaches are often used in order to gain diverse views about such social phenomena (Robson, 2002). For qualitative research, there is an inductive view of the relationship existing between theory and research; an epistemological position described as interpretivist, which rather than adopt the natural scientific models in quantitative research, stresses the understanding of the real world through interpretation given to it by the research participants. This involves in-depth understanding of the social context through interviews, participant observation, ethnography, and documentary analysis (Hesse-Biber and Leavy, 2008). Similarly, it can involve describing and tracking down the fundamental causes of problems within a geographical location or institution from words and themes expressed by the respondents (Hesse-Biber and Leavy, 2008). However, despite the above advantages of using qualitative research, it has been criticised for being impressionistic and subjective as it relies on the researcher's view and the personal relationships they develop with the people being studied. In addition, there is the problem of replication because it is unstructured and analysis relies on the researcher's ingenuity. The restriction of understanding human behaviour from the perspectives of those being studied is another critique of qualitative approaches, where either participant observation or unstructured interviews (conducted with a small number of people in a locality or geographical area) are used. This implies that methods of participant observation or unstructured interviews cannot be used to make generalisations in other settings. In addition, there can be a lack of transparency about how respondents are selected for the data collection (Bryman, 2004). Similarly, measurement processes are seen as an artificial way of ascertaining precision and accuracy, thereby holding on to assumptions rather than reality since its analysis of relationships between variables could create an image of a rather static social context that is unrepresentative of people's way of life (Bryman, 2004).

In contrast, quantitative approaches emphasise quantification in data collection and analysis. They entail a deductive approach in the relationship between theory and research with the overriding aim of testing theories; incorporating positivism and norms and practices of natural science; and "viewing social reality as an external objective reality" (Bryman, 2004:19). Quantitative data is collected through questionnaires, surveys, and experiments in order to be able to measure, generalise, replicate, and demonstrate causal relationships among the data set (Becker and Bryman, 2004) as well either confirm or refute existing theories. Quantitative research tends to uncover large-scale social trends in studies using relationships between variables while qualitative research is better at identifying and presenting social reality.

3.3.1 Adopting a Mixed-Method Approach

In spite of the varying and divergent views about the possibility of combining qualitative and quantitative research in a study, it has been highlighted to be a credible means of collecting data (Becker and Bryman, 2004). When the two approaches are combined in a single piece of research (which is referred to as mixed methods, multistage or multiple methods), triangulation (though this literally is a combination of three methods) is achieved, thereby allowing merged data to be given one interpretation (Hesse-Biber and Leavy 2008; Becker and Bryman, 2004; Bryman, 2004). For instance, Hesse-Biber and Leavy (2008) argue that combining two methods allows better understanding of a research problem. Not only this, the strengths of quantitative approaches (numbers, trends, generalization) and qualitative approaches (words, context, meaning) complement each other in offsetting their weaknesses. In addition, it is flexible and incorporates emerging designs without changing the overall design during the research study. According to Becker and Bryman (2004), combining the two approaches has helped in bridging the gulf between research and practice. In accomplishing and developing a robust conclusion from findings, the combination of the two approaches might be a valid and credible way of arriving at better results in research. When triangulation is achieved, findings appear more credible as more than one source of data is used (Becker and Bryman, 2004). Nevertheless, Hesse-Biber and Leavy (2008) emphasise that combining the two approaches needs expertise and skills both for data collection and for analysis, coupled with the possible challenge of insufficient funding to support research, which could prove problematic when integrating the two approaches.

For this study, qualitative and quantitative approaches are combined for the data collection process bearing in mind the inherent benefits of the various research methods adopted. For instance, this adopted approach allowed the results from one research method to be compared and crosschecked against the results from other research methods (Bryman, 2008). In addition, using this approach emphasized the social dimensions of human life, notably how people organise into groups when providing the necessities of life in culturally acceptable ways (Helman, 2007) which is core to this research. Furthermore, with this mixed approach, the expected social and cultural dimensions of health, ill health, and medicine as regards biomass fuels use were confirmed to yield interesting insights into the nature of problems associated with different local environments (Lambert and McKevitt, 2002). In summary, the aforementioned benefits of adopting a mixed method approach for this research provide an underlying basis for combining approaches in social science investigation and justify the research approaches adopted in this investigation.

3.4 Selecting the Study Location

The research was conducted in peri-urban areas occupied by migrant farmers in Ado Ekiti, South Western, Nigeria. Ado Ekiti is located on latitude 7^0 40′ North of the equator and longitude 5^0 16′ East of the Greenwich meridian (see Figure 3.1). It lies at over 400 meters above sea level, and has a land area of 265km^2 (Adebayo, 1993). With Ado Ekiti being one of the oldest towns in Nigeria, the rapid development and growth in the 1940s necessitated the clearing of forest areas to allow the expansion of built up areas for urban dwellers. In 1913, a district made up of Ekiti land was formed when southern and northern Nigeria were amalgamated. By 1915, Ekiti and Ondo Divisions formed the Ondo Province. Since then, Ado Ekiti has been a political administrative centre and later it was named the headquarters of the Ekiti Divisional Council until 1952 (Adebayo and Adefolalu, 1993).

In 1976, Ado Ekiti became the headquarters of the Ekiti Central Local Government and by 1996 when more states were created in Nigeria; Ekiti State was created with Ado Ekiti serving as its state capital. The town has however, been regarded as cultural headquarters for Ekiti people since 1916, thereby attracting people from various locations across Nigeria.

As there have been changes in the administrative setup of Ado Ekiti over the last fifty years, the physical expansion of the urban area has grown from 2.6 Km^2 (1956) to 36.7 Km^2 (2006) (Oriye, 2013). The population has grown from 151,519 in 1963 to 308,621 by 2006 (Ekiti State of Nigeria, 2006). The effects of urbanisation are perhaps best seen through the conversion of agricultural land into urban uses such as construction of houses, roads, and public places. The encroachment into peri-urban areas of Ado Ekiti as a result of these developments has forced farmers to move further into the hinterlands (Ojo, 2002). Changes in land uses continue to put forest resources under pressure, because of conversion of land from to provide of social infrastructure for the growing population. Apart from this, more than 50 percent of deforestation in the area has been attributed to lumbering activities (Ibimilua, 2012). This is why, starting from 1996, the government has been initiating various afforestation programmes backed by local government headquarters in the state. In Ado Ekiti, over 72.52 Km^2 land area has been established as forest reserve and woodlots to combat the problem of deforestation (Ibimilua, 2012).

The maintenance of Ado Ekiti's cultural and administrative role was an important factor in selecting this location for this research. Although energy data are not yet available for the area, I have lived in Ado Ekiti for over 20 years and my personal observations indicated that most rural households used wood fuel for cooking. Focusing on peri-urban areas further provided me with the opportunity to investigate indoor air pollution at a scale different from the predominately-rural areas studied in previous research (see Fullerton *et al*., 2009; Ezzati and Kammen, 2002b).

Nineteen communities in peri-urban areas of Ado Ekiti, Ekiti State, Nigeria were chosen for this study as illustrated in Figure 3.2 and Table 3.2. These communities are Aba CAC, Agọ Aduloju, Agọ Corner, Alagorugba, Aroto, Asọ

Ayegunle, Ejiko, Ejimakogo, Elemi, Igbaitu, Igbaye, Ilamọ, Ilokun, Irasa, Isegere, Odoro, Oke Epa, Ologunja and Ọlora Camp. Though peri-urban areas are situated quite close to urban centres, the communities residing there lack a range of infrastructural facilities (drinking water, electricity, hospitals, schools, and roads). In addition, comparable basic facilities in the urban centres do not trickle down to these communities. With this in mind, the study location of Ekiti State is of interest as it has one of the largest concentrations of rural and peri-urban areas in Nigeria, with the highest poverty level in Southwest Nigeria. Further motivation for selecting this study location was because different ethnic groups reside here, thus providing greater opportunity to understand varying cultural views in the choice and use of different energy types.

Considering that people in these peri-urban communities are mainly farmers who have to provide many of their basic needs individually and/or as a community, the study area also provided an opportunity to investigate household and community influences on energy needs in the area. In addition, the houses layout in this area provided a means of examining the impacts of indoor air pollution and how air quality can be assessed at the household and local scale.

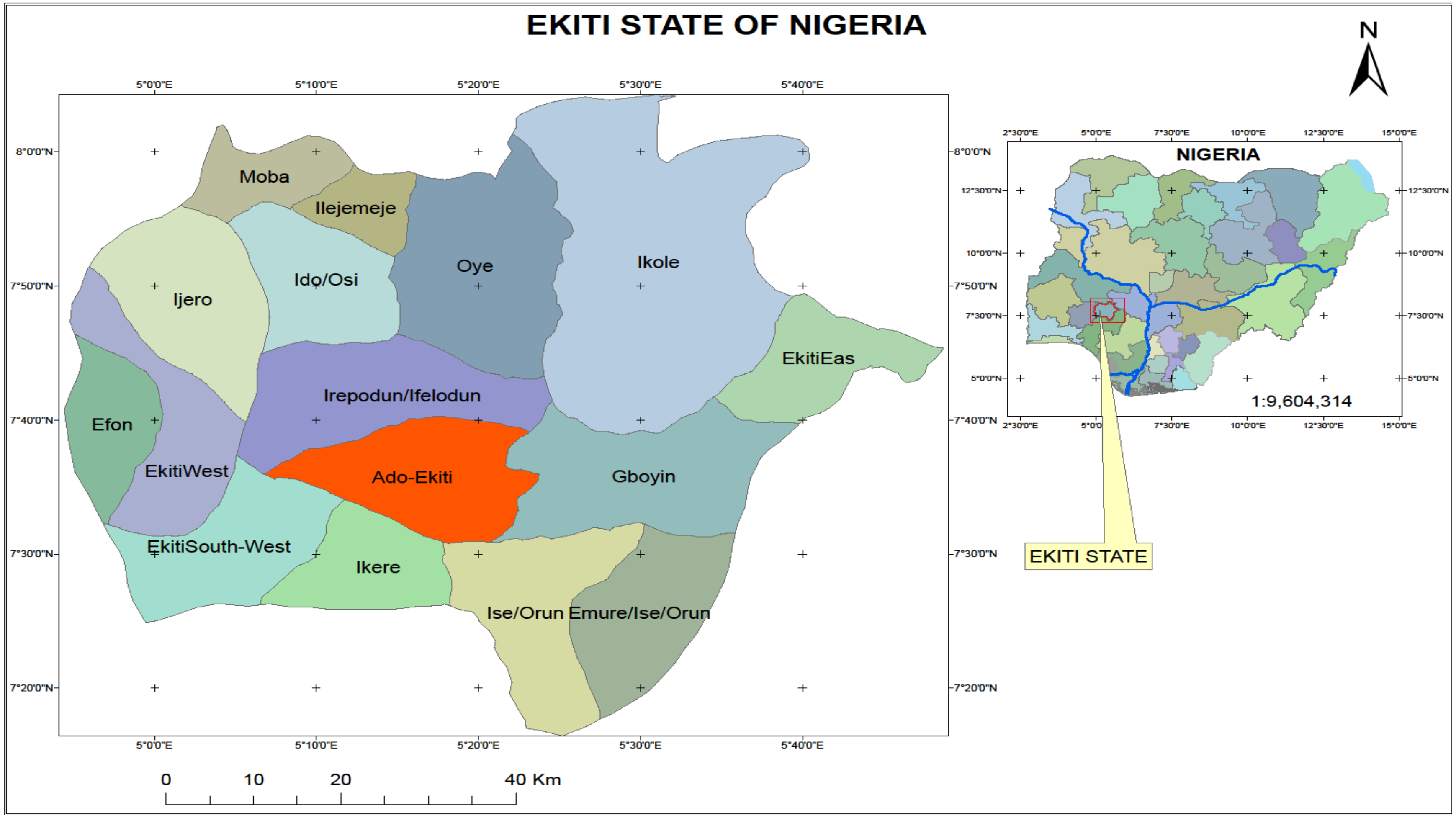

Figure 3.1: Map of Ekiti State showing the study area – Ado Ekiti
Source: Map drawn using ArcGIS

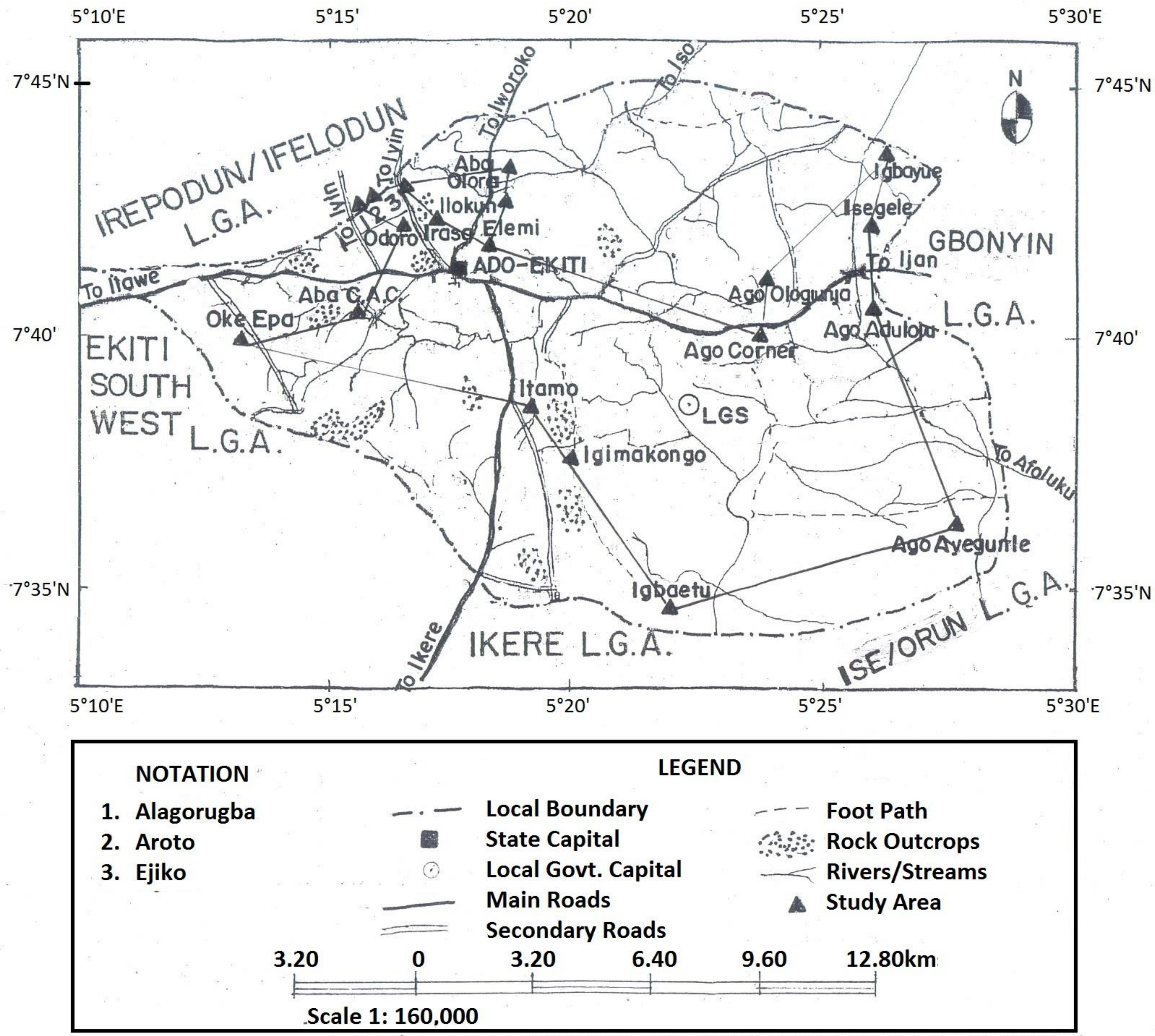

Figure 3.2: Map of Ado Ekiti showing communities that participated in the study
Source: Ado Ekiti Local Government and Ekiti State University

3.5 The Peri-Urban Migrant Farmers

Typically, in Nigeria, migrant farmers occupy peri-urban areas. Migrant farmers form a distinct group of people who move from their home base to settle in landed areas at the fringe of Nigeria's urban areas (Udo, 1975). These migrants include those who settle to cultivate farmland leased to them by the host community and those who harvest specific crops for a specified lease period for landowners who employ them on their farm. Migrant farmers rent land areas that are not required by the host community. The primary objective of migrant farmers is to increase their income and economic viability (Weiping, 2008) and, to improve the income inequalities characteristic of this group in comparison to urban dwellers (Lynch, 2005). According to Iwachukwu *et al*. (2008), migration in Nigeria is associated with social, cultural, political, and economic factors that often necessitate the move to other areas in the country.

An important point to bear in mind about the residents of the peri-urban areas is that they maintain interaction with their 'home' communities. A majority of them make remittances back 'home' to support families and acquire properties. By doing this they have migration plans to return 'home' and, it also strengthens their membership rights when they eventually return to their 'roots' (Osili, 2004). However, if sending remittances is a financial burden, and there are no means of offsetting the costs, they postpone investment until they return 'home'. It can therefore be argued that their membership rights at 'home' are more important than remittances.

Yearly, or as occasion demands, they visit their 'home' communities as a way of upholding social interaction with kinsfolk. Not only this, going back 'home' on a regular basis engenders togetherness and goodwill that fosters ethnic cohesion amongst them (Ododo, 2001), as they hold the belief that *ile labọ isimi oko* (meaning: 'home' is where to retire to no matter the length of stay in a foreign land). Most householders' look forward and hope to return 'home' even in old age so that they can be buried beside their ancestors. They therefore maintain a strong link with their homeland, as it symbolises attachment to their ancestral land. In addition, their visits home involve a process of self-evaluation as they reflect on their successes and failures, and at the same time take advantage of the opportunity to find marriage partners.

3.5.1 The Physical Environment

Ado Ekiti is located in a central position relative to major towns in Ekiti State as shown in Figure 3.1. Ado Ekiti enjoys a tropical climate with distinct wet and dry seasons. The tropical continental air mass blowing from the Sahara desert brings the dry weather experienced between the months of November and March, while the tropical maritime air mass that originates from the Atlantic Ocean brings the onset of the wet season between the months of April and October (Adebayo, 1993).

Comprehensive and historical weather data for the study area are not available as the newly established Nigeria meteorological station based at Ado Ekiti only became operational in 2011. The available monthly mean temperature and total monthly rainfall are presented in Table 3.1. The monthly mean maximum temperature ranges between 28^0C to 33^0C with an annual mean of 31^0C. The minimum temperature is between 16^0C and 23^0C with an annual mean of 21^0C. The total rainfall in 2011 for Ado Ekiti was about 1222.5mm.

Table 3.1 Average monthly temperature and total rainfall for Ado Ekiti in 2011

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temp (max) ^0C	33	32	33	31	31	30	28	28	29	29	32	33
Mean Temp (min) ^0C	18	23	23	23	23	22	22	22	22	20	21	16
Total Rainfall mm	0	46.8	59.7	77.2	118.6	175.2	143.7	125.6	257.8	213.6	4.3	0

Source: Nigeria Meteorological Station, Ado Ekiti

Ado Ekiti has a relatively low relief, with isolated hills, ridges and dome-shaped inselbergs (Ekiti State of Nigeria, 2006). This even informed the name of the area 'Ekiti' which is coined and used as the suffix for all settlements in the Ekiti State so as to identify with the isolated hills (referred to as '*Okiti*' in local dialect) found there. Geologically, the area is dominated by crystalline rock, which forms part of the basement complex (igneous rock) of South Western Nigeria (Omotoyinbo and Okafor, 2008). Ado Ekiti falls within the rain forest zone that is characterised by lowland rainforest vegetation, woodland, and grass on the steep slope of the scarps, inselbergs and residual hills. Over time, various human activities have replaced this with secondary forest, fallows, herbaceous vegetation, cocoa plantations, and farmlands on the lowlands (Adeniyi, 1993). It is along the stream courses and steep slope of the inselbergs that primary forest vegetation can be found in the area. The vegetation can, therefore, be classified as tropical forest in the south and guinea savannah in the north (Ekiti State of Nigeria, 2006).

3.5.2 Households, Ethnicity and Livelihoods

As there are three levels of administration in Nigeria (Federal, State and Local governments), Ado Ekiti doubles as Ekiti State capital and Ado Local government headquarters. The dual role that Ado Ekiti is performing has continued to encourage migrants into the area. The 2006 census estimated the population of Ado Ekiti to be 308,621 (National Population Commission, 2009) with an annual population growth rate of 2.5 percent (Ekiti State of Nigeria, 2006). Ado Ekiti is adjoined by various farm settlements occupied by migrants who reside in the peri-urban areas. The predominant ethnic group in Ado Ekiti is Yoruba, while Ebiras, Tivs and Hausas have migrated from the surrounding and even more distant states (Ondo, Kogi, Kwara etc.), to the peri-urban areas of Ado Ekiti.

The peri-urban zone is often an interface between rural and urban areas characterised by mixed land uses with a transition zone that is rural on one side and urban on the other hand (Olujimi and Gbadamosi, 2007). Migrants establish settlements in the peri-urban zone with the aim of deriving infrastructural benefit from the nearby urban centres. As a result, the land tenure system practiced in this area sees that the land is leased by the host community to farmers for an agreed number of years (usually for more than 10 years) before it is cultivated, thereby limiting cultivation to only annual and biennial crops.

In this Ado Ekiti peri-urban zone, 75 percent of the population are primarily involved in agriculture, while the remaining 25 percent engage in trading and vocational jobs (tailoring, barbering/hairdressing, vulcanizing). The main agricultural systems include, but are not limited to, mono-cropping, inter-cropping mixed farming and livestock farming (Kayode, 1993). Crops cultivated in the area are yam, cassava, tomatoes, and vegetables, and cash crops, which include cocoa, palm oil, and plantain/banana. Crop cultivation is largely rain-fed and practised by traditional methods (the use of hoe and cutlasses) as farmers in this area have not embraced mechanized systems of farming and/or crop production specialization because of inadequate funds.

As this study focused on peri-urban households in Ado Ekiti, of the three hundred and fifty questionnaires administered in the nineteen communities, the dataset comprises Ebira (76 percent), Yoruba (16 percent), Tiv (7 percent), and Hausa (1 percent) ethnic groups. Because the majority of the respondents that participated in the survey are of the Ebira ethnic group, this could have underestimated views of other ethnic groups. However, responses from all ethnic groups are important in highlighting how householders' views vary. In addition, participants have varying tenancy agreements that span from less than five years to over thirty years. The discussions below explain the cultural setting of each ethnic group, while Section 3.6 describes the general characteristics of communities that participated in the study. Detailed information about each community is provided in subsequent chapters.

Ebira Ethnic Group

In these communities, the Ebira ethnic group, (Figure 3.3) has a social and political structure based on clans, groups and lineages (Bunza and Ashafa, 2010). The head of the family assumes both the administrative role of determining marriage solemnization and settling disputes amongst family members, and, the prerogative role of controlling the production system that relates to land, farm produce and clan activities. However, within their community, a leader coordinates all social, religious, and traditional activities amongst them. As part of the family structure, it is expected that male children will remain and work on the parent's family land until they get married (Bunza and Ashafa, 2010). Men have responsibility for harvesting crops from the farm, and women sell the excess at the market to meet family needs.

Figure 3.3: Ebira community
Source: Author, August 2010

Hausa Ethnic Group

The Hausa ethnic group place a high premium on loyalty, obedience, and allegiance to whoever is powerful in status amongst them (Aluko, 2003). They tend not to query authority except on matters relating to religion and traditional rulers. Religion, therefore, is central and influences all aspects of their life (social, economic, political, and cultural). Women within this ethnic group have a relatively low status and are not allowed to work or go to school. Their socio-economic life is impeded by the practice of '*purdah*'[20] whereby they are dependent upon their spouse for a means of livelihood and sustenance. Women who do not practise '*purdah*' engage in small scale trading, while the men practice peasant farming and cattle rearing. The housing type illustrated in Figure 3.4 depicts makeshift tents for adult males as from the age of sixteen adult males in the family sleep separately until

[20] The practise of keeping women away from the sight of male strangers. Women observing purdah normally spend most of their time inside and close to the house. Usually when they go out, it is in the company of an escort and their faces are fully covered.

they are married. The main type of housing for Hausa families, however, are the mud type shown in Figure 3.3.

Figure 3.4: Unmarried men's makeshift tents within the Hausa community
Source: Author, March 2011

Yoruba Ethnic Group

Within the Yoruba ethnic group (as illustrated in Figure 3.5), the family structure is seen as the most sacred and significant institution controlled by adults and ruled by the elders. Family units are often considered as classrooms where honour, shame, discipline, affection, and personal appreciation are taught to younger members, and seniority acts as a form of social ranking where respect and preferences are always given to elders (Balogun, 2010; Stone, 2009). The community of this group of people is seen as the school where education and inspirations are drawn from cultural values (Fayemi and Macaulay-Adeyelure, 2009). The natural environment of their settlement includes but is not limited to farming, hunting, weaving, and fishing often dictates their occupation.

Figure 3.5: Yoruba Community
Source: Author, March 2011

Tiv Ethnic Group

For the Tiv ethnic group, the key form of social organisation could be classified as 'segmentary lineage' – organising the society into segments, such that no administrative divisions, chiefs, or councils exists. The segments are 'egalitarian' where only age and affluence dictates leadership, and in each lineage there are leaders who arbitrate on internal and external conflicts (Tesenôngu, 2011). This lineage system is the basis for forming the settlement pattern and political system where the compound is the basic unit of political organisation. Women in this ethnic group implement most of the farming activities, which include planting, weeding, fertilizer application, harvesting, transporting, storing, and selling of crops (Ogundele, 2006). Figure 3.6 illustrates houses within the Tiv community.

Figure 3.6: Tiv community
Source: Author, February 2011

Furthermore, the variety of ethnic groups in the study area reconstructs forms of social relations that connect them with their 'home' method of food preparation. Irrespective of the housing structure, the method of cooking takes the form of '*aro meta*' (three hearth stone). This can be interpreted as a cooking place where a pot can be firmly placed without it falling down or breaking. This method of cooking is used across all ethnic groups in the study area. Households over the years have formed a level of trust and reliance on this traditional cooking method. The ideology of cultural cooking practices, where biomass fuel is burnt over an open fire is central to this study. In addition, the particular way a house is constructed by peri-urban dwellers, (Figures 3.3 – 3.6), is also central in understanding the impact of indoor air pollution when using '*aro meta*' in the area.

Another important aspect of social relations among migrants is keeping their family as a traditional unit. Each family unit ensures that food is available for every member even when they are not living within the same building (as long they are within reach). Every household head ensures respect for elder community members who are held in high esteem. This invariably allows responsibilities to be shared among household members according to age, which in turn fosters unity among them. This form of unity is further transferred into the community and encourages communal living.

The different ethnic groups discussed above have formed themselves into small representative ethnic communities away from their 'home' within the peri-urban areas of Ado Ekiti. Each ethnic group has its own historical past and cultural focus, and common interest. Some ethnic groups do co-exist peacefully together in these communities. The majority of ethnic groups however are against cultural assimilation and do not integrate with the host community (Ado Ekiti). Even though they do not integrate with the host community, they provide complementary services (farming, trading), which often add value to the economy. The majority of the migrant farmers engaging in farming activities have low levels of education (Bah *et al*., 2003).

As mentioned earlier, agriculture is the main source of livelihood of migrant farmers in Ado Ekiti. This way they have been contributing to the development of the agricultural sector, though using traditional methods of farming and specialising in yam cultivation. As a result, the host community abandoned yam cultivation because of migrant farmers' high yielding technique of planting yams and they now have to rely on migrant farmers for the supply of the crop in the area, and this has created markets for the migrants' agricultural goods. This shows that trade is the main factor influencing interactions with the urban area. The urban dynamics benefit peri-urban dwellers as they have a monopoly over yam cultivation in the area. Consequently, the increase of agricultural prices has enhanced agricultural productivity and further serves as a means of maintaining market-based activities in the area. This market function and linkages with the urban areas enhances migrant income in the peri-urban areas. Although urban households have physical access to the peri-urban market, the informal market networks sometimes put peri-urban farmers at a disadvantage in terms of negotiating value for their produce. The underdevelopment of these markets seems to be one of the reasons for low income in these areas despite producing the majority of food for the urban areas (Adenegan *et al*., 2012).

It is important to note that the migrants fall back on traditional rulers in the urban areas to retain claims to land in the peri-urban areas. So long as the land is within the territory of the traditional ruler, it is secured with the payment of '*isakọlẹ*' (royalty investment payment made in cash or in kind). Furthermore, being in the minority group, politicians count on their support and votes during elections.

3.5.3 Available Infrastructure

The infrastructural facilities available in Ado Ekiti include but are not limited to electricity, drinking water, garbage collection, health facilities (western and traditional), and roads. However, the majority of migrant farmers' settlements considered for this study do not enjoy these facilities because of unequal distribution in the area. With some of the communities having close proximity to the urban and/or rural areas, the provision of infrastructural facilities does not trickle-down to most of the communities in peri-urban areas. Water for drinking and domestic uses in the settlements is obtained largely from hand-dug wells and streams. Roads linking these communities are not tarred which makes it difficult for people to access services in the adjoining urban and/or rural areas. An important point to bear in mind about the study area is that urbanisation (of Ado Ekiti city) is ongoing, and will benefit the peri-urban dwellers in future by creating better road access to the communities. The dual role of Ado Ekiti has been an important driver behind its physical expansion and emphasis on better road networks. In time, it may also encourage the development of social infrastructure such as hospitals, schools, drinking water, and electricity to be provided for households in peri-urban areas.

As western medical facilities are not available within the peri-urban communities, households usually rely on traditional medicine available locally with health services sought from urban medical facilities only in severe situations. In these communities, there is no access to electricity. A report from IEA (2011) indicates that only 50.6 percent of the Nigerian population in 2009 could access electricity. Even in Ekiti State, 58.7 percent of the population are still dependent on wood fuel for cooking (National Bureau of Statistics, 2013). Although, urbanisation is ongoing in Ado Ekiti, it has not changed the preference for wood fuel[21]. One advantage of the increase in population (especially within the study area) for politicians at least, is that they can canvass for votes during the electioneering period, with the promise to provide infrastructural facilities in the communities (a promise which has never yet been following elections).

3.6 Fieldwork and Data Collection in the Study Area

As all of the households are using biomass fuel for cooking and lighting, all householders willing to participate in the study area were targeted for the survey. Data collection was achieved in two phases. The first phase was implemented during the preliminary survey carried out from 4th – 24th August 2010, while the second phase of the fieldwork was conducted between February and June 2011. The latter provided a detailed fieldwork survey that sought to achieve the objectives of this research (Section 1.3). The purpose of the preliminary survey was to become familiar with the research environment and ensure that the area was suitable for the study. The visit also sought to examine the feasibility of the objectives set for the study and to pre-test the research instruments.

Before embarking on the preliminary survey, negotiating access into the study area began with telephone conversations with family members in Ado Ekiti, who assisted in finding a 'gatekeeper' who was familiar with the research participants. The 'gatekeeper' was a middle-aged woman of the Yoruba ethnic group who speaks the Ebira language and trades in foodstuffs in some of the communities. Her role was to establish contact between the community leader and myself in Irasa as she had had access into the

[21] National Bureau of Statistics (online) Harmonised Nigeria living standard survey 2009/10: core welfare indicators http://www.nigerianstat.gov.ng/ (accessed 08/07/2013)

community for over ten years. She informed the community leader in Irasa about my research prior to the start of fieldwork. Although this was just for one location, it was important to have an established relationship in Irasa community since the community has one of highest numbers of households in the study area (Table 3.2). For the remaining locations, access was negotiated through each of the community leaders. The community leaders were, therefore, the 'community gatekeepers' used to establish links with households. They had no influence on whether or not community members participated in the research. The supportive role they played in ensuring (after the purpose of the study was explained to them) that access to community members was not a barrier during fieldwork made them an important intermediary between householders and myself. It is important to note that community gatekeepers were not involved in recruiting participants.

The gatekeeper in Irasa facilitated communication between the community leader and me. The community leader had the final say on accessing participants for the study, and so the gatekeeper was neither part of the research nor responsible for disseminating information to householders. She also had no power over the households in influencing their participation during the fieldwork. On arrival at the study area in 2010, meetings were held with leaders in various communities where the research was carried out to further discuss the objectives of the research and, to allay their fears that the research was not politically motivated but was for academic purposes. After these meetings, community leaders gave permission for research to be conducted in the area amongst householders.

During the first phase (preliminary fieldwork), 100 household questionnaires were pre-tested and 20 interviews conducted with householders' and stakeholders. In administering the questionnaire, I discovered that it was difficult to engage householders in the morning because the study took place during the harvest period and they needed to sell their farm produce. I also became aware that most householders, especially farmers, left their houses early in the morning for their farming activities. To ensure better response and participation, I then chose the evening periods for subsequent interviews and administering questionnaires in households. With the permission I sought from the community leader, the householders are encouraged to participate willingly in the pilot study and subsequent fieldwork. On account of my experience during the first phase of the fieldwork, changes were made to my original fieldwork plans and my data collection strategy was changed from random to convenience sampling techniques as discussed in Section 3.6.2.

To understand the points of view of the different stakeholders, I conducted stakeholder interviews during the pilot study. I presented a letter of introduction from the University of Nottingham to organisations that hold responsibility for enlightening, educating, and disseminating information about environmental problems in the study area. With a follow up letter, four organisations stated their willingness to participate in the study and convenient dates and times were scheduled for interviews with them. Apart from consulting government stakeholders, I also sought to establish the opinions of NGOs in regards to biomass fuels and indoor air pollution in Nigeria. Due to the fact that there are no NGOs working on energy issues within my study area, I made efforts to locate offices of NGOs in Lagos, Nigeria who had given information on their websites. Unfortunately, the addresses given on the website did not always correspond with their in-country location, and it became increasingly difficult to obtain further information or even new addresses for these organisations.

When it came to the main phase of data collection, I built on the relationships that I had established during the 2010 preliminary survey and community leaders granted me permission to carry on with my research. As previously mentioned, the main fieldwork period (second phase) was carried out between February and June 2011. The general characteristics of participants and communities are presented in Section 3.6.2. Questionnaires were administered using the convenience sampling method. The initial plan of adopting a random sampling strategy in selecting householders to participate in the study had to be changed during the 2011 fieldwork session in order to address some of the setbacks of the 2010 preliminary survey. The key difficulty was gaining access to randomly selected households. The reluctance of some households to participate in the research resulted in a shift to convenience sampling methods to minimise the risk of not collecting any field data (Bryman, 2008). The change in the strategy for administering household questionnaires to a convenience sampling technique allowed greater access to participants and more responses were recorded as the timing of the survey shifted to evening periods (4 – 7 pm).

3.6.1 Air Pollution Monitoring

To better understand air pollution levels in the study area, air quality measurements needed to be made in the area. I made concerted efforts to secure high quality monitors and ensured they were pre-tested before fieldwork to ascertain their performance status. I established both email and telephone conversations with staff at the University of Liverpool (through Duncan Fullerton) regarding the possibility of loaning HOBO and UCB[22] monitors from their institution. Unfortunately, at the final stage of arranging

[22] University of California, Berkeley (UCB) monitors were used as they are specifically developed for measuring indoor air pollution in developing countries.

the transfer and insurance of the equipment to the University of Nottingham, the contact at the Liverpool University was no longer interested in releasing the equipment. I then had to rely on equipment from the University of Nottingham, which malfunctioned during the preliminary survey in 2010.

Without reliable monitors, I would not be able to achieve the first objective of this study (Section 1.3) during the second phase of the fieldwork in 2011. I sought advice from my contact at Liverpool University on the type of monitor that could be used in developing countries based on their previous experience conducting air pollution measurements in Malawi. An UCB monitor was suggested based on proven field experience in developing countries, as this type of monitor would not require battery charging and was thus reliable. With information and assurance that the UCB monitor would be able to measure particulate matter, two new UCB monitors are ordered. Prior to the second phase of fieldwork in 2011, the UCB monitors were pre-tested[23] at Birmingham University's Institute of Occupational and Environmental Medicine laboratory in order to calibrate and compare data collected from it with the Dust Track monitor. The Dust Track monitor runs off battery and uses size-selective impactors (the size ranges from PM_1 to PM_{10} µm) which can be attached to the monitor inlet. The selection of a cap determines the particle size to be measured. For the impactors to achieve correct measurements, it has to be set at the factory default of 3.0 L/min[24]. When particle measurement is completed, the monitor is connected to the computer to download data.

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[23] Tested at the University of Birmingham (with the assistance of Prof. Jonathan Ayres and Om Kurmi).

[24] http://fieldenvironmental.com/assets/files/Manuals/TSI%20DustTrak%20II%20Manual.pdf (accessed 13/08/2013)

After initial pre-testing of the UCB monitors, they are able to measure particulate matter based on comparable results from the Dust Track monitor data. Further pre-testing of the monitors with a Dust Track monitor was required in the School of Geography laboratory at the University of Nottingham. The data downloaded from the two devices (UCB and Dust Track) were comparable and the UCB monitor was used during the fieldwork. The Dust Track monitor could not be used because it required battery charging, which was difficult to ensure during fieldwork, as electricity was not always available or constant. The UCB monitor measures particulate matter of a size fraction similar to respirable dust (0.1 – 10 μm) using photoelectric methods and logs concentrations each minute (Edwards *et al*. 2006). The monitors also use less energy so they can run for several days. During the second phase of fieldwork, the monitors successfully measured air quality levels within respondents' homes and the resulting data were downloaded for further analysis. Although, the initial plan was to measure both $PM_{2.5}$ and carbon monoxide (CO) during the 2011 fieldwork, the CO monitor malfunctioned and readings could not be downloaded from it.

During the second phase of fieldwork, the monitoring of indoor air pollution in the study area was completed in buildings of the Irasa community. Households were chosen based on their kitchen types (see Section 4.6) bearing in mind that I sought to obtain a sample set that reflected site-specific concentration levels of particulate matter in the community (Irasa). The sampling technique employed focused on people relevant to the research as "researchers don't usually pull research sites out of a hat, rather, they rely on their judgement to find one that reflects the things that they are interested in" (Bernard, 2002; Bryman, 2008: 185). This type of purposive sampling allows intensive study of a few selected cases (Bernard, 2002), but it may not be representative of the population. Numbers may often be small here and once again the “fit for purpose” defence of the method may be deployed (May, 2001:95). With regard to the Irasa community, the intention was to monitor the air quality in buildings of householders who have kitchens indoors or outdoors over a 24-hour period continuously for a week (see Appendix 1). The Irasa community was chosen because it has one of the highest numbers of households in the study area (see Table 3.2). Not only this, the better access and relationship established with householders during preliminary surveys helped in choosing this community. In addition, householders were familiar with the use of air monitors in homes, had an understanding of how the monitor works and were reassured that there were no health-related side effects based on their experiences during the 2010 pilot study. Although air quality measurements were not taken in other communities to give a comparable data set, the results obtained from the Irasa community were used to generate site-specific air quality data for the area.

As detailed in Chapter Four, houses in the different ethnic communities have similar architectural designs (see Section 4.3) and kitchen characteristics (see Section 4.6), and so, the Irasa community was chosen as a prototype/example of the most common house type (see Section 4.3.1) found in the study area for the air pollution monitoring. In particular, I wanted to measure the level of air quality in this environment empirically since it has not been measured in this community. Although the results might not be representative for all the communities, they gave an indication of possible air pollution levels in buildings irrespective of the kitchen location.

In monitoring air quality in Irasa, houses that had their kitchen and/or hearth inside or outside were specifically chosen for the study to allow a comparison of the air quality levels in these buildings. In comparison to other communities, the Irasa community represents a nuclear settlement. Despite having different kitchens and/or hearth locations (Chapter Five), houses are clustered with about 5 meters between each building.

The UCB monitor was used to measure $PM_{2.5}$ for both indoor and outdoor kitchens, as this type of instrument had been used in previous studies in Guatemala, Malawi, and Ghana (Fullerton *et al*., 2009; Pennise *at al*., 2009; Cyntia *et al*., 2008). Each monitor was differently marked for indoor and outdoor use for ease of identification while being placed in buildings and during data download. In measuring $PM_{2.5}$ in the indoor kitchens, the standard protocol is 125cm above the floor (this height relates to the approximate breathing height of a woman standing), 100cm from the stove and 150cm away (horizontally) from doors and windows (Chowdhury *et al*., 2007). Monitors were placed in participants' houses as illustrated in Figure 3.7 and to ensure the safety of the equipment.

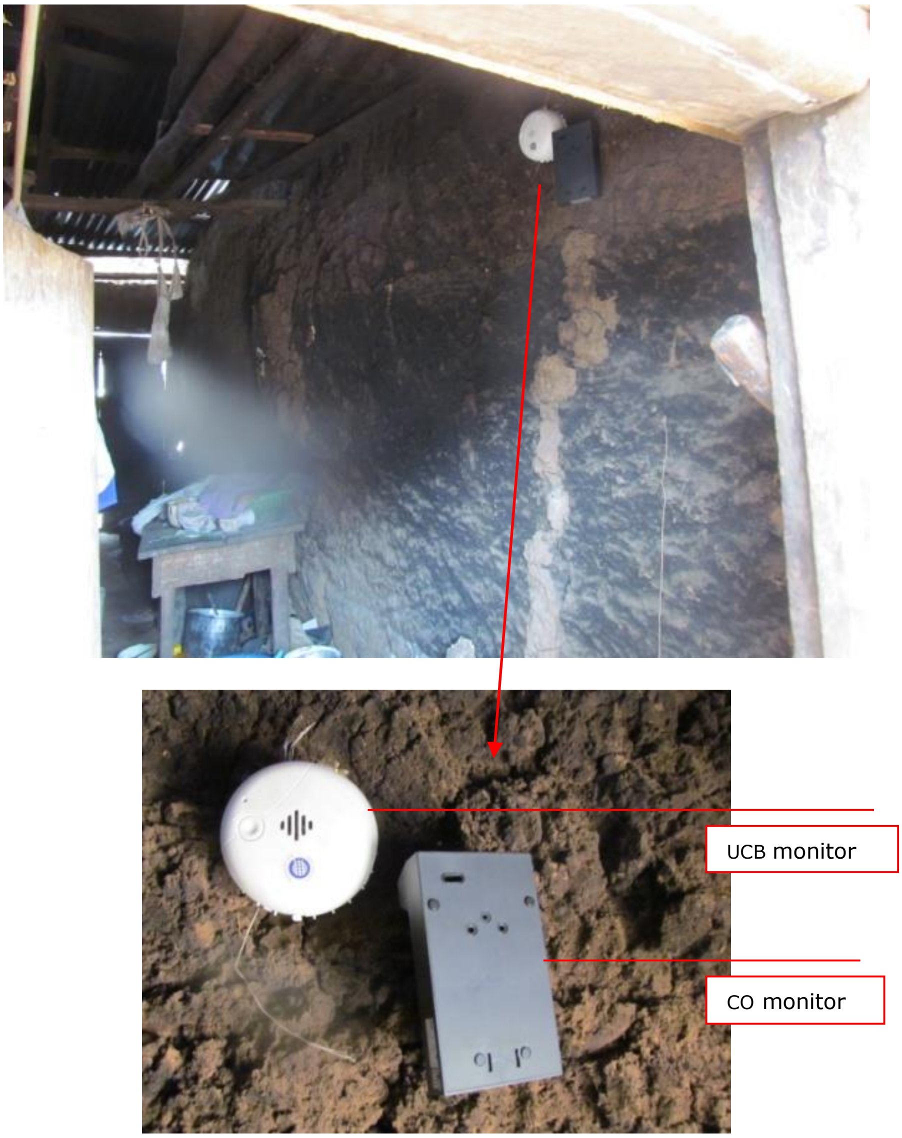


Figure 3.7: Locating monitors in householders buildings
Source: Author, February 2011

For the outdoor kitchens[25], the protocol was modified in order to capture concentration levels of $PM_{2.5}$ inside the buildings by placing the monitor 125cm above floor and 150cm away from the door and windows, which is in line with the protocol used for the Agra, North-Central study (Massey *et al*., 2012) as stove locations are not included. These protocols were used with the assumption that the monitors would capture air quality within breathable

[25] Monitors were placed inside the building for PM measurements because such kitchens are very close to the building.

height of householders in buildings. To compare concentration levels as uniformly as possible, monitors were placed in the corridor of houses with indoor kitchens as well as those with outdoor kitchens where householders normally stay while carrying out cooking activities. This was because 60 percent of households in the study did not have a special living room (see Section 4.3). The photoelectric chamber of the UCB monitor was cleaned weekly after use with isopropyl alcohol and Ziploc bags were used to zero the monitor before each use as stated in the manual. The zeroing of the monitor was conducted 30 minutes before placing the monitors in buildings. After retrieving the monitors from the buildings after each measurement, the devices were again placed inside the Ziploc bag for a post-sampling zeroing period of 20 minutes before downloading the data.

The cooking period in the Irasa community was determined through information given by householders and later confirmed with field observations before installing monitors in buildings. In order to capture all of the householders' cooking episodes, UCB monitors were left in place to capture concentrations of indoor air pollution in the microenvironment (indoors) during the day, which covered cooking and non-cooking periods in buildings during the weekly measurement. In order to check the reliability of data downloaded, it was first checked in accordance with the protocols stated in the manual (i.e. minimum particle concentration is considered reasonable when it is between ≥30μg/m^3 and ≤75μg/m^3). When minimum particle concentration exceeded or fell below this standard, 50μg/m^3 (which is the approximate detection limit of the monitor and typical background concentration) was entered manually on the software to edit the limit of detection[26]. However, there are limitations of the UCB monitor due to its

[26] http://www.berkeleyair.com/products-and-services/instrument-services/87-ucb-pats (accessed 29/12/2010).

limit of detection, which made readings of particulate matter below 30 – 50 μg/m^3 inaccurate. Since there were no other monitors (such as the gravimetric method) co-located with the UCB monitors in Irasa to measure the very low limit of detection of air quality, this was one of the limitations associated with this aspect of the research. Although the monitors used in this study were unable to capture the low particulate matter readings indicated as safe by WHO guidelines, they were able to capture typical levels of PM in buildings in developing countries. In addition, while the use of seven days measurements were consistent for the between-days variability, they may not have captured it all, which could have led to some uncertainty in the results. Another source of uncertainty was the quality of responses obtained from householders on their time-activity. It was clear during surveys that many did not have an accurate sense of their time-activity patterns. Therefore, this could have led to significant error in determining the contribution of the microenvironment to particulate matter concentrations. As the air monitoring was limited to one community (Irasa), the results obtained could not be generalizable to all communities because of differences in the community setting as will be explained in Section 3.6.2. However, the sampling of particulate matter in indoor microenvironments within the Irasa community did give an estimate of concentration levels of $PM_{2.5}$ in the area and thus allowed for an evaluation of air quality.

3.6.2 Household Questionnaire

Once within a community and with the assistance of that community leader, I established contact and located other peri-urban communities in Ado Ekiti. This snowball type of sampling selection process allowed me to focus on households relevant to my enquiry. According to Bernard (2002:180), "despite our best efforts, it is often impossible to do probability (random) sampling under real research conditions." As such, appropriate non-probability sampling (quota, purposive, convenience, and snowball) was used during data collection.

Bryman, (2008) posits that data generated from convenience sampling may not be generalised it can, "provide a springboard for further research or allow links to be forged with existing findings in an area" (p.183). With the use of appropriate non-probability methods, reality can be understood, and not only this, change can be made when structures properly identify the distinctiveness of humans within the social world (Bryman, 2004). This switch provided a richer and wider coverage of administered questionnaires within all nineteen communities visited for the fieldwork in 2011 as later discussed, and further facilitated a better chance of receiving back all the questionnaires.

The opportunity presented by households volunteering to participate in the questionnaires was "too good an opportunity to miss" during fieldwork, which "may be acceptable but not ideal" as it does not ensure the probability that participants will be selected (Bryman, 2008:183). Nevertheless, this approach frequently used in social research when random sampling cannot be attained although there are limitations, in that there is a possibility of excluding households who would have contributed a more comprehensive dataset to this research. Efforts were made to address this limitation by having spatial representation of participants from a range of different communities. Information gathered about biomass fuels in Ado Ekiti, Nigeria provided a means of understanding the socio-cultural context surrounding indoor air pollution in the area and helped to improve knowledge about 'locally' acceptable measures for intervention.

A questionnaire was developed to investigate these issues and to meet objectives 1, 3 and 5 (see Section 1.3). The structure of the questionnaire included both open and closed questions, allowing appropriate questions to be asked and collected from participants during fieldwork. The type of information collected was divided into three sections. The first section sought to collect information about householders' socio-economic characteristics (gender, age, income, educational qualifications, housing characteristics etc.); the second section focused on socio-cultural factors (cooking methods, cooking location, stove designs etc.); and the third section concentrated on knowledge, information and education about indoor air pollution (Appendix 2).

Based on data obtained from questionnaires, the characteristics of participants in the communities (Figure 3.2) were identified in Table 3.2, which presents background information about each individual community. However, as this table shows, there are some very small sample sizes (less than 10 responses) amongst the Hausa ethnic group and also some of the communities in the sample (Aba CAC, Alagorugba, Asọ Ayegunle, Ejiko, Elemi, Igbaitu, Igbaye, Isegere, Oke Epa, and Ologunja). Therefore, in order not to over and/or underestimate results from such limited samples, less emphasis is placed on these data in the empirical chapters. Data on gender distribution in the study communities indicate that two hundred and twenty three females (63.7 percent) and one hundred and twenty seven males (36.3 percent) participated in the survey. The age distribution of householders that participated in the survey was mostly between thirty and forty years (see details in Figure 5.6).

Table 3.2: Characteristics of respondents in the communities

Parameters	Community																		χ^2	p = 0.05
	Aba CAC	Agọ Aduloju	Agọ Corner	Alagorugba	Aroto	Asọ Ayegunle	Ejiko	Ejimakogo	Elemi	Igbaitu	Igbaye	Ilamọ	Ilokun	Irasa	Isegere	Odoro	Oke Epa	Ologunja	Ọlora Camp		
	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)	% (N)		
Gender																				14.631	0.687
Male	50(2)	28.3(17)	30.6(11)		23.1(3)	33.3(2)	50(4)	39.1(9)	44.4(4)	50(1)	83.3(5)	42.9(9)	41.8(23)	30(18)	33.3(1)	42.3(11)	50(1)	50(2)	40(4)		
Female	50(2)	71.7(43)	69.4(25)	100(2)	76.9(10)	66.7(4)	50(4)	60.9(14)	55.6(5)	50(1)	16.7(1)	57.1(12)	58.2(32)	70(42)	66.7(2)	57.7(15)	50(1)	50(2)	60(6)		
Ethnic group																				233.186	0.0001
Ebira	100(4)	40(24)	91.7(33)	100(2)	100(13)	16.7(1)	87.5(7)	91.3(21)	88.9(8)	100(2)	100(6)	4.8(1)	96.4(53)	95(57)	100(3)	69.2(18)	100(2)		100(10)		
Yoruba		40(24)	8.3(3)			83.3(5)	12.5(1)					81(17)	1.8(1)	1.7(1)		3.8(1)		50(2)			
Tiv		11.7(7)						8.7(2)	11.1(1)			14.3(3)	1.8(1)	3.3(20		26.9(7)		50(2)			
Hausa		8.3(5)																			
Years of Occupancy																				31.789	0.007
≤5		25(15)	22.2(8)		7.7(1)	33.3(2)	12.5(1)	30.4(7)	11.1(1)	50(1)	16.7(1)	19(4)	30.9(17)	18.3(11)		19.2(5)		25(1)	20(2)		
6 – 10		18.3(11)	16.7(6)		7.7(1)			17.4(4)				9.5(2)	21.8(12)	26.7(16)	66.7(2)	34.6(9)		25(1)	50(5)		
11 – 15		3.4(2)	16.7(6)	50(1)	23.1(3)	16.7(1)	12.5(1)	4.3(1)			16.7(1)	4.8(1)	10.9(6)	18.3(11)	33.3(1)						
16 – 20	25(1)	20(12)	25(9)		30.4(4)	33.3(2)	12.5(1)	17.4(4)	55.6(5)	50(1)		23.8(5)	14.5(8)	18.3911)		15.4(4)			10(1)		
21 – 30	25(1)	18.3(11)	11.1(4)		15.4(2)		50(4)	26.2(6)	33.3(3)		66.7(4)	14.3(3)	10.9(6)	10(6)		19.2(5)	100(2)		10(1)		
31$^+$	50(2)	15(9)	8.3(3)	50(1)	15.4(2)	16.7(1)	12.5(1)	4.3(1)				28.6(6)	10.9(6)	8.3(5)		11.5(3)		50(2)	10(1)		

In addition, Table 3.2 gives an overview of respondents' characteristics and data generated from questionnaires in the different communities. In this study, Ebira households were found to reside in all the communities visited while Yorubas and Tivs households reside in Agọ Aduloju, Ilamọ and Odoro communities.

As highlighted in Table 3.2, households from all the different ethnic groups reside in Ago Aduloju community indicating that it is ethnically more heterogeneous than other communities. On the other hand, some communities (Aroto and Ọlora Camp) are more homogeneous and contain only Ebira households (Table 3.2). As most communities are neither totally homogenous nor heterogeneous, caution must be adopted when attempting to generalise results to all communities. The generalizability of the results is also limited by the uneven distribution of participants within ethnic groups.

The majority of householders were found to have tenancies lasting between six years and above thirty years. The possible influence of their length of stay in the communities on building types and cooking practices is discussed in Chapter Four.

The background information generated from the dataset indicates that individual communities have sample populations comprising of one ethnic group in some communities and mixed ethnic groups in other communities (see Table 3.2). This has shown that when drawing conclusions about biomass fuel use and indoor air pollution in peri-urban areas of Ado Ekiti, consideration must be given to the highly varied dataset in the analysis. Undoubtedly, apart from the differences in the community settings, there is a limit to generalising the results because the sample frame was made up mainly of female participants, and respondents largely of the Ebira ethnic group.

A Chi-square test was used to establish the statistical significance between gender, ethnic groups, years of occupancy and the communities at $p < 0.05$ level (after first checking the assumption concerning the 'the minimum expected cell frequency' which should be 5 or greater) (Pallant, 2010; 219). The Chi-square test results are presented in Table 3.2 and shows that there is association between ethnic groups, years of occupancy, and the individual community, whereas there appears to be no association between gender and the individual community.

However, with the data generated from this study, it is possible to begin to analyse in the empirical chapters the differences and views about biomass fuels and indoor air pollution in terms of gender, ethnicity, and at the different communities in the area.

3.6.2.1 Validity and Reliability of the Questionnaire

Questionnaires have proved to be highly effective in gathering large amounts of information in social science research. The fact that they are inexpensive, quick to administer and can be completed at the speed and convenience of the researcher further recommends their use for collecting data in social research (Bryman, 2008).

Research instruments used for data collection are usually subjected to reliability and validity tests in order to ascertain whether there is consistency and/or variation in results obtained over a period of time (Bryman, 2008). Reliability measures the consistency of data through administering and re-administering the research instrument to know whether results are repeatable in quantitative research. Validity is concerned with determining the extent to which research instruments are able to document what is being measured in any research study.

In testing the reliability and validity of the questionnaire used for data collection in this study, it was first established that there is a *face validity* that addressed the objectives of the research (Bryman, 2008). To ensure that the questionnaire design was conducive to developing a good understanding of the continued use of biomass fuels in Ado Ekiti, Nigeria. Nigerian volunteers at the University of Nottingham reviewed the draft questionnaire and made suggestions for re-framing certain questions. I also engaged research students in the same research office to help with further reviews of the questionnaire along with suggestions from my supervisors and experience from the field to improve the content of the questionnaires that were finally used for data collection. The preliminary survey conducted in 2010 allowed the questionnaire to be tested with one hundred householders. Feedback from householders during the preliminary survey suggested that they understood the questions and that the questionnaire addressed the key focus of the research in the study area. In cases where a question was complex, it was re-worded prior to the 2011 detailed fieldwork.

3.6.2.2 Method of Administering the Questionnaire

As explained earlier, a convenience sampling method (Section 3.6.1) was used in administering the questionnaire in the study area. In order to reduce the time and cost of commuting between study locations, research assistants (undergraduate students from the Ekiti State University, Ado Ekiti, Nigeria) recruited during the preliminary survey of 2010 were also employed during the detailed fieldwork session of 2011. Refresher training was conducted with research these assistants to remind them how best to elicit information from householders and this enabled wider coverage among the communities. To avoid inconsistency when administering the questionnaire, debriefing sessions were held every day after data collection to provide solutions to any problems identified (Lewin, 2011).

In spite of the unplanned building layout in the communities, I attempted to obtain an even spatial selection of questionnaire participants. This was achieved by making sure that there was a spatial representation of households selected within each of the communities (see Table 3.2). Using the convenience sampling method, a household was selected and an adult member of the household approached. If consent was given, the participant would complete the questionnaire. A good number of the householders were familiar with the research assistants and I because of their previous encounter with us during the preliminary survey which gave them confidence to participate in the main study. Also, daily visits to the community during data collection made us 'normal' and 'familiar visitors' allowing questions about wood fuel and cooking practices to be asked. Once a relationship had been formed with households and communities, householders were usually open and helpful in providing contextual information underpinning energy use in the area. As the literacy level in the study area was low, research assistants helped to complete the questionnaire to avoid non-response of questions. Questionnaires that were completed by literate respondents were collected later that day by the research assistants to minimise non-response that might have occurred if the questionnaire had been left for collection at a later date. Bearing in mind that it is often envisaged that not all administered questionnaires will be returned (Bryman, 2008) the approach of waiting and having the questionnaire completed before leaving the householder reduced the risk of non-response because of uncertainty of how to respond to a particular question. It also allowed all questionnaires to be retrieved in the study area (see Table 3.2 for distribution of respondents). With this approach, it was also possible to monitor who filled in the questionnaire to ensure the right person answered all questions (Bryman, 2008).

Although gaining physical access to the peri-urban areas of Ado Ekiti was important in researching domestic energy use in the area, "flexibility in looking for the data and open-mindedness about where to find them" (Soulsby, 2004:47) was also considered to fully understand householders' viewpoints. The limitations of the sampling strategy described in both Sections 3.6 and 3.6.2, indicate that it was very unlikely that the sampling approach would be representative of the population. However, this is not to suggest that the dataset generated from this study is irrelevant. Another important aspect of this study is to highlight the importance of geographically specific, in-depth investigations of households' socio-cultural characteristics in terms of gender, ethnicity, and community as a means of obtaining views about biomass fuels and indoor air pollution in understudied communities like the peri-urban areas of Ado Ekiti. As such, the need to obtain representative data was deemed to be less important than the need to obtain detailed, culturally specific understandings arising from the use of biomass fuels (see Section 1.3). This approach allowed all the required data to be collected during fieldwork, which formed the basis of discussion in Chapters Five, Six and Seven.

3.6.3 Conducting Households and Stakeholders Interviews

Upon identifying communities and stakeholders participating in the research, I was able to select participants for interview discussions based on their willingness and availability during the period of fieldwork. This pre-defined selection of participants' categories required the selection of householders in the peri-urban areas of Ado Ekiti (see Section 3.5) and, stakeholders involved in public health programmes in Ado Ekiti. In total thirty householder interviews were conducted in nineteen communities as shown in Table 3.3. The household interview was split among ethnic groups identified in the communities and the participants selected were also questionnaire respondents who had indicated a willingness to be interviewed. For the stakeholder interviews, five interviews were conducted with media organisations (Radio and Television stations) and policy makers at the Ministries of Information and Environment in Ado Ekiti (see Table 3.4).

Table 3.3: Participants of the household interviews

ID	Date	Gender	Ethnic group	Age group (years)	Community
Householder 1	17/02/2011	F	Ebira	>50	Ilokun
Householder 2	28/02/2011	M	Ebira	31-40	Ejimakogo
Householder 3	02/05/2011	F	Ebira	31-40	Agọ Aduloju
Householder 4	23/02/2011	M	Ebira	>51	Irasa
Householder 5	17/02/2011	F	Ebira	21-30	Ilokun
Householder 6	02/05/2011	F	Yoruba	30-40	Agọ Aduloju
Householder 7	16/05/2011	F	Ebira	41-50	Igbaitu
Householder 8	23/02/2011	M	Ebira	30-40	Irasa
Householder 9	11/05/2011	F	Ebira	30-40	Ejiko
Householder 10	17/02/2011	M	Ebira	21-30	Ilokun
Householder 11	09/02/2011	F	Ebira	41-50	Agọ Corner
Householder 12	11/03/2011	F	Tiv	30-40	Irasa
Householder 13	09/07/2011	F	Ebira	>51	Aroto
Householder 14	22/02/2011	F	Yoruba	41-40	Asọ Ayegunle
Householder 15	03/05/2011	F	Yoruba	31-40	Agọ Aduloju
Householder 16	02/07/2011	F	Ebira	31-40	Alagorugba
Householder 17	09/07/2011	F	Yoruba	21-30	Ologunja
Householder 18	13/07/2011	M	Ebira	21-30	Oke Epa
Householder 19	11/03/2011	F	Ebira	31-40	Irasa
Householder 20	11/03/2011	M	Ebira	41-50	Irasa
Householder 21	02/05/2011	M	Ebira	41-50	Agọ Aduloju
Householder 22	09/02/2011	M	Yoruba	>51	Agọ Corner
Householder 23	24/02/2011	F	Ebira	21-30	Igbaye
Householder 24	17/02/2011	F	Ebira	41-50	Elemi
Householder 25	08/05/2011	F	Ebira	31-40	Ọlora Camp
Householder 26	03/05/2011	F	Hausa	>51	Agọ Aduloju
Householder 27	21/02/2011	M	Tiv	41-50	Odoro
Householder 28	24/02/2011	M	Yoruba	41-50	Ilamọ
Householder 29	29/02/2011	F	Ebira	>51	Isegere
Householder 30	01/03/2011	F	Ebira	41-50	Aba CAC

Table 3.4: Distribution of stakeholders' interviews

ID	Date	Organisation	Gender
Staff MOI	10/03/2011	Ministry of Information	Male
Staff MOE	14/03/2011	Ministry of Environment	Male
Staff SGR	18/03/2011	State government local radio station	Male
Staff FGT	21/03/2011	Federal government local television station	Female
Staff MOH	11/05/2011	Ministry of Health	Female

In order to reduce biases, interviewees were chosen based on gender, ethnicity, age and place of residence. Even though an effort was made to balance the gender response of interviewees in order to minimise bias, an even representation of the categories (gender, ethnicity) among the respondents could not be achieved. However, in reducing the risk of bias in various communities visited, I tried to reflect the population parameters of interest (Bernard, 2002) by making sure that I interviewed households from all ethnic groups.

Interviews thus mainly took place with women but occasionally with men when women are not available at home during the visit or when women indicated that they would prefer their husbands to respond to the questions. The act of respecting heads of household in Nigeria applies to all ethnic groups, in that they are allowed to first converse with visitors, and also approve their partner's choice to partake in interviews if they are not at home. Although, culturally in Nigeria, women do the cooking, generating samples from both men and women obviously gave more in-depth insights into biomass fuel use in these communities. The questions posed to the interviewees were based on prepared interview guides (see Appendix 3).

The majority of interviews with householders were conducted in the Yoruba language, except for those interviews conducted within the Ebira and Hausa communities where one of the research assistants acted as an interpreter. It was vital for a researcher to have interpreter where there was a language barrier to act as a "cultural informant" who was not only able to translate the language, but provided interpretations of the environment and participant's behaviour (Soulsby, 2004:48). To guide against misinterpretation of ideas and views on the part of both the interviewer and interviewee, questions and responses were re-read several times until both sides were satisfied and happy with the interpretations given. When householders nodded during the interpretations of answers given to questions posed, this further validated and checked for consistencies in the direct translation of responses. The interviews in each household lasted between one to two hours.

Prior to the start of the householders' interviews, some level of rapport with respondents was created by asking questions about their welfare and coping strategies in the local environment given the limited availability of social infrastructure in the area. According to May (2001) interviewers must make the interviewees' participation and answers valued and their cooperation fundamental to successful research. Bearing this in mind, attention was given to maintaining a high level of cooperation and interaction amongst participants at all times during interview sessions in the study area. After affirming the interviewees' confidentiality in participating in the discussion outlined in the checklist, notes were taken during the conversation sessions. Under these relaxed conditions, interviewees were able to open up about salient traditional and cultural beliefs held by their ethnic group (Yoruba, Ebira, Hausa, and Tiv) regarding cooking practices and wood fuel. As Gray (2003) emphasises, by abiding with structures and routines, "we make sense of the world through observation, picking up clues based on our social and cultural competence, through relating to others via conversation and discussion" (p.20). The overall aim of interviewing is to stimulate respondents to give more information relevant to data needed, without allowing them to be influenced by the researcher's opinions or views about the questions asked (Bernard, 2002). Interviewers however, should always seek further clarification and elaboration on answers given at each interview session (May, 2001). This was demonstrated during interview sessions where interviewees from each ethnic group were given enough time to expound on their particular traditional beliefs in relation to wood fuel and cooking practices and describe their local culture and norms in relation to the use of biomass fuels.

During interview sessions with the householders, recordings were made when there was consent to do so, but in most cases permission was sought through the head of the community who customarily allowed the householders to participate in the interview sessions, but declined to have conversations recorded. The following quote from one such community head explained this position on this:

> A lot of people have been coming here to interview us about various issues; we don't allow any form of recording from them because we don't know the motive and reasons for recording the conversation. And without our consent you see the interview sessions and photographs on television programmes, especially the politicians portraying us either as very poor people or community. We know that most of the politicians used this for cheap popularity to canvass for our votes with the promise of improving on our living condition(s). We never get to see them again (politicians) until the next electioneering process. I learnt some of them (politicians) even get money from the federal government on our behalf for infrastructural facilities to be located in our communities, howbeit, such, are never done. The community therefore has resolved not allow any form of cheap propaganda or recording in our village irrespective of what it's going to be used for and being the head, I won't want to break that rule. From what you (referring to the researcher) have explained to me about the wood fuel, I know that our community will benefit immensely from this study, because it's a problem that nobody have [sic] spoken about to us since we have been residing here (Community Head, February 16 2011)[27]

The majority of community heads did not want to be recorded because they were worried about what the results might be used for. Many were concerned that they could be used to over exaggerate their living conditions with the aim of collecting money from either the national government or international organisation. In most instances, the communities are not aware when such donations are made (if there are any), but only to hear

[27] This negotiating interview was conducted in Yoruba language with the community head in order to seek consent for access into the community before starting data collection.

about such donations from friends or through the media (local radio). My explanation that the purpose of conducting the study was solely for academic reasons failed to yield any positive response, and so I had to comply with the community leader's instruction rather than being denied access to participants. This necessitated the collection of detailed field notes and in order to make the interviewees comfortable, I assured them that I would keep to the terms of the access given by their leader to express their views and opinions about wood fuel in the area. Notes taken during each interview session were read to the interviewee for the assurance that they represented their views and contribution. The themes of the questions were developed around the following: factors determining the use of biomass fuel, underlying socio-cultural factors associated with the use of biomass fuels as a domestic energy source, knowledge information, education about indoor air pollution, and, identifying barriers to solving the problem of indoor air pollution in the study area (see Appendix 3).

For the stakeholders interviews, upon deciding on the sub-population that was of greatest interest for the research (Lewin, 2011), I also adopted the convenience sampling method to select interviewees. Of all the contacts made with stakeholders and follow-up telephone calls during fieldwork, I was able to negotiate access to five people. In conducting interviews with stakeholders, a prior appointment was usually made by handing the letter of introduction from my supervisor to them in order to introduce myself and the purpose of my research. Afterwards, a convenient date and time was scheduled for the interview sessions. On the day of the appointment, I arrived early at the offices and I made sure that the protocol officers had my meeting scheduled among the day's tasks. All interviews with stakeholders were conducted in their offices and in English. Bearing in mind that the interview sessions took place during office hours, I tried to maximise the time allotted by the interviewee by adhering to the checklist prepared during each interview session. Recording was not permitted in some of the interview sessions and I had to take notes. Notes are later transcribed for analysis. The information gathered was sufficient to give a general overview of household energy use and problems in the area from the stakeholders' perspective, but it became clear that many of the stakeholders are more concerned about sanitation issues rather than the health impacts of indoor air pollution. My assumption that the diversified roles of the stakeholders would generate varying information about household energy use and indoor air pollution did not materialise, because government determined the functions of the stakeholders. In performing their roles, they are not expected to go outside their pre-defined functions as outlined in Chapter Seven (Section 7.3).

The stakeholders' interview questions focused on themes relating to their role and function within the area, strategies adopted for disseminating environmental problems to target populations in the area and the plans and policies they had for eradicating environmental problems in the area (Appendix 4).

Gaining access to these organisations was easier than in the householders' in communities, because high regard was given to the letter of introduction written by my supervisor indicating my research aim. My affiliation with an *overseas* academic institution gave me an added advantage of having access and on time attention during visits to these organisations. However, I never allowed my status as a student at a British University to supersede my nationality – a Nigerian. Nevertheless, all the necessary assistance was given (without any long bureaucratic processes) in obtaining approval for conducting interviews with the relevant heads of unit in various organisations. Those heads of unit who finally consented were interviewed at their convenience in their offices, with the interviews lasting between one and two hours. Being an *overseas* student required much humility in relating with them. More so, an idea of '*being to*' (a term used for those that have either travelled or lived outside their country of origin, who they believed are subtle in seeking information that could later implicate either public or private organisations in negative ways) could jeopardise the intention of the interview. I overcame this by letting them know that I am a citizen of Ekiti State, which I always made clear and laid emphasis on, while introducing myself at the start of the interview and also when outlining the aim of the research to them.

The interview method allowed conversations to be generated with individuals on specific topics or issues with the sole aim of interpreting the respondent's views, beliefs, opinions and experiences (May, 2001). The technique allowed the interviewer to seek clarification and elaborate on answers given by the interviewee in order to have in-depth understandings of the context, content, and justification of issues underlying their responses. The assurance that all questions are answered or attempted by the respondent during the fieldwork further indicates the usefulness of interviews in social research (Bryman, 2008). This technique used in previous studies (Fullerton *et al*., 2009; Balakrishnan *et al*., 2002) was employed to obtain information from householders and stakeholders about indoor air pollution in Ado Ekiti and to further ascertain information gathered through questionnaire and field observation in order to achieve triangulation in the research study. The analysis of the transcripts provided the themes discussed in Chapters Six and Seven.

3.6.3.1 Validity and Reliability of the Interview Checklist

The interview checklist guide was developed in line with the objectives of this study by making sure that interview questions covered all relevant themes. Since, there is a uniform structure of questions, comparability of responses was made possible, in checking for reliability (May, 2001) of householders responses. To eliminate bias in terms of gender distribution, I included a variety of participants and their views and perspectives are incorporated in the later discussions in Chapters Seven and Eight. This also allowed for checking consistencies and/or inconsistencies within the datasets.

3.6.4 Field Observation

To elicit additional information on the social and cultural context of householders, direct observation was used to record people's behaviour over a period of time, thereby generating useful data on the socio-cultural aspects of and responses to indoor air pollution in the area. To understand householders' behaviours in a specific local environment and/or context, May (2001) encourages researchers to immerse themselves in the day-to-day activities of the people whom they are trying to understand. It is only when researchers become part of the environment that people's actions and how they make meanings from their environment can be understood in producing their defined culture and symbolic behaviour (May, 2001). Participant observation, therefore, involves spending long periods of time in the research environment, securing and maintaining relationships with people in order to understand the culture and context being investigated in the area (Bryman, 2008; May, 2001). The complexity of understanding culture means that the participant observer must also be an ethnographer, which is a method that focuses specifically on the culture of the people that the researcher is immersed in studying (Bryman, 2008). Because of access problems explained earlier, permission needed to be sought from community leaders, therefore, I had to be an 'overt' researcher in the study area.

By 'hanging around' and 'watching the action' (May, 2001:154) of householders before and during cooking, I gathered fascinating insights into their social life that assisted in understanding their lifestyle in relation to biomass fuel. Being a 'participant observer' in the communities, I wanted to know more from the people about their cooking practices and use of fuels. This involved "getting close to the people and making them feel comfortable with your presence so that you can observe and record information about their lives" (Bernard, 2002:322). Learning their local language of greetings further enabled me to develop a good rapport with some of the participants, though they often wondered why an '*elite*' person like myself would be interested in the details of their cultural values and norms. Although there was initial suspicion that I might be a government 'spy' as preparations for the general election were in full swing, my identity as a student and citizen of Ekiti State and the interest I showed in their living condition(s) always helped out in such situations. I was careful to avoid giving the impression that I could provide any solutions to their household energy problems.

The observations made in the study area significantly contributed to understanding how householders perceived indoor air pollution. By experiencing first hand air quality in the buildings during cooking and measuring the concentration level of $PM_{2.5}$ in buildings, I was able to match their understandings and views about wood smoke with the reality of indoor air pollution which has associated health impacts caused by exposure to cooking smoke over time.

3.7 Data Analysis

After making sure that all household questionnaires were fully completed, a codebook was prepared to define each variable and assign numbers to all responses. SPSS 17.0 and Microsoft Excel 2010 were used to analyse the quantitative data gathered through the household questionnaire after coding. In addition, contingency tables were used to analyse associations between variables based on gender, ethnicity and at individual community level. This was presented in tabular form. Chi-square tests based on contingency tables were used because the dataset generated from the household questionnaire involved categorical data (Pallant, 2010). To ascertain associations between variables "the assumptions of Chi-square concerning the 'minimum expected cell frequency', which should be 5 or greater (or at least 80 percent of the cells have frequencies of 5 or more)" were first checked to see if the assumptions had been violated or not (Pallant, 2010: 219). Results are presented for variables that did not violate this assumption. In presenting the results, the main value from the SPSS 17 output to extract is the pearson Chi-square value and the maximum level of statistical significance that is acceptable in social research is $p < 0.05$ (Bryman, 2008). For the observed distribution to be significant, the value presented in the column labelled Asymp. Sig. (2-sided) in SPSS 17 needs to be .05 or smaller (Pallant, 2010).

The descriptive details of the analysis captured themes relating to domestic energy types and sources in the area, socio-economic characteristics of householders, dwelling conditions in the communities and knowledge and information about environmental problems in Ado Ekiti, Nigeria. The analysis also detailed health problems encountered by the householders during cooking. Results from the questionnaire survey are presented in simple averages and percentages. Microsoft Excel and the UCB particle monitor data browser software 2.5 are also used to present the descriptive analysis of air quality (particulate matter) monitored in the Irasa community.

In regards to the qualitative data generated from both the field observation and interview sessions from householders, transcripts were carefully reviewed to establish themes relating to the socio-cultural context associated with the use of biomass fuels, cooking practices, perceived uses of wood smoke and prioritised environmental problems in the area. The emerging theme of what needs to be considered in scaling up householders to cleaner fuels in the community was also identified. Data from the stakeholders' interviews provided a context for prioritised environmental problems in the study area. For the household interviews, a manuscript was first translated into English from the original Yoruba script used when conducting the interviews. The stakeholders' interviews did not need translating as they were all originally conducted in English. The transcribed views of respondents were manually summarised. In collating households' interviews, responses were separately treated and each excerpt of data was collated according to ethnic group. After this, the collated information was coded and similar views were grouped together into themes and/or headings. Guided by the themes generated from the data, quotations most relevant to each of the emerging themes derived from the data were extracted and provided content discussed in this thesis. The interview data provided diverse lines of enquiry, which I drew upon in identifying themes discussed in Chapters Six and Seven.

There were some limitations in the method of data collection used for the study in that three hundred and fifty householders participated in the survey as against the initial plan of five hundred householders. This was constrained by the reluctance of some householders to participate in the study where access was granted, coupled with government restrictions on movement elsewhere because of the election process taking place during the 2011 fieldwork in Nigeria. Apart from the timing of the fieldwork, I had to rely on limited financial resources in meeting the cost of travelling and paying all research assistants and householders who allowed monitoring of air quality in their buildings. As my study location is within South Western Nigeria, my financial constraints did not allow a visit to Eastern Nigeria where clean cookstoves have been piloted in order to evaluate the pre and post cultural perceptions of householders towards the intervention.

Taking into account methods used for data gathering in this study, there is a possibility that data gathered might not be comprehensive enough to reflect views of all householders in areas where the survey was conducted. It is difficult to generalise results to the entire peri-urban population of Ado Ekiti as I had more data responses from the Ebira ethnic group, which is a larger community than the Yoruba, Tiv, and Hausa. Nevertheless, the research does provide an in-depth, spatially specific analysis of biomass fuel use and indoor air pollution set in my objectives (Section 1.3).

3.8 Positionality

A researcher's position during fieldwork can either make or mar the study, or can prevent the gathering of robust data during the study (Moser, 2008). According to Bourke *et al*., (no date) the privileged advantage of the researcher's identity, gender, race and educational background often made participants less suspicious of them carrying out their research in the local environment, as researchers are seen as insiders in whom they could confide and share problems and experiences. Navigating through communities when conducting research requires that researcher's personality should be receptive to participants' ways of life and protocol, so as to achieve success and better responses to one's inquiry (Moser, 2008). Although a researcher's personal traits such as shyness or appearing domineering, outgoing, hot tempered and impatient are rarely discussed, they can have significant impacts during the research process (Moser, 2008).

Positionality in Moser's view (2008:386) has some limitations which include amongst others, addressing "categories and issues important to academic analysis over those relevant in fieldwork" and challenges of navigating the research environment where there are differences in culture, language and education. Nonetheless, emotional dynamics might provide insights about people that are being studied. Although this can shape the context expressed and experienced during a research study (Jansson, 2010), it is crucial in negotiating for access and building relationships within the research environment. Herod (1999:230) argues that, being perceived as an insider "gives the researcher a privileged position from which to understand processes, histories and events as they unfold" in that research environment. This means that familiarity with the study area can enhance access to information during research, which might not be given to an 'outsider'. Mullings (1999), however, is of the opinion that, 'outsiders' have a greater degree of objectivity and ability to evaluate and interpret information without distorting their meaning. The contrasting views about positionality during research are quite important and might have an impact on data collected during research. In view of this, the researcher should be aware of their positionality and guide against impacts that can affect the information obtained from respondents. In order not to compromise the objective of my research with the impact that anticipated solutions from householders to their social facility's needs might have on my survey, I always made the householders aware that I could not meet any of their social needs. By distinguishing the purpose of my research from the provision of social needs, I found out that the more I interacted with the householders; their requests for me to facilitate the provision of social needs became fewer.

Being aware of my personality and identity, I always complied with protocols acceptable to each ethnic group in the area. This was essential during fieldwork, as I had to salute everybody that I came across because it is expected in the community to always exchange salutations with people as a way of recognising and respecting them. In addition, greeting people demanded that I make a low bow and I had to kneel to address them, and, often when local residents see an educated person showing that form of respect to them, it generates a good rapport and cooperation.

Researching within my own country, Nigeria makes me an insider, as I am familiar with the study area, having lived in that environment and having witnessed the neglect of development in peri-urban areas by various governments in Nigeria. On the other hand, I was regarded as an outsider because of my ethnic background (Yoruba), which is different from that of the study area (most of whom are Ebiras). At the same time, some people saw me as a 'government spy' because of the prevailing political antagonism in the State (Ekiti) following contention over the winner of the last governorship election. In spite of this, my research investigation was outlined to the participants and stakeholders that participated in the study by making them understand that conducting academic research within their environment was not for any political and/or economic motive. This helped to erase suspicion or resentment about playing the role of a research participant. Also, by presenting a letter of introduction from the University of Nottingham, I was able to further convince them that the intention of the research was academic and not political. In addition, negotiating access through a gatekeeper who had earlier informed the community leader about my intention of carrying out research in the area prior to my arrival provided reassurance to the participants. It further enhanced the gathering of robust data and information about the socio-cultural context underpinning the use of biomass fuels in the area, which would not have been given to an 'outsider'.

3.9 Ethical Issues

Informed consent was sought from participating households and stakeholders by explaining the purpose of the research to them from the onset of the discussion. On the basis of this information, participants volunteered to take part in the survey because the ethical principle of informed consent suggests that participants must be fully aware of the research process (Bryman, 2008).

In seeking consent for the monitoring of air quality in a range of different households, I explained that the equipment posed no danger to their wellbeing. Upon agreeing with my explanations, householders attached a condition to my request whereby I had to give a token incentive to place the equipment in their homes. With the assistance of the gatekeeper a sum of ₦500 (£2) was agreed upon to secure the participation of householders to monitor air quality in homes in Irasa community. Incentives were given to volunteers spanning nine weeks for each of the houses used. Monetary incentives have been seen to significantly increase response rates over gifts or pre-paid incentives (Lipps, 2010; Davern *et al*., 2003). Lipps (2010) posits that incentives encourage and motivate participants to see them as being valued in their help rendered during fieldwork, upon which the researcher reciprocates based on *reciprocity* theory – a "norm that people should help those who helped them" (p.81). However, according to Shaw (2005) such incentives should be given with the utmost precaution on the part of the researcher so as not to take advantage of the participants' material deprived condition. Bearing in mind the ethical issues regarding monetary incentives during fieldwork, potential participants were made aware that their participation was voluntary and they could withdraw at any time during the research, so as not to coerce them in participating in the study (Hill *et al*., 2008).

The issue of confidentiality and anonymity was addressed during fieldwork by not giving the actual names of those that participated in the survey. I also ensured that specific details that could make participants identifiable were altered by using pseudonyms. Where specific photographs have been used for illustrations, participants gave their consent.

3.10 Conclusion

This chapter has considered the underlying philosophical framework of epistemological and ontological approaches adopted for data collection in the study. To gain diverse views of participants about indoor air pollution in Ado Ekiti, Nigeria, qualitative research was considered the most appropriate approach for exploring the spatially specific cultural and socio-economic contexts underpinning the use of biomass fuels in the area.

By integrating the two approaches (quantitative and qualitative) in this study, their strengths complement each other in offsetting their weakness. A robust dataset was collected for the investigation of indoor air pollution in the study area.

The inability to gain access to randomly selected households during fieldwork resulted in making changes to the method of data collection. The rationale for adopting the various strategies and methods used for the data collection was also explained in this chapter. Although there are limitations to the sampling strategies, the statistical analysis (Chi-square test) performed on the dataset generated from the survey indicated that the results are still able to reliably document what was being measured in the study area. Some variables are statistically tested, and from the results, it is presumed that ethnicity influences householders' choice of residence in a specific community, rather than gender. Community location is also important, because of the ethnic composition of householders in the area. This probably attracts people of similar cultural background to the individual community. The unusual characteristics of individual communities with a representation of heterogeneous and homogeneous characteristics, based on ethnic groups residing in the communities provided insights when interpreting the data and caution when making generalisations of the findings.

My identity as an Ekiti citizen and as an overseas student created an impression of me to be seen as an insider and/or outsider in the study area. The level of rapport created with the participants in abiding with their structures and routines allowed them to expound and clarify on their particular traditional beliefs about biomass fuels. In instances where incentives were used during fieldwork, participants are also made aware of the ethical issues surrounding their use, not as a means of coercing them to participate in the study but as a means of reciprocating those who helped during the data collection. Data generated from methods described in this chapter was used in presenting results discussed in Chapter Four and succeeding chapters.

Chapter Four

Air Quality Levels, Householders' Dwelling Characteristics and Health Impacts of Indoor Air Pollution in Ado Ekiti, Nigeria

4.1 Introduction

Recognising that indoor air pollution is a serious environmental and health problem in developing countries, this chapter examines the housing and kitchen characteristics of householders in peri-urban areas of Ado Ekiti and the extent to which these are contributing to poor air quality experienced in the area. The chapter highlights important dwelling conditions that perhaps affect building air quality in line with the first objective of this study (Section 1.3).

There have been continual attempts in the literature to estimate actual levels of particulates in homes (Dionisio *et al*., 2010: Fullerton *et al*., 2009: Massey *et al*., 2009), and so an attempt was made in this research to estimate average daily and weekly concentration levels of $PM_{2.5}$ in buildings in Irasa community (objective two: Section 1.3). The concentration of particulate matter was measured because it is a key indicator pollutant for health effects of combustion products (Zhou *et al*., 2006). This chapter also discusses the health impacts identified within this study area and relates it back to the wider literature. To avoid the detrimental health effects of householders' exposure to $PM_{2.5}$, the concentration of particulate matter must be within the WHO guideline values, especially when cooking with wood fuel in indoor kitchens over an open fire by householders.

Section 4.2 discusses the mean 24-hour daily and weekly readings of $PM_{2.5}$ for indoor and outdoor kitchens in the Irasa community. The highest 15-minute average for $PM_{2.5}$ and maximum level recorded for $PM_{2.5}$ is also presented in this section in order to account for shorter and longer term exposures. Sections 4.3 – 4.6 examine householders' housing types, and highlight the inadequacy of ventilation, presence of eaves, kitchen location, and stove type that affect air quality in buildings when cooking takes place.

Section 4.7 discusses the health discomforts reported by householders during cooking in relation to the identified health problems of using biomass fuels and linking them to the health impacts associated with exposure to indoor air pollution. Section 4.7.1 provides an overview of groups vulnerable to the health impacts associated with indoor air pollution in Ado Ekiti, Nigeria. Data from questionnaires, interviews, field observation, and measurements are used in presenting analysis in this chapter. The presentation of the questionnaire analysis in Sections 4.3 – 4.7 first considers the responses as a whole before disaggregating parameters by communities, ethnic groups, and gender. The statistical significance of variables are tested at $p = 0.05$ for the Chi-square tests.

4.2 $PM_{2.5}$ Concentration for Indoor and Outdoor Kitchens in the Irasa Community

Respirable particulates, which represent a key component of biomass fuel smoke, was measured in buildings with indoor and outdoor kitchens for each sample household/building over 24 hours for nine weeks (Figure 4.9 and 4.10 for illustrations of indoor and outdoor kitchens). The study site of Irasa community (Figure 3.2), which has one of the largest numbers of respondents (Table 3.2), was selected to ascertain particulate matter concentration in buildings (Section 3.6.1).

Between February 2011 and May 2011, air monitoring was carried out in some buildings in Irasa. The eighteen households were drawn from households with indoor and outdoor kitchens (open space and attached to building external wall). Based on these criteria, nine households each using indoor and outdoor kitchens were selected for air quality monitoring. The questionnaire analysis shown in Table 4.1 presents the building characteristics of the houses used for the air pollution monitoring. All house owners used mud and corrugated iron sheets in constructing their buildings. Among households that cook indoors, seven buildings had eaves, while amongst households with outdoor kitchens seven had eaves. Of these seven, four cooked in open spaces and three cooked in kitchens attached to the external walls of buildings. The preferred fuel type as categorised in Section 5.2.1 is the category 2 fuel type (firewood user, but lights wood with kerosene) which is used in all the kitchens, while the sources of lighting varies.

Table 4.1: Building characteristics of houses used for $PM_{2.5}$ measurements

Parameters	Indoor kitchen N= 9	Outdoor kitchen	
		Open space N= 5	Attached to building external wall N= 4
Building materials			
Mud and corrugated iron sheet	9	5	4
Eaves			
Yes	6	4	3
No	3	1	1
Cooking fuel type			
Category 1	2	2	1
Category 2	4	3	3
Category 3	3	0	0
Source of lighting			
Local lamp	2	2	1
Candle	1	0	1
Kerosene lamp	5	3	1
Local lamp and kerosene lamp	1	0	1

Note: Fuel type is by category 1=wood only; category 2=wood/kerosene; category 3=kerosene only

In measuring $PM_{2.5}$ for the indoor kitchen, a standard protocol was used but for outdoor kitchens, the protocol was modified in order to measure for $PM_{2.5}$ concentration in buildings (Section 3.6.1). UCB monitors were secured to the wall around 150cm away from the cooking place and the nearest window and door, and at a height of 125cm above the ground. They were secured to the wall with nails. With this measured point of protocol, particulate matter (within the building) concentration was captured through the period of measurement in the Irasa community.

During the two and half months of monitoring, the weather conditions at the site fell within the wet season, during which most of the gathered wood fuel is wet and thus takes longer to burn and produces more smoke. As explained in Section 5.2, about 75 percent of householders use wood fuels for cooking (in both indoor and outdoor kitchens) and most of the wood is usually gathered during the dry season and stored in open spaces and shelters around buildings. As monitoring was carried out during the wet season, it might not be reflective of the time activity pattern of household members throughout the year, as comparisons could not be made with the dry season.

In the eighteen households where monitoring was conducted (in the Irasa community), kerosene lamps are usually lit in the evening (depending on the time of sunset) until the early hours of the following day as the community is not connected to the national electricity grid. The average indoor temperature during the period of investigation varied between 23 ^{0}C and 40 ^{0}C in the study location.

When selecting households for $PM_{2.5}$ monitoring, householders who cook indoors were selected. Usually, households with indoor kitchens do not have a closing door at the main building entrance and exit and so it is just an open space. Householders with outdoor kitchens are characterised by those who cook in an open space, which is about 5 meters away from buildings and also those that use the external walls of their buildings as a make-shift outdoor kitchen. Houses of the latter type, unlike those houses with indoor kitchens, have a door, which can be opened to allow natural ventilation into the buildings especially during cooking periods.

The continuous seven-day monitoring was undertaken to capture the average daily 24-hour measurement of $PM_{2.5}$ and to determine if there was consistency and representation in the distribution of the air pollution level for all the days at the study location. The data recorded with the UCB was then downloaded from the computer using the UCB Data Browser 2.5 software (see Appendix 5 and 6)[28]. The graphs in Appendix 5 and 6 show

[28] Note: buildings 2, 3, 5, 6, 8, and 9 with indoor kitchen and buildings 1, 3, 5, 6, 7, 8, and 9 with outdoor kitchen limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3.

periods when $PM_{2.5}$ concentrations peak, which corresponds with different cooking times.

In Irasa, both the average daily and weekly levels of $PM_{2.5}$ are calculated with Microsoft Excel 2010 from the downloaded readings from the UCB monitors. The detailed concentration level of $PM_{2.5}$ for each day of the nine weeks' measurement is shown in Table 4.2 and the detailed graphs of the nine buildings with indoor kitchen are shown in Appendix 5.

Table 4.2 below demonstrates the calculated mean 24-hour data from recordings of $PM_{2.5}$ levels in nine buildings with indoor kitchens in Irasa community. From Table 4.2, the average $PM_{2.5}$ concentrations in buildings ranged between 53μg/m^3 and 648μg/m^3 during the monitoring period.

The trend in levels of concentrations changed in weeks three, eight, and nine. Interrogation of the questionnaire analysis presented in Table 4.1 indicates that the activity patterns of households may have been disrupted during these weeks by the elections in Nigeria (Section 3.7) as some householders travelled 'home' to vote, resulting in less cooking being done in those households. In addition, the low particulate matter recorded in these buildings may reflect the fact that some of these buildings do not incorporate eaves into their design and use category 3 fuel types (kerosene only) for cooking. However, as not all householders gave accurate accounts of their time-activity patterns, it is difficult to pinpoint the contributing factor. This uncertainty in time-activity information from householders is a limitation as it could have led to significant error in determining other factors contributing to indoor air pollution in these buildings.

Table 4.2: Daily mean 24 hour level of $PM_{2.5}$ for indoor kitchens

Days	**$PM_{2.5}$ (µg/m³)**								
	Week 1 16/02/2011 – 23/02/2011	Week 2 23/02/2011 – 02/03/2011	Week 3 03/03/2011 – 09/03/2011	Week 4 11/03/2011 – 18/03/2011	Week 5 18/03/20011 – 25/03/2011	Week 6 26/03/02/2011 – 02/04/2011	Week 7 30/04/2011 – 07/05/2011	Week 8 08/05/2011 – 15/05/2011	Week 9 15/05/2011 – 22/05/2011
1	107	648	73	97	165	133	539	63	132
2	109	110	77	164	232	185	207	60	83
3	103	106	96	86	171	100	53	60	60
4	136	120	104	226	161	114	541	59	61
5	127	100	77	171	152	140	48	62	70
6	126	109	133	103	144	139	149	69	62
7	136	118	-	103	71	111	74	63	68

The mean 24-hour daily readings for $PM_{2.5}$ levels in the selected indoor kitchens ranged from 48μg/m^3 to 648μg/m^3 for the study location. The highest concentration level of $PM_{2.5}$ from the one-minute data log of the UCB recorded for all buildings with indoor kitchens was 31537μg/m^3. This result which peaked at 31537μg/m^3 was similar to the results found in the study conducted in Malawi and Ghana where daily $PM_{2.5}$ peaked above 30000μg/m^3 and 42000μg/m^3 in buildings respectively (Fullerton *et al*., 2009; Pennise *et al*., 2009). However, for the Ghana study, other non-stove sources of kerosene lamps, cigarettes, incense and mosquito coils were considered to be factors that might have caused high concentrations of particulates in the area. The source of lighting as presented in Table 4.1 may perhaps be contributing to background particulate matter in the buildings during the night-time when there are no cooking activities.

Most householders start their days at around 5am when the fireplace is lit to prepare breakfast. The usual practice amongst householders is to leave the remaining unburned wood fuel in the hearth, thereby making it active until dinner is prepared around 6pm. This practice is one of the factors that dominates air pollution exposure paths in the study area, "since exposure is a function of both the concentration in an environment and person-time spent in the environment" (Smith-Sivertsen *et al*., 2004:138). For example in Figure 4.1 during breakfast preparation during week one in the building with an indoor kitchen, excerpts of measurements from 17/02/2011 to 18/02/2011 from the UCB data log indicate that around 5:32am particulate matter level peaked at 2594μg/m^3. Similarly, in the same building around at 17.51pm when preparing supper, particulate matter peaked at 669μg/m^3 (Figure 4.2).

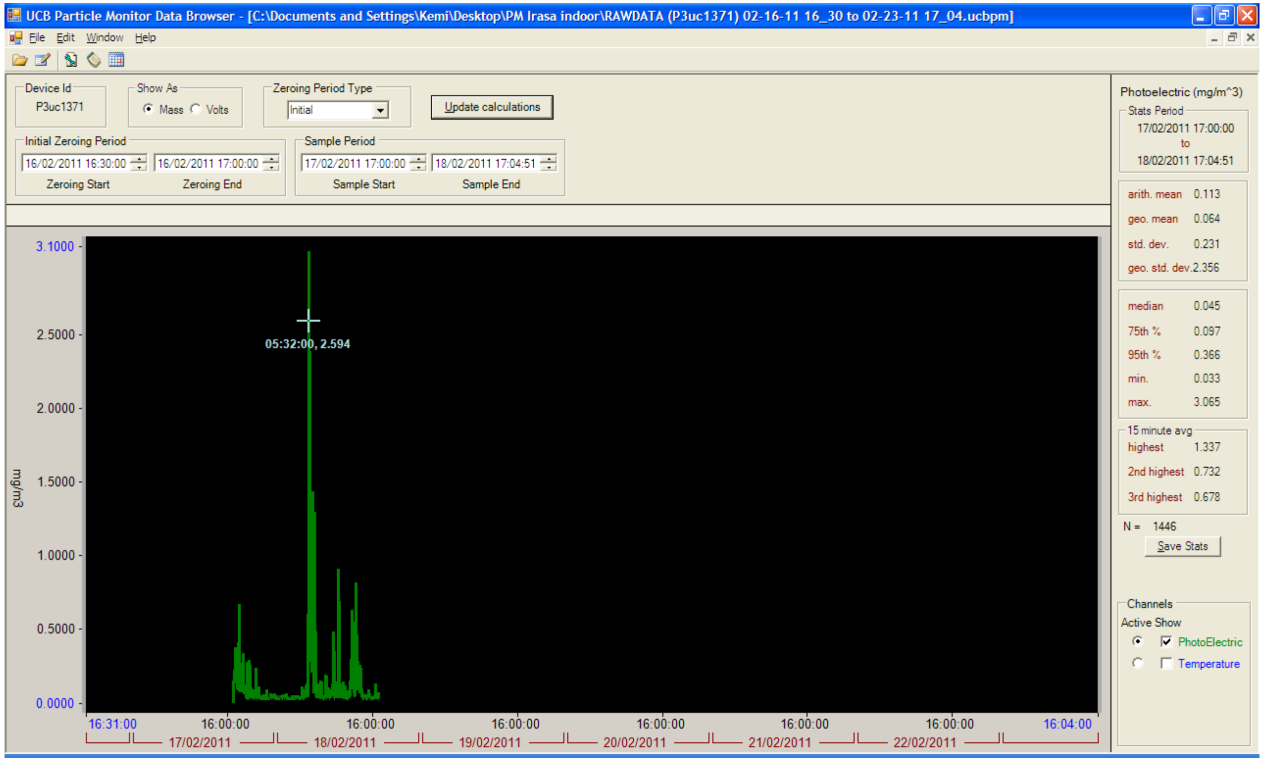


Figure 4.1: An example of $PM_{2.5}$ peak during breakfast preparation in an indoor kitchen building
Source: Author, February 2011

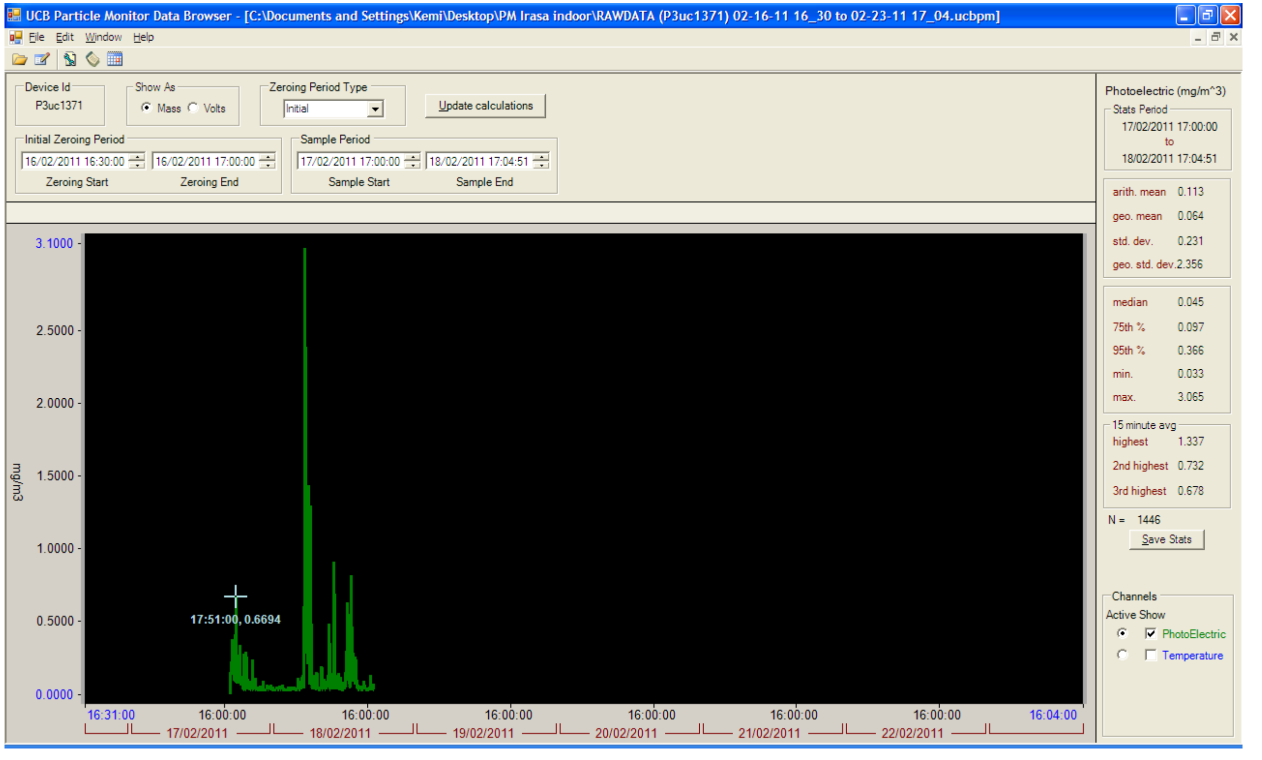


Figure 4.2: An example of $PM_{2.5}$ peak during supper preparation in an indoor kitchen building
Source: Author, February 2011

The tendency of many households' to not fully quench their hearth fires is therefore a great source of indoor air pollution that poses risks to health in the study area. In the buildings, particulate matter from neighbours' fireplaces also penetrates through eaves into the structure, more so when buildings are clustered together as earlier mentioned. This probably contributes to poor ambient air quality in the community.

The graphs presented in Appendix 5 for all nine buildings with indoor kitchens where air monitoring was carried out, indicates that air quality in the buildings may be affected by particulate matter from the continuous hearth activity during the daytime, from neighbours' wood smoke, poor ventilation and the layout of buildings in the area. The findings in the Irasa community are similar to results identified by Massey *et al*. (2012) conducted in Agra, North-Central India where cracks and spaces in buildings, broken doors and window panels and window openings allow cooking smoke to penetrate into the building which contributed to the consistently increased levels of particulate matter concentrations inside them. The nature of the material used for constructing the roof and walls, as discussed earlier may affect the extent to which smoke leaks from outdoor to indoor environments (Dasgupta *et al*., 2009). The use of mud walls by most householders (Table 4.1 and Section 4.3) might act as a sealant against airflow in or out of the building (Dasgupta *et al*., 2006b).

The graphs in Appendix 5 show that there is a trend towards higher levels of particulate matter in buildings especially when wood fuel is used in homes, which further support the findings of the study conducted in Malawi (Fullerton, *et al*., 2009).

The summary recordings presented in Table 4.3 shows the average weekly (and standard deviation in parentheses) level of $PM_{2.5}$ for householders cooking indoors. The particulate matter levels are 120µg/m^3 (211µg/m^3), 188µg/m^3 (532µg/m^3), 93µg/m^3 (231µg/m^3), 135µg/m^3 (693µg/m^3), 172µg/m^3 (822µg/m^3), 131µg/m^3 (460µg/m^3), 229µg/m^3 (1234µg/m^3), 62µg/m^3 (110µg/m^3) and 77µg/m^3 (133µg/m^3) during the nine weeks of measurement in the study location. The UCB monitor data browser 2.5 software calculated the 15 minute highest, second highest, and third highest during the monitoring period, and each of the 15 minute consecutive measurements do not overlap. The highest 15 minute average for all weeks ranges from 659µg/m^3 to 9650µg/m^3, second highest is between 266µg/m^3 and 9298µg/m^3 and the third highest ranges between 248µg/m^3 and 8922µg/m^3. A similar high level of 12500 µg/m^3 in the first 15 minute average in buildings was also recorded in Ghana (Pennise *et al*., 2009).

Table 4.3: Summary of $PM_{2.5}$ recordings for buildings with indoor kitchens for seven consecutive days in Irasa community

ID HH	Indoor kitchen $PM_{2.5}$ concentration (µg/m^3) levels							
	No. of Records	Mean	Max	Highest 15 min Ave	2nd highest 15 min Ave	3rd highest 15 min Ave	St. dev.	95th %
1	10006	120	4841	1463	1337	1086	211	438
2	10034	188	6125	4428	3843	3630	532	458
3	8731	93	16255	2579	1017	797	231	223
4	10171	135	31575	6884	3665	3499	693	354
5	10169	172	23612	5559	5355	4753	822	414
6	10171	131	14633	2725	2421	2347	460	351
7	10171	229	25603	9650	9298	8922	1234	365
8	10051	62	2861	659	266	248	110	48
9	10051	77	9211	5771	652	623	133	295

Note: data extracted from charts in Appendix 5

Table 4.3 highlights that concentration levels of $PM_{2.5}$ are consistently high in all the buildings monitored in Irasa. In evaluating the consistency in the levels of $PM_{2.5}$ concentrations at the study location, Table 4.3 also indicates the distribution of the continuous parameter (95 percentile) corresponding to the weekly measurement. This value varies from 48μg/m^3 to 458μg/m^3 over the period.

Readings from the average daily 24-hour level of $PM_{2.5}$ for buildings with outdoor kitchens are all high. The detailed concentration levels of $PM_{2.5}$ for each day of the nine weeks of measurement are shown in Table 4.4, while the detailed graphs of each building are shown in Appendix 6.

Table 4.4 presents the calculated 24-hour mean from the recordings of $PM_{2.5}$ levels in nine buildings with outdoor kitchens in Irasa community. From Table 4.4, the average $PM_{2.5}$ concentrations in building one for week one ranged from 103μg/m^3 to 275μg/m^3 during the monitoring period. In week two, the readings ranged between 80μg/m^3 and 152μg/m^3 in the second building. During week three, concentration levels are between 61μg/m^3 and 101μg/m^3 for the third building. In week four, recorded particulate matter levels for the fourth building was between 42μg/m^3 and 91μg/m^3. For the fifth building, the concentrations are between 60μg/m^3 and 208μg/m^3 during week five. For the sixth building, between 95μg/m^3 and 188μg/m^3 levels of particulate matter was measured during week six. During week seven, the reading ranged between 87μg/m^3 and 123μg/m^3. In week eight, concentration levels in the eighth building are between 60μg/m^3 and 130μg/m^3. In the ninth building, concentration levels are between 66μg/m^3 and 189μg/m^3 during week nine.

Table 4.4: Daily mean 24 hour level of $PM_{2.5}$ for outdoor kitchens

Days	$PM_{2.5}$ (μg/m³)								
	Week 1 16/02/2011 – 23/02/2011	Week 2 23/02/2011 – 02/03/2011	Week 3 03/03/2011 – 09/03/2011	Week 4 11/03/2011 – 18/03/2011	Week 5 18/03/20011 – 25/03/2011	Week 6 26/03/02/2011 – 02/04/2011	Week 7 30/04/2011 – 07/05/2011	Week 8 08/05/2011 – 15/05/2011	Week 9 15/05/2011 – 22/05/2011
1	275	87	78	72	159	188	123	130	189
2	168	80	60	45	104	129	87	60	88
3	103	152	61	47	62	104	-	65	88
4	211	132	65	91	60	110	-	66	81
5	140	95	66	51	208	111	-	77	66
6	134	101	101	65	130	119	-	71	75
7	154	98	-	42	91	95	-	70	94

Note: week 7 incomplete data

The trend in levels of concentrations changed in weeks three, four, eight, and nine probably because of the changes in household activity patterns (i.e. householders were away from home during election and their inability to provide detailed time-activity patterns) as earlier mentioned. In addition, questionnaire data presented in Table 4.1 suggests that buildings with high concentrations of particulate matter used kitchens attached to the external wall of building, while those with low concentrations used the open space type of kitchen (see Figure 4.11).

The mean 24-hour daily reading of $PM_{2.5}$ levels for selected buildings with outdoor kitchens is between 42μg/m^3 and 275μg/m^3 in the study area. The maximum concentration level of $PM_{2.5}$ from the one-minute data log of the UCB monitor recorded for all the buildings with outdoor kitchens was 22602μg/m^3. The analysis in Table 4.4 shows that even when the fireplaces are located outdoors, indoor levels of $PM_{2.5}$ exceed health guidelines for ambient air. The indoor air of households with outdoor kitchens in the community has high particulate matter levels because buildings have broken doors and window panels, and eaves that allow cooking smoke to penetrate into buildings. This suggests that the overall air quality in the community is poor. As such, whether one is cooking or not in the community, all houses are affected by indoor air pollution from neighbours' hearths. This result supports Balakrishnan *et al*.'s (2004) findings in rural districts of Andhra Pradesh, India, where householders have the common practice of cooking in a separate kitchen or open space, but particulate matter levels (of 251μg/m^3 of daily mean 24-hour monitoring) and personal exposure of all family members exceeded the WHO guideline values.

As discussed, the same pattern of activity is recorded for householders with indoor and outdoor kitchens. Charts in Appendix 6 show that particulate matter levels start to increase when breakfast is prepared, at around 5am.

This continues until the evening period when dinner is being prepared, and then plummets during the night. During week four in building four, the excerpt of measurement from 12/03/2011 to 13/03/2011 from the UCB data log indicates that around 7:09am and 19.07pm (breakfast and supper food preparations), particulate matter level peaked at 3823μg/m^3 and 173μg/m^3 in a building with outdoor kitchen respectively (Figures 4.3 and 4.4).

Despite the fact that cooking activities had ceased overnight, buildings with both indoor and outdoor kitchens still have some recorded background levels of particulate matter. This further supports Saksena *et al*.'s (2003) study in Dehli, where night-time respirable suspended particulates were measured in the area.

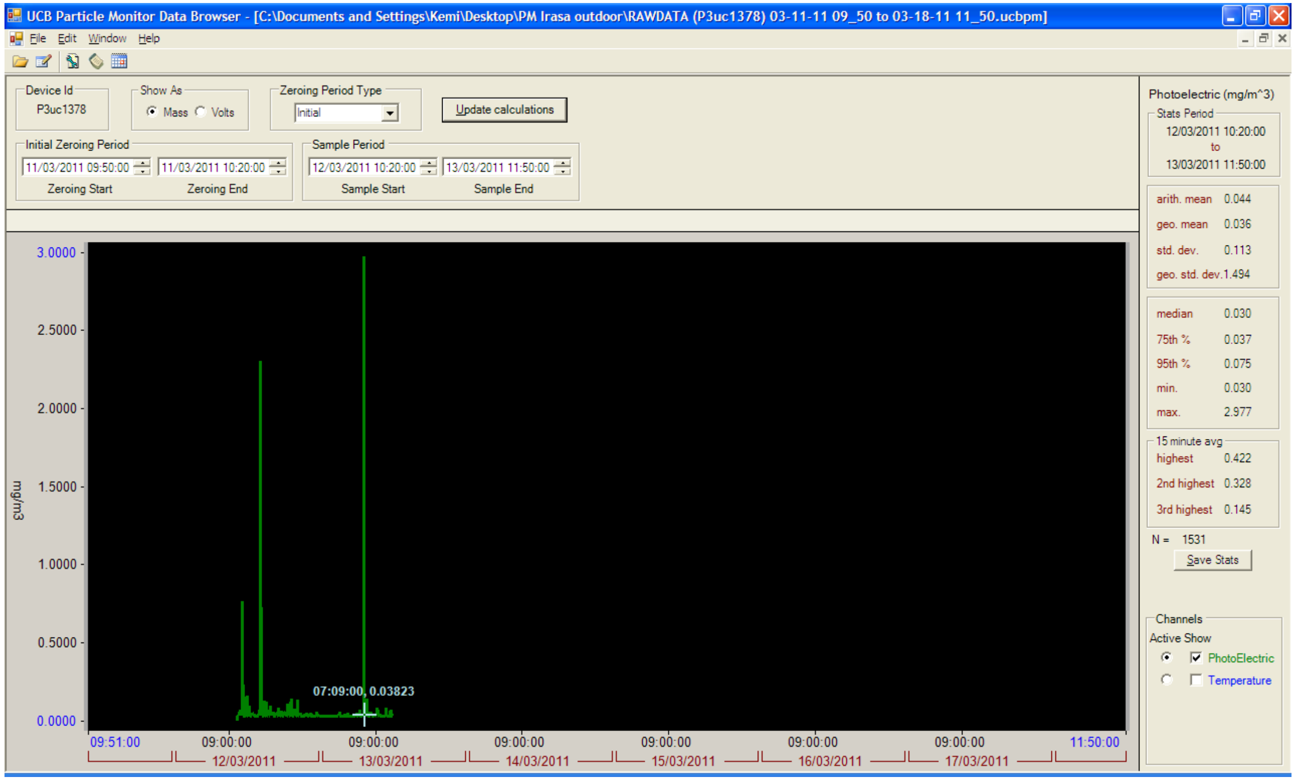


Figure 4.3: An example of $PM_{2.5}$ peak during breakfast preparation in an outdoor kitchen building
Source: Author, March 2011

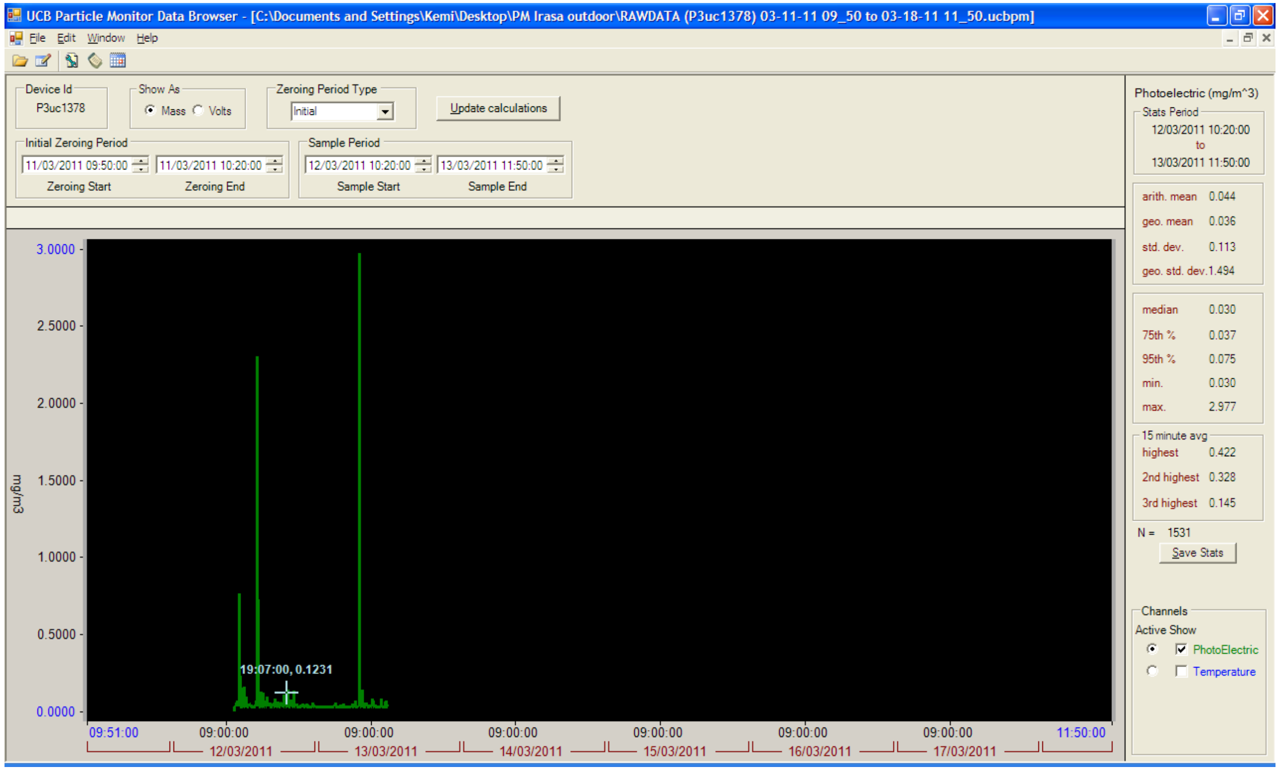


Figure 4.4: An example of $PM_{2.5}$ peak during supper preparation in an outdoor kitchen building
Source: Author, March 2011

Table 4.5 presents the summary of average weekly (and standard deviation in parentheses) level of $PM_{2.5}$ for householders cooking outdoors throughout the nine weeks of monitoring. The particulate matter levels are 169μg/m^3 (526μg/m^3), 106μg/m^3 (260μg/m^3), 72μg/m^3 (78μg/m^3), 59μg/m^3 (107μg/m^3), 116μg/m^3 (370μg/m^3), 122μg/m^3 (379μg/m^3), 110μg/m^3 (211μg/m^3), 76μg/m^3 (286μg/m^3) and 97μg/m^3 (434μg/m^3) during the nine weeks of measurement in the study location. The highest 15 minute average for all the weeks ranges from 727μg/m^3 to 8728μg/m^3, second highest is between 484μg/m^3 and 3645μg/m^3 and the third highest ranges between 438μg/m^3 and 3500μg/m^3.

Table 4.5: Summary of $PM_{2.5}$ recordings for buildings with outdoor kitchens for seven consecutive days in Irasa community

ID HH	Outdoor kitchen $PM_{2.5}$ concentration (μg/m^3) levels							
	No. of Records	Mean	Max	Highest 15 min Ave	2nd highest 15 min Ave	3rd highest 15 min Ave	St. dev.	95th %
1	10045	169	22602	3202	2750	2734	526	455
2	10035	106	7341	2108	1605	1565	260	271
3	8731	34	3294	752	482	438	78	103
4	10171	59	2977	727	719	686	107	153
5	10171	116	6149	4124	3645	3500	370	269
6	10171	122	10433	7174	1583	1170	379	356
7*	2348	110	3262	1031	882	687	211	359
8	10046	76	10122	4434	833	796	286	137
9	10051	99	11801	8728	1465	800	434	200

Note: data extracted from charts in Appendix 6

***** Incomplete data, monitor battery stolen midway of measurement

Table 4.5 shows that concentration levels of $PM_{2.5}$ are consistently high in all the buildings monitored at the study location. Findings from the Irasa community, therefore, challenge Zhang and Smith's (2007) argument that concentration levels of particulate matter are usually lower for buildings with outdoor kitchens. For buildings in the study area, the common use of wood fuels by large numbers of householders seems to have created 'neighbourhood' pollution as a result of community-level emissions which often lead to significant re-entry of pollution back into buildings (Zhang and Smith, 2007) with the use of outdoor kitchens. This could be one of the reasons for the high concentrations of $PM_{2.5}$ in buildings despite cooking outdoors. As explained in Sections 4.3 and 4.5 the clustering of buildings and the presence of eaves (Table 4.1) in the study location also affect air exchange rates, because household-level pollution in densely populated communities contributes to ambient neighbourhood pollution (Röllin *et al*., 2004).

In comparing the weekly mean of indoor air pollution levels in all the weeks of monitoring in buildings with indoor and outdoor kitchens (Tables 4.2 and 4.4), readings varied from 62μg/m^3 to 172μg/m^3, and, 59μg/m^3 to 169μg/m^3 respectively. In addition, the mean 24-hour level in Tables 4.3 and 4.5 indicates that air quality levels in householders' buildings are mostly high. The distribution of the continuous parameter (95 percentile) corresponding to the weekly monitoring at the study location ranges from 110μg/m^3 to 458μg/m^3 over the period. This indicates that both users of indoor and outdoor kitchens contribute to household and community levels of pollution because the use of biomass fuels has the tendency of increasing the concentrations of indoor air pollution in buildings (Siddiqui *et al*., 2009). The contribution of air pollution emissions (outdoor) and exposures (indoor) prominent in this community made householders susceptible to greater health risks associated with indoor air pollution.

Nevertheless, the levels of particulate matter measured in buildings with indoor and outdoor kitchens in this study is considered to be a reasonable indicator for estimating different types of health risk from the complex mixture of pollutants emitted in the area (Rehfuess *et al*., 2011). However, as the types of outdoor kitchen vary in the Irasa community, it shows the differences in the concentration levels of particulate matter for buildings in the area. Although outdoor (ambient) monitoring in the community was not undertaken, the levels measured indoors showed that air quality is poor in buildings.

4.3 The Dwelling (Physical) Characteristics of Householders

The crucial role that house characteristics play in stimulating good air quality is pivotal to understanding how aeration can be affected with the chosen energy type used for domestic activities in the study area (bearing in mind that health impacts have been associated with incomplete combustion of biomass fuels as discussed in Chapter Two). Indoor air pollution depends on the fuel type used, structural characteristics of the house, ventilation, cooking location, and stove type. Given that householders in the study area use biomass fuel as their energy source, it is perhaps necessary to explain first the structural characteristics of buildings in the study area generally, then at individual community level, by ethnic group and gender.

In general, the community leader allocates land for building to householders, with no restriction on the number of rooms each building must contain. When there is a need for a family to have a house constructed, farm activities are shelved in that community on that day to assist the new owner. To facilitate the construction of buildings in the nineteen communities as a whole, various materials are used as illustrated in Figure 4.5. The mud used for the wall construction is sourced within the community from un-allotted open space. Amongst the respondents, the main combination of materials used is mud and corrugated iron sheet roof (78.9 percent). Others include buildings with mud and thatched leaves (8.3 percent), cement blocks and corrugated iron roof sheets (6.6 percent) and the least common type of building is a mix of mud and cement blocks and corrugated iron roof sheets (6.3 percent).

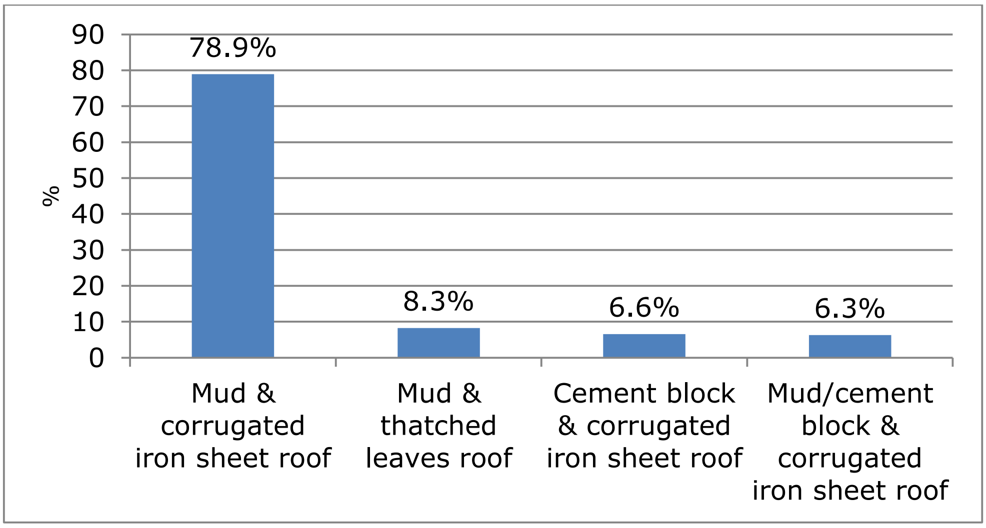


Figure 4.5: Building materials used in the communities
Source: Author's Fieldwork, 2011

Tables 4.6, 4.7, and 4.8 highlight the association between types of building materials in relation to individual communities, ethnicity, and years spent within the community respectively. Before recording significance values for the variables, assumptions were first checked as explained in Section 3.7. The Chi-square test indicates that there is a significant association between communities, ethnic groups, gender, years spent in the community and householders' building material types. As a result, householders' responses in regards to building material types in the communities are different mainly because of the fact that different ethnic groups seek to maintain their identity by keeping to architectural designs from their 'home' communities. The building materials chosen could also be associated with access to certain local materials (mud) in each community. In addition, with a majority of relatively new entrants (householders who have spent less than five years in the communities) using the same building material types as those that have lived in the communities for over thirty years (see Section 3.5.2; Table 4.8), there is probably cultural influence that has cut across the generations in the area. However, there could also be external factors (such as income) that are not accounted for during the survey which could have influenced householders using different building material types (see Table 4.7) to those used by most households of the same ethnic background. However, the type of building materials used by householders irrespective of community or ethnic group play an important role in understanding air quality in buildings because permeable materials lower air quality (see Section 2.2 and Dasgupta *et al*., 2009).

Table 4.6 indicates the type of materials householders used for constructing houses in their communities. Houses in Agọ Aduloju, Aroto, Ilamọ, Ilokun, Irasa, and Odoro construct some of their buildings with mud with thatched leaves used on the roof. In addition, two communities (Agọ Aduloju and Irasa) have householders that have built their houses with many different building materials. In all of the communities, householders mainly construct their buildings using mud and corrugated iron sheet roof materials.

Building material types vary amongst the Ebira, Yoruba, and Tiv ethnic groups (as shown in Table 4.7). However, the small sample size of some of the ethnic groups could possibly have underestimated how building material types used in house construction varied amongst them (Section 3.6.2). Nevertheless, the questionnaire results have shown that whether at the individual community level, or among the ethnic groups, most houses are built from mud with corrugated iron sheets.

Table 4.6: Percentage of building materials types by community

S/N	Community	Building Materials			
		Mud and thatched leaves 8.3% (N=29)	Mud and corrugated iron sheet roof 78.9% (N=276)	Mud/cement and corrugated iron sheet roof 6.3% (N=22)	Cement block and corrugated iron sheet roof 6.6% (N=23)
1	Aba CAC N = 4	0 (0)	100% (4)	0 (0)	0 (0)
2	Agọ Aduloju N = 60	1.7% (1)	48.3% (29)	23.3% (14)	26.7% (16)
3	Agọ Corner N = 36	0 (0)	94.4% (34)	2.8% (1)	2.8% (1)
4	Alagorugba N = 2	0 (0)	100% (2)	0 (0)	0 (0)
5	Aroto N 13	15.4% (2)	84.6% (11)	0 (0)	0 (0)
6	Asọ Ayegunle N = 6	0 (0)	33.3% (2)	16.7% (1)	50% (3)
7	Ejiko N = 8	0 (0)	100% (8)	0 (0)	0 (0)
8	Ejimakogo N = 23	0 (0)	95.7% (22)	4.3% (1)	0 (0)
9	Elemi N = 9	11.1% (1)	88.9% (8)	0 (0)	0 (0)
10	Igbaitu N = 2	50% (1)	50% (1)	0 (0)	0 (0)
11	Igbaye N = 6	0 (0)	100% (6)	0 (0)	0 (0)
12	Ilamọ N = 21	19% (4)	76.2% (16)	4.8% (1)	0 (0)
13	Ilokun N = 55	9.1% (5)	85.5% (47)	5.3% (3)	0 (0)
14	Irasa N = 60	20% (12)	76.7% (46)	1.7% (1)	1.7% (1)
15	Isegere N = 3	0 (0)	100% (3)	0 (0)	0 (0)
16	Odoro N = 26	11.5% (3)	84.6% (22)	0 (0)	3.8% (1)
17	Oke Epa N = 2	0 (0)	100% (2)	0 (0)	0 (0)
18	Ologunja N = 4	0 (0)	100% (4)	0 (0)	0 (0)
19	Ọlora Camp N = 10	0 (0)	90% (9)	0 (0)	10% (1)

Note: χ^2 148.281 $p<0.0001$

Table 4.7: Percentage of building materials types by ethnic groups

Ethnic Group	Building materials			
	Mud and thatched leaves roof 8.3% (N=29)	Mud and corrugated iron sheet roof 78.9% (N=276)	Mud/cement block and corrugated iron sheet roof 6.3% (N=22)	Cement block and corrugated iron sheet roof 6.6% (N=23)
Ebira N = 265	8.3% (22)	87.2% (231)	3% (8)	1.5 (4)
Yoruba N = 55	1.8% (1)	52.7% (29)	16.4% (9)	29.1% (16)
Tiv N = 25	24% (6)	52% (9)	12% (3)	12% (3)
Hausa N = 5	0 (0)	60% (3)	40% (2)	0 (0)

Note: χ^2 98.195 p<0.0001

Table 4.8: Percentage of building materials types in relation to years spent in the community

Years spent in the community	Building materials			
	Mud and thatched leaves roof 8.3% (N=29	Mud and corrugated iron sheet roof 78.9% (N=276)	Mud/cement block and corrugated iron sheet roof 6.3% (N=22)	Cement block and corrugated iron sheet roof 6.6% (N=23)
< 5 N = 77	9.1% (7)	71.5% (55)	9.1% (7)	10.4% (8)
6 – 10 N = 69	17.4% (12)	65.2% (45)	8.7% (6)	8.7% (6)
11 – 15 N =35	2.9% (1)	88.6% (31)	2.9% (1)	5.7% (2)
16 – 20 N = 68	8.8% (6)	79.4% (54)	5.9% (4)	5.9% (4)
21 – 30 N = 58	1.7% (1)	87.9% (51)	6.9% (4)	3.4% (2)
>31 N = 43	4.7% (2)	93% (40)	0 (0)	2.3% (1)

Note: χ^2 25.543 p<0.043

Houses constructed of mud trap less air than houses constructed of cement blocks (Dasgupta *et al*., 2009), which presumably contributes to poor air quality in buildings. The mud used to construct houses in the study is readily available and is usually used to manufacture mud blocks. Perhaps because of its accessibility, durability, and low cost, it is widely used by resource poor households (Chan, 2011). The building technique involves the use of either adobe (sun-dried-bricks) or wattle and daub (mud wall construction) together with bamboo splints as reinforcement, while coconut palm is used for the rafters. Usually, in constructing the walls, a mixture of straw, hay, and earth are used for cohesion. The wattle and daub method is commonly used in the study area unlike blocks, which required mortar, moulding, and burning before being used for construction.

4.3.1 Classifying Householders' Housing Types

In my own assessments of the buildings, many failed to incorporate basic housing conveniences (i.e. toilet, bathroom, and kitchen) into their plan. In short, the purpose of the building is to provide a place to sleep. The common structural design characterised by rows of single rooms makes up 60 percent of the houses occupied by the respondents. Another common design has a sitting room and bedrooms along the same row and makes up 34 percent of houses in the sample. A less common design is a 'flat' (bungalow with separate kitchen outside). Only 6 percent houses in the study site were of this type. However, at the individual community level, taking account of ethnic group, a breakdown of these categories shows both different and similar structural building design in the area (Tables 4.9 and 4.10). The Chi-square tests further indicate that there is no association between individual communities, ethnic groups, and building types.

From the analysis presented in Table 4.9, more householders live in a ‘single room’ type house than either houses with a ‘sitting room or a ‘flat’. All three of these houses types are present in the communities of Agọ Aduloju, Ilamọ, Ilokun, Irasa, Odoro, and Ọlora Camp. It is to be expected that variations in levels of indoor air quality would be greater in communities with a range of different house types than in communities that have only one house design.

Table 4.9: Percentage of house types by community

S/N	Community	House Type		
		Single room 60% (N=210)	Sitting room and bedroom 34% (N=119)	Flat 6% (N=21)
1	Aba CAC N = 4	50% (2)	50% (2)	0 (0)
2	Agọ Aduloju N = 60	98.3% (29)	43.3% (26)	8.3% (5)
3	Agọ Corner N = 36	58.3% (21)	41.7% (15)	0 (0)
4	Alagorugba N = 2	100% (2)	0 (0)	0 (0)
5	Aroto N 13	69.2% (9)	30.8% (4)	0 (0)
6	Asọ Ayegunle N = 6	66.6% (4)	16.7% (1)	16.7% (1)
7	Ejiko N = 8	75% (6)	0 (0)	25% (2)
8	Ejimakogo N = 23	82.6% (19)	17.4% (4)	0 (0)
9	Elemi N = 9	88.9% (8)	0 (0)	11.1% (1)
10	Igbaitu N = 2	50% (1)	50% (1)	0 (0)
11	Igbaye N = 6	66.6% (4)	16.7% (1)	16.7% (1)
12	Ilamọ N = 21	61.9% (13)	28.6% (6)	9.5% (2)
13	Ilokun N = 55	50.9% (28)	43.6% (24)	5.5% (3)
14	Irasa N = 60	63.4% (38)	33.3% (20)	3.3% (2)
15	Isegere N = 3	33.3% (1)	66.7% (2)	0 (0)
16	Odoro N = 26	50% (13)	46.2% (12)	3.8% (1)
17	Oke Epa N = 2	100% (2)	0 (0)	0 (0)
18	Ologunja N = 4	75% (3)	0 (0)	25% (1)
19	Ọlora Camp N = 10	70% (7)	10% (1)	20% (2)

Note: χ^2 48.024 $p<0.087$

Table 4.10: Percentage of house types by ethnic groups

Ethnic Group	House Types		
	Single room 60% (N=210)	Sitting room and bedroom 34% (N=119)	Flat 6% (N=21)
Ebira N = 265	63% (167)	32.5% (86)	4.5% (12)
Yoruba N = 55	54.5% (30)	32.7% (18)	12.7% (7)
Tiv N = 25	44% (11)	48% (12)	8% (2)
Hausa N = 5	40% (2)	60% (3)	0 (0)

Note: χ^2 13.529 $p<0.113$

Further analysis of housing type by ethnic group (see Table 4.10) indicates that 63 percent of Ebira and 54.5 percent of Yoruba householders live in single room houses, while 48 percent of Tiv householders live in sitting room and bedroom house types.

Regardless of the building structure adopted by the householders as highlighted above, houses are clustered around one another in the study area. The dense clustering of houses as shown in Figure 4.6 further compounds the problem of ventilation and air quality within buildings.

Figure 4.6: Illustration of clustered buildings in Ilokun
Source: Author, August 2010

The implications of this analysis are that the arrangement of rooms (Moturi, 2010; Ezzati *et al*., 2005) in the different house types affects air quality in buildings in peri-urban areas of Ado Ekiti.

4.3.2 Classifying Householders Floor Materials

Upon completion of the buildings presented in Table 4.9 above, 64.9 percent of householders generally use mud for the flooring and those that have the financial capability do so use sand and cement (35.1 percent). To understand the floor types used in the area, I further broke down the analysis by community and ethnic group (Tables 4.11 and 4.12). The Chi-square tests indicate that there is an association between individual community, ethnic group, and floor types. The variations in floor types by ethnic group (see Table 4.11) may reflect financial constraints but this cannot be determined with certainty from the questionnaire analysis.

Table 4.11 indicates that householders in all communities used mud flooring. In addition, householders in some communities used more than one floor type (usually mud and concrete) in their buildings.

Table 4.11: Percentage of floor types by community

S/N	Community	Type of flooring	
		Mud 64.9% (N=227)	Concrete 35.1% (N=123)
1	Aba CAC N = 4	100% (4)	0 0
2	Agọ Aduloju N = 60	28.3% (17)	71.7% (43)
3	Agọ Corner N = 36	72.2% (26)	27.8% (10)
4	Alagorugba N = 2	100% (2)	0 (0)
5	Aroto N 13	84.6% (11)	15.4% (2)
6	Asọ Ayegunle N = 6	16.7% (1)	83.3% (5)
7	Ejiko N = 8	100% (8)	0 (0)
8	Ejimakogo N = 23	69.6% (16)	30.4% (7)
9	Elemi N = 9	100% (9)	0 (0)
10	Igbaitu N = 2	100% (2)	0 (0)
11	Igbaye N = 6	83.3% (5)	16.7% (1)
12	Ilamọ N = 21	52.4% (11)	47.6% (10)
13	Ilokun N = 55	69.1% (38)	30.9% (17)
14	Irasa N = 60	70% (42)	30% (18)
15	Isegere N = 3	33.3% (1)	66.7% (2)
16	Odoro N = 26	80.8% (21)	19.2% (5)
17	Oke Epa N = 2	50% (1)	50% (1)
18	Ologunja N = 4	75% (3)	25% (1)
19	Ọlora Camp N = 10	90% (9)	10% (1)

Note: χ^2 68.888 p<0.000

Table 4.12 Percentage of floor type by ethnic groups

Ethnic Group	Type of flooring	
	Mud 64.9% (N=227)	Concrete 35.1% (N=123)
Ebira N = 265	74.7% (198)	25.3% (67)
Yoruba N = 55	23.6% (13)	76.4% (42)
Tiv N =25	52% (13)	48% (12)
Hausa N = 5	60% (3)	40% (2)

Note: χ^2 54.169 p<0.000

The ethnic groups analysis in Table 4.12 above indicates that the Ebiras are more inclined to use mud floors (74.7 percent) than concrete floors (25.3 percent) and, this is similar for the Tivs (mud: 52 percent; concrete: 48 percent) and Hausas (mud: 60 percent; concrete: 40 percent). Nonetheless, concrete floors (76.4 percent) are commonly used among Yoruba householders with a lower percentage (23.6 percent) of them using mud floors. This points to slightly higher levels of socio-economic status amongst Yoruba households compared to other ethnic groups, which allowed a higher proportion of them to construct concrete floors in their houses.

The results in Tables 4.11 and 4.12 corroborate findings in other sections (3.6 and 4.5) regarding the importance of community and ethnicity for understanding dwelling characteristics (eaves) in the study area. It also accounts for factors relating to poor ambient air quality when using biomass fuels for domestic activities.

4.3.3 Classifying Householders Ceiling Materials

As illustrated in Figure 4.7, different types of ceiling materials are used by householders. 23.7 percent made use of sack and 10.6 percent of householders used bamboo with mud mortar for their ceiling. The sacks are derived from used food packaging bags, which are sold at a low cost to be re-used by householders. In addition, 5.1 percent and 6 percent of the householders used asbestos and wood planks materials respectively for their ceilings, while 54.6 percent did not have ceilings. The Chi-square tests indicate that there is an association between individual community and ceiling material type. The diversity of ceiling materials used probably reflects households' different financial capabilities or social status. It may also reflect cultural influences as a majority of the householders, regardless of their ethnicity, do not have ceilings as shown in Table 4.13.

A – Sack ceiling

B – Bamboo with mud mortar ceiling

C – No ceiling

Figure 4.7: Types of ceiling used by the householders
Source: Author, February 2011

As shown in Table 4.13, residents of Ọlora Camp community do not use sacks as ceiling materials. Bamboo with mud mortar ceilings are used in all but five of the communities while wood planks are used in Aroto, Ejimakogo, Ilamọ, Ilokun, Irasa, and Odoro. Households in Agọ Aduloju, Aroto, Ejimakogo, Irasa, and Odoro indicated the use of asbestos as ceiling materials. Virtually all communities have households with no ceilings.

Table 4.13: Percentage of ceiling materials types by community

S/N	Community	Ceiling Materials				
		Sack 23.7% (N=83)	Bamboo with mud mortar 10.6% (N=37)	Wood planks 6% (N=21)	Asbestos 5.1% (N=18)	None 54.6% (N=191)
1	Aba CAC N = 4	0 (0)	50% (2)	0 (0)	0 (0)	50% (2)
2	Agọ Aduloju N = 60	36.7% (22)	10% (6)	0 (0)	10% (6)	43.3% (26)
3	Agọ Corner N = 36	27.8% (10)	5.6% (2)	0 (0)	0 (0)	66.6% (24)
4	Alagorugba N = 2	50% (1)	0 (0)	0 (0)	0 (0)	50% (1)
5	Aroto N 13	7.7% (1)	15.4% (2)	7.7% (1)	15.4% (2)	53.8% (7)
6	Asọ Ayegunle N = 6	33.3% (2)	0 (0)	0 (0)	33.3% (2)	33.3% (2)
7	Ejiko N = 8	0 (0)	25% (2)	12.5% (1)	12.5% (1)	50% (4)
8	Ejimakogo N = 23	26.1% (6)	8.7% (2)	8.7% (2)	4.3% (1)	52.2% (12)
9	Elemi N = 9	0 (0)	11.1% (1)	55.6% (5)	0 (0)	33.3% (3)
10	Igbaitu N = 2	0 (0)	0 (0)	0 (0)	0 (0)	100% (2)
11	Igbaye N = 6	16.7% (1)	16.7% (1)	0 (0)	0 (0)	66.7% (4)
12	Ilamọ N = 21	4.8% (1)	4.8% (1)	9.5% (2)	0 (0)	80.9% (17)
13	Ilokun N = 55	18.2% (10)	16.4% (9)	10.9% (6)	0 (0)	54.5% (30)
14	Irasa N = 60	30% (18)	8.7% (4)	5% (3)	5% (3)	53.3% (32)
15	Isegere N = 3	66.7% (2)	33.3% (1)	0 (0)	0 (0)	0 (0)
16	Odoro N = 26	26.9% (7)	3.8% (1)	3.8% (1)	11.5% (3)	53.8% (14)
17	Oke Epa N = 2	0 (0)	50% (1)	0 (0)	0 (0)	50% (1)
18	Ologunja N = 4	50% (2)	0 (0)	0 (0)	0 (0)	50% (2)
19	Ọlora Camp N = 10	0 (0)	20% (2)	0 (0)	0 (0)	80% (8)

Note: χ^2 128.189 p<0.000

Table 4.14: Percentage of ceiling materials types by ethnic group

Ethnic Group	Ceiling materials				
	Sack 23.7% (N=83)	Bamboo with mud mortar 10.6% (N=37)	Wood planks 6% (N=22)	Asbestos 5.1% (N=18)	None 54.6% (N=191)
Ebira N = 265	23.4% (62)	12.8% (34)	6.8% (18)	4.2% (11)	52.8% (140)
Yoruba N = 55	23.6% (13)	1.8% (1)	3.6% (2)	9.1% (5)	61.8% (34)
Tiv N = 25	28% (7)	4% (1)	4% (1)	8% (2)	56% (14)
Hausa N = 5	20% (1)	20% (1)	0 (0)	0 (0)	60% (3)

Note: χ^2 11.738 $p<0.467$

As shown in Table 4.14 having no ceiling is also a common practice across the different ethnic groups. Among the Ebiras, 52.8 percent had no ceilings, 23.4 percent used sack materials and only 4.2 percent used asbestos. Similarly, 61.8 percent of Yoruba households had no ceilings, 23.6 percent used sacks, 9.1 percent used asbestos, 3.6 percent used wood planks, and 1.8 percent used bamboo with mud mortar. 56 percent of Tiv households have no ceilings, while 28 percent and 8 percent used sacks and asbestos respectively.

4.4 Characteristics of Householders' Windows

As part of the attempt to assess indoor air quality in communities, an observation was made about the number(s) of windows per room in a building. In this regard, householders had only one window in each room (Figure 4.8). During the day, people living in houses with a main entrance door usually leave the door open to allow light and ventilation into the building. Most (98 percent) respondents have wood framed windows. The windows are about 45cm^2 and are made with a wooden frame and a shutter as illustrated in Figure 4.8. Other types of windows include louver blades

(0.6 percent); corrugated iron sheets (0.3 percent), but 1.1 percent of buildings have no windows. Tables 4.15 and 4.16 provide data on window type by individual community and ethnic groups and show that the wooden frame and shutter window type is the most common. This may indicate the influence of socio-economic factors (examined in Section 5.3) on householders' window types in different communities. Although, only two households use louver blades, their interaction with the urban centre (see Section 3.5.3) may have influenced their window choices, encouraging them to replicate the window types in nearby urban areas. One household in the Ilokun community has corrugated sheets for windows and four households (in Ilamọ, Igbaitu and Odoro) have open spaces.

Figure 4.8: Illustration of window sizes in the communities
Source: Author, August 2010

Table 4.15: Percentage of window types by community

S/N	Community	Window types			
		Wooden frame and shutter 98% (N=343)	Louver blades 0.6% (N=2)	Corrugated iron sheet 0.3% (N=1)	Open space 1.1% (N=4)
1	Aba CAC N = 4	100% (4)	0 (0)	0 (0)	0 (0)
2	Agọ Aduloju N = 60	100% (60)	0 (0)	0 (0)	0 (0)
3	Agọ Corner N = 36	100% (36)	0 (0)	0 (0)	0 (0)
4	Alagorugba N = 2	100% (2)	0 (0)	0 (0)	0 (0)
5	Aroto N 13	100% (13)	0 (0)	0 (0)	0 (0)
6	Asọ Ayegunle N = 6	83.3% (5)	16.7% (1)	0 (0)	0 (0)
7	Ejiko N = 8	100% (8)	0 (0)	0 (0)	0 (0)
8	Ejimakogo N = 23	100% (23)	0 (0)	0 (0)	0 (0)
9	Elemi N = 9	100% (9)	0 (0)	0 (0)	0 (0)
10	Igbaitu N = 2	50% (1)	0 (0)	0 (0)	50% (1)
11	Igbaye N = 6	100% (6)	0 (0)	0 (0)	0 (0)
12	Ilamọ N = 21	95.2% (20)	0 (0)	0 (0)	4.8% (1)
13	Ilokun N = 55	96.4% (53)	1.8% (1)	1.8% (1)	0 (0)
14	Irasa N = 60	100% (60)	0 (0)	0 (0)	0 (0)
15	Isegere N = 3	100% (3)	0 (0)	0 (0)	0 (0)
16	Odoro N = 26	92.3% (24)	0 (0)	0 (0)	7.7% (2)
17	Oke Epa N = 2	100% (2)	0 (0)	0 (0)	0 (0)
18	Ologunja N = 4	100% (4)	0 (0)	0 (0)	0 (0)
19	Ọlora Camp N = 10	100% (10)	0 (0)	0 (0)	0 (0)

Table 4.16: Percentage of window types by ethnic groups

Ethnic Group	Window types			
	Wooden frame and shutter 98% (N=343)	Louver blades 0.6% (N=2)	Corrugated iron sheet 0.3% (N=1)	Open spaces 1.1% (N=4)
Ebira N = 265	98.9% (262)	0.4% (1)	0.4% (1)	0.4% (1)
Yoruba N = 55	23.6% (54)	1.8% (1)	0 (0)	0 (0)
Tiv N = 25	88% (22)	0 (0)	0 (0)	12% (3)
Hausa N = 5	100% (5)	0 (0)	0 (0)	0 (0)

The use of biomass fuel to cook in buildings with poor aeration due to limited number of windows in a densely clustered settlement pattern increases the concentration levels of particulates. As there is a low exchange of indoor air with outdoor air in the buildings, this corroborates the findings of Torres-Duque *et al*. (2008) who argue that inadequate ventilation in buildings where biomass fuels are used for cooking results in high levels of indoor air pollution. Ventilation in buildings helps to create an indoor air quality more suitable for people's dwellings than what occurs in unventilated buildings, which cannot dilute and remove pollutants hazardous to health (CIB, 2004). Ventilation therefore dictates the exchange of polluted air with fresh outdoor air in the communities (Section 2.4). Inadequate ventilation in buildings in the various communities suggests that it constitutes a major risk factor for health effects because unventilated buildings cannot disperse and remove particulates created by their cooking activities (Sundell, 2004).

4.5 The Effect of Eaves in the Study Area

Studies elsewhere have demonstrated that the physical characteristics of housing such as eaves influence pollution levels in buildings during cooking (Bruce *et al*., 2006) as they provide a simple way to reduce wood smoke levels in buildings when householders cannot afford a chimney, hood or vent (Bates, 2005). In contrast, Ezzati *et al*. (2005) argue that closing up eaves in buildings reduces the infiltration of wood smoke from the neighbourhood. Within the study area of the present project, 26 percent of respondents indicated that they did not have eaves, and 74 percent of buildings had eaves between 10cm to 15cm on the outside wall. I also observed spaces between the partitioning walls of the rooms and the inside of the roof.

Chi-square tests indicate there is an association between individual community and eaves. This suggests that householders' decisions about whether or not to incorporate eaves into their building design may reflect cultural factors although a majority of householders do incorporate eaves in their buildings regardless of ethnicity. This may indicate that the presence of eaves in buildings where biomass fuel is used influences indoor air levels as cooking smoke can infiltrate buildings through them.

Table 4.17: Percentage of the use of eaves by community

S/N	Community	Eaves	
		Yes 73.1% (N=256)	No 26.9% (N=94)
1	Aba CAC N = 4	100% (4)	0 (0)
2	Agọ Aduloju N = 60	73.3% (44)	26.7% (16)
3	Agọ Corner N = 36	50% (18)	50% (18)
4	Alagorugba N = 2	0 (0)	100% (2)
5	Aroto N 13	100% (13)	0 (0)
6	Asọ Ayegunle N = 6	83.3% (5)	16.7% (1)
7	Ejiko N = 8	75% (6)	25% (2)
8	Ejimakogo N = 23	82.6% (19)	17.4% (4)
9	Elemi N = 9	66.7% (6)	33.3% (3)
10	Igbaitu N = 2	50% (1)	50% (1)
11	Igbaye N = 6	50% (3)	50% (3)
12	Ilamọ N = 21	52.4% (11)	47.6% (10)
13	Ilokun N = 55	81.8% (45)	18.2% (10)
14	Irasa N = 60	83.3% (50)	16.7% (10)
15	Isegere N = 3	100% (3)	0 (0)
16	Odoro N = 26	69.2% (18)	30.8% (8)
17	Oke Epa N = 2	50% (1)	50% (1)
18	Ologunja N = 4	50% (2)	50% (2)
19	Ọlora Camp N = 10	70% (7)	30% (3)

Note: χ^2 38.136 $p<0.004$

Table 4.18: Percentage of the use of eaves by ethnic groups

Ethnic Group	Eaves	
	Yes 73.1% (N=265)	No 26.9% (N=94)
Ebira N=256	75.1% (199)	24.9% (66)
Yoruba N=55	69.1% (38)	30.9% (17)
Tiv N=25	60% (15)	40% (10)
Hausa N=5	80% (4)	20% (1)

Note: χ^2 3.291 p<0.349

The majority of householders have eaves in their buildings, though 26.9 percent of houses do not. According to Bruce *et al*. (2006) and Ezzati *et al*. (2005), however, having eaves is unlikely to improve air quality as the clustering of buildings allows wood smoke from neighbours' hearths to penetrate through the eaves into buildings. The next section examines the various types of kitchen in the study area and their locations since this also affects air quality in buildings when cooking. Wood smoke at household and community levels (Section 2.3) contributes to poor air quality in buildings as explained in Section 4.2.

4.6 Kitchen Characteristics of the Householders

Within communities, the kitchens mainly have permanent hearths and cooking utensils are normally washed and stored in the bedroom after each use. In the bedroom, all kitchen utensils are kept in a moveable cupboard, the height of which is about 70 cm and the top of which serves as a table for placing lamps in the night.

Cooking takes place at around the same time within the entire community, since householders' daily activities do not vary significantly. Breakfast and dinner are the main meals prepared at home. Breakfast is taken early, before householders set out to their farms and children go to school. In the evening when the sun sets, householders are back at home in order to prepare dinner, which is a daily routine during weekdays. At weekends, every member of the household (with the exception of elderly people) will work on the farm and arrive back in the evening time, and similar cooking patterns to weekdays are usually followed.

Pictures of kitchens are presented in Figures 4.9 and 4.10. In regards to indoor kitchens, the cooking fire is situated in the corner of the corridor, whereas in outdoor cooking places, it is usually in an open shed and/or space or besides the external building walls (Figure 4.11).

Figure 4.9: Picture of indoor kitchen
Source: Author, March 2011

Figure 4.10: Picture of outdoor kitchen[29]
Source: Author, February 2011

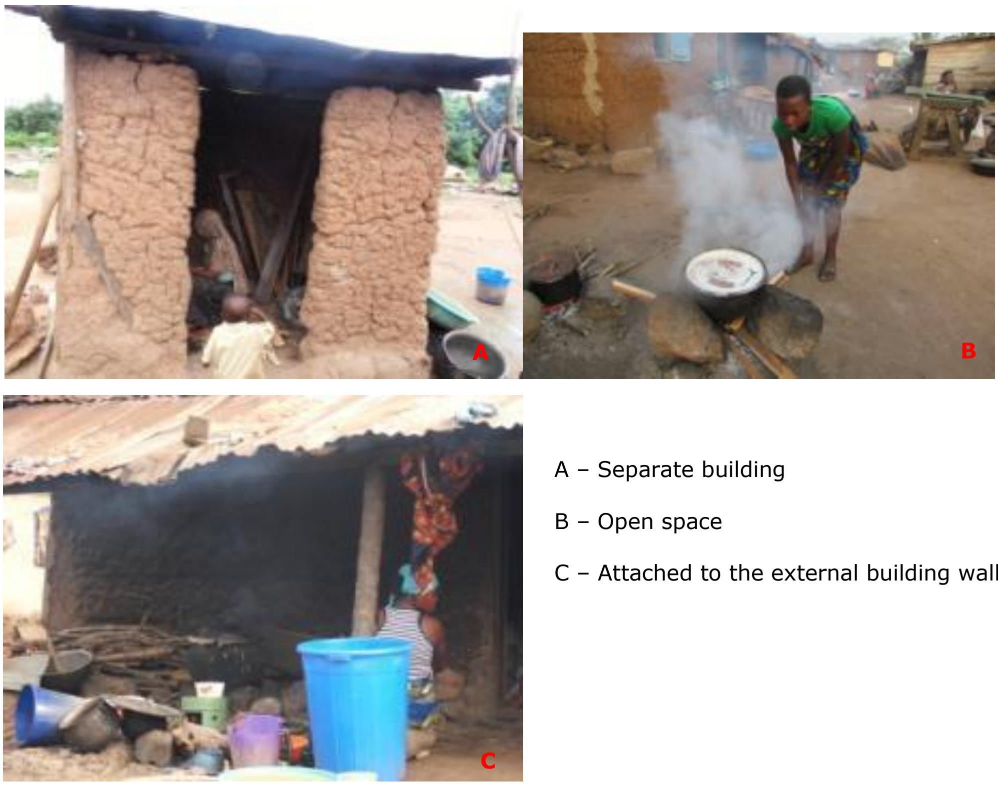
Figures 4.9 and 4.10 highlight the use of different types of cooking areas in the study communities. Household responses from questionnaires indicate that the majority of households cook in open spaces (71.1 percent) (Table 4.19).

Table 4.19: Respondents kitchen types in the study area

Kitchen type	N (350)	Percentage
Inside	26	7.4
Open space away from buildings	249	71.1
Attached to the external building wall	65	18.6
Separate building	10	2.9

[29] 'Outdoor kitchens' refer to as those located outside the building.

In some instances, because of the proximity to the house, the external walls of the building double as the wall for constructing the fireplace. This type of kitchen is used by 18.6 percent of the respondents. In addition, 7.4 percent of the respondents have their kitchen indoors, while 2.9 percent have a separate building serving as the kitchen. Figure 4.11 illustrates these types of kitchen in the study areas. As observed in the communities, the open space and/or separate kitchen is located around 5 metres from the home. At this distance, wood smoke easily disperses into the building thereby contributing to the pollution level of the house and the overall pollution levels of the community as a whole.



A – Separate building

B – Open space

C – Attached to the external building wall

Figure 4.11: Types of kitchen used by the householders
Source: Author, August 2010, & March 2011

As examined in previous sections, the significance of variables by individual community, ethnic group, and gender is also considered in this section. Chi-square tests indicate that there is no association between individual community, gender, years spent in the community and kitchen type. The test did find associations between ethnic group, and kitchen types. This suggests that householders have a tendency to reconstruct kitchen types according to what is used in their 'home' community (Section 3.5.2).

As shown in Table 4.20, indoor kitchens are used by households in the Agọ Aduloju, Agọ Corner, Aroto, Ilamọ, Ilokun, and Irasa communities. The open spaces and outside kitchen function as a kitchen in a majority of the communities. Households with separate kitchens are present in Agọ Aduloju, Ilamọ, Ilokun, Irasa, and Odoro. In the Agọ Aduloju, Ilamọ, Ilokun and Irasa communities, the full range of kitchen types shown in Table 4.20 and illustrated in Figures 4.9 and 4.10 are used by the householders.

Information on the kitchen types used by different ethnic group as presented in Table 4.20, suggests that Ebiras mostly used open space type kitchens (70.2 percent) while only a few used a separate kitchen for cooking (1.5 percent). More Ebiras have kitchens attached to the external building wall (21.9 percent) than indoor kitchens (6.4 percent). Open space kitchens (74.5 percent) are also common among the Yorubas with some having kitchens inside their building (14.5 percent) and attached to the external building wall (10.9 percent). Most (72 percent) Tivs also use open space as kitchens in the study area although 24 percent have separate buildings for kitchens. Only one (4 percent) household had a kitchen attached to the external building wall.

Table 4.22 clearly shows that men are more disposed to the use of open space (63.8 percent) as kitchens, while only 3.1 percent consider using a separate kitchen. Similarly, women are more inclined to use open space (75.3 percent) as kitchens.

Table 4.20: Percentage of kitchen types by community

S/N	Community	Kitchen Type			
		Inside 7.4% (N=26)	Open space 71.1% (N=249)	Attached to the external building wall 18.6% (N=65)	Separate building 2.9% (N=10)
1	Aba CAC N = 4	0 (0)	100% (4)	0 (0)	0 (0)
2	Agọ Aduloju N = 60	8.3% (5)	81.7% (49)	6.7% (4)	3.3% (2)
3	Agọ Corner N = 36	5.6% (2)	66.7% (24)	27.8% (10)	0 (0)
4	Alagorugba N = 2	0 (0)	0 (0)	100% (2)	0 (0)
5	Aroto N 13	7.7% (1)	76.9% (10)	15.4% (2)	0 (0)
6	Asọ Ayegunle N = 6	0 (0)	83.3% (5)	16.7% (1)	0 (0)
7	Ejiko N = 8	12.5% (1)	75% (6)	12.5% (1)	0 (0)
8	Ejimakogo N = 23	0 (0)	82.6% (19)	17.4% (4)	0 (0)
9	Elemi N = 9	0 (0)	55.6% (5)	33.3% (3)	11.1% (1)
10	Igbaitu N = 2	0 (0)	50% (1)	50% (1)	0 (0)
11	Igbaye N = 6	0 (0)	83.3% (5)	0 (0)	16.7% (1)
12	Ilamọ N = 21	19% (4)	71.4% (15)	4.8% (1)	4.8% (1)
13	Ilokun N = 55	7.3% (4)	61.8% (34)	27.3% (15)	3.6% (2)
14	Irasa N = 60	15% (9)	65% (43)	18.3% (11)	1.7% (1)
15	Isegere N = 3	0 (0)	100% (3)	0 (0)	0 (0)
16	Odoro N = 26	0 (0)	65.4% (17)	26.9% (7)	7.7% (2)
17	Oke Epa N = 2	0 (0)	100% (2)	0 (0)	0 (0)
18	Ologunja N = 4	0 (0)	75% (3)	25% (1)	0 (0)
19	Ọlora Camp N = 10	0 (0)	80% (8)	20% (2)	0 (0)

Note: χ^2 58.337 p<0.319

Table 4.21: Percentage of kitchen types by ethnic groups

Ethnic Group	Kitchen Types			
	Inside 7.4% (N=26)	Open space 71.1% (N=249)	Attached to the external building wall 18.6% (N=65)	Separate building 2.9% (N=10)
Ebira N=265	6.4% (17)	70.2% (186)	21.9% (58)	1.5% (4)
Yoruba N=55	14.5% (8)	74.5% (41)	10.9% (6)	0 (0)
Tiv N=25	0 (0)	72% (18)	4% (1)	24% (6)
Hausa N=5	20% (1)	80% (4)	0 (0)	0 (0)

Note: χ^2 56.826 $p<0.0001$

Table 4.22: Percentage of kitchen types by gender

Gender	Kitchen Types			
	Inside 7.4% (N=26)	Open space 71.1% (N=249)	Attached to the external building wall 18.6% (N=65)	Separate building 2.9% (N=10)
Male N=127	11.8% (15)	63.8% (81)	21.3% (27)	3.1% (4)
Female N=223	4.9% (11)	75.3% (168)	17% (38)	2.7% (6)

Note: χ^2 7.508 $p<0.057$

It is clear that wood smoke can easily infiltrate into buildings during cooking (Figure 4.11). Even when an outside space is used for cooking, poor ventilation (Section 4.4) and the presence of eaves in buildings (Section 4.5) compromises air quality, making householders more susceptible to the health impacts of indoor air pollution.

4.6.1 Seasonal Location of Kitchens

Another significant influence on kitchen location is the weather. The right location for cooking is often determined by weather conditions as the study area falls within the tropics and experiences, as already noted earlier a wet and dry seasonal period every year. Generally, during the rainy season, cooking takes place within buildings and 47.4 percent of householders move their kitchens indoors to prevent themselves, their hearths and wood fuel from getting wet. 69.1 percent of householders confirmed that they cook in open spaces or sheds during the dry season (Figure 4.12).

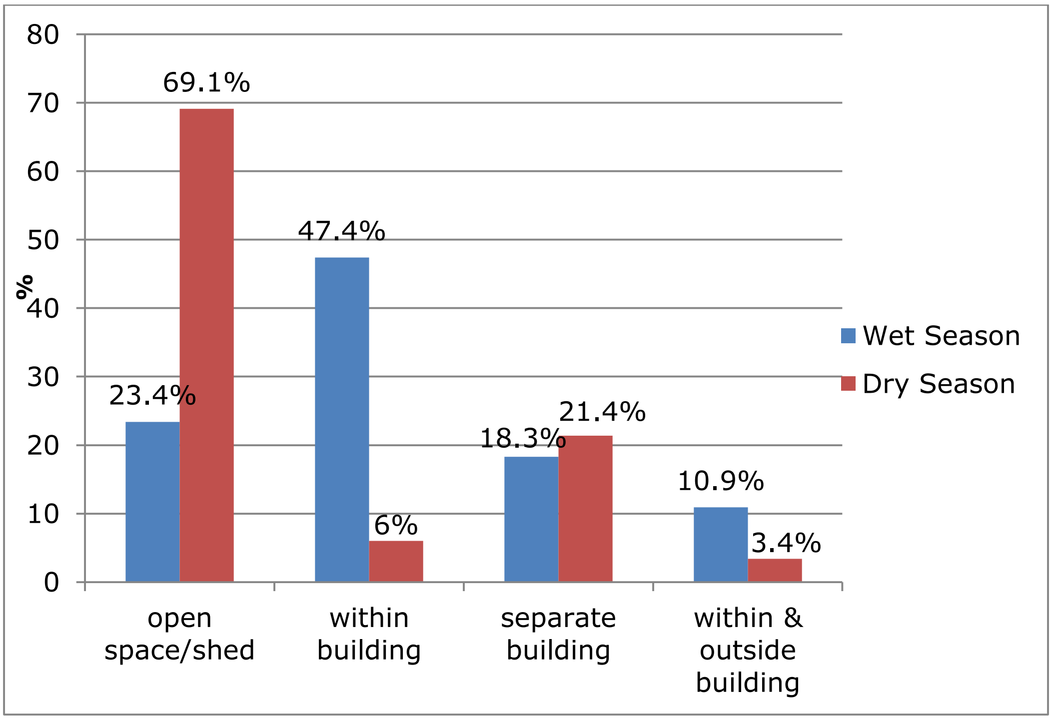
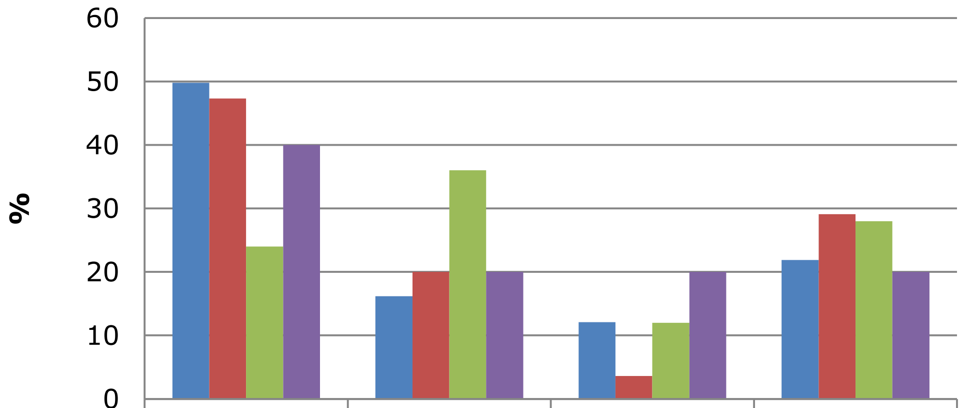


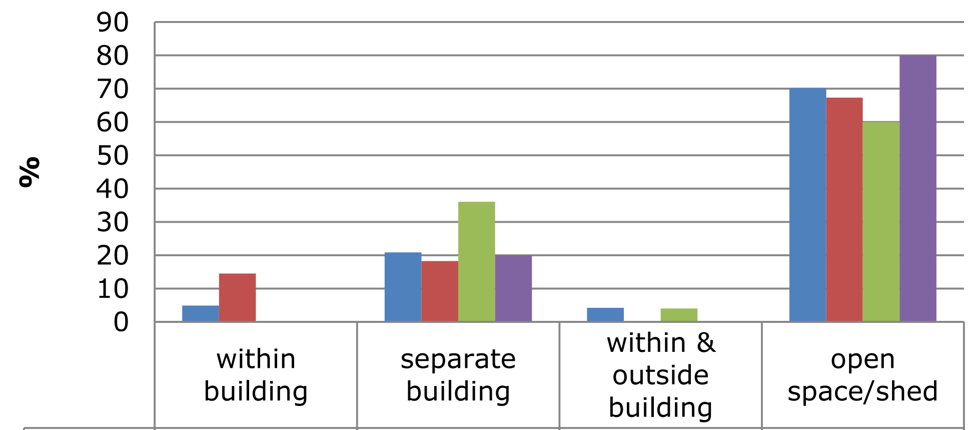
Figure 4.12: Seasonal location of householders' kitchen

Building on the linkages between ethnicity to kitchen location discussed in Section 4.6, Figures 4.13 and 4.14 illustrate the seasonal location of kitchen among the different ethnic groups. The results in Figure 4.13 below suggests that the Ebiras (49.8 percent) and Yorubas (47.3 percent) preferred cooking within the building during the wet season as this allowed them to avoid adverse weather conditions. However, despite the sometimes challenging weather conditions during the wet season, some householders used an open space/shed as a kitchen location. The questionnaire data did not reveal any clear explanations for this.



	within building	separate building	within & outside building	open space/shed
Ebira	49.8	16.2	12.1	21.9
Yoruba	47.3	20	3.6	29.1
Tiv	24	36	12	28
Hausa	40	20	20	20

Figure 4.13: Kitchen location among different ethnic groups during the wet season



	within building	separate building	within & outside building	open space/shed
Ebira	4.9	20.8	4.2	70.2
Yoruba	14.5	18.2	0	67.3
Tiv	0	36	4	60
Hausa	0	20	0	80

Figure 4.14: Kitchen location among different ethnic groups during the dry season

In comparison with kitchen location during the wet season, analysis in Figure 4.14 shows that the majority of householders, regardless of ethnicity, use open spaces/shed kitchens locations during the dry season. Only the Ebiras (4.9 percent) and Yorubas (14.5 percent) still cook within buildings during this period. All groups identified a preference for cooking in separate buildings during the dry season. Notwithstanding the weather conditions, all groups used an open space/shed for the location of the kitchen. This suggests that this kitchen type will contribute to community and household level pollution in the area when cooking smoke infiltrates into buildings through eaves (Sections 4.2 and 4.5).

As mentioned in Section 4.3.1, most houses are built as single rooms lined in two rows with a corridor in between. This form of building does not usually incorporate a space for an indoor kitchen, which explains why cooking places are usually located along the exit of the corridor. In addition, householders often have multiple hearths of the same type to efficiently meet their domestic activities. Evaluating the location of the kitchen as regard to air quality, substantial wood smoke infiltrates into buildings either when cooking indoors or outdoors as most houses have eaves (Section 4.5).

4.6.2 Stove Types amongst the Householders

As different kitchen locations are used as highlighted in Section 4.6, there are also different stoves types used for cooking as illustrated in Figure 4.15.

Figure 4.15: Tradition cooking places in the communities
Source: Author, August 2010 & May 2011

A – Traditional three stone fireplace; B – U-shaped clay blocked fireplace; C – Metal stand fireplace; D – kerosene stove

The majority of households using biomass fuels in developing countries typically have their stoves at ground level, thereby making it necessary for the user to squat and/or bend over the fireplace, a position that exposes them to smoke, more so than if the hearth was higher and they were standing. Stove characteristics in the study areas are similar to the above description with 76 percent of householders using a combination of wood fuelled three stone stoves (with kerosene to light the wood fuel) in order to cook in open spaces around their building. Only 19.7 percent made exclusive use of biomass-fuelled traditional three stone stoves, U-shaped clay blocked stoves and metal stand hearths. 4.3 percent cook exclusively with kerosene stoves. After identifying the stoves in the nineteen communities as illustrated in Figure 4.15, Tables 4.23 and 4.24 highlight the association between different types of stoves used in individual communities and amongst different ethnic groups.

As explained in Section 3.7, assumptions for the statistical test were first checked before recording significant values. The Chi-square test indicates that there is a significant association between ethnic group and stove type. This indicates that householders' responses for stove types according to their ethnic groups varied because of their different cultural backgrounds. On the other hand, all groups showed a preference for the three stone stove, which reflects cultural cooking practices, that relied on '*aro meta*' (see Section 3.5.2).

The analysis presented in Table 4.23 below demonstrates that residents of Agọ Aduloju community do not exclusively use the three stone stove, while majority of the householders exclusively used it in other communities. The combination of wood-fuelled three stone stoves with kerosene (to light wood) is used in virtually all the communities.

Table 4.23: Percentage of stove types by community

S/N	Community	Stove Types				
		Three stone 17.1% (N=60)	Kerosene stove 4.3% (N=15)	Three stone and kerosene 76% (N=266)	U-shaped clay blocked stove 1.4% (N=5)	Metal hearths stand 1.1% (N=4)
1	Aba CAC N = 4	50% (2)	0 (0)	50% (2)	0 (0)	0 (0)
2	Agọ Aduloju N = 60	11.6% (7)	10% (6)	75% (45)	1.7% (1)	1.7% (1)
3	Agọ Corner N = 36	27.8% (10)	0 (0)	69.4% (25)	2.8% (1)	0 (0)
4	Alagorugba N = 2	0 (0)	0 (0)	100% (2)	0 (0)	0 (0)
5	Aroto N 13	38.8% (4)	0 (0)	69.2% (9)	0 (0)	0 (0)
6	Asọ Ayegunle N = 6	16.7% (1)	16.7% (1)	66.6% (4)	0 (0)	0 (0)
7	Ejiko N = 8	12.5% (1)	0 (0)	87.5% (7)	0 (0)	0 (0)
8	Ejimakogo N = 23	21.7% (5)	0 (0)	78.3% (18)	0 (0)	0 (0)
9	Elemi N = 9	0 (0)	0 (0)	88.9% (8)	0 (0)	11.1% (1)
10	Igbaitu N = 2	0 (0)	0 (0)	100% (2)	0 (0)	0 (0)
11	Igbaye N = 6	66.6% (4)	16.7% (1)	16.7% (1)	0 (0)	0 (0)
12	Ilamọ N = 21	0 (0)	4.8% (1)	95.2% (20)	0 (0)	0 (0)
13	Ilokun N = 55	16.3% (9)	3.6% (2)	76.3% (42)	1.6% (1)	1.6% (1)
14	Irasa N = 60	10% (6)	6.7% (4)	80% (48)	1.6% (1)	1.6% (1)
15	Isegere N = 3	33.3% (1)	0 (0)	66.7% (2)	0 (0)	0 (0)
16	Odoro N = 26	30.8% (8)	0 (0)	65.4% (17)	3.8% (1)	0 (0)
17	Oke Epa N = 2	0 (0)	0 (0)	100% (2)	0 (0)	0 (0)
18	Ologunja N = 4	50% (2)	0 (0)	50% (2)	0 (0)	0 (0)
19	Ọlora Camp N = 10	0 (0)	0 (0)	100% (10)	0 (0)	0 (0)

Note: χ^2 46.832 $p<0.107$

Table 4.24: Percentage of stove types by ethnic groups

Ethnic Group	Stove Types				
	Three stone 17.1% (N=60)	Kerosene stove 4.3% (N=15)	Three stone and kerosene 76% (N=226)	U-shaped clay blocked stoves 1.4% (N=5)	Metal stand hearths 1.1% (N=4)
Ebira N=265	18.7% (50)	2.3% (6)	77.4% (205)	0.8% (2)	0.8% (2)
Yoruba N=55	7.3% (4)	14.5% (8)	69.1% (38)	5.5% (3)	3.6% (2)
Tiv N=25	16% (4)	4% (1)	80% (20)	0 (0)	0 (0)
Hausa N = 5	40% (2)	0 (0)	60% (3)	0 (0)	0 (0)

Note: χ^2 18.476 $p<0.005$

As shown in Table 4.24, the Ebiras, Yorubas, and Tivs used the kerosene stoves, while the U-shaped clay blocked and metal hearths are used only among Ebiras and Yorubas households.

The most common biomass stoves are constructed with three stones, which can be adjusted to different sized pots at any time during cooking (Section 3.5.2). Fireplaces can also include clay U-shaped stoves and metal stands (Figure 4.11). The metal stand is an impermanent fireplace that can be placed anywhere at any location during cooking. With this fireplace, provision is made in between the stands to allow easy stocking and tending of wood. The women in the house prepare, on average, three daily meals (78.6 percent). Sometimes food left over from earlier prepared meals – either breakfast or lunch – is consumed at subsequent meals. Food is securely kept inside the pot used to prepare it, only to be re-heated before consumption. Many households in the study area have at least two hearths of the same type, both of which are used simultaneously during cooking. During the cooking process whether in the morning or in evening, the fire is not put out so that it can be rekindled again anytime.

Wood-fuelled open fires are in prominent use by the householders. Householders' in this study are likely to suffer from health impacts associated with inhaling wood smoke during cooking. Evidence from previous studies has highlighted the debilitating health impacts of indoor air pollution when using biomass fuel to cook, heat, and light houses (see Ezzati, 2005; Schei *et al*., 2004; Smith, 2000a). It is expected that as people's exposure (time spent multiplied by pollution level) to wood smoke increases, it poses health threats to them, especially when there are insufficient ventilation outlets (Moutri, 2010) which is the case in this study area as earlier explained.

In this section, the importance of ethnicity (Tables 4.7, 4.12, 4.16 and 4.21) was identified by householders for its influence on the various materials used for house construction. Housing characteristics are strongly influenced by ethnic background. Although migrants are living far away from 'home', they have replicated their traditional architectural styles into their present location. In addition, the individual community in the area is also significant (Tables 4.11, 4.13, 4.15, and 4.17) in influencing how materials are chosen for house construction. The community of residence most probably facilitates access to building materials and provide help during house construction.

Furthermore, the analysis in Section 4.3 has shown that dwelling characteristics tend to inhibit the circulation of fresh air into the building during cooking. The types of buildings in the study area suggest that most householders depend on low-cost materials in constructing their buildings. The use of construction materials like mud and earth, which is freely obtained from un-allotted land in the community, compares with how free energy sources are chosen by the householders, emphasising how access influences choice of building materials and domestic energy.

The structural design of buildings is characterised by a limited number of windows, the size of which is usually small, thereby limiting exchange of indoor air with outdoor air. Since biomass is used for cooking and kerosene for lighting, particulates cannot disperse properly in unventilated buildings and the clustering of buildings hampers aeration. In the study area, both household and community levels of pollution contribute to poor air quality irrespective of the indoor or outdoor location of kitchens. Invariably the air quality in these types of buildings exceeds acceptable limits as measured in one community (Irasa, see Section 4.2). The inhalation of particulates by householders in these buildings makes them susceptible to the health impacts of indoor air pollution.

This section has described the dwelling conditions of householders in peri-urban areas of Ado Ekiti in order to understand lived realities in these communities and their link to indoor air pollution. The use of biomass fuels for domestic energy and the physical conditions of buildings gives some insight into the impact that indoor air pollution has on householders' in the study area.

4.7 Links between Indoor Air pollution and Health Amongst Householders

The combustion of biomass fuel is the main source of indoor air pollution, which contributes to the total burden of ill health in developing countries (Zhang and Smith, 2007). It is evident from householders' responses in Table 4.25, that some of them do experience health difficulties during cooking, an indication of poor air quality in these homes.

Table 4.25: Health discomforts reported by householders during cooking

Health discomforts	N (350)	Percentage
Eye problem	123	35.1
Headaches	86	24.6
Tears from the eyes	29	8.3
Eye problem, headaches and catarrh	15	4.3
Eye and breathing problem	11	3.1
Headaches, cough and running nose	2	0.6
None	84	24.0

From Table 4.25, the health discomforts most reported by householders during cooking are eye-related problems (35.1 percent). On further enquiry, these eye problems are associated with itching and irritation causing redness of the eyes. One householder further recounted that 'some people in the community have blurred vision, I cannot say whether it is the wood smoke that is causing it or not [...] they cannot see things around them properly' (Householder 25, F, Ebira). The burning of biomass fuel produces smoke that irritates the eyes (Pokhrel *et al*., 2010). In addition, some of the householders had tears in their eyes whilst cooking (8.3 percent). Tears or smarting eyes during cooking is an indicator of IAP from cooking related activities in an environment, which is associated especially with wood fuel used for cooking (Ellegård, 1996a). As 8.3 percent of the householders experience tears from the eyes, the findings corroborate previous studies, which relate eye tears to the effects of exposure cooking smoke (Ellegård, 1996a).

24.6 percent of respondents reported that during and after cooking, they had headaches (see Table 4.25). The headaches were usually mild while cooking, but they observed that after a while when they have completed cooking activities the headache was sometimes severe. Householder 24 (F, Ebira) recounted that 'we find it difficult to sleep very well at night, [...] but can't link it with fuelwood used for cooking'.

There are combinations of discomforts experienced among householders that include eye problems, headaches and catarrh (4.3 percent), headaches, coughs and running nose (0.6 percent), and eye and breathing problems (3.1 percent). On the other hand, about 24 percent maintained that they did not record and/or notice any form of discomfort during cooking. This further supports the statement of householder 24 above, who despite finding it difficult to sleep at night, did not associate it with the effect of wood smoke during or after cooking. As shown in Table 4.25, a majority (76 percent) of householders reported discomfort while cooking and the remaining 24 percent did not experience any form of discomfort during cooking.

Apart from generally analysing health discomforts as explained above, efforts were made to investigate whether there were any linkages between health discomforts and either ethnic groups or gender. As previously discussed in Section 3.7, the assumption for the statistical test was first checked. The result of the Chi-square test indicates that there is an association between ethnic group and health discomforts identified during cooking, while there is no association between gender and health discomforts identified during cooking. One of the reasons that probably accounts for variation amongst ethnic groups' to responses about health discomforts could have been due to how they socially/culturally construct health problems associated with air pollution (Section 2.3.1). On the one hand, the differences in their responses to health discomforts during cooking could reflect variations in their knowledge of the causes of diseases because of their educational level (Section 5.3.2, Table 5.10, and Bickerstaff, 2004). On the other hand, the limited sample size of some of the ethnic groups may have either overestimated or underestimated what the wider responses would have been if there had been a larger participants from certain communities (Section 3.6.2).

As highlighted in Table 4.26, the main health discomfort reported by the Ebiras during cooking is eye problems (32.5 percent). Similarly, the Yorubas (43.6 percent) and Tivs (52 percent) also indicate eye problems as the major health discomfort among them. Table 4.26 suggests that health discomforts vary among the ethnic groups. The different cultural background of the householders (Section 3.5.2) may influence how they interpret causes of health discomforts during cooking.

The results obtained in Table 4.27 indicated that both men (33.1 percent) and women (36.3 percent) identified eye problems as the health discomfort during cooking.

Table 4.26: Percentage of health discomforts classification by ethnic groups

Ethnic Group	**Health discomforts**						
	Eye problem 35.1% (N=123)	Headaches 24.6% (N=86)	Tears from the eyes 8.3% (N=29)	Eye problem, headaches and catarrh 4.3% (N=15)	Eye and breathing problem 3.1% (N=11)	Headaches, cough and running nose 0.6% (N=2)	None 24% (N=84)
Ebira N= 265	32.5% (86)	27.9% (74)	9.4% (25)	3.8% (10)	3.4% (9)	0.8% (2)	22.3% (59)
Yoruba N= 55	43.6% (24)	10.9% (6)	5.5% (3)	1.8% (1)	1.8% (1)	0 (0)	36.4% (20)
Tiv N= 25	52% (13)	16% (4)	4% (1)	8% (2)	0 (0)	0 (0)	20% (5)
Hausa N= 5	0 (0)	40% (2)	0 (0)	40% (2)	20% (1)	0 (0)	0 (0)

Note: χ^2 42.139 $p<0.001$

Table 4.27: Percentage of health discomforts classification by gender

Gender	Health discomforts						
	Eye problem 35.1% (N=123)	Headaches 24.6% (N=86)	Tears from the eyes 8.3% (N=29)	Eye problem, headaches and catarrh 4.3% (N=15)	Eye and breathing problem 3.1% (N=11)	Headaches, cough and running nose 0.6% (N=2)	None 24% (N=84)
Male N= 127	33.1% (42)	26.8% (34)	11% (14)	2.4% (3)	4.7% (6)	0 (0)	22% (28)
Female N= 223	36.3% (81)	23.3% (52)	6.7% (15)	5.4% (12)	2.2% (5)	0.9% (2)	25.1% (56)

Note: χ^2 7.202 p<0.303

Furthermore, health problems experienced amongst householders are believed to be linked to non-conformity to cultural norms and values (Section 6.4) that forbid the use of sacred trees as wood fuel in the study area, rather than to daily exposure to wood smoke as discussed in this chapter.

The type of building materials and kitchens discussed in Sections 4.3 and 4.6 coupled with the use of wood fuel, seem to affect air quality in buildings and householders health. It is likely that pollution levels for both indoor and outdoor kitchens are probably above WHO guideline values (Sections 2.2.1 and 2.3.2; Rohr and Wyzga, 2012; Stanek *et al*., 2011).

Despite these health risks, most householders in the study area have completely different perspectives on indoor air pollution (Section 7.2). Section 4.7.1 discusses householders views about vulnerability to the burden of ill health associated with exposure to indoor air pollution.

4.7.1 Who Suffers From Indoor Air Pollution?

In the household questionnaire, respondents were asked to discuss issues of vulnerability to disease burdens associated with IAP and were encouraged to indicate whether (and if so how) they thought they were affected by cooking smoke. The analysis was collated by categorising responses into groups as shown in Table 4.28. The data gathered from communities show that 97.7 percent of householders indicated that women are more vulnerable to indoor air pollution. 1.4 percent felt that everybody (men, women, and children) is affected by their exposure to wood smoke, and a negligible proportion (0.9 percent) of householders did not indicate those affected by indoor air pollution. To further investigate householders perceptions about vulnerability to indoor air pollution, the relationships between IAP and ethnic group and gender were analysed. The Chi-square test results indicate that there is an association between ethnic group and groups vulnerable to indoor air pollution, while there is no association between gender and groups vulnerable to indoor air pollution. Householders' response regarding vulnerable groups varies according to their ethnic group, which suggests that their different cultural backgrounds (Section 3.5.2) may influence their perception of who is more susceptible to ill health.

It is clear from the analysis presented in Table 4.29 that 100 percent of the Tiv ethnic group indicated women and children are perceived to be most vulnerable to the effects of indoor air pollution compared to respective figures of 98.2 percent among Yorubas and 97.7 percent among Ebiras. This suggests that women's responsibility of cooking family meals and providing care for children (who often stay close to the cooking area) could have influenced how they perceive those vulnerable to indoor air pollution (Section 6.2 and Figure 6.2). Again, gender analysis presented in Table 4.30 further corroborates the views among the ethnic groups as 97.6 percent and 97.8 percent (men and women) respectively shared this view among them.

Table 4.28: Percentage of vulnerable group to indoor air pollution in the study area

Vulnerable group	N (350)	Percentage
Women and children	342	97.7
Women, men and children	5	1.4
No response	3	0.9

Table 4.29: Percentage of vulnerable group to indoor air pollution by ethnic groups

Ethnic group	Vulnerable group		
	Women and children 97.7% (N=342)	Women, men and children 1.4% (N=5)	No response 0.9% (N=3)
Ebira N= 265	97.7% (259)	1.1% (3)	1.1% (1)
Yoruba N= 55	98.2% (54)	1.8% (1)	0 (0)
Tiv N= 25	100% (25)	0 (0)	0 (0)
Hausa N= 5	80% (4)	20% (1)	0 (0)

Note: χ^2 13.788 p<0.032

Table 4.30: Percentage of vulnerable group to indoor air pollution by gender

Gender	Vulnerable group		
	Women and children 97.7% (N=342)	Women, men and children 1.4% (N=5)	No response 0.9% (N=3)
Male N= 127	97.6% (124)	1.6% (2)	0.8% (1)
Female N= 223	97.8% (218)	1.3% (3)	0.9% (2)

Note: χ^2 0.041 p<0.980

The analysis described above suggests that householders put into context their ethnic background when prioritising those vulnerable to impacts of indoor air pollution. In addition, the measured level of particulate matter (though in one community) is above WHO guideline values (Section 2.2.1) for buildings with indoor and outdoor kitchens (Section 4.2). Data suggest that air quality levels for all householders, irrespective of their gender and age (children and adults), makes them vulnerable to diseases related to exposure from indoor air pollution (Rahul and Sundeep, 2012; Rehfuess *et al*., 2011). Because both indoor and outdoor kitchens contribute to poor ambient air (Section 4.2), everyone in the community, therefore, is affected by indoor air pollution.

4.8 Conclusion

This chapter has examined householders' housing conditions in peri-urban areas of Ado Ekiti in order to identify the extent to which it influences indoor air pollution in the area. Notably, ethnicity is important when choosing materials for house construction and has an influence on architectural design, irrespective of location in the area. It is also important in understanding the premise upon which those vulnerable to impacts of indoor air pollution is identified because of the differences in householders' cultural backgrounds. Individual communities or places of residence sometimes shape householders' conceptions about building materials and specification in the area. All of these factors account for varying opinions concerning dwelling types, housing characteristics and perception about effects of indoor air pollution in the area.

It is apparent from the analysis that inadequate ventilation, eaves and clustering of buildings contribute to poor ambient air quality irrespective of whether cooking is carried out indoors or outdoors. The high levels of particulate matter measured in buildings also have health implications on householders.

The influence of housing conditions informed by individualised property development in Ado Ekiti, which is not controlled by the government, plays a major factor in house construction, as housing structures lack basic facilities. This affects the ventilation and layout of buildings, thus contributing to indoor air pollution amongst householders and causing poor ambient air in buildings. The distinctive housing layout in this study area seems to influence kitchen location, in which some are located indoors and some outdoors. There are no gender disparities for choice of kitchen types in the study area. The significance of the location of kitchens has shown that houses with outdoor kitchens as well as indoor kitchens seem to be polluted with wood smoke and air quality levels were high.

As food is cooked at the same time by householders with the use of wood fuel on open fires either in indoor or outdoor kitchens, there is a noticeable increase in air pollution concentrations in buildings in the Irasa community. This sees daily averages ranging between 48μg/m^3 and 648μg/m^3 (indoor kitchen) and, 42μg/m^3 and 275μg/m^3 (outdoor kitchen) respectively. This study has provided comparable air quality information for indoor and outdoor kitchen buildings in one community. The evidence suggests that cooking outdoors does not improve ambient air quality indoors. In addition, householders allow wood fuel to smoulder until the remaining fuel is consumed both in the daytime and at night, while air dispersion and dilution in the area is affected by neighbourhood pollution. Although cooking activities cease at night there is always a recorded background level of particulate matter in buildings. The outdoor kitchens contribute to 'neighbourhood' pollution, which infiltrates buildings through eaves, wall cracks and broken door and window panels, thereby polluting indoor ambient air quality. It makes no difference where kitchens are located in the Irasa community at least; householders' buildings have high concentrations of

$PM_{2.5}$. Owing to the differences in the layouts of different communities (Sections 3.5.2 and 3.6.3); there is a limitation to making generalisations based on results from IAP measurement in the Irasa community to the wider study area. However, the Irasa community results have been able to document particulate matter levels by providing site-specific air quality levels for the area.

The chapter identified householders' health problems during cooking to include eye problems, headaches, catarrh, breathing problems, and tears from the eyes. It is clear that ethnicity may also play an important role in understandings of health discomforts experienced by the householders because of how responsibilities are shared within the family. However, the small sample size of some of the ethnic groups might have influenced the results by overestimating views, which might not be representative of communities as whole. Ironically, the highlighted health difficulties are not linked with wood smoke despite their experiences during cooking. The high measured levels of particulates in Irasa indicates that householders here are predisposed to environmental health risks, and inhaling these particulates is likely to have debilitating health effects on everyone in the community.

The chapter also evaluated the groups of people considered most vulnerable to the impacts of cooking smoke. Women and children were identified as having the highest vulnerability to the impacts of indoor air pollution, but with the use of biomass fuel for domestic activities, all residents in the communities are likely to bear the burden of exposure to wood smoke. The next chapter discusses the socio-economic characteristics of householders in relation energy issues.

Chapter Five

Biomass Fuels: Socio-economic Factors contributing to Indoor Air Pollution

5.1 Introduction

This chapter presents findings from household questionnaires on biomass fuel and factors responsible for its continued use in cooking and lighting by householders in Ado Ekiti, Nigeria. In order to have a holistic understanding of the use of biomass fuel in the community, discussions in this chapter are based on objective three, 'to identify the socio-economic factors responsible for indoor air pollution'. The chapter highlights some of the factors that affect fuel types and their use amongst householders in Ado Ekiti.

Section 5.2 discusses the fuel types available to householders in the study area and also identifies various sources of fuel in the community used for cooking and lighting. Section 5.3 examines the socio-economic characteristics (income, age, and educational levels) of householders and reflects on how these determine domestic energy choices in the study area. In Section 5.4, the relationship between these socio-economic factors and fuel types in the study area is discussed.

5.2 Fuel Types and Uses in the Study Area

Householders rely significantly on biomass fuel (wood) and kerosene as their main energy sources in the study area. Various types of biomass fuels are used for cooking, heating and lighting in the global South which include but are not limited to wood, charcoal, agricultural waste and sawdust (Section 2.7). In Nigeria, although heating is not required in buildings due to the tropical weather conditions all the year round, domestic energy is needed for cooking and lighting. Each of these activities uses different energy sources as discussed in Section 5.2.1.

5.2.1 Cooking Fuels and Sources

Analysis of householder questionnaires indicates that the two main types of domestic energy used for cooking are wood and kerosene. Wood accounts for 96 percent of household cooking fuel and kerosene accounts for 4 percent. Householders still rely on biomass fuel for cooking, the efficiency and cleanliness of which is low and reflects the low availability and accessibility to cleaner fuels in the area.

In accessing these two types of fuel as identified above, wood fuel is sourced from the forest by 94.6 percent of the householders in the study area. Householders have to buy kerosene from either fuel stations or retail outlets. Although wood fuel and kerosene are the main sources available, householders use multiple fuels and so three main groups of fuel users have been identified in the study area. Category 1 relates to firewood use only, category 2 relates to households that use firewood but light it with kerosene, and category 3 is made up of households that use only kerosene. 17.7 percent, 78 percent and 4.3 percent of the householders within this study fall within categories 1, 2 and 3 respectively. Tables 5.1, 5.2 and 5.3 highlight these categories in relation to community, ethnicity, and gender. As previously discussed in other sections, the assumption for the statistical test was first checked (Section 3.7) before recording the significant values for the variables. The Chi-square tests indicated that there is no association between individual community, gender, and fuel type. The test found associations between ethnic groups, and fuel types (Table 5.3). This suggests that household cultural cooking practices that rely on '*aro meta*' (Sections 3.6.2 and 4.6.2) probably influence the use of biomass fuels. In addition, it appears that limited access to alternative fuels in all communities encourages greater use of biomass fuels (Section 2.6). Also, a lack of awareness about the health effects of using biomass fuel encourages biomass fuel use (Section 7.2), a problem exacerbated by the lack of stakeholders highlighting the problem of IAP in the area (Section 7.3). However, having access to and/or information about cleaner fuels is no guarantee that householders would use them (Section 2.6) due to their reliance on freely available biomass (Section 5.3.1).

Table 5.1: Percentage of fuel types by community

S/N	Community	Cooking fuel types		
		Category 1 17.7% (N=62)	Category 2 78% (N=273)	Category 3 4.3% (N=15)
1	Aba CAC N = 4	25% (1)	75% (3)	0 (0)
2	Agọ Aduloju N = 60	11.7% (7)	80% (48)	8.3% (5)
3	Agọ Corner N = 36	25% (9)	72.2% (26)	2.8% (1)
4	Alagorugba N = 2	100% (2)	0 (0)	0 (0)
5	Aroto N 13	30.8% (4)	69.2% (9)	0 (0)
6	Asọ Ayegunle N = 6	16.7% (1)	66.6% (4)	16.7% (1)
7	Ejiko N = 8	12.5% (1)	87.5% (7)	0 (0)
8	Ejimakogo N = 23	21.7% (5)	78.3% (18)	0 (0)
9	Elemi N = 9	0 (0)	100% (9)	0 (0)
10	Igbaitu N = 2	0 (0)	100% (2)	0 (0)
11	Igbaye N = 6	0 (0)	100% (6)	0 (0)
12	Ilamọ N = 21	0 (0)	95.2% (20)	4.8% (1)
13	Ilokun N = 55	18.2% (10)	76.3% (42)	5.5% (3)
14	Irasa N = 60	16.7% (10)	76.7% (46)	6.6% (4)
15	Isegere N = 3	33.3% (1)	66.7% (2)	0 (0)
16	Odoro N = 26	34.6% (9)	65.4% (17)	0 (0)
17	Oke Epa N = 2	0 (0)	100% (2)	0 (0)
18	Ologunja N = 4	50% (2)	50% (2)	0 (0)
19	Ọlora Camp N = 10	0 (0)	100% (10)	0 (0)

Note: χ^2 43.624 $p<0.179$

Note: Fuel type is by category 1=wood only; category 2=wood/kerosene; category 3=kerosene only

Table 5.2: Percentage of fuel types by ethnic group

Ethnic Group	Cooking fuel types		
	Category 1 17.7% (N=62)	Category 2 78% (N=273)	Category 3 4.3% (N=15)
Ebira N=265	17.7% (47)	79.6% (211)	2.6% (7)
Yoruba N=55	16.4% (9)	69.1% (38)	14.5% (8)
Tiv N=55	216% (4)	84% (21)	0 (0)
Hausa N=5	40% (2)	60% (3)	0 (0)

Note: χ^2 18.938 $p<0.004$

Table 5.3: Percentage of fuel types by gender

Gender	Cooking fuel types		
	Category 1 17.7% (N=62)	Category 2 78% (N=273)	Category 3 4.3% (N=15)
Male N=127	16.4% (22)	77.2% (98)	5.5% (7)
Female N=223	17.9% (40)	78.5% (175)	3.6% (15)

Note: χ^2 0.734 $p<0.693$

From Table 5.1, it can be demonstrated that no householders in Ilamọ and Ọlora Camp fall into category 1 (firewood user only). Category 2 (firewood user, but lights wood with kerosene) households are present in all of the communities, while a small proportion of householders in Agọ Aduloju, Agọ Corner, Ilamọ, Ilokun, and Irasa fell into category 3 (kerosene user only). Table 5.1 above further shows that households in some communities (Agọ Aduloju, Agọ Corner, Ejimakogo, Ilokun, Irasa, and Odoro) used at least two different fuel sources.

As noted in Table 5.2, 17.1 percent, 79.6 percent and 2.6 percent of households used categories 1, 2, and 3 respectively among the Ebira ethnic group. For the Yoruba householders, 16.4 percent, 69.1 percent and 14.1

percent used categories 1, 2, and 3 respectively. The Tiv households all fell into category 1 and 2 (16 percent and 84 percent respectively) as shown in Table 5.2. Notwithstanding ethnic background, all households had a strong preference for category 2 fuel use.

Table 5.3 identifies that both men (77.2 percent) and women (78.5 percent) have a strong preference for category 2 fuel and are least likely to opt for category 3 fuel for domestic activities. These Ado Ekiti results contrast with Rao and Reddy's (2007) findings that gender is a key factor influencing the choice of fuel for domestic activities. Most communities in this study appear to have access to fuel wood and kerosene, which brings to light the importance of availability and access to energy sources (Section 2.6).

The preference for fuel wood irrespective of community of residence, ethnic group, and gender (Tables 5.1, 5.2 and 5.3) can be influenced by cultural cooking practices (Section 3.5.2). Women and/or children have to trek between 0.5 and 10 kilometres from their houses to the forest in order to gather fuel wood. Distances travelled to collect wood fuel are usually determined by the prevailing weather conditions, with most collection taking place when weather conditions are dry. This is because in the rainy season, most footpaths and untarred roads leading to the forest become flooded and can be dangerous.

Table 5.4 shows a comparison of the quantities of wood fuel gathered during the wet and dry seasons. According to householders, it is easy to walk to the forest and collect wood fuel in the dry season, but the forest is bushy and difficult to navigate during the wet season. This echoes the study of Webb and Dhakal (2011) in Nepal who found that the convenience of collecting wood fuel is usually lowest during the rainy season.

This helps to explain why the largest proportion of households (75.5 percent) collects 'very sufficient' or 'sufficient' quantities[30] of wood fuel during the dry season. The wood is later left in open spaces within the community or under a shelter close to the collector's house to continue drying.

Table 5.4: Percentage of seasonal wood gathering amongst householders

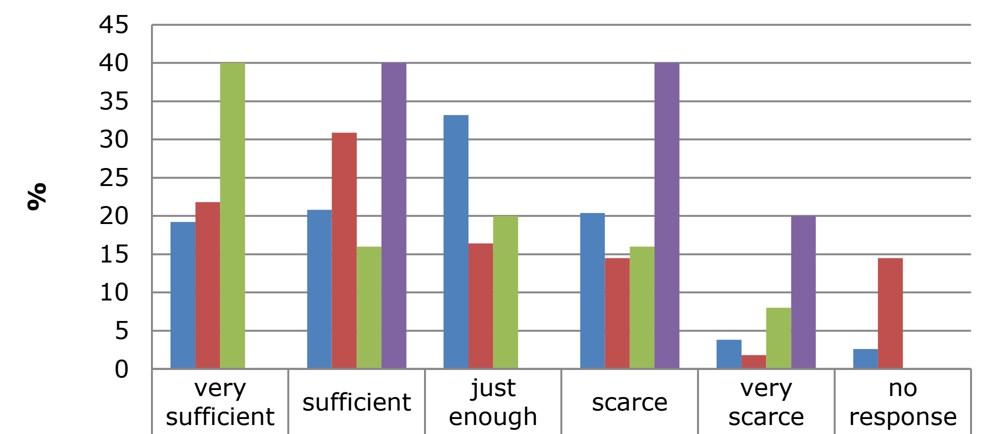
Scale	Wet season (N=350)	Dry season (N=350)
Very sufficient	20.9% (73)	50.6% (177)
Sufficient	22.3% (78)	24.9% (87)
Just enough	29.1% (102)	17.1% (60)
Scarce	19.4%(68)	2.6% (9)
Very scarce	4%(14)	0.3% (1)
No response	4.3% (15)	4.6% (16)

Despite the difficulties, fuel wood collection is still undertaken during the wet season and 42.2 percent of householders' claimed to collect 'very sufficient' or 'sufficient' quantities of wood fuel during this period.

From the analysis in Table 5.4, 29.1 percent of householders collect 'just enough' fuel to meet their immediate cooking needs in the wet season. On the other hand, 19.4 percent and 4 percent of the householders indicated that they collect 'scarce' or 'very scarce' amount of wood fuel during the wet season, because they have sufficient quantities stored for use in this period. The surplus wood fuel collected, either during the dry or wet season, is stored to compensate for future shortfalls when adequate quantities cannot

[30] I classified 'very sufficient' as wood fuel gathered to last for a period of 3 months; 'sufficient' – wood fuel that can last for 1 month; 'Just enough' – wood fuel for 2 weeks; 'scarce' – householders that rarely gather wood fuel within a month and 'very scarce' – those that rarely gather wood fuel within 2 months.

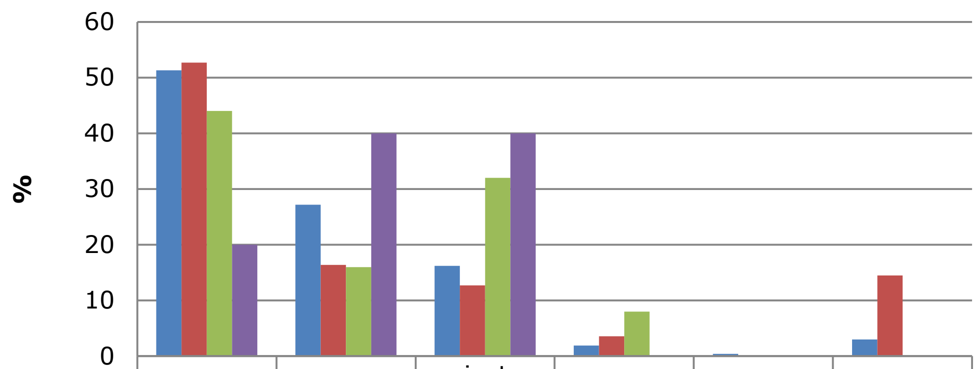
be gathered at once. Figure 5.1 shows that during the wet season, all ethnic groups indicated that they collect 'sufficient' quantities of wood fuel. As illustrated, 'just enough' wood fuel is collected by the Ebiras, Yorubas, and Tivs. All ethnic groups collect sufficient quantities of fuel so that they have enough to last a month and it is rare or very rare for them to gather wood fuel due to forest access difficulties in the wet season.



	very sufficient	sufficient	just enough	scarce	very scarce	no response
Ebira	19.2	20.8	33.2	20.4	3.8	2.6
Yoruba	21.8	30.9	16.4	14.5	1.8	14.5
Tiv	40	16	20	16	8	0
Hausa	0	40	0	40	20	0

Figure 5.1: Percentage of wood collection among the ethnic groups during wet season

On the other hand, during the dry season all ethnic groups indicated that they collect 'very sufficient' or sufficient' quantities of wood fuel (Figure 5.2). Interestingly, few Ebira householders (0.4 percent) reported the collection of 'very scarce' quantities of wood fuel during the dry season in comparison to other ethnic groups who do not undertake any wood collection during this period. This is probably because they have better access to the forest during the rest of the year (Section 6.2.1).



	very sufficient	sufficient	just enough	scarce	very scarce	no response
Ebira	51.3	27.2	16.2	1.9	0.4	3
Yoruba	52.7	16.4	12.7	3.6	0	14.5
Tiv	44	16	32	8	0	0
Hausa	20	40	40	0	0	0

Figure 5.2: Percentage of wood collection among the ethnic groups during dry season

5.2.2 Lighting Fuels and Sources

As mentioned earlier, the lack of electricity in communities necessitates the use of alternative forms of energy for lighting. Households make use of different energy sources to meet their needs.

As illustrated in Figure 5.3, other means through which houses are lit include kerosene lamps (59.1 percent), a combination of kerosene and local lamps (19.4 percent), a combination of kerosene lamp and generators (2.9 percent), the use of local lamps only (17.1 percent) and the use of candles only (1.4 percent). Local lamps are powered by batteries and come in two main forms: one having the shape of a kerosene lamp, while the other one is locally manufactured using old compact discs (CDs), which are then attached to a wooden base. Wires are then connected to batteries, bulbs and a control to switch it on and off (Figure 5.4).

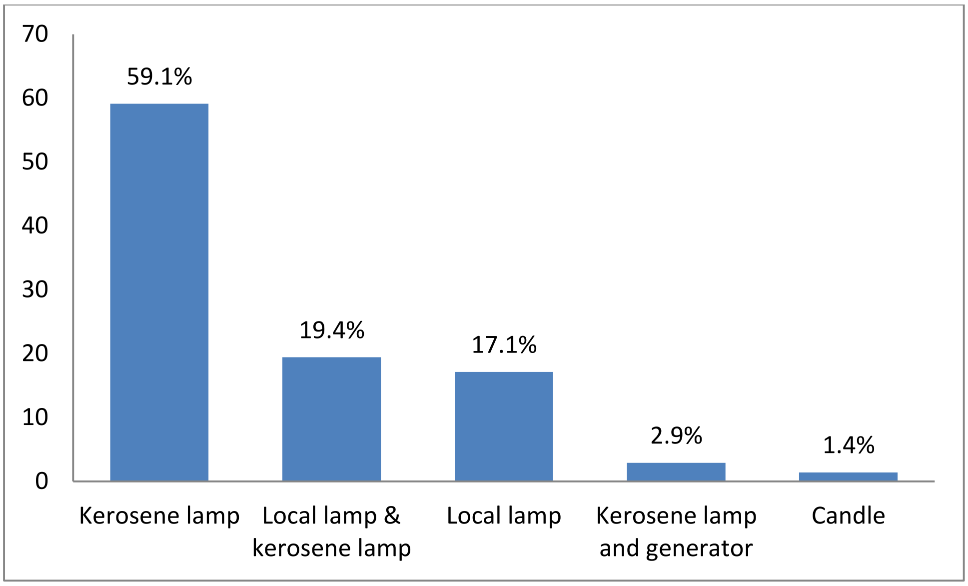


Figure 5.3: Means of lighting in the communities

Figure 5.4: Battery and Local lamps used by householders
Source: Author, August 2010

It is worth noting that 22.3 percent of householders in Ado Ekiti use multiple fuels (local and kerosene lamps, and, generator and kerosene lamp) for lighting. The local lamps are fairly efficient and clean and can probably be classified as clean fuels; however, availability and affordability (present and future cost) of batteries is one relevant attribute that householders take into consideration when deciding to make use of this type of lighting. Tables 5.5, 5.6, and 5.7 demonstrate how the source of lighting varies in the research area, broken down by community, ethnicity, and gender.

With the identification of different sources of lighting in Figure 5.3, a statistical test was performed to identify the significance of community, ethnicity, and gender to the source of lighting in the area. The Chi-square tests shows that there is an association between individual community and source of lighting. This indicates that the lack of infrastructural facilities like electricity (Section 3.5.3) has influenced local creativity in sourcing alternative technology for lighting purposes as later examined.

The sources of lighting shown in Table 5.5 reflect the types used in each of the communities. Local lamps are used at Aroto, Ejimakogo, Ilamọ, Ilokun, and Irasa. By contrast, it is only in Agọ Aduloju and Irasa communities that householders use candles. Kerosene lamps are used among householders in almost all the communities. There are kerosene and generator users amongst respondents from Agọ Corner, Aroto, Ilamọ, Ilokun, and Odoro. This perhaps suggests that these households have the financial capability to use cleaner fuels.

Table 5.5: Percentage of source of lighting by community

S/N	Community	Source of lighting				
		Local lamp 17.1% (N=60)	Candle 1.4% (N=5)	Kerosene lamp 59.1% (N=207)	Kerosene lamp and generator 2.9% (N=10)	Local lamp and kerosene lamp 19.4% (N=68)
1	Aba CAC N = 4	0 (0)	0 (0)	100% (4)	0 (0)	0 (0)
2	Agọ Aduloju N = 60	8.3% (5)	3.3% (2)	63.3% (38)	0 (0)	25% (15)
3	Agọ Corner N = 36	19.4% (7)	0 (0)	3.3% (12)	2.8% (1)	44.4% (16)
4	Alagorugba N = 2	100% (2)	0 (0)	0 (0)	0 (0)	0 (0)
5	Aroto N 13	30.8% (4)	0 (0)	23.1% (3)	7.7% (1)	38.4% (5)
6	Asọ Ayegunle N = 6	33.3% (2)	0 (0)	66.7% (4)	0 (0)	0 (0)
7	Ejiko N = 8	0 (0)	0 (0)	62.5% (5)	12.5% (1)	25% (2)
8	Ejimakogo N = 23	21.7% (5)	0 (0)	60.9% (14)	0 (0)	17.4% (4)
9	Elemi N = 9	0 (0)	0 (0)	77.8% (7)	11.1% (1)	11.1% (1)
10	Igbaitu N = 2	0 (0)	0 (0)	100% (2)	0 (0)	0 (0)
11	Igbaye N = 6	0 (0)	0 (0)	83.3% (5)	16.7% (1)	0 (0)
12	Ilamọ N = 21	14.3% (3)	0 (0)	52.4% (11)	9.5% (2)	23.8% (5)
13	Ilokun N = 55	18.2% (10)	0 (0)	67.3% (37)	1.8% (1)	12.7% (7)
14	Irasa N = 60	23.3% (14)	5% (3)	60% (36)	0 (0)	11.7% (7)
15	Isegere N = 3	33.3% (1)	0 (0)	66.7% (2)	0 (0)	0 (0)
16	Odoro N = 26	19.2% (5)	0 (0)	57.7% (15)	7.7% (2)	15.4% (4)
17	Oke Epa N = 2	0 (0)	0 (0)	100% (2)	0 (0)	0 (0)
18	Ologunja N = 4	50% (2)	0 (0)	50% (2)	0 (0)	0 (0)
19	Ọlora Camp N = 10	0 (0)	0 (0)	80% (8)	0 (0)	20% (2)

Note: χ^2 93.634 p<0.044

Table 5.6: Percentage of source of lighting by ethnic group

Ethnic Group	Source of lighting				
	Local lamp 17.1% (N=60)	Candle 1.4% (N=5)	Kerosene lamp 59.1% (N=207)	Kerosene lamp and generator 2.9% (N=10)	Local lamp and kerosene lamp 19.4% (N=68)
Ebira N=265	15.8% (42)	1.5% (4)	60.4% (160)	3% (8)	19.2% (51)
Yoruba N=55	20% (11)	1.8% (1)	50.9% (28)	1.8% (1)	25.5% (14)
Tiv N=25	24% (6)	0 (0)	64% (16)	4% (1)	0 (0)
Hausa N=5	20% (1)	0 (0)	60% (4)	0 (0)	0 (0)

Note: χ^2 5.732 p<0.929

Table 5.7: Percentage of source of lighting by gender

Gender	Source of lighting				
	Local lamp 17.1% (N=60)	Candle 1.4% (N=5)	Kerosene lamp 59.1% (N=207)	Kerosene lamp and generator 2.9% (N=10)	Local lamp and kerosene lamp 19.4% (N=68)
Male N=127	12.6% (16)	1.6% (2)	67.7% (86)	3.9% (5)	14.2% (18)
Female N=223	19.7% (44)	1.3% (3)	54.3% (121)	2.2% (5)	22.4% (50)

Note: χ^2 8.566 p<0.073

Table 5.6 reveals that all ethnic groups show a preference for kerosene lamps. Only Ebiras and Yorubas use all of the different sources of lighting identified in the study area, whereas the preferences of Tiv householders varied. In addition, both men and women indicated a preference for kerosene lamps as shown in Table 5.7, but no significant gender differences were identified regarding preferences for different lighting sources. Instead, emphasis was placed on the suitability of different lighting source depending on what tasks are carried out in household.

The relative accessibility, affordability, availability, and acceptability of different householders' energy choices as discussed in Section 2.4.1 provide a useful framework for investigating trends and impacts of household fuel use in the communities. For household lighting, accessibility and affordability are the main attributes determining fuel choice. For cooking fuel, convenience, access and cost are the main criteria which explains the preference for biomass fuel (wood) and kerosene, both of which are less efficient than clean energy (Ruiz-Mercado *et al*., 2011). Essentially, multiple fuels are being used for cooking and lighting by the majority of householders in the community at present and there was little indication that a complete switch to cleaner fuels would take place in the near future. This contrasts with the energy ladder, which indicates that householders progress to cleaner fuels (Section 2.4.1; Nansaior *et al*., 2011; Schlag and Zuzarte, 2008; Bailis, 2004; Masera *et al*., 2000). It also indicates that the energy ladder model needs to take more account of the socio-economic factors influencing fuel choice amongst resource poor households in the global South.

5.3 Socio-economic Characteristics of the Householders

In the account given in Section 5.2 of the uses, sources and types of domestic energy used by householders in the study area, it is clear that the constant demand for biomass fuel for cooking and lighting by the peri-urban population is multidimensional. There are a number of factors accounting for household fuel choices. Previous studies on domestic energy use in the global South (Rehfuess *et al*. 2011: Rao and Reddy, 2007) have indicated that householders' socio-economic status, education, age and dwelling characteristics have a clear impact on the type and choice of energy used for cooking and lighting.

Gender information (Section 3.6) is important because both men and women use domestic energy for either lighting or cooking and the socio-economic status of both gives a better perspective on how this indicator can influence fuel use in communities. As income is regarded as the key influence on access to modern energy services (OECD/IEA, 2010), it is important to consider how both males and females contribute to the financial needs of the family.

Riaz and Sughis (2011) argue that the use of biomass fuel is related to socio-economic class, which is greatly influenced by people’s income. The disproportionate distribution of income in developing countries is usually associated with people in rural areas having lower incomes compared to the residents of urban areas. This disadvantaged position typically encourages them to opt for low-cost domestic energy (Akther *et al*., 2010).

5.3.1 Income

As illustrated in Figure 5.5, income is derived from a variety of activities. 39 percent of the householders engage in trading (selling of palm wine foodstuff, cow skins, roasted meat and fish, fried cassava – *gari*, clothing materials). 38 percent of householders engage in farming activities in the communities. Other sources of income include a combination of farming and trading (17 percent), a dependence on families for their livelihoods (3 percent), public/private employment (2 percent), and the operation of commercial motors or motor cycles (1 percent). In communities, some men occasionally engage in hunting. Animals killed during the process are usually given to their wives to be sold. These are sold as roasted meat to passers-by and form part of the resources used in their trading activities but householders did not account for any wood fuel used for the smoking of such meat during the questionnaire survey. This echoes Bailis's (2004) finding that trading activities usually constitute a significant fraction of energy consumption unaccounted for in any society where they are practised, thereby creating knowledge gaps regarding such aspects of household energy consumption.

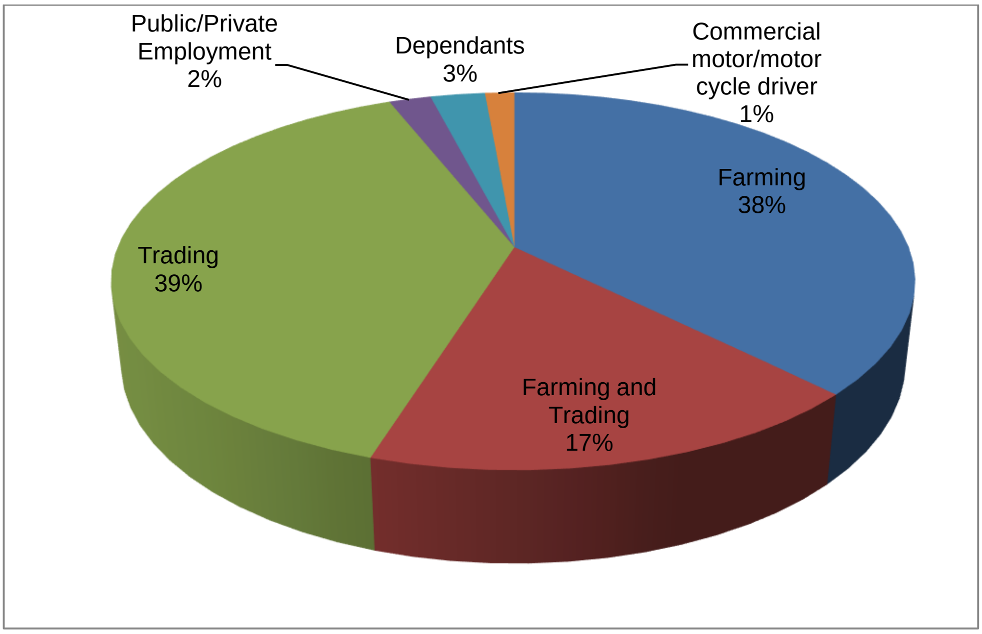


Figure 5.5: Sources of income of the respondents

As mentioned in Section 3.5, though some householders make remittances 'home', they did not describe how this affects their monthly income. Nonetheless, the significance of their years of occupancy (see Section 3.6.2) in the communities suggests that they perhaps give more attention to their needs in their present location than to 'home' as a majority of them have lived in the communities for more than five years (Table 3.2).

According to Sesan (2011), income groups in Nigeria can be classified into three levels: 'low-income earners' (US$ 0 – 130 per month), 'middle-income earners' (US$ 130 – 750 per month), and 'high-income earners' (US$ 750).

Bench marking these categories[31] with the incomes of householders in the study area, average income levels can be grouped into low-income earners (₦0 – 20000/month) and middle-income earners (above ₦20000/month) groups.

In classifying the average monthly income data presented in Figure 5.6, the largest number (39.4 percent) of respondents' fell within the ₦5000 – ₦10000[32] (£20 - £40/$32 - $65) monthly income category and 38.1 percent of respondents earned an average income below five thousand naira. 8.9 percent and 5.4 percent earned monthly incomes of between ₦10001 – ₦15000 and ₦15001 – ₦20000. Only 6.9 percent of the respondents earned above ₦20000 in the study area. Further analysis in Tables 5.8 and 5.9 highlights the variation of income broken down by ethnicity and gender.

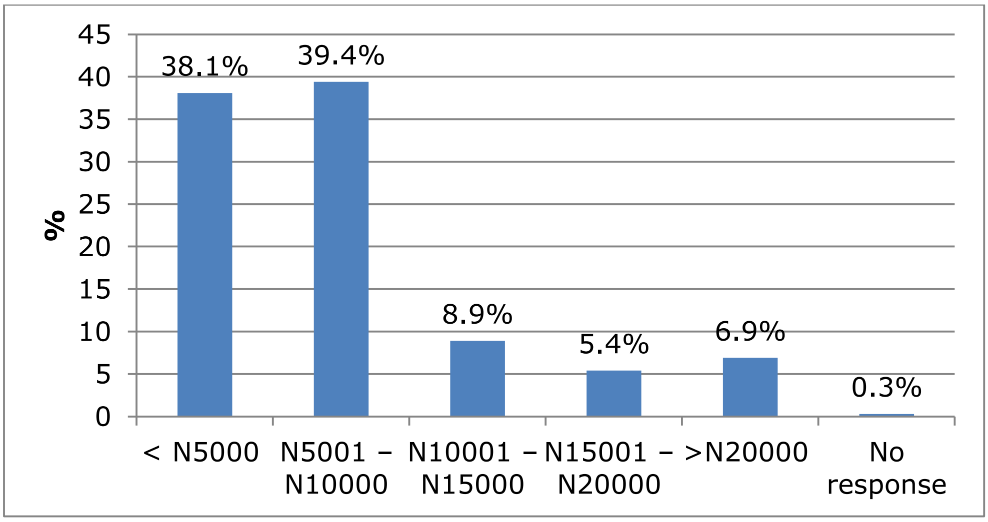


Figure 5.6: Monthly income of the respondents

To understand the influence of ethnicity and gender on income in determining the choice of domestic fuel amongst householders, the Chi-square tests show that there is an association between ethnic group, gender,

[31] Where $1 = ₦155 (exchange rate at the time of data collection)

[32] Where £1 = ₦250 (exchange rate at the time of data collection)

and income. This means that householders' income probably reflects earnings associated with their occupation, which would determine the allocation of money within the family.

As shown in Table 5.8, 39.2 percent of Ebira households earned below ₦5000/month while 53.6 percent earned between ₦5001 – 20000/month). For the Yorubas, 32.7 percent have incomes below ₦5000/month and the income of 58.2 percent of householders was between ₦5001 – 20000/month. Among the Tivs, 40 percent of the householders earned below ₦5000/month and 56 percent of them had incomes of between ₦5001 – 20000/month. Apart from the 7.2 percent of Ebira and 9.1 percent of Yoruba households who fall within the middle-income category (above ₦20000/month), the rest fell within the low-income category (₦0 – 20000/month), while all Tiv households are low-income earners.

Furthermore, the income analysis based on householders' gender in Table 5.9 highlights that 31.5 percent of men earned below ₦50000/month, 55 percent of men had incomes between ₦5001 – 20000/month and 13.4 percent of them earned above ₦20000/month. Among the women 43.3 percent, 52.9 percent and 3.1 percent earned below ₦50000/month, between ₦5001 – 20000/month and above ₦20000/month respectively. 13.4 percent of men and 3.1 percent of women can be considered within the middle-income category but ultimately the remaining householders can be classified as low-income earners.

Table 5.8: Percentage of monthly income by ethnic group amongst study participants

Ethnic Group	Monthly income ₦					
	<5000 39.1% (N=137)	5001 – 10000 39.4% (N=138)	10001 – 15000 8.9% (N=31)	15001 – 20000 5.4% (N=19)	>20000 6.9% (N=24)	No response 0.3% (N=1)
Ebira N=265	39.2% (104)	39.6% (105)	9.1% (24)	4.9% (13)	7.2% (19)	0 (0)
Yoruba N=55	32.7% (18)	40% (22)	7.3% (4)	10.9% (6)	9.1% (5)	0 (0)
Tiv N=25	40% (10)	44% (11)	12% (3)	0 (0)	0 (0)	4% (1)
Hausa N=5	100% (5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Note: χ^2 28.615 p<0.018

Table 5.9: Percentage of monthly income by gender amongst study participants

Gender	Monthly income ₦					
	<5000 39.1% (N=137)	5001 – 10000 39.4% (N=138)	10001 – 15000 8.9% (N=31)	15001 – 20000 5.4% (N=19)	>20001 6.9% (N=24)	No response 0.3% (N=1)
Male N=137	31.5% (40)	41.7% (53)	10.2% (13)	3.1% (4)	13.4% (17)	0 (0)
Female N=138	43.5% (97)	38.1% (85)	8.1% (18)	6.7% (15)	3.1% (7)	0.4% (1)

Note: χ^2 18.544 p<0.002

With the highlighted economic classification and similar findings by the Cleancook project in Nigeria (Sesan, 2011), it is easy to see why low (or no) cost fuels such as biomass (wood) and kerosene are dominant in the study community. In addition, the pricing (both monetary and non-monetary) of energy resources vis-à-vis household income determines energy used for domestic activities (Miah *et al*., 2011).

The energy cost for householders using wood fuel could not be calculated as most householders are unable to quantify either the quantities or cost of wood used monthly. Part of the difficulty relates to the fact that households did not keep records of the volumes of wood fuel collected. In addition, most wood fuel is freely collected from the forest although there is a clear non-financial energy cost in the form of the opportunity cost of time spent in wood gathering. Zerriffi (2011), however, argues that when comparisons of the effective cost of energy per unit (in terms of time and transaction costs of gathering fuel) are made between poorer and richer households, poor households are at a disadvantage, as they spend more time collecting each unit of energy that they consume.

The price of different energy sources at the time of data collection in 2011 varied from kerosene costing ₦450 for four litres and a 12.5kg cylinder of LPG costing ₦3200. One 12.5kg LPG cylinder typically lasts a seven-person household[33] for four weeks (28 days) with three meals being cooked daily, which makes an average energy cost of ₦16.33 per person/day. This shows that any householder within the middle-income earner group will be spending 16 percent of their income on domestic energy.

On the other hand, for an average family of seven cooking three meals daily with a cooking duration of at least two hours for each meal, the four litres of kerosene will only last for seven days. This means they will have to spend an average of ₦1800 on fuel per month (28 days), thereby, making the energy cost ₦9.18 per person/per day. For a middle-income earner, 9 percent of their monthly income will be spent on domestic energy. With the monthly income of a middle-income earner, those using LPG will spend more on fuel in comparison to someone whose key energy source is kerosene.

An energy cost of ₦9.18 per person/day for kerosene may not be affordable for low-income households in the study area, as they have to spend higher

[33] About 70 percent of households in the study area have an average of at least seven members.

percentages of their income on domestic energy. This is unlikely to be sustainable over time: a situation that accounts for the high degree of reliance on cheaper (or free) energy such as fuel wood. Given that households have additional expenditure such as food, clothing, and transportation, the use of modern fuels is likely to be quite difficult. This is especially the case for 92.8 percent of the householders in this study who are classed as low-income earners (₦0 – 20000/month) (Figure 5.6).

It can therefore be summarised that slight differences in income levels amongst the low-income households do not result in great variations in energy choice in the study area. The implication of this is that energy requirements for fulfilling the basic needs of householders (cooking and lighting) in the study area focus on the lowest possible cost (Wickramasinghe, 2011), especially since 92.8 percent of households are regarded as low-income.

5.3.2 Educational Qualifications

The preceding section has illustrated how the fuel types identified earlier in the chapter are linked to income groups in the study area, indicating the importance of income for energy choice in homes. This section focuses on the educational level of the householders, as this can also influence their choice of domestic energy (Smith, 2002).

In this study, 38 percent of householders had attended primary school, and 32.3 percent do not have any formal education. In addition, 26 percent of householders have secondary school education and the remaining 3.8 percent have higher educational qualifications (Figure 5.5). The Chi-square tests further indicate that there is an association between ethnic group, gender, and educational qualifications. This probably shows that most people that engage in farming activities in the area usually have low educational levels (Section 3.5.2). This may reflect limited access to educational facilities (Section 3.5.3), and/or householders' paucity of funds to support educational training.

The analysis presented in Table 5.10 highlights that 32.1 percent of Ebira householders have no formal education. 39.1 percent and 26.8 percent have primary and secondary school level education, and 1.9 percent have education above secondary school level. Among the Yorubas, 27.3 percent have no formal education, whereas, 32.7 percent and 29.1 percent have primary and secondary school education and 10.9 percent have education above secondary school level. Among the Tivs, 32 percent are without formal educational and 44 percent have primary school education. In addition, 16 percent have secondary school education and 8 percent have education above secondary school level.

The analysis presented in Table 5.11 shows that 26 percent of the men lack any formal education, while the remaining 74 percent have formal education. Among women, 35.9 percent have no formal education and 64.1 percent have attained some level of education in the area. Considering the primary level of education of householders (Table 5.11), women appear to have had a better education than men but as girls grow and their socio-cultural responsibilities become greater than boys, there is a wider educational gap between men and women.

As illustrated in Figure 5.7 and Tables 5.10 and 5.11, there is a decline in education after primary school level. One of the possible reasons for the higher numbers of residents who have primary and secondary education might be linked to the provision of free education available to residents of the state. All education above secondary school level has to be paid for and there is no provision for bursaries from the government to support students.

Parents or guardians thus bear the cost of schooling and this can increase family expenditure (paying tuition) leaving less available finances to allow a shift in their energy choices away from biomass fuels (wood).

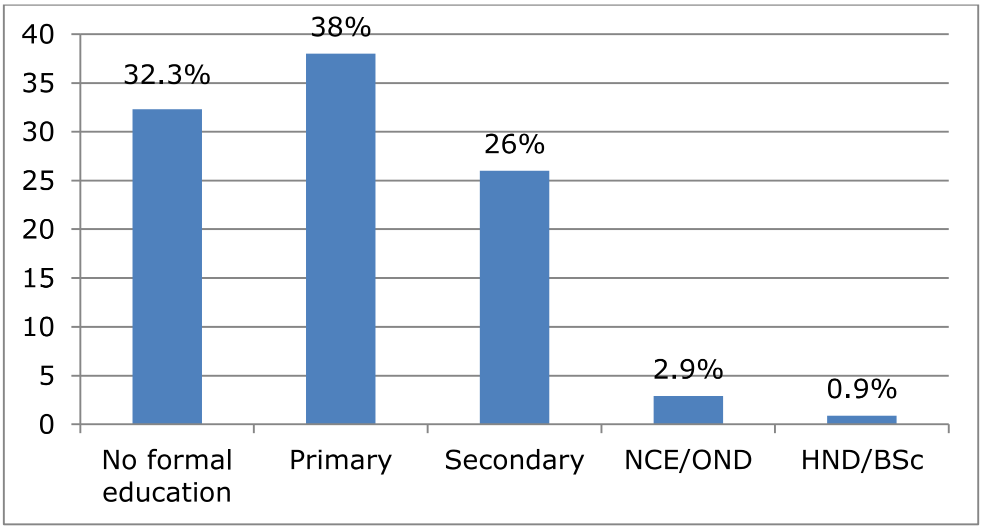


Figure 5.7: Educational qualification of the respondents in percentages

Table 5.10: Percentage of educational qualification by ethnic group amongst study participants

Ethnic Group	**Educational Qualification**				
	Primary 38% (N=133)	Secondary 26% (N=91)	NCE/OND 2.9% (N=10)	HND/BSc 0.9% (N=3)	No formal education 32.3% (N=113)
Ebira N=265	39.2% (104)	26.8% (71)	1.5% (4)	0.4% (1)	32.1% (85)
Yoruba N=55	32.7% (18)	29.1% (16)	7.3% (4)	3.6% (2)	27.3% (15)
Tiv N=25	44% (11)	16% (4)	8% (2)	0 (0)	32% (8)
Hausa N=5	0 (0)	0 (0)	0 (0)	0 (0)	100% (5)

Note: χ^2 26.529 $p<0.009$

Table 5.11: Percentage of educational qualification by gender amongst the study participants

Gender	Educational Qualification				
	Primary 38% (N=133)	Secondary 26% (N=91)	NCE/OND 2.9% (N=10)	HND/BSc 0.9% (N=3)	No formal education 32.3% (N=113)
Male N=127	31.5% (40)	36.2% (46)	3.9% (5)	2.4% (3)	26% (33)
Female N=223	41.7% (93)	20.2% (45)	2.2% (5)	0 (0)	35.9% (80)

Note: χ^2 18.760 $p<0.001$

More importantly from the above figure and tables, it is possible to predict the influence of education as it relates to the chosen fuels used by householders in the study area and confirms earlier studies in developing countries. People with low levels of education in developing countries mostly use biomass fuels for cooking, heating, and lighting (Rehfuess *et al*., 2010). Based on a Bangladeshi case study, Miah *et al*. (2011) argue that there is a latent effect of literacy on energy choice, household income, availability of energy resources and pricing (both monetary and non-monetary) which cannot be separated from what determines domestic energy use in homes. The study further noted that a key obstacle in choosing efficient energy sources was education deficiency among rural dwellers of Bangladesh who preferred biomass fuel, in comparison to their more literate counterparts in semi-urban areas who chose kerosene as their main energy source. The findings from research in Ado Ekiti where householders are mainly low-income earners (Section 5.3.1) and have low educational qualifications (Figure 5.7) confirms the results of Miah et al.'s (2011) study with regard to the linkages between energy choices, income and educational level.

Rao and Reddy (2007) argue that education and geographical location of householders in rural India are also influential in their choice of energy along with income, occupation, religion, caste and gender which are the most important factors influencing choice in the area. As the number of years spent in school increases, households' probability of opting for modern fuels (LPG) also increases and they are less likely to use wood fuel. In addition, it was found that higher educational levels create additional opportunities for employment, thereby increasing income levels and opening up the possibility of using modern energy sources. Pachauri *et al*. (2004) in contrast note that households in India with informal education and low-income levels do not tend to use biomass fuels if they have access to more efficient energy sources.

In summary, the low educational level of householders in Ado Ekiti, Nigeria to an extent translates into household income status, presumably indicating why the dominant energy source in the study area (wood) is chosen for their domestic energy. Energy services in Ado Ekiti, Nigeria are multidimensional and cannot be based only on households' educational and income levels. Other indicators such as age might also influence fuel choice. The next section examines the age composition of householders in the study area as one of the key factors that might influence decisions for which type of fuel is used for cooking and lighting.

5.3.3 Age Distribution of the Householders

In Nigeria, the active working population is within the 20 – 59 years age group (National Bureau of Statistics, 2009). From the observations in Figure 3.6, 99.7 percent of the householders fall within this group (Section 3.6). Findings from the study area as presented in Figure 5.8 indicate that a minimal number of people below the age of twenty participated in the survey (4.3 percent). 26.3 percent of selected householders were within the age cohort of 21 – 30 years. The largest average age group for sample householders in the study area was within the range of thirty one to forty years (32 percent). Other age groups comprising of 41 – 50 (18 percent) and above fifty years (19.4) made up the remaining sample of householders in the study area. However, a further breakdown of the analysis in Tables 5.12 and 5.13 by ethnic group and gender ascertain the age distribution of those that participated in the survey. The Chi-square tests show that there is an association between ethnic groups and age. As farming activities support a majority of householders' means of livelihoods, this may have encouraged people of active working age to settle in these communities.

The analysis presented in Table 5.12 indicates that 30.9 percent of respondents are 31 – 40 years old, 20 percent are between 41 – 50 years, and 7.2 percent of the householders are over 50 years. Amongst the Yorubas 9.1 percent are below twenty and 12.7 percent are between 21 – 30 years. Those between the ages of 31 – 40 years are 30.9 percent, 10.9 percent among them are of the age cohort of 41 – 50 years, and 9.1 percent are above fifty years of age. Among the Tivs, nobody below the age of twenty and above fifty years participated in the survey, while 28 percent are between 21 – 30 years. The remaining householders are between 41 – 50 years (16 percent).

Furthermore, the gender analysis of householders that participated in the study as shown in Table 5.13 indicated that 3.9 percent of men are below twenty years. 28.5 percent are between 21 – 30 years and 27.6 percent are between 31 – 40 years. Among women participants 4.5 percent are below twenty years and 25.1 percent are within the age of 21 – 30 years and 34.5 percent of them fell within the age cohort of 31 – 40 years, 18.4 percent between 41 – 50 years, and 17.5 percent are above fifty years.

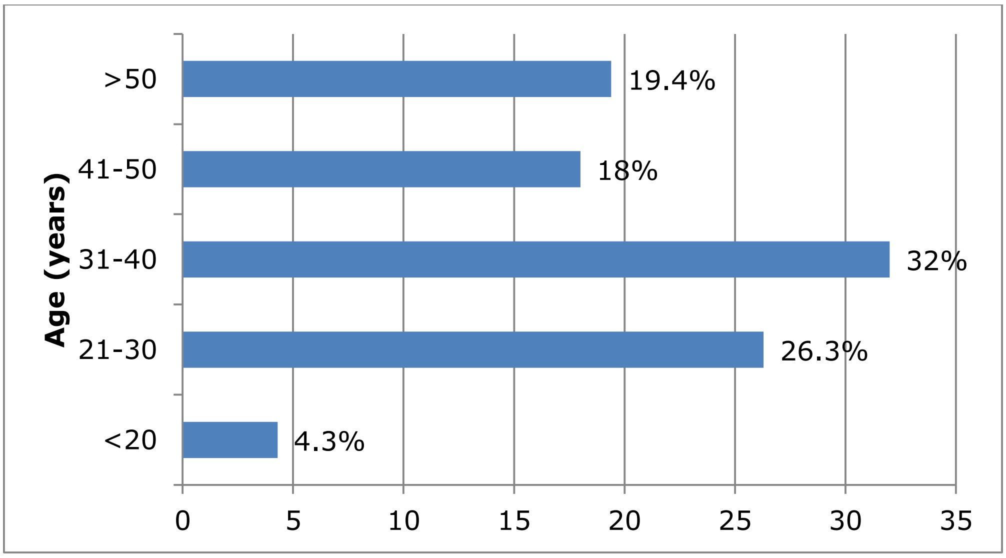


Figure 5.8: Age distribution of the respondents

Table 5.12: Age distribution among the ethnic group amongst study participants

Ethnic Group	Age group				
	<20 4.3% (N=15)	21 – 30 26.3% (N=92)	31 – 40 32% (N=112)	41 – 50 18% (N=63)	>51 19.4% (N=68)
Ebira N=265	3.7% (10)	29.1% (77)	30.9% (82)	20% (53)	7.2% (43)
Yoruba N=55	9.1% (5)	12.7% (7)	30.9% (17)	10.9% (6)	9.1% (20)
Tiv N=25	0 (0)	28% (7)	44% (11)	16% (4)	0 (0)
Hausa N=5	0 (0)	20% (1)	40% (2)	0 (0)	40% (2)

Note: χ^2 24.870 $p<0.015$

Table 5.13: Age distribution by gender amongst study participants

Gender	Age group				
	<20 4.3% (N=15)	21 – 30 26.3% (N=92)	31 – 40 32% (N=112)	41 – 50 18% (N=63)	>51 19.4% (N=68)
Male N=117	3.9% (5)	28.3% (36)	27.6% (35)	17.3% (22)	22.8% (29)
Female N=223	4.5% (10)	25.1% (56)	34.5% (77)	18.4% (41)	17.5% (39)

Note: χ^2 2.848 $p<0.584$

On the basis of the graph and tables above, it appears that the majority of householders have the potential to earn income for family subsistence. Income earners within the active working age group have the potential to influence energy choice in homes since they provide funds for domestic energy purchases. The implication of this is that age naturally correlates with income and expenditure, which might influence fuel type used for cooking and lighting (Lenzen *et al*., 2006). When householders cannot afford clean energy fuels, they opt for low priced fuels, a relationship which is examined in detail in Section 5.4.

An overview of the analysis in this section has shown the importance of ethnicity and gender (Tables 5.8, 5.9, 5.10, 5.11, and 5.12) among householders in relation to socio-economic factors contributing to choice of cooking fuel and lighting. This suggests that cultural ideology could possibly influence educational training in the area, which could have increased knowledge about the effects of using biomass fuels for domestic activities.

As mentioned previously, most householders in peri-urban areas in Ado Ekiti belong to the low-income group whose earnings are presumably reflected their fuel types and choices (Section 5.3.1). The Ado Ekiti findings corroborate Pachauri *et al*.'s (2004) position that a high percentage of households with low incomes are reflected in the energy consumption pattern of households in developing countries, who often lack the purchasing power for cleaner fuel and have to depend highly on biomass. The limitation constituted by their low educational qualification excludes them from the possibility of earning higher wages that might sustain the use of cleaner fuel. As the enormous task of fulfilling family commitments increases, it is likely that households with a number of dependents that require financial support will continue to use biomass fuel. Though the importance of each of these factors has been highlighted, there are additional factors (i.e. norms, jealousy) that will be discussed in Chapters Six and Seven. Section 5.4, relates socio-economic factors together with the fuel types in the study area and will draw comparisons between key influences on choice.

5.4 Relationship between Fuel Types, Income, Education, and Age in the Study Area

The discussion in earlier sections explained how income, education, and age factors of the householders related to the choice of energy types in the study area. However, combining these factors is critical to understanding fuel choice in the study area. This section therefore examines the relationship between fuel type(s) and socio-economic factors of householders. In this section, fuel types as categorised in Section 5.2.1 (category 1 – firewood user only; category 2 – firewood user, but lights wood with kerosene and category 3 – kerosene user only) form the basis for the discussion. People in rural areas of developing countries often use multiple stoves and fuels to efficiently meet household domestic energy needs (Balakrishnan *et al*., 2004) as against the linear progression to clean fuels suggested by the energy ladder (Chapter Two; Schlag and Zuzarte, 2008; Bailis, 2004; Masera *et al*., 2000). This seems to suggest that rather than measure progress for uptake of cleaner fuels, it is more important to understand factors determining energy choice. This is also the case in this study where 78 percent of households, like those in Bangladesh observed by Miah *et al*. (2011) used kerosene to ignite wood fuel.

From Table 5.14, the energy source within each income group suggests that for those whose income is less than ₦5000, 18.2 percent, 77.4 percent and 4.4 percent use category 1, 2 and 3 fuels respectively. For the income group of ₦5000 – ₦10000, the category 1, 2 and 3 fuel type users vary from 14.5 percent, 79.7 percent to 5.8 percent respectively. For both income groups

(₦10000 – ₦15000 and ₦15000 – ₦20000), category 1 and 2 fuel type represent 22.6 percent and 77.4 percent, and 26.3 percent and 73.7 percent respectively. In the last income level where householder's average monthly earnings are above ₦20000, 20.8 percent, 75 percent and 4.2 percent fall within category 1, 2 and 3 respectively. It is clear from Table 5.14 that low-income earners (as earlier defined), use energy sources ranging from category 1 – 3. Furthermore, the Chi-square tests carried out shows that there is association between educational qualification, and fuel types. The test found no association between income, age, and fuel types. This means that householders' responses regarding fuel types by their educational qualifications are different from one another, while responses are not different when income and age were considered.

The analysis in Table 5.14 shows that even amongst the middle-income earners, the category 2 type of fuel is most widely used. Although the percentage of respondents from the middle-income group is minimal in comparison to those in the low-income groups, the results presented show that even with increased income householders preferred category 2 fuel. Although 4.4 percent of households with incomes of less than ₦5000 and, 5.8 percent earning above ₦15000 use the category 3 (kerosene) fuel type, this does not translate into a complete switch to clean fuels. Balachandra (2011:5560) found that even where subsidised kerosene was provided, poor rural households in India still preferred cooking with biomass fuels, because the reality was that such households could not move away from 'free cooking fuels' to 'paid cooking fuels' even if provided at low prices.

Table 5.14: Percentage of income, education, and age of the respondents by fuel types

Fuel Type*	Income groups					
	<₦5000 39.1% (N=137)	₦5001-₦10000 39.4% (N=138)	₦10001-₦15000 8.9% (N=31)	₦15001-₦20000 5.4% (N=19)	>₦20000 6.9% (N=24)	NR 0.3% (N=1)
Category 1 N=62	18.2% (25)	14.5% (20)	22.6% (7)	26.3% (5)	20.8% (5)	0 (0)
Category 2 N=273	77.4% (106)	79.7% (110)	77.4% (24)	73.7% (14)	75% (18)	100% (1)
Category 3 N=15	4.4% (6)	5.8% (8)	0 (0)	0 (0)	4.2% (1)	0 (0)
Note: χ^2 5.467 p<0.858						
	Educational Qualifications					
	None 32.3% (N=113)	Primary 38% (N=133)	Secondary 26% (N=91)	NCE/OND 2.9% (N=10)	HND/BSc 0.9% (N=3)	
Category 1 N=62	27.4% (31)	10.5% (14)	16.5% (15)	20% (2)	0 (0)	
Category 2 N=273	71.1% (81)	85% (113)	76.9% (70)	70% (7)	66.7% (2)	
Category 3 N=15	0.9% (1)	4.5% (6)	6.6% (6)	10% (1)	33.3% (1)	
Note: χ^2 22.958 p<0.003						
	Age Distribution					
	<20 4.3% (N=15)	21-30 26.3% (N=92)	31-40 32% (N=112)	41-50 18% (N=63)	>51 19.4% (N=68)	
Category 1 N=62	13.3% (2)	13% (12)	22.2% (17)	22.2% (14)	25% (17)	
Category 2 N=273	80% (12)	81.5% (75)	76.2% (89)	76.2% (48)	72.1% (49)	
Category 3 N=15	6.7% (1)	5.4% (5)	1.6% (6)	1.6% (1)	2.9% (2)	
Note: χ^2 7.120 p<0.524						

Note: NR – No response

*Fuel type is by category 1=wood only; category 2=wood/kerosene; category 3=kerosene only

As a higher percentage of householders use category 1 and 2 energy sources, earning a higher income does not necessarily translate into shift to cleaner fuels in the study area. Though the number of respondents with high income is minimal (Section 5.3.1 and Figure 5.6), householders' responses as indicated in Table 5.14 suggests that their choice of fuel type is similar to the low-income groups. In addition, the Chi-square test has shown that income is not significant for householders when choosing fuel types. This result is at variance with other studies (Balachandra, 2011; Rehfuess, *et al*., 2011; Massey, *et al*., 2009; Heltberg, 2004; Bruce, *et al*., 2004; Mishra *et al*. 1999) which argue that as income increases, householders have increased access to modern fuels. Householders in all income groups in this study preferred non-commercial fuel, which Pachauri *et al*. (2004) suggest will always happen when there is no access to markets to purchase commercial fuels as discussed in Chapter Two. A crucial issue influencing the choice of energy type is accessibility. In this study, if cleaner fuels are not easily accessible for householders to purchase, when their income increases, a shift to cleaner fuel might be difficult. It is, however, important to note that householders with low incomes might not be able to afford energy services that modern energy carriers can provide (Balachandra, 2011) even if they have access to them.

Data from Ado Ekiti suggests that increases in income do not increase access to cleaner fuels as connecting to modern energy sources such as LPG requires some initial cost in terms of households facilities that need to be put in place (this involves purchase of LPG cylinder, gas cooker, regulator etc.). Since Nigeria has not put into place any form of central infrastructure for distributing LPG into homes in either urban or rural areas, increased access to cleaner fuel in the study area is likely to be difficult for low income households. In addition, energy choice can reflect the geographical location of householders' settlements in relation to fuel retail points with distant retail points being less accessible and also frequently more expensive. There is also the additional cost of commuting between home and fuel retail outlets to purchase fuel such as LPG, which is likely to discourage the adoption of cleaner fuel and encourage the use of biomass fuels, which supports Zhou *et al.*'s (2011) study. It is apparent in the study area that free wood fuel has a tendency to compete with cleaner fuels, because switching to cleaner fuels means an increase in energy expenditure in the household as discussed in Section 5.3.1.

In addition, it appears that physical access to the market does not automatically translate into households having the purchasing power to use cleaner fuel. For example, Howells *et al*.'s (2005) study in South Africa among rural households with low-incomes shows that when a subsidized electricity programme was set up, it failed because households were unable to pay their bills and the electricity was disconnected. In Ado Ekiti, market prices of fuel are important as there are varying retail fuel prices in Nigeria that fluctuate with global petroleum prices. The on-going full deregulation of the petroleum sector (that started in January 2012 by the Nigerian government) will encourage energy prices to continue to rise in retail outlets, thus, putting low-income earners at a further disadvantage in purchasing cleaner fuels. This supports Haines *et al.*'s (2007) position that people have the propensity to use the energy resources that they can afford. The results from Ado Ekiti further confirm Peng *et al.*'s (2010) study on household fuel switching in rural Hebei where resource scarcity and access to fuels act as barriers to households using clean energy sources. As the monetary cost of commercial fuel can change over time, stabilizing energy cost in line with householders' incomes might be practically impossible, as they have to cater for other needs in the family. Decisions therefore are made according to pressing needs and resource allocation patterns that depend on the needs of other family members, rather than being based solely on planned expenditure (Wickramasinghe, 2011). This means that provision for domestic energy is excluded from the list of priority concerns among the householders in the study area.

More importantly, the energy costs discussed in Section 5.3.1 suggest that the average monthly earnings of householders compared to the amount spent on energy per person/day will increase if households use cleaner fuels. As family members increase, households are even less likely to choose cleaner fuels in the face of rising energy costs. The Ado Ekiti findings support Miah *et al.*'s (2011) position that as people with more family members consume relatively more energy for their domestic activities, household expenditure on energy will increase with family size, and is likely to act as a barrier to using cleaner fuels. As the economic situation of Nigeria continues to deteriorate, the increasing cost of living has caused a downwards spiral in the quality of life (Maconachie and Binns, 2006) which means that over time households may not be able to afford clean energy.

Not only does income affect energy choice amongst householders in the study area, but also their educational status presumably reflects on their choice of fuel type as earlier stated in the statistical test. With reference to Table 5.14, householders with no formal education are the lowest users of category 3 fuel (0.9 percent), while 27.4 percent and 71.1 percent used category 1 and 2 fuels respectively. The data suggest that householders with primary education in the study area do make use of fuel types in all categories (1=10.5 percent; 2=85 percent and 3=4.5 percent). For the secondary educational level, energy types include category 1 (16.5 percent), category 2 (76.9 percent) and category 3 (6.6 percent). For householders with NCE/OND educational level, their energy types include category 1 (20 percent), category 2 (70 percent) and category 3 (10 percent). The last educational levels in the table use category 2 (66.7 percent) and category 3 (33.3 percent) energy types.

Within the age groups in Table 5.14, householders below twenty years of age mostly use category 2 fuel type (80 percent) with 13.3 percent and 6.7 percent using category 1 and 3 respectively. In the age group of 21 – 30 years, energy sources vary between categories 1 – 3 (13 percent, 81.5 percent and 5.4 percent respectively). For those in age groups 31 – 40 years and 41 – 50 years, the percentages of householders using category 1 – 3 fuel types are the same (22.2 percent, 76.2 percent and 1.6 percent respectively). For those in the age group above fifty years, 25 percent use category 1 fuel type, while 72.1 percent and 2.9 percent used category 2 and 3 fuel types respectively. As the table shows, category 2 is widely used across age groups in the study area. Consistent with discussions in Section 5.3.1, age cannot be decoupled from income level of the householders; hence, energy costs that bear on householders' expenditure will be discounted for biomass fuel (Gupta and Köhlin, 2006).

It is clear that socio-economic factors in relation to fuel types used by householders in the study area are not closely linked to energy choices. The Ado Ekiti study supports Wickramasinghe's (2011) assertion that decisions on energy sources for domestic use are made in relation to income for a majority of households that live below or marginally above the poverty level. Householders in this study can be described as living below the poverty level as a majority of the householders (77.5 percent) earned below N10000/month (below $2/day) (Figure 5.6).

Balachandra (2011) suggests that low income constrains householders in rural areas of developing countries from accessing cleaner fuels. This is confirmed in the Ado Ekiti study where 92.8 percent of householders fall into the low-income category. As such, householders are not limited by financial constraints, as wood fuel is free but there are associated constraints such as time spent in harvesting wood that impact on energy choices. Non-commercial energy sources (wood and other biomass) are preferred amongst most householders as is the case in rural Sri Lanka despite the fact that householders have access to electricity (Wickramasinghe, 2011). Increases in income, therefore, do not necessarily mean using cleaner fuel. Householders in the global South have been found to use multiple fuels (Pachuari *et al*., 2004). This gives an indication that when considering fuel types in the study area, it is perhaps best to consider the educational qualifications and income of the householders in understanding their choice of domestic energy. In all of the relationships studied in this section, the data analysis from the household questionnaire has provided data on key socio-economic factors influencing household energy choices. A more qualitative analysis of these energy choices will be provided in Chapters Six and Seven which provide in-depth insights into the core reasons for using biomass fuels in peri-urban areas of Ado Ekiti.

5.5 Conclusion

This chapter has identified energy types used for cooking and lighting in the study area. The questionnaire responses revealed that respondents relied on biomass fuels for carrying out their domestic energy activities. The choice of fuel type(s) in Ado Ekiti is influenced by accessibility (the free harvesting of wood fuel from the forest) and the convenience of harvesting wood fuel with no restrictions on time and the quantities that are needed. The analysis in this chapter, suggests that income, education, and age factors contributed to households’ decisions on fuel types in Ado Ekiti. Education, however, was found to be statistically significant in influencing choice of fuel types in the area probably because the results only reflected the views of those that participated in the study, which possibly cannot be generalised. As stated previously, the efficiency and cleanliness of wood fuel is low as it is commonly burnt over an open fire. However, some alternative technologies that run on batteries are used for lighting in the study area.

It was noted from the data analysis that socio-economic factors (income, education, and age) cannot be separated easily from other influences on fuel choices. Even though the number of high-income participants is low in the study area, the results highlighted householders' views when choosing fuel types. While statistical tests showed that income is not that important in determining types of fuel used for domestic activities in the area, this might reflect the fact that most householders are low-income earners, which however limits the generalizability of the results. It is instructive that earning a higher income does not translate into an inclination towards using cleaner fuel. Indeed, it is likely that fuel stacking will become more likely as cost and accessibility issues prevent low and middle-income households from purchasing cleaner fuel.

Beyond the socio-economic factors, an underlying socio-cultural context constitutes a barrier to the uptake of cleaner fuels in developing countries, which is vital to fully understand the difficulties of the resource poor in their use of biomass fuels for domestic energy. This socio-cultural context is discussed in the next chapter in relation to the use of biomass fuels and thoughts about indoor air pollution.

Chapter Six

Socio-cultural Context of Indoor Air Pollution in Ado Ekiti

6.1 Introduction

The preceding chapters have identified how housing characteristics affected air quality in the study area and the extent to which socio-economic factors contributed to the use of biomass fuel as a source of domestic energy. This chapter explores the underlying socio-cultural factors influencing the use of biomass fuels in peri-urban areas of Ado Ekiti, Nigeria. In line with the fourth objective of this study (Section 1.3), this chapter will analyse information gathered from the thirty household interviews conducted (see Table 3.3 and Section 3.6.3). Considering that Nigeria is a heterogeneous society with over 250 ethnic groups (Anati, 2010), the cultural norms of different ethnic groups in the study area highlighted that culture is important in dealing with distinct beliefs and cooking practices amongst householders.

In section 6.2, the decision making process on who decides the use of energy sources in the household is discussed. The section also identifies additional factors aside from the ones examined in Chapter Five which influence energy choices amongst householders. Section 6.3 puts into context social perceptions of householders regarding air quality when using fuel types in the study area. Section 6.3 also describes the behaviours of householders while tending the hearth. Section 6.4 explores householder beliefs surrounding wood harvesting and the consequences of not conforming to standard cultural norms. Aside from cooking, the alternative uses of trees are also examined in terms of health, income generation, and structural security of households. The cultural realities of the health impacts associated with tree-related sources and perceptions of diseases linked with exposure to indoor air pollution are also highlighted. In Section 6.5, I identify culturally approved attitudes and behaviours during cooking.

6.2 Biomass Fuel: Who Decides on Energy Choices?

The decision about the choice of energy sources used for cooking in the study area depends on how roles and responsibilities are viewed in the family. Interviewees suggested that there varying opinions about who chooses household energy sources. For example:

> "If you need answers to all the questions about firewood, cooking, it is the women that can provide the detailed information. Honestly, as a man I'm not keen in knowing how the cooking is done [...] I only eat the prepared food" (Interview with Householder 2, M, Ebira).

> "Women usually make do with whatever is available for cooking, although our husband provides the money, but we reasonably set our priorities considering other needs in the family. Our husbands don't mind what form of cooking fuel we use, all they are after is having the meal prepared and we decide on what type of household energy to use" (Interview with Householder 15, F, Yoruba).

> "The decision to provide for my family is my prerogative role [...], I therefore can decide what form of energy is used or at most I buy such for my wife but not without her input" (Interview with Householder 18, M, Ebira).

The opinions expressed suggest that regardless of ethnicity, it would appear that women have the primary role of choosing household energy sources but such decisions are sometimes taken jointly. It is apparent from the first statement that some men's perspective on energy choice in this local environment are connected to the women's duty of preparing a meal for the family. How and what to use for cooking is entirely left for the woman to decide. It would appear that men having this view are not necessarily bothered about the type of energy source used by their wives for cooking as long as food can be prepared on time. The finding that women can choose their energy source in this study echoes research elsewhere (Zambia) where women have the responsibility of providing household energy in rural areas (Oparaocha, 2009). In addition, although women have the decisive choice over fuel type, Householder 15 (who is a woman), does not consider the specific source of energy needed to cook to be important. In relation to broader household dynamics and the need to prioritise family needs, the provision of domestic fuel is usually excluded from this prioritisation. Hence, Householder 15 will make do with whatever energy source that will allow her to prepare the family meal on time.

6.2.1 The Economics of Fuel Wood

Generally, the 'free availability' and 'unlimited access to firewood' amongst peri-urban households in Ado Ekiti further promotes its use for cooking activities due to factors such as availability, accessibility, and cost. This is especially the case in this research as many householders are low-income earners. To further demonstrate the importance of factors influencing energy choice Householder 13 stated that:

> "Firewood is free, accessible and available at our convenience [...] all we do is to gather enough each time we want to cook. It's gathered at no cost, unlike when you have to buy kerosene which is not always available'" (Interview with Householder 13, F, Ebira).

The above statement demonstrates the importance of the community forest and the free availability of wood fuel for domestic energy use. Households are able to gather enough wood for their needs (see Section 5.2) as compared to kerosene that is not often available (which creates problems in meeting household energy demand). The findings from the study area confirm the IARC (2010) report on wood fuel choice in developing countries. According to Rehfuess *et al*. (2011), about 80 percent of rural dwellers in sub-Saharan Africa and South Asia rely on gathered biomass fuels. Making a shift to other fuels might be difficult as rural householders are constrained by low income, complex fuel-allocation decisions and unreliable electricity supply (Zulu, 2010). This wood fuel is gathered at no (financial) cost and there is no commercialization of the product as it is only used for meeting family cooking needs (US-OTA, 1991). This is also the situation in the study area as householders only gather wood fuel for family use from the forest. Upon further enquiry, I understood that wood fuel is not sold at any time to boost family income. Furthermore, Taylor *et al*. (2011) argue that wood fuel used for domestic cooking in developing countries is unlikely to result in large-scale deforestation. Observations from this study found that families gathered only what they required for cooking purposes. As a major portion of fuel wood extracted from forests comes from dry wood, it "may not necessarily lead to deforestation as advocated by mainstream views" (Nagothu, 2001:331). By the mid-1990s, emphasis started to shift from efficient to cleaner stoves following challenges to the assumption that fuel wood was a major driver of deforestation (see Johnson and Bryden, 2012; Simon, 2010; Arnold *et al*., 2006; Hanbar and Karve, 2002; United Nations, 2000 and Section 2.5). Although the process of urbanisation is on-going, householder responses do suggest that population change has neither increased wood harvesting drudgery in the area nor reduced reliance on wood fuel for domestic energy (Sections 3.4 and 5.2.1). The following statements by householders indicate that urbanisation has not impacted on wood harvesting in communities:

> "Wood fuel collection is done in forests surrounding our community" (Interview with Householder 6, F, Yoruba).
>
> "We collect wood fuel from nearby forests and there is more than enough […] if we need more at any time we quickly go to forest and harvest more" (Interview with Householder 12, F, Tiv).

Indeed, it suggests that the rate of urbanisation is much slower than anticipated and does not negatively impact on households (Potts, 2012). Nevertheless, it does tend to open up more distant forest areas as improvements occur in local transport system (Arnold *et al*., 2006). The extent to which human activities contribute to environmental problems varies, because of the complex interactions with the natural environment and relationship with wider economic, social, and political factors (United Nations, 2001).

It is clear from the study, that biomass fuel is largely used because it is available and accessible at all times. Echoing the findings of the IARC (2010) report, energy choice in the study area is based primarily on physical access and affordability.

In addition to access and affordability, cultural cooking practices also influence the choice of fuel by householders.

6.2.2 Cultural Influences on Energy Choices

Householders have learnt their cooking methods from their parents and as they migrate to other settlements, they generally tend to maintain the cooking practices that they are familiar with. They explained that:

> 'We are used to wood fuel in cooking. Even when we travel to our home state wood fuel is still used for cooking. That's what we have been brought up in using for cooking, although we complement it with kerosene, and sometimes use electric cookers but that is very rare' (Interview with Householder 11, F, Ebira).

> "Our ancestors used three stones and wood for cooking […], it is the same cooking method we're using today" (Interview with Householder 16, F, Yoruba).

> "The familiar cooking method is '*aro meta*' which has been in use even before I was born. It is the cooking method we have learnt from our parents and it dates back to generations of users" (Interview with Householder 26, F, Hausa).

Clearly, regardless of the environment – (urban, peri-urban or rural areas), – wood fuel is used for cooking. The act of using wood fuel and '*aro meta*' for cooking has been a way of life passed to householders by their ancestors, the practice of which is being maintained in their homes (Section 3.5.2). This practice is 'all that they have known in cooking their food' (Householder 23, F, Ebira). This is consistent with Ruiz-Mercado *et al*.'s (2011) findings in rural Mexico where families conserve their cooking behaviour embodied in their deep-rooted traditional culture, which is reflected in the use of ceramic pots to cook traditional dishes. In contrast, Heltberg (2005) argues that preference for fuel wood among indigenous groups in Guatemala was because of their limited integration into the formal economy in the area. Lutzenhiser (1992) asserts that cultural institutions in society, which are primarily the 'styles' of life and 'culturally-sensible' way of life, shape energy choice. In addition, Taylor *et al*. (2011) argue that preferences for wood fuel are based on experience and cooking methods learnt over the years. This is also attested to by householders in Ado Ekiti who use biomass fuels because 'we are used to wood fuel'. This further suggests that though access and cost do contribute to how householders make energy choices; the culture of cooking methods is also an important factor that needs to be considered in the study area. Knowing that householders use biomass fuel to cook over open fires, and that this cooking method impacts on air quality in buildings, Section 6.3 discusses the cultural context in relation to air quality in the building environment and IAP.

6.3 Indoor Air Pollution: Experimental or Cultural Perceptions?

Householders in the study area mostly use fuel wood for cooking, and cleaner fuel (battery powered local lamp) for lighting as discussed in Chapter Five. The discussion in Chapters Four and Five demonstrate that dwelling characteristics and householders' socio-economic status do contribute to the preference for fuel wood, and the burning of this fuel either indoors or outdoors heighten levels of indoor air pollution (Chapter Two). To understand fuel choices in the study requires an understanding of not only the socio-economic factors (Section 5.3) influencing household energy choices, but also an examination of the socio-cultural context that might hinder the uptake of "cleaner" fuels.

Interaction with people entails gaining a holistic understanding of their "origins, development, social and political organisations, religions, languages, art and artefacts" (Helman, 2007:2) which shape their perspectives and views of the world. In relating information gathered about indoor air pollution from householders', I made observations about the living environment of householders so that interpretations could be made in relation to indoor air pollution. For instance, whilst monitoring indoor air quality within the Irasa community, I found it difficult to breathe and had to use a mask due to the high levels of wood smoke (Figure 6.1). Sundell (2004) recognised that it is the perceived level of indoor air pollution that causes people to complain, and it is also the perceived air quality that provides a first indication of possible health risks to householders. Awareness of poor air quality in an environment is thus provided through sensory experiences and the power of vision – (experience of physical dirt or soot in homes and smoke and fume emissions from specific sources) (Bickerstaff, 2004; Bickerstaff and Walker, 2001).

Figure 6.1: Installing UCB monitor in a household in Irasa
Source: Author, February 2011

My perception of indoor air quality in the study areas indicated that householders are vulnerable to health problems associated with indoor air pollution. Many householders by contrast did not seem to be bothered by the cooking smoke as they have become accustomed to poor air quality whilst carrying out their daily cooking activities. Many regarded it as an unavoidable problem because the use of biomass fuel for cooking is taught within families and has been used for many years. One householder expressed:

> "The pollution suffered is not from the fuel wood; rather, it is the course of nature that blows the wood smoke into the buildings which is causing the pollution" (Interview with Householder 4, M, Ebira).

Householders' interpretations of the causes of indoor air pollution were frequently attributed to the natural ventilation blowing particulates into buildings, rather than to the act of cooking with biomass fuels. Householders' misinterpretation of the causes of indoor air pollution reflects a complex mix factors and finding further confirms Bickerstaff's (2004) assertion that the perception of hazards in an environment is interpreted at the individual level and involves beliefs, attitudes, judgments, feelings, and dispositions towards hazards.

I also found out from women who were cooking at the time that one of the main reasons for cooking indoors or close to their home was to minimise travel time during cooking. According to one woman interviewee:

> "The proximity of the cooking fireplace to the house affords us the opportunity of quickly getting the meal prepared without having to waste too much time in sorting out utensils because it is only required materials that are taken out of the store each time we're cooking" (Interview with Householder 3, F, Ebira).

The cook and her helpers (in most cases children above 6 years) often stay indoors making sure that the food is properly cooked by constantly tending the firewood to keep it burning. Young children are often strapped to their mothers' back while cooking, or are allowed to play in the surroundings of the kitchen so that mothers can keep an eye on them (Figure 6.2).

Figure 6.2: A child strapped to her mother's back (A) and children around the hearth during cooking (B) in Ilokun

Source: Author, August 2010

In the process of tending the wood fuel and staying within the cooking environment (whether indoors or outdoors), women, children and helpers are directly exposed to wood smoke which is inhaled during cooking. By socially interacting with householders, I was able to understand better their perceptions of air quality and indoor air pollution. Householders locate their kitchens either in or outside of their house because it is convenient for them. As illustrated in Figure 6.2, the cultural practice of strapping a child to a mother's back exposes children to the health impacts of indoor air pollution. Therefore, children and adults in the kitchen are vulnerable to the health impacts associated with exposure to indoor air pollution in the study area.

6.3.1 Familial Cooking Practices: Remembering the Act of Fire Tending

It is commonplace that as least one person (the main person cooking or a helper) permanently positions themselves around the fireplace to allow constant fire tending during the cooking process. This in turn exposes householders to wood smoke[34] (Rehfuess *et al*., 2011). This is linked with the scenario that Heltberg (2009:879) describes as a 'technique of cooking' and revolves around the cooking area and the indoor environment that is filled with wood smoke (Padhi and Padhy, 2004). The routine pattern of carrying out daily chores as observed in this research in a polluted indoor environment seems to be of little concern to the householders. The account of women in Malawi given in the study by Fullerton *et al*. (2009) showed higher exposure levels to particulate matter when they have close contact with the fireplace during cooking or when tending to wood fuel. This is comparable with the Ado Ekiti study. As long as householders stay indoors,

[34] Exposure is the time spent multiplied by the pollutants levels in microenvironments (Monn, 2001).

they are constantly exposed to particulates irrespective of where the kitchen is located, as the ambient air quality is poor indoors. This everyday exposure to wood smoke, linked with the results in Chapter Four that indicate particulate matter levels above the WHO safe limit predisposes them to the health risks discussed in Chapter Two (see also Hosgood and Lan, 2011; Zhang and Smith, 2003; Mishra *et al*., 1999).

In an attempt to reduce cooking time, extra wood fuel is sometimes added to increase the burning rate, although Shailaja (2000) argues that such practices are more likely to increase indoor emissions of smoke and decreases the thermal efficiency of the fireplace. However, according to householders, 'the food is quickly done' when additional wood fuel is used during meal preparation, especially in the mornings when the hearth is dormant and wood fuel is dampened by overnight drizzle. The Ado Ekiti study further brings to light Bailis's (2004) argument that people who generally cook with wood fuels daily have valuable knowledge about stoves, fuels, and cooking practices, which are different from experts' knowledge of stoves and fuels. In demonstration of local knowledge about stoves and wood fuel, Householder 30 stated that:

> "…with large quantities of wood fuel in the hearth, thermal efficiency is substantially achieved thereby reducing cooking time" (Interview with Householder 30, F, Ebira).

The use of local knowledge to coordinate hearths with fuel wood quantities may also influence cookstove choice. For example, cleaner and more efficient cookstoves which have been introduced as a result of interventions to reduce indoor air pollution or fuel wood use (Balis *et al*., 2009; Bates, 2007) may not be considered appropriate for local cooking practices.

In order to encourage the use of more efficient cookstoves that use less wood fuel, householders claim to need practical illustrations of how these stoves work (using available fuels and local technology within the financial reach of the people) rather than being informed through hearsay (Bazilian *et al*., 2011) and failing to understand the technicalities involved in using the cookstove. In appreciating the importance of 'local-technology', a recent study conducted in Guatemala by Taylor *et al*. (2011) indicates that many householders preferred wood fuel because food can be cooked more slowly for longer on wood stoves. Such characteristics are particularly suitable for people using corn as a staple crop as it is cooked twice (first by boiling it and again after milling it). Such a process might burden the family economy if LPG stoves are used, as it is costly and householders cannot always easily obtain bottled LPG.

Some householders in the Ado Ekiti study area believe that their cooking pots are suitable only for wood fuels and as a result are happy to continue to use their traditional cooking utensils. The following statement by one of the householders indicates concern about cooking pots that reduce cooking duration:

> "Our food types (beans, yam, rice, cassava flour) can take a longer time to prepare [...], not only that we use big cast iron cooking pots that require much heating before cooking can be done [...] considering all these factors then, I think firewood will be faster during cooking [...] also this type of pot is not convenient for use on the kerosene stove" (Interview with Householder 17, F, Yoruba).

Householders might be hesitant to buy or test unproven utensils in case they do not suit their cooking conditions. For example, preparing cassava flour into edible food – *amala* – requires sprinkling the flour into boiling water on the fire and constantly stirring it with a wooden spoon until a smooth paste is formed. If the pot is not made from a suitable material, it can crack during the stirring process, due to it not being able to withstand the high cooking temperatures required and the force exerted on the flour mixture may cause lumps in the paste (Householder 17, F, Yoruba). A lack of demand for alternative cooking systems has given people more confidence in the use of locally made products (the iron cooking pots) as it is believed that these are needed to achieve the quality of cooking that they are used to. This suggests that improved traditional stoves in the study area must consider the cookware ideologies of householders.

Bearing this in mind, 'product-specific' factors such as safety and usage cost (involving the need to change cooking utensils and convenient food preparation methods) must consider users' existing/preferred products. Acceptance, therefore, of any introduced product in a given environment entails putting these products to the test over time, which invariably changes 'individual' (Tsephel *et al*., 2009:7) perceptions of adopting such products for use during cooking. Essentially, cultural perceptions about technology and products have a major influence on householders' decision-making about cooking practices and fuel use and, if not addressed, might represent a barrier to the uptake of clean fuels. The data collected suggest that cultural perceptions of indoor air pollution are 'ethnic-specific' and are reflected in the type of wood harvested for cooking and cooking practices used. The next section discusses the perceived 'health' repercussions of contradicting cultural cooking and fuel wood use norms as against the health impacts of burning biomass fuels.

6.4 Beliefs Surrounding Sources of Biomass Fuels

Ideas about what is good, fair and just in a society are deep-rooted in its cultural values, which are shared and socially transmitted down the generations (Halbert *et al*., 2007). The impetus for individuals to adhere to cultural beliefs influences their perception and line of thinking of their lived social systems. Relating what one knows through personal experiences to others in similar social settings strengthens cultural understandings of how to reconstruct the past while making sense of the present (Garro, 2000). Recalling everyday activities and personal knowledge among householders, therefore, helps to shape the socio-cultural context of wood fuel gathering. As an example, Householder 20 (M, Ebira) recounted his experiences when a (woman) neighbour who is not of the same ethnic group as him harvested a tree, which for the Ebira was forbidden (*Ochuku*[35]: Figure 6.3). His neighbour was not aware of the cultural implications of using this type of wood for cooking among the Ebira and observed that as a result one child (who incidentally was of the Ebira group), convulsed immediately upon having close contact with the wood while playing around the kitchen. Householder 20 (M, Ebira), mentioned that he had been told of the repercussions of using *Ochuku* wood as fuel by his grandparents, but had not witnessed its effects until he witnessed this child's convulsing.

Another female householder who is of the Ebira tribe further confirmed that:

> "When trees like '*Ochuku*' are gathered from the forest to be used for cooking any Ebira child around will have convulsions" (Interview with Householder 1, F, Ebira)

[35] Ochuku (*African calabash tree*) is the local Ebira name of this tree.

She continued:

> "The effects (holes in skin, convulsion) of using this tree are only applicable them [the Ebiras] other ethnic groups don't necessarily experience this type of problem. We have other ethnic groups in this community (Yorubas, Tivs) for whom using this type of tree is not a taboo. I am quite sure that nothing will happen to them if such wood is used for cooking. If you don't mind I can pluck the wood now from the forest and put it beside my baby in the house, you will see what I'm telling you [...]" (Householder 1, F, Ebira)

Figure 6.3: Ochuku tree (*African Calabash Tree*)
Source: Author, April 2011

Apart from the convulsions reported amongst the Ebira children when the *Ochuku* tree was used for cooking, the other main 'culturally-diagnosed' symptom of ill health among children is constant ailments such as headaches, high body temperature, and pains. The above statement of Householder 1 indicates that it is only Ebira children that are susceptible to the cultural health effects of using *Ochuku* to cook. The following statement by one householder indicates that disobeying cultural norms can have negative effects on that household, and in most cases, on the children in that house:

> "Child bearing age women that used '*Ochuku*' trees to cook do have their children constantly falling sick [...]" (Interview with Householder 5, F, Ebira).

A number of symptoms and ailments, which include but are not limited to headache, high temperature and diarrhoea, were mentioned by Ebira householders as some form of ill health experienced by children of defiant parents who do not adhere to cultural traditions. It is worth noting that the identified ailments of headaches and high temperature are symptoms associated with indoor air pollution, while the lack of access to good quality drinking water might render the children susceptible to diarrhoeal infection.

On further enquiry as to why such health impacts are not directly felt by the person that contravenes cultural norms, the response was that it is believed that as children are highly esteemed by parents, anything that happens to them has a significant impact on the family as a whole.

Therefore, concern by the Ebira ethnic group about the use of the *Ochuku* reflects a cultural taboo that means that it cannot be used for cooking. The practical experience of children having convulsions when such trees are used for cooking might further deter Ebiras from using it, given that some have had first-hand experience of this when *Ochuku* was unintentionally used for cooking.

In addition, the felling of another tree, the *Iroko*[36] is traditionally forbidden for Yorubas. The belief is that any woman that gathers such wood for cooking will experience a miscarriage or still birth. This belief means women do not harvest this tree in the forest whenever they are out gathering wood fuel.

Furthermore, among the Yoruba group, the *Akoko tree*[37] is a sacred tree dedicated for the conferment of traditional titles. One Householder stated that:

> "Nobody dare make use of it. That is our tradition, which has been passed on to us by our forbearers and we strictly abide by that injunction, and we similarly pass the same instructions to our children" (Interview with Householder 6, F, Yoruba).

There is significant cultural value attached to the *Akoko* tree in addition to being used for the conferment of traditional titles and traditional rites, it is also used during the traditional rites used in enthroning a new king; therefore, it can never be harvested for wood fuel. The honour given to the king as the head of the community is further transferred to the emblems used for coronation. Householder 6 however, did not specify the type of risks associated with harvesting this type of wood fuel. A taboo in traditional settings cannot be queried, because of the negative effect it may have on defiant villagers. Undoubtedly, this type of tree can never be gathered from the forest to be used as wood fuel; a situation that may presumably help in preserving this particular tree in the area. Amongst the Hausa, meanwhile, there did not appear to be any specific fuel wood related taboos and

[36] *Iroko* tree (*Milicia excelsa*) a hardwood commonly found in tropical Africa.

[37] *Akoko* tree – *newboldia laevis*

Householder 26 (F, Hausa) stated that there are no cultural constraints on harvesting any type of tree for domestic use amongst them.

Garro (2000:296) suggests that, "culture is carried in individual minds, manifested and transformed in social interactions, and distributed unevenly in any given society." The incident of the child convulsing, for example, made Householder 20 adhere to cultural norms and values and when Householders 20 and 5 talked about their personal experiences, they did so within the framework of their culture, the knowledge of which becomes situated in an 'ethnic-specific' context.

The traditional way of life of householders influences their experiences and was manifested in their perception of which wood fuels should and should not be gathered in the forest. In as much as it is the responsibility of women to gather fuel, caution is taken not to harvest 'ethnic-specific' forbidden wood. In order to avert casualties of the type experienced by Householder 20, parents educate their children from a young age so they know their 'ethnic-identity' in relation to standards of acceptable behaviour, which are passed by word of mouth across generations (Coker and Coker, 2008).

I observed that irrespective of wood type, wood smoke is often generated during cooking and contributes to the poor air quality in buildings may be responsible for some of the health impact that householders currently 'culturally-diagnose' as being attributable to the use of sacred trees. Traditional cultural norms and values are deep rooted and the failure to consider them can have negative consequences, which in this case would be a perceived risk of miscarriage and constant recurring sickness amongst the children of those that violated the instructions. Aside from the health impacts associated with traditional cultural beliefs, householders have failed to recognise the health effects associated with inhalation of wood smoke as discussed in Chapter Two.

Although, the presence of chemical compounds in the wood of the *Ochuku* tree could not be ascertained, the cultural norms associated with burning biomass fuel do not exclude the fact that chemical compounds found in wood smoke are dangerous to human health. Children are most vulnerable because of their on-going physiological development which wood smoke can truncate, thereby leading to diseases (e.g. respiratory problems, asthma etc.). In addition, as children's immune systems are not developed enough to defend the body against any infection, they are susceptible to diseases. Indeed, there was indirect evidence (of carbon monoxide from wood smoke) from the research area to suggest that exposure to poor air quality indoors and outdoors, and poor ventilation is likely to have adverse outcomes on pregnancy (Section 2.3.2).

When carbon monoxide diffuses into the alveolar, capillary membranes and bloodstream, it reduces oxygen delivery to the brain, cardiovascular system, heart, skeletal muscle and to the developing foetus in pregnant women (Rehfuess *et al*. 2011); a condition that can lead to miscarriage. However, cultural perceptions are significant in the identification of health impacts amongst householders, as they are believed to be the consequences of disobeying cultural norms.

Apart from the use of forbidden trees, which have health related impacts, householders in the study area pointed out an association between indoor air pollution and health problems in the area. There is a local perception that inhaling wood smoke causes people to 'reason negatively' which may relate to scientifically proved linkages between smoke inhalation and impaired brain function such as Massey *et al*.'s (2009) finding which recorded mental fatigue amongst households using biomass fuels in Agra, India. Inhalation of smoke can result in severe immediate and delayed neuropathologies in the body system by down-regulating genes associated with synaptic function, neurotransmission, and neurotrophic support (Lee *et al*., 2005).

The communal cohesion amongst householders in this study subliminally allows ethnicity to determine house location and building design. Ethnic identity tends to be strong when people desire to retain their identities in the face of perceived hostility, rejection and in asserting cultural pride in their community (Phinney *et al*., 2001). For people to live in harmony and unity and at the same time freely observe individuals' cultural norms, the same ethnic group sharing a common sense of values tends to affiliate by residing within the same environment (Phinney *et al*., 2001). Findings amongst Ado Ekiti householders agree with Phinney *et al*.'s viewpoint, as ethnic groups of the same origin are observed to reside within the same vicinity (see Table 3.2), as they have a common language and set of cultural traits. The layout of buildings in the study area suggests that Ebira householders have their buildings within the same vicinity as each other and this is the same for the Yoruba and Tiv ethnic groups. It was also observed that houses belonging to one ethnic group are not intermingled amongst those of other ethnic groups. Even though all ethnic groups reside within the same environment, buildings are separated because they do not share similar ethnic characteristics.

This section has identified sacred trees specific to ethnic groups that cannot be harvested for domestic energy in the study area. Ethnicity determines sacred trees that are forbidden from being gathered because of the perceived 'ethnic-specific' health impacts they have on children and women or because they represent emblems for conferring traditional titles. Besides the personal experience of the householders regarding the consequence(s) of harvesting sacred trees, harvesting forbidden trees can only be undertaken for medicinal purposes. The next section proceeds to examine in detail the 'trado-medical' usefulness of some of the trees in the study area (Adedokun *et al*., 2010) in the study area.

6.4.1 Uses of Biomass Fuels amongst Peri-Urban Ado Ekiti Households

Apart from the varying negative perceptions about fuel wood species, a number of householders spoke of how they used different tree species to produce traditional medicine, especially in the peri-urban areas where there are limited medical facilities. To this end, one Ebira Householder noted that:

> "High respect is given to the '*Ochuku*' tree because it's used as an antidote for snake bite" (Interview with Householder 10, M, Ebira).

Freshly picked leaves from the *'Ochuku'* are ground and then applied to the spot of the snake bike. Over time, it is believed that the poisonous substance from the snakebite will leave the body. In the absence of western medicine, a health issue (such as snakebite) is treated with the use of leaves extracted from medicinal trees. With regard to the efficiency of the process for curing snakebite, Householder 10, affirms that:

> "There are witnesses in the community who have literally been healed of their snake bite, [...] and they can confirm that the venom burst out after applying the medicinal leaf extract on the spot".

Traditional medicine practised by householders in Ado Ekiti can, be categorised as the use of herbal remedies that use chemical compounds from the extract of leaves in treating their ailments. The herbal medication (extracted from *Ochuku* leaves) that Householder 10 linked to treatment of snake bite in the community, further confirms other findings in Nigeria that use herbal remedies to treat snake bites (see Adzu *el al*., 2005).

Adzu *et al*. (2005) affirm that when plant extracts are applied on the spot of a bite, its active components (methanol) bind to the venom protein, thereby detoxifying the venom. The phospholiphase A_2 (PLA_2) are the toxic components associated with the toxicological properties of snakebites and the plant extracts act on the enzymes by inhibiting the lethality of the venom on the bite spot. This sort of traditional medicine or ethno medicine is widely used in rural areas of Nigeria because of the widespread belief that it is an efficient way of solving health problems that allopathic orthodox medicine sometimes cannot address (Oladele *et al*., 2011).

So far, the analysis above has revealed beliefs associated with wood fuel gathering. Overall perceptions about wood fuel are reflected in the social and cultural lives of the householders and their beliefs play a significant and positive role in the observance of rules and values that shape wood fuel use in communities. Each ethnic group (aside from the Hausa) identified trees that cannot be used as wood fuel, along with repercussions for violating the ingrained norms and values for their 'ethnic-specific' group. As has been shown, personal experiences regarding the [assumed] consequences of using sacred trees for cooking among the householders served to further reinforce their beliefs in fuelwood-related taboos amongst some of the communities. Householders also believe that there are repercussions associated with contravening such taboos as they often set the standards that govern morals, laws, politics, economics, history, philosophy, and religion in each local environment. In guarding against the aftermath of violating cultural norms, there is the tendency for every household to ensure that norms and values are upheld within the society at all times, an action which may encourage them to resist any form of “alien” culture. Any culture that does not uphold the beliefs of the people is considered alien.

Apart from the medicinal use of biomass fuels in the study area, wood smoke is also frequently used by women to sustain their enterprises (income generating activities) and is widely thought to have the capacity to strengthen building walls.

Some householders depend on using wood smoke (Figure 6.4) as a ‘local-technology’ that helps to sustain small enterprises linked to food processing activities (Oparaocha and Dutta, 2011). Indeed because of its role in preserving food for household use or marketing purposes, many householders regard wood smoke as healthy and useful.

Figure 6.4: Food preservation using wood smoke
Source: Author, March 2011

As one householder pointed out:

> "The use of wood smoke does no harm to the food; it only prolongs food shelf life" (Interview with Householder 29, F, Ebira).

The perception that wood smoke is healthy for householders stems from the fact that it can be used to preserve food items that can easily rot, since refrigeration is not possible due to absence of an electricity supply.

Many women in the study area have built up small enterprises (Miah *et al*., 2011) which require a low level of start-up capital of approximately ₦1500 (£6). Some of them engage in fish and meat selling, which helps to complement their family income. The fish are usually purchased from cold rooms/stores in the urban centre, while animals killed during hunting by the men are given to their wives to sell as discussed in Chapter Five. Wood smoke is employed to preserve and process fish and meat for consumption and storage. Indeed it is one of the oldest methods of food preservation widely used today in rural areas as shelf life can be prolonged for a couple of weeks (Stolyhwo and Sirkorshi, 2005). This traditional smoking method involves treating pre-salted fish or meat with wood smoke as they hang above the kitchen area or are laid out on mesh trays. Such methods are commonplace in areas where electricity facilities are lacking. One Householder stated:

> "...wood smoke enables smoked fish and meat to be preserved for some weeks [...]" (Interview with Householder 3, F, Ebira).

The motives for using wood smoke to preserve their stocks lies in the fact that such goods cannot always be sold within a day. The difficulty of access to transport between cold rooms in urban areas and maintaining farming activities with fish and meat selling enterprises makes it sensible to use wood smoke as a preservative method. The smoking process involves the woman spending between two and three hours beside the mesh tray, constantly turning the fish or meat (Figure 6.4). After a while, the fish or meat is covered with a tray and the PAHs contained in the wood smoke penetrate into the fish or meat. Although, PAHs in wood smoke can be carcinogenic depending on the type of wood used and more importantly on the temperature and air supply during the process of burning (Stolyhwo and Sirkorshi, 2005), many householders consider it to be 'healthy', as their priority is staying in business and preserving food. Social enterprise activities are considered important as they provide additional household income. In this respect, the use of wood smoke for food preservation is likely to continue to be an important feature of income generation in these households until alternative systems of preserving food become affordable.

Another point relating to the perceived benefits of wood smoke is its frequent use during the construction of mud blocks walls in individual households. As indicated in Chapter Four, houses are mainly constructed with mud blocks using a wattle and daub technique. In some of the interview sessions householders indicated that when they were constructing a new building and wanted to move in quickly, they used wood smoke to fast track the drying of the mud blocks. Even if it takes some time to move into a new building, it is believed that the wood smoke will prolong the life of that building. In the words of one householder:

> "It solidifies the walls of the building (referring to the mud blocks building) [...] the building will stand for several years. I can assure you that the walls cannot just collapse, unless you deliberately pulled them down "(Interview with Householder 4, M, Ebira).

The techniques and construction methods used encourage villagers to believe that continually allowing wood smoke into their building strengthens and prolongs the life of the mud bricks. This local technology knowledge is linked to the firing of bricks to achieve greater strength, even though it is carried out after constructing the building.

This section has attempted to evaluate the justification for ‘healthy’ wood smoke as a technology used for preserving food and prolonging building life. Principally, one of the reasons is tied to livelihoods. Tackling energy problems in rural areas of developing countries is often advocated in literature on women’s empowerment through entrepreneurship (see Skutsch, 2005, 1998; Batliwala and Reddy, 2003; De Souza *et al*., 2003). The benefit derived from wood smoke by householders in preserving food that supports their enterprise must not be discouraged when attempting to alleviate problems of indoor air pollution in the community. The analysis presented in this section suggests that wood smoke is pivotal to the subsistence and survival of householders and that attempts to challenge/contravene these priorities might impede efforts to ameliorate health impacts associated with indoor air pollution. The specific knowledge, information, and education of people discussed in this chapter provide a starting point in dealing with indoor air pollution amongst the householders.

To evaluate health impacts of indoor air pollution in the study area, cultural values of householders must be taken into consideration when addressing the problem. Householders associated health problems to the contravention of cultural norms rather than to impacts of indoor air pollution. Householders’ accounts of their cultural beliefs were not limited to the harvesting of trees. Many other actions associated with cooking practices are also guided by cultural norms and values, which is the focus of the next section.

6.5 Socio-cultural Discourses and Taboos Associated with Cooking Practices

The cooking practices employed in developing countries often rely on biomass fuels as the main energy source. In Nigeria, space heating is not common as the weather is favourable (warm) at all times, but energy is required for lighting. When using energy for cooking and lighting of the type discussed in Section 5.2, indoor air pollution depends on how the source of pollution (fuel and stove type) is dispersed within the building during its burning (OECD/IEA, 2006). The key behavioural factors affecting pollution exposure include the amount of time spent indoors and proximity to the cooking area (Ezzati and Kammen, 2002c). Cooking practices can sometimes represent behavioural responses to information and knowledge (Wood and Newborough, 2003) passed across to householders in relation to their cultural norms and values. Cooking, according to Balmer (2007), is linked to cultural, religious, and societal beliefs that are both valued within the family and in the community and which, on the whole, are associated with the well-being of the people. As discussed earlier, cooking activities are modified by cultural beliefs, norms, and values, which subsequently determine energy use behaviour (Jin *et al*., 2006) and practices put forward during cooking.

As a way of ensuring compliance with fireplace practices, women are required to vigilantly monitor all activities around the kitchen environment. It is on this note that women are seen to take the central role in the cooking area, which is often jokingly referred to by their husbands as their *office* in the study communities. The term *office* is used to make a comparison with men's work on the farm with regard to the planting and harvesting of crops. With the exception of younger, newly married women, most women are left by themselves to decide on the location and design of the kitchen; a duty they conscientiously carry out. Gender relations in households, therefore, impact on decision making in terms of fuel and appliance use and acquisition (Hooper-Box *et al*., 1997 cited in Balmer, 2007). Mueller (2009) stresses that households cannot be taken as a single entity; rather the diversity of apportioning roles within households should always be recognised.

In various cultural settings in Nigeria for example, some *taboos* are based on ethical issues and hygiene, particularly when eating and preparing food. A detailed explanation provided by Householder 7 (F, Ebira) indicates that when eating, one must not talk because it is believed that it is discourteous to adults around the dining table, and also because, the food can mistakenly go into one's airway. During food preparation, women are not supposed to talk, and if there is going to be any form of conversation the household head will converse with the individual or instruct the person to come back after a given time. This practice is particularly strongly observed during the pounding of yams with a pestle and mortar and if any woman is found talking during the process, she is seen as not holding her husband in high esteem and could be sanctioned by the husband refusing to eat subsequent meals prepared by her. At other times, women are not supposed to taste the food during preparation, but they are always expected to know the amount of ingredients to be used for food. If a woman goes against the norm, her action is believed to limit full potential attainment of her husband in the society. One interviewee describes how a single act of disobedience can affect her husband:

> "During cooking you must not taste it. If one tastes the food, it can cause high blood pressure for men and reduces his ability to become great in life and be able to attain his full potential" (Interview with Householder 7, F, Ebira).

The indispensable cultural practices and/or norms allowed during cooking and food preparation are significant and must be religiously kept by the cook. During interview sessions, I observed that householders watch closely over the hearth during cooking. At intervals, when wood fuel is being tended (especially in the open space kitchen), some practices are disallowed not only by the cook, but also by neighbours who know the cultural implications of engaging in acts forbidden by their ethnic group. An interviewee explained to me that she will never allow anybody to tamper with her fireplace by trying to heat up any form of metal. The practice to her and the community at large is taboo and is linked to incidences of diseases in families. According to her:

> "...heating a knife or cutlass in a cooking fire place can cause high blood pressure, chest pain, fast heartbeat, hypertension and thunderstorms [...]" (Interview with Householder 30, F, Ebira).

This reflects wider cultural beliefs that health problems are associated with the contravention of norms guiding activities taking place in association with the fireplace. The belief that the fireplace must not be used for any purpose other than preparing food and traditional medicine is particularly strong. A special fireplace is, therefore, used for the heating of metals and is usually at a central location in the community accessible to all householders. In a similar way, a special fireplace is created for cooking medicinal herbs in homes. An explanation by one householder expounded on the significance of the cooking process. She described the need for a dedicated cooking utensil for gathered herbs, gave an account of the arrangement of the wood fuel in the fireplace and explained the implications of violating cultural procedure stipulated for preparing herbs:

> “When preparing the herbs we have pots dedicated for its boiling. It’s something special and must be handled with caution. Ordinarily when cooking my meals I don’t pay attention to the wood arrangement, but for the herbs, the wood must not be chunked in the fireplace but be appropriately arranged at an equal distance to other wood [...] it’s not everybody that can do that; but only those that have learnt or observed the practice from our parents. Also, the fireplace used in cooking herbs must not be tampered with; if this happens it reduces the efficacy of the herb in treating the proposed ailment(s) and further causes complications of such ailments without any cure [...]” (Interview with Householder 9, F, Ebira).

The traditionally held belief is that the procedure involved in preparing medicinal herbs influences its potential effectiveness. According to Gideon (2009), traditional medicine is an integral part of the indigenous knowledge of local communities, which is a complete body of knowledge, know-how and practices upheld and built-up by people in rural areas based on their extended histories of interaction with the natural environment. This interaction with nature is complex and can only be understood, interpreted and assigned meanings within local cultural contexts. Traditional medical knowledge is tacit and handed down by observation from generation to generation in a local community and through the practices and experiences of its holder. Usually, taboos are not limited to traditional medicine; they apply to the fireplace, especially with un-burned wood fuel used during cooking. This is evident from the statement of one householder that:

> “Water must not be used in quenching burning fire wood, [...] if it happens; it can cause fever, respiratory problems [...]” (Interview with Householder 10, M, Ebira).

Typically when householders finish cooking, wood is spread apart and any charcoal that has formed on the wood is removed while the rest is left in the open to cool down naturally as illustrated in Figure 6.5.

Figure 6.5: An example of wood cooling in the community
Source: Author, March 2011

During the process of quenching the wood fire, wood ash mixes with water, which makes the fume-vapour unpleasant, thereby causing eye irritation. Further discussions with Householder 10, however, indicated that the unpleasant fume-vapour, which causes eye irritation, did not seem to be the main reason for not pouring water directly on wood fires. Nevertheless, as mentioned earlier, issues of hygiene (whereby fumes that settle on cloth can find their way into food), could be linked to taboos compelling people to revere cultural norms in their communities. When householders were asked whether or not they had any concern about the fume-vapour causing the eye irritation, one person responded:

> "Those that inhale smoke (referring to the fume-vapour) have fuzzy perceptions about life [...] they can't reason very well, you can call it dull brain or mental retardation" (Interview with Householder 25, M, Ebira).

In addition, another householder stated,

> "…constant exposure to fumes can make one reason negatively" (Interview with Householder 29, M, Ebira).

As such wood fumes are believed to be the major cause of brain dysfunction which is premised on 'cultural-diagnosis', as against the effect of wood smoke that causes delayed neuropathologies in the body system (see Lee *et al*., 2005).

All the above actions are seen as taboo and are not necessarily linked to the actual health impacts of indoor air pollution associated with the burning of biomass fuels. Householders have been able to identify salient norms relating to the sacredness of the fireplace/hearth and its management. Householders in the study area observed and adhered to taboos believing that negative consequences can always be averted by observing traditional norms in regards to the use of sacred materials in the community. Not only should norms be observed in fireplaces, but also while preparing herbal medicine and the processes involved are conscientiously observed in consonance with cultural norm frameworks. Under no circumstance should one's actions during cooking contravene the highly esteemed cultural values in each of the local environments. Mafimisebi and Oguntade, (2010) state that using wooden batons to remove the bark of medicinal plants is taboo in Nigeria when preparing herbs and going against such rules will make the herbs ineffective in curing the disease they seek to treat. It is believed that diseases or ailments can be contracted by not adhering to the rules and values associated with the usage of wood fuel rather than by seeking to address the potentially harmful effects of indoor air pollution arising from the burning of biomass fuels.

Similarly, in preparing herbs, dedicated hearths are used which are never used for daily meal preparation. On the other hand, women are not expected to taste and/or talk while cooking as a mark of respect for their husbands in the community.

6.6 Conclusion

The chapter has examined and highlighted the socio-cultural context underlying the use of biomass fuels and the different perceptions regarding indoor air pollution in Ado Ekiti, Nigeria among householders of different ethnicities. In particular, the themes generated by the ethnic groups brought to light how culture is embedded in the type of wood harvested for domestic activities. As noted from the study, the Ebiras and Yorubas give particular attention to the type of wood fuel harvested for domestic activities. While reflecting differences in cultural background, the Tivs and Hausas consider all types of tree good enough for cooking. Ebira and Yoruba culture seems to be influenced more by traditional norms and taboos when it comes to cooking practices and hearth tending in comparison to Tivs and Hausas culture. This possibly reflects a greater interest by Ebira and Yoruba groups in sustaining their cultural heritage when it comes to the use of fuel wood.

Significant findings from this study suggest that the consideration of energy type(s) to be used for domestic activities was not deemed as a household priority (especially when related to the immediate needs of the family) and individual family set-ups (man, woman or both) influence decisions on the choice of energy type(s) in households. Not only this, access (free harvesting of wood fuel), affordability (no attached cost) and cultural cooking practices influenced householders' choice of energy source(s) in the study area.

In particular, the cultural practices of using wood fuel, as learnt from their forebears are the only means of cooking that householders knew. This tradition has been upheld as a result of the cultural institutions shaping the way of life of all householders. Householders' cooking methods are based on long standing experience and local knowledge of wood fuel use that is deep rooted in norms associated with preparing traditional dishes. Recognising the particular cultural cooking technology of householders is a sensitive reality that is important for understanding indoor air pollution in peri-urban areas in Ado Ekiti.

This study also found that most households are accustomed to poor ambient air, and cultural beliefs will not stop them from using biomass fuel in carrying out their domestic activities. Interpretations of the causes of indoor air pollution were complex as they involved householders' beliefs and cultural dispositions towards it. Evidence from this study suggests that the perceived level of indoor air pollution in Ado Ekiti by householders reflects their cultural judgment regardless of high levels of particulate matter measured in the area as discussed in Chapter Five.

Householders do not consider their behavioural pattern of staying close to fireplace, tending the hearth and strapping young children to their backs as capable of causing ill health amongst them. Rather, the key causes of the diseases are ascribed to an inability to conscientiously comply and adhere to traditional norms of not harvesting sacred trees for cooking activities. The repercussions of using these sacred trees as wood fuel have reconstructed their views on energy sources. Restrictions on the harvesting of sacred trees are 'ethnic-specific' and it is forbidden to act and live contrary to this cultural social system. Notwithstanding, one of the sacred trees (*Ochuku*) identified in the study area can only be harvested for medicinal use by the Ebira group. The traditional medicine system practised in the community made use of extracts from this sacred tree in treating their ailments. Some of the chemical compounds found in these leaf extracts have scientific merit in the form of herbal remedies used by rural households in Nigeria who have limited access to hospital facilities and medical care.

With the exception of the negative impacts of wood smoke, which has been culturally contextualised and entrenched in the norms and values that prohibit the use of forbidden trees for cooking activities, there are perceived benefits of using wood smoke. Biomass fuels are useful as a means of sustaining small enterprises and are linked to the longevity of mud buildings in the study area.

The concluding section of this chapter demonstrated the onus laid on the cook in ensuring that taboos associated with cooking practices are strictly observed. The norms acted as a means through which information is disseminated through generations in the community and as a way of making traditional values all-encompassing across people in the community. In a way, it created seemingly more important forms of acceptable cultural requirements adopted for lived realities within the community without endangering one's life. The next chapter discusses environmental concerns in the study area.

Chapter Seven

Transforming Communities: Knowledge, Information and Education about Indoor Air Pollution

7.1 Introduction

Chapters Five and Six examined the role socio-economic factors played in the choice of energy sources and identified the norms and values guiding the use of biomass fuels amongst householders in peri-urban areas of Ado Ekiti, Nigeria. This chapter examines the fifth objective of this study: to evaluate householders' knowledge, information, and education about indoor air pollution (Section 1.3). This chapter contextualises the cultural considerations needed when providing appropriate interventions in order to reduce indoor air pollution in the area.

In Section 7.2, environmental problems and concerns of householders are identified. The various environmental problems are ranked according to how householders prioritise these problems. The section further examines how nested local and global scales of indoor air pollution affect the environment. Environmental concerns from the perspective of different stakeholders are identified in Section 7.3. Section 7.4 examines contending socio-cultural contexts that might affect the uptake of cleaner fuels and interventions attempting to improve air quality in the study area.

7.2 Environmental Problems and Concerns of the Householders

Analysis of the household questionnaire survey indicated that 93.6 percent of householders had not been given information regarding indoor air pollution from government or NGOs. Only 6.4 percent claimed that they had been able to access information about indoor air pollution. This was mainly through the means of pilot questionnaires from this study (5.1 percent), schools (1 percent), and, relatives and friends (0.3 percent).

This suggests that the pilot study carried out for this research in 2010 may have been the main means through which householders learnt about indoor air pollution.

In order to better understand levels of awareness about environmental problems in the study area, the questionnaire survey requested respondents to rank what they perceived to be the most important/pressing environmental problems. The environmental problems which householders were asked to rank on a scale in order of preference (from 1 (lowest) to 5 (highest)) included malaria, sanitation, drinking water and cooking smoke. As shown in Table 7.1, 36.6 percent of the respondents identified the lack of drinking water as the most important environmental problem, and one that they highly prioritised above other environmental problems. 28.6 percent and 32.3 percent of the respondents respectively felt that sanitation and cooking smoke were less significant environmental problems. As can be seen from Table 7.1, householders considered the need to have access to drinking water as more important to them amongst the other pressing environmental problems with a mean ranking of 3.39, while cooking smoke with the lowest mean ranking (2.54) was not considered to be a particularly important environmental problem. The data that contributed to these mean rankings are presented in Table 7.1. The table shows that the environmental problems have generally low standard deviation values, indicating low variation in the ranking process and a lack of specific trends in the data.

An investigation into the statistical significance of three parameters (gender, ethnic group, and age) was conducted. The assumption for the Chi-square test was first checked (Section 3.6) and the results are presented in Tables 7.2 – 7.5.

Table 7.1: Percentage ranking of environmental problems in peri-urban areas of Ado Ekiti

Environmental Problems	Ranking					Mean	SD
	1 (low) %(N)	2 %(N)	3 %(N)	4 %(N)	5 (high) %(N)		
Drinking water	13.1 (46)	14.9 (52)	13.7 (48)	36.6 (128)	21.7 (76)	3.39	1.328
Sanitation	28.6 (100)	17.1 (60)	22.6 (79)	14.6 (51)	17.1 (60)	2.75	1.445
Malaria	24.6 (86)	31.1 (109)	14 (49)	20.6 (72)	9.7 (34)	2.60	1.316
Cooking Smoke	32.3 (113)	16.9 (59)	22 (77)	22.3 (78)	6.6 (23)	2.54	1.319

Drinking Water

As indicated in Table 7.2, there is no association between gender, age, and access to clean drinking water as an environmental concern/problem. There is an association with ethnic group as highlighted in the table. This might reflect the low sample sizes of some of the ethnic groups.

Table 7.2 highlights how on a scale of 1 – 5 the gender preferences indicated that both men (46.5 percent) and women (30.9 percent) respectively considered a lack of drinking water as the most important environmental problem in the study area. Similarly, when the ethnicity of householders was considered as illustrated in Table 7.2, the Ebiras (32.1 percent), Yorubas (52.7 percent) and Tivs (48 percent) households indicated a lack of drinking as the most pressing need they considered as the major environmental problem in the area.

The trend of ranking drinking water access as important is probably not influenced by age. Householders regardless of their age were most concerned about a lack of drinking water problems as an environmental problem as illustrated in Table 7.2.

Table 7.2: Percentage ranking of drinking water as an environmental problem

Parameters	Ranking					χ^2	p = 0.05
	1 (low) %(N)	2 %(N)	3 %(N)	4 %(N)	5 (high) %(N)		
Gender						8.941	0.063
Male	11(14)	13.4(17)	12.6(16)	46.5(59)	16.5(21)		
Female	14.3(32)	15.7(35)	14.3(32)	30.9(69)	24.7(55)		
Ethnic group						23.278	0.025
Ebira	15.5(41)	16.2(43)	16.2(43)	32.1(85)	20(53)		
Yoruba	3.6(2)	12.7(7)	5.5(3)	52.7(29)	25.5(14)		
Tiv	12(3)	8(2)	8(2)	48(12)	24(6)		
Hausa	0(0)	0(0)	0(0)	40(2)	60(3)		
Age group						13.927	0.604
<20	13.3(2)	13.3(2)	13.3(2)	53.3(8)	6.7(1)		
21 – 30	14.1(13)	18.5(17)	16.3(15)	34.8(32)	16.3(15)		
31 – 40	8.9(10)	16.1(18)	15.2(17)	33.9(38)	25.9(29)		
41 – 50	14.3(9)	11.1(7)	12.7(8)	42.9(27)	19(12)		
>50	17.6(12)	11.8(8)	8.8(6)	33.8(23)	27.9(68)		

Sanitation

Another environmental problem that householders ranked highly during the survey was sanitation as shown in Table 7.3. Table 7.3 also indicates that there is no association between ranking of sanitation and ethnicity in the area. The table does, however, indicates an association between gender, age, and sanitation and it can be inferred that gender and age may be important in drawing out householder differences in the ranking of sanitation as an environmental problem.

Using the scale stated above, 35.4 percent of women felt sanitation was not a pressing environmental problem, and 74 percent of Ebiras and 29.1 percent of Yorubas shared similar view. There are differences in the identification of sanitation as an environmental problem between those in the 21 – 30 age group, who considered access to sanitation important (22.8 percent) and those above fifty-one years old who do not think that sanitation is an important environmental problem (45.6 percent). The differences in the ranking might be a function of the fact that younger people are more educated and aware of sanitation problems.

Table 7.3: Percentage ranking of sanitation as an environmental problem

Parameters	Ranking					χ^2	p = 0.05
	1 (low) %(N)	2 %(N)	3 %(N)	4 %(N)	5 (high) %(N)		
Gender						17.065	0.002
Male	16.5(21)	21.3(27)	26(33)	13.4(17)	22.8(29)		
Female	35.4(79)	14.8(33)	20.6(46)	15.2(34)	13.9(31)		
Ethnic group						12.369	0.417
Ebira	27.9(74)	18.5(49)	21.1(56)	16.2(43)	16.2(43)		
Yoruba	29.1(16)	9.1(5)	27.3(15)	10.9(6)	23.6(13)		
Tiv	36(9)	16(4)	32(8)	4(1)	12(3)		
Hausa	20(1)	40(2)	0(0)	20(1)	20(1)		
Age group						29.155	0.023
<20	20(3)	20(3)	20(3)	20(3)	20(3)		
21 – 30	17.4(16)	15.2(14)	22.8(21)	21.7(20)	22.8(21)		
31 – 40	31.3(35)	15.2(17)	27.7(31)	13.4(15)	12.5(14)		
41 – 50	23.8(15)	17.5(11)	25.4(16)	12.7(8)	20.6(13)		
>50	45.6(31)	22.1(15)	11.8(8)	7.4(5)	13.2(9)		

Malaria

As Table 7.4 shows, there is no association between ethnic group, age, and malaria in the area, while the statistical test found an association with gender. This could perhaps reflect how roles are apportioned in the family whereby the females have the responsibility of caring for family members whenever they are unwell. In addition, it may reflect the fact that stakeholders have helped raised awareness of malaria risks (Section 7.3).

Of the women that participated in the survey, 33.6 percent of them think that malaria cannot be categorised as an important environmental problem in the area, and a similar view is also shared amongst the Ebiras (27.9 percent), Yorubas (45.5 percent) and Tivs (40 percent). In addition, when the ages of the householders are considered, less significance was given to malaria as an environmental problem as shown in Table 7.4.

Table 7.4: Percentage ranking of malaria as an environmental problem

Parameters	Ranking					X^2	p = 0.05
	1 (low) %(N)	2 %(N)	3 %(N)	4 %(N)	5 (high) %(N)		
Gender						42.831	0.000
Male	8.7(11)	48(61)	17.3(22)	19.7(25)	6.3(8)		
Female	33.6(75)	21.5(48)	12.1(27)	21.1(47)	11.7(26)		
Ethnic group						18.334	0.106
Ebira	26(69)	27.9(74)	13.6(36)	21.5(57)	10.9(29)		
Yoruba	14.5(8)	45.5(25)	16.4(9)	18.2(10)	5.5(3)		
Tiv	24(6)	40(10)	8(2)	20(3)	8(2)		
Hausa	60(3)	0(0)	40(2)	0(0)	0(0)		
Age group						13.351	0.647
<20	0(0)	53.3(8)	13.3(2)	13.3(2)	20(3)		
21 – 30	26.1(34)	31.5(29)	12(110	20.7(19)	9.8(9)		
31 – 40	26.8(30)	32.1(36)	12.5(14)	18.8(21)	9.8(11)		
41 – 50	20.6(13)	31.7(20)	19(12)	22.2(14)	6.3(4)		
>50	27.9(19)	23.5(16)	14.7(10)	23.5(16)	10.3(7)		

Cooking Smoke

The environmental problem of cooking smoke was ranked by householders and the Chi-square test indicated that there is no association between ethnic group, age, and cooking smoke in the area. There is an association with gender, which may reflect how responsibilities are shared in the family (Section 6.2) and, possibly the cooking methods they have learned to use from their parents (Section 6.2.2). In addition, the perception that natural ventilation causes indoor air pollution may have shaped householders understanding of the problem in the area (Section 6.3).

As shown in Table 7.5, 40.8 percent of the women that participated in the survey indicated that they do not consider cooking smoke as an environmental problem, and the Ebira (31.7 percent) and Yoruba (36.4 percent) households echo this view. Similarly, respondents over 31 years (Table 7.5) indicated that cooking smoke is not an important environmental problem.

Table 7.5: Percentage ranking of cooking smoke as an environmental problem

Parameters	Ranking					χ^2	p = 0.05
	1 (low) %(N)	2 %(N)	3 %(N)	4 %(N)	5 (high) (N)		
Gender						25.504	0.000
Male	17.3(22)	15.7(20)	31.5(40)	28.3(36)	7.1(9)		
Female	40.8(91)	17.5(39)	16.6(37)	18.8(42)	6.3(14)		
Ethnic group						11.103	0.520
Ebira	31.7(84)	17(45)	21.1(56)	21.9(58)	8.3(22)		
Yoruba	36.4(20)	16.4(9)	27.3(15)	18.2(10)	1.8(1)		
Tiv	28(7)	20(5)	16(4)	36(9)	0(0)		
Hausa	40(2)	0(0)	40(2)	20(1)	0(0)		
Age group						25.535	0.061
<20	20(3)	6.7(1)	26.7(4)	33.3(5)	13.3(2)		
21 – 30	21.7(20)	20.7(19)	26.1(24)	22.8(21)	8.7(8)		
31 – 40	33.9(38)	17(19)	16.1(18)	27.7(31)	5.4(6)		
41 – 50	38.1(240	19(12)	15.9(10)	17.5(11)	9.5(6)		
>50	41.2(28)	11.8(8)	30.9(21)	14.7(10)	1.5(1)		

Field observation in the study area showed that most of the communities do not have access to clean drinking water. They rely on hand-dug wells, streams and rain water for their domestic supply. In disposing of refuse, most communities have their own open dumpsites where the refuse is dumped and burnt occasionally (once in a month). In a follow up to the questionnaire survey, interview sessions conducted with householders sought to understand what householders know about environmental problems and especially indoor air pollution. When I drew their attention to soot-blackened walls and curtain materials caused by years of cooking indoors with biomass fuels, most respondents had never considered it as a serious environmental problem:

> "The pollution we suffer is not from the fuelwood, it is the course of nature that brings the pollution" (Interview with Householder 4, M, Ebira).

> "Our forefathers made use of firewood to cook and light their house [...] they even lived longer [...]" (Interview with Householder 14, F, Yoruba).

> "The wood smoke is not good, [...] we experience headaches, and tears in the eyes [...] these are problems that we can easily find solution to. What we need a solution to is how to get good drinking water, because we have to rely on streams and boreholes. We are worried that indiscriminate dumping of wastes around in the communities easily pollutes the water. Also, having toilets is what we desire for each household in this community" (Interview with Householder 18, M, Ebira).

"Smoke from firewood? Though it is bad, but, the greatest problem here in this community is mosquitoes, once this is settled then other things can follow" (Interview with Householder 22, M, Yoruba).

"This information you (referring to the researcher) have given us about the wood smoke is an eye opener for us all in this community, [...] it never crossed our mind that it is an environmental problem that is as important as water, sanitation and malaria [...] we often clamoured for facilities to be put in place in solving them [...]. We need people like you to inform the government to equally have radio and television adverts in this respect so as to further inform our people, I mean everybody in this country" (Interview with Householder 24, F, Ebira).

Indoor air pollution from wood smoke is perceived by some householders to be caused by natural air blowing cooking smoke into their buildings. The act of using wood fuel is not recognised as a contributing factor. Needless to say, this perception makes it hard for them to recognize the detrimental health impacts of being exposed to indoor air pollution (see Section 2.3.2). Householder 14 (F, Yoruba) opines that despite the use of wood by their grandparents, their life expectancy according to him was higher than most of the community at present. This research further confirms that people "tend to intellectualise a lot and minimise any potential harm" by relying on their experiences rather than realities that their actions could have caused them (Walker, 2010:77). Drawing from Householder 18's statements and Figure 7.4 above, it is suggested that the people do not perceive indoor air pollution as a significant health risk; rather they prioritize other needs (sanitation, clean drinking water) over energy fuel, which also confirms Mobarak *et al*.'s (2012) findings in Bangladesh. In addition, as householders have for a long period of time relied on wood fuel in meeting their energy needs in Ado Ekiti, the lack of awareness about cleaner fuels discourages them from changing their traditional cooking methods which further supports Troncoso *et al*.'s (2010) findings.

In the light of Householder 24's view, advocacy has been for the provision of water and sanitation facilities and there has been a neglect of infrastructural facilities and a lack of support for energy sources by the government. The lack of government attention to making cleaner fuel accessible in Ado Ekiti may well be linked to householders' lack of interest in it, but if better infrastructural facilities were provided in Ado Ekiti for the distribution of clean fuels, it might ease the problem of accessibility. This further echo Peng *et al*.'s (2010) study on fuel switching in rural Hebei, China, suggesting that when there is construction of modern facilities in the countryside, it makes cleaner energy accessible.

Most householders' perception about indoor air pollution is that it is a problem that they can always find solution to, especially when they experience headaches, tears from the eyes etc. Householder 18 seems to downplay the health impacts associated with being constantly exposed to concentration levels above WHO guideline values as discussed in Chapter Two. Therefore, the low levels of attention given to cooking smoke as an environmental health problem in the study area obviously influences the level of attention that householders give to it. The fact that householders do not show an interest in problems created by indoor air pollution indicates that they are not fully conscious of the effects of poor ambient air quality. The findings support Bickerstaff's (2004) assertion of attributing negative effects of IAP to natural and/or geographical occurrences in the environment. In addition, this further confirms Muchawaya's (2006) study in rural areas of Zimbabwe where the effects of indoor air pollution on health are perceived as normal symptoms that are not taken seriously other than that they cause mild headaches and sore eyes, but are not associated with severe respiratory-related health threats. The Ado Ekiti findings further agree with Dodman's (2004) assertion that individual perspectives and construction of environmental problems can affect concern about them and may go a long way in effecting changes in the physical environment. It can be seen that in the study area householders are more concerned about making demands to the government regarding better access to infrastructural facilities that will improve access to clean drinking water, provide refuse waste systems and toilet facilities with the aim of improving environmental sanitation in the area, and preventing malaria by making available insecticide treated nets and establishing health care clinics in the community (See Tables 7.2, 7.3, and 7.4).

The above statements of the householders showed that indoor air pollution is not considered to be a pressing environmental problem that affects their well-being. What people therefore know about their environment and feel about it is critical in determining actions that can help establish sustainable communities (Sudarmadi *et al*., 2001). The concealed and possibly long term effects of exposure to wood smoke over the years might account for the little attention given to the problem, unlike malaria, a lack of sanitation and a lack of potable water that have more noticeable and immediate health impacts. Householders are aware of these problems through direct experience, government information programmes (in the form of radio jingles, drama and posters) and via health workers working with the communities in administering vaccines to eradicate childhood diseases (polio, measles). Basically, householders want information about indoor air pollution to be disseminated through media organisations (local radio and television stations) in the community in order to learn more about this environmental problem that the majority are unaware of. Essentially, in this study area, the focus of the householders is on the provision of physical needs that will improve their living conditions and environment. As stated above, householders believed that they can easily deal with the symptoms and effects of wood smoke. Nevertheless, the non-prioritising of the health effects of indoor air pollution is likely to have impacts on the overall well-being of the householders.

From the analysis of environmental problems (drinking water, sanitation, and malaria) discussed above, it can be argued that householders' perceptions about environmental problems irrespective of gender, ethnicity, and age, reflects a lack of infrastructure (Section 3.5.3). The fact that mosquito bites and sanitation/water quality problems are visible and can produce noticeable health impacts within a relatively short time frame may account for their higher prioritisation in the rankings (see Table 7.1) than the health risks created by exposure to indoor air pollution (Section 2.3.2). Householders' direct experiences of health issues arising from malaria, sanitation, and poor water quality may also account for the high priority given to them in the area. In addition, the awareness created by the Ministries of Environment, Information, Health and media organisations on the health impacts of these environment problems (Section 7.4) is likely to have enhanced householders' risk perceptions on these issues. However, having knowledge and information about environmental problems does not necessarily mean that householders would make changes to their way of living (Moyihan *et al*., 2000).

The environmental-energy linkage, which most householders do not recognise, is the contribution of particulate emissions from their chosen energy source to local and community (neighbourhood) environmental problems. The by-product of the incomplete combustion of biomass fuel burning creates indoor and outdoor air pollution, which diminishes air quality in the homes and communities of the householders. A fraction of particulates inhaled by householders in their buildings, no matter how small, might have health-damaging effects on them. With the daily average levels of ambient air quality of between 21μg/m^3 and 541μg/m^3 (Chapter Four) based on measurements taken in Irasa, householders are at risk of illnesses associated with indoor air pollution. Drawing from similar results in other parts of the global South where air quality levels are above WHO 25μg/m^3 guideline values (Section 2.2), there have been recorded health impacts associated with exposure to indoor air pollution from cooking/wood smoke, which further shows that peri-urban householders in Ado Ekiti are likely to be predisposed to similar diseases (see Sections 2.3.2 and 4.7). In addition, Ellegård's (1996b) study in Mozambique indicates that wood fuel users experience actual health problems including coughs and respiratory symptoms all of which are related to indoor air pollution. According to Smith *et al*. (2000), biomass smoke is a complex mixture of pollutants of which carbon monoxide and particulate matter pose the greatest risk to infant mortality, and health problems in children and adults. Arguably most air pollution from the combustion of biomass and fossil fuels have nested local-scale (householders' health), community-scale (acid rain) and global-scale (greenhouse gases) impacts on the environment, and can therefore be reduced in the study area with the scaling-up of householders to cleaner fuels.

7.3 Stakeholders Perspectives

Discussions about indoor air pollution resulting from the burning of biomass fuel took place in the form of interviews with various stakeholders at local radio and television stations and the Ministries of Information, and Environment in Ado Ekiti, Nigeria (Table 3.4). Part of the responsibilities of these stakeholders includes gathering information on various problems/issues identified in communities where their organisations are situated and purportedly making the government aware of such problem(s) with the aim of finding solutions to them. These solutions include drawing-up programmes that will change attitudes amongst people affected and/or suffering from environmental related diseases, promoting cultural values within communities, creating sanitation enlightenment programmes, disseminating government-related environmental policy and enforcing compliance to this policy.

The Ministry of Environment is the main body responsible for issues connected with environmental problems in the study area. An overview of their activities range from ensuring the proper disposal of faecal wastes in private and public buildings to controlling insects in the communities. In addition, the Ministry seeks to improve awareness about environmental health programmes (e.g. malaria, drinking water, refuse disposal, and indiscriminate bush burning), educate people about occupational health and hygiene in the workplace and controlling communicable diseases in the communities. None of these activities considers indoor air pollution. The responses from the Ministries of Environment, Information and Health and media organisations concerning indoor air pollution problems are expressed as follows:

> "Enlightenment programmes for environmental problems are geared towards poor sanitation, malaria, lack of drinkable water, general filthiness [...] we don't have programmes for indoor air pollution, [...] although now that we are aware we shall include that in our programme" (Staff MOE, March 14 2011).

> "Information on environmental issues is provided in line with the government agenda […] there is no specific information addressing indoor air pollution" (Staff MOI, March 10 2011).

> "Health issues focus on alleviating the problem of malaria, HIV/AIDS. At the moment health issues, relating to indoor air pollution are not yet addressed. We might be looking at it as time goes on" (Staff MOH, May 11 2011).

> "Most of the jingles and programmes only provided enlightenment on sanitation, HIV/AIDS, vaccinations" (Staff SGR, March 18 2011).

> "There isn't awareness about indoor air pollution. TV programmes only focus on sanitation, malaria" (Staff FGT, March 21 2011).

The interview responses indicate that there are no organisations creating awareness about indoor air pollution in the area. The ultimate goal of organisations is to target and create awareness of wider environmental and health issues such as sanitation, malaria, and HIV/AIDS. This supports the ranking of environmental problems by householders as examined in Section 7.2. The Ministry of Health is aware of the health implications of exposure to IAP, but addressing the problem has not been given priority. Information was given to other stakeholders during the interview sessions about the health implications of exposure to wood smoke from biomass fuels during the pilot study carried out in August 2010 upon which stakeholders promised that action would be taken. A revisit in 2011 revealed that no programme had been put in place to enlighten people of the disease burden associated with burning biomass fuels. Part of the reason given was the instability of the political government in the state, which had made bureaucratic approval difficult for most government organisations when embarking on new projects.

Counting on government organisations for the dissemination of information about indoor air pollution in the study area cannot therefore be totally relied upon. If combating indoor air pollution is not on the government's agenda, it is likely to receive little support unlike China's NISP programme that received national government support (Section 2.5). This is because issues that do not reflect the agendas of the political party in government are not necessarily seen as a priority. The wider political situation thus needs to be understood when government organisations are approached in order to disseminate information about indoor air pollution. In the absence of strong administrative, technical support and sustained national-level interest as found in China's NISP (see Sinton *et al*., 2004); similar successes in combating indoor air pollution are unlikely to be recorded in peri-urban areas of Ado Ekiti. The starting point in addressing the IAP problem in peri-urban areas of Ado Ekiti is for government to prioritise and show interest in solving the problem. Although in recent times the Nigerian government has been formulating energy policies for the country, there is little implementation of the policies at the national, state, and local levels.

As mentioned in Section 2.7, international organisations and NGOs are now taking the lead in promoting clean fuel and stoves in the country to alleviate the problem of indoor air pollution. However, Ekiti State does not currently fall within the scope of intervention embarked upon by these organisations. As there are no NGOs in the State where this study was carried out, comparisons could not be made of what their responses would be vis-à-vis those of the government towards combating the problem.

7.4 Transforming Communities through Appropriate Interventions

In providing appropriate interventions for peri-urban households in Ado Ekiti, Nigeria, some factors specific to this local environment need to be considered to customise interventions that will target local needs.

The specificities of energy sources (wood and kerosene) in this study area are influenced by social, economic, and cultural factors, and the dwelling conditions of the householders, which have contributed to indoor air pollution. Interventions that have a chance of being self-sustaining must consider the cultural values of the householders. The technology must respond to the needs of the householders by also respecting their local culture and making use of materials and labour within their domain (Troncoso *et al*., 2011). In view of the varying cultural contexts prevalent amongst householders in the study area, recognition must be given to these divergent views and traditional values in proffering solutions to the problem of indoor air pollution in Ado Ekiti, Nigeria – by applying the 'software' approach (Section 2.5). As an example, the communal ways of life in the study area see householders who own generators sharing electricity generated with neighbours for lighting, watching television and charging mobile phones. This communal way of life allows free interaction with one another without any intent to oppress or exploit anyone.

In appreciating the type of communal life shared by householders, however, this attitude can act as a disadvantage to introducing cleaner fuels and stoves, in that householders might find it difficult to conceal their material acquisition. This shows that community acceptance (Section 2.5.1) is vitally important when introducing cleaner fuels even when there are national policies encouraging the use of such fuels (Section 2.5). This can create problems where projects single out individuals either to purchase or receive (free of cost or at a reduced price) material from outsiders visiting their communities unless great care is taken to liaise with community leaders. Clean cookstove programmes are also likely to succeed if they consider the cultural cooking methods, needs and resources of users (Sections 2.5.1 and 3.5.3; Troncoso *et al*, 2011). However, cultural conflicts associated with the perceived benefits derived from cooking smoke (Section 6.4.1) might be a drawback in the adoption of clean fuels and stoves. In providing interventions for IAP, previous examples of ICSs have included the installation of chimneys in buildings and ICSs provided for households (Section 2.5). Chimney installation as used in India's NPIC for IAP intervention are not likely to be adopted amongst Ado Ekiti householders because the building design is unfamiliar (Figures 3.3 and 3.5). Householders' communal way of life, on the other hand, may either promote or hinder the adoption of cleaner fuels, depending on the circumstances, as illustrated by the following statements from householders:

> "You cannot just receive anything from visitors, because you don't know if everybody is happy, [...] our community is small. You can't hide anything [...] there is only one road that leads here, so, no secret, that is why one has to be very careful, that way you get along well with everyone" (Interview with Householder 21, M, Ebira).

> "One is careful in receiving gifts from visitors, you can be sure that virtually everyone in the community is aware of whatever you're doing" (Interview with Householder 22, M, Yoruba).

> "We understand ourselves […] there is no secret amongst us, the more reason we're careful in interacting with visitors and take caution in receiving gifts from them. Although receiving gifts from visitors is not a bad idea, but this is a small community and nothing hidden" (Interview with Householder 30, F, Ebira).

The community related characteristics of householders which place importance on communal life, appear to shape social interactions with outsiders. This corroborates Gadenne *et al*.'s (2011) findings on the role that social and community influence plays in the uptake of any domestic energy technology, which has a strong positive influence on adoption of the technology, and the social norms in an environment have influence in developing their values. This further affirms Troncoso *et al*.'s (2007) finding in rural Mexico that appropriate interventions must not contravene the entrenched traditional norms of the people, but must be useful in substituting existing technology and be a participative process. Some of the householders perceived that this form of favouritism might be envied and they are constrained in singularly receiving gifts from outsiders without the consent of the community leader. They believed that if anything happens in the future in the form of sickness or premature death, the cause is usually attributed to those who felt excluded and hurt for not being chosen. The best way of making the adoption of new technology in the study area feasible, is by encouraging the participation of both the community leaders and householders in developing models of appropriate technology suitable to their cooking needs.

Another point that must be considered from Householder 21 is the issue of ‘jealousy’, which in itself might hold them back in adopting cleaner energy. Householders are careful in interacting with ‘outsiders’ and there is a possibility of being reluctant to accept material gifts from them. This supports Wüstenhagen *et al*.’s (2007) point that interacting with some sections of the community at the expense of others gives room for suspicion and jealousy to polarise relationships amongst residents. The resentment shown by householders towards accepting material items from visitors would appear to undermine the viability of clean technology in Ado Ekiti. These all point to a ‘software’ (Section 2.5.1) approach in addressing energy issues in peri-urban areas of Ado Ekiti. In addition, it has further highlighted that socio-economic characteristics (e.g. income, education) as discussed in Chapter Five are not the only factors influencing the uptake of clean energy in peri-urban areas in Ado Ekiti.

The scaling-up of householders to clean fuels and stoves in the area require interventions that carry along all householders in the community, because of the norms associated with favouritism.

On the other hand, indications have also emerged from the study area that parents are desirous to have their children live a better life as compared to them:

> “In life parents wish a better life, livelihood, education for their children. Indeed when I compared my present living condition with my own parents, I can say that it is much better for me than my parents. Moreover, my children are expected to out pass me in their own living condition. The world is changing; our children are better informed to acquire facilities that make life comfortable ...” (Interview with Householder 19, F, Ebira).

The meaning of the ‘better life’ to most of the householders interviewed relates to factors such as education, household amenities (television, radio, cars, etc.) and/or any material properties that they as parents do not have. These priorities do not consider energy fuels as part of the desired changes needed in the lives of their children. Whatever local communities classify as their basic priority needs must be considered in providing appropriate technology for their energy services.

When parents receive gifts from their children, the issue of jealousy does not play a role in this aspect. The problem arises with material items received from outsiders, which are capable of provoking jealousy amongst the householders. Regardless of the accrued advantage of energy technologies, householders most value interventions that do not conflict with their traditional way of life. Interventions targeted at children may therefore trickle down to their parents over time. According to Kowsari and Zerriffi (2011) innovation diffusion of a new technology entails social communication from person to person in creating knowledge, awareness, intention, and behaviour on how the technology can be adapted for their use. However, Foell *et al*. (2011) argue that behavioural change takes time, and it requires long-term investment in scaling up householders to cleaner fuels.

The above claim in contextualising the needs of the householders in the study area is significant in understanding how to move them to cleaner fuels. It implies that householders find it easy to spend money on material needs such as radios or mobile phones in the family rather than providing for cleaner energy sources. In as much as appropriate technology is desired by householders, social acceptance embedded in cultural norms and values are important in adopting the technology.

7.5 Conclusion

In this chapter, householders' knowledge and information about indoor air pollution was examined. It was noted that the experimental scientific practicalities of the causes of poor air quality in buildings broadly differ from householders' views in that it was attributed to the effects of natural aeration blowing cooking smoke from other households into their buildings as against the burning of biomass fuels in the area. Ethnicity is influential when it comes to ranking environmental problems because of the differences in householders' cultural background. However, the limited sample size from some ethnic groups could have overestimated perceptions about environmental problems in the area, hence, the results cannot be generalised. The lack of synergy between cultural and scientific interpretations of the main causes of poor ambient air in the study area makes it difficult for householders to comprehend the potential health impacts of IAP.

Stakeholders whose core responsibility is to enlighten households about the detrimental effects of exposure to wood smoke only focused on providing access to drinking water and improving sanitation facilities in Ado Ekiti. The thoughts of both stakeholders and householders aligned because indoor air pollution is not considered, or prioritised, as an environmental problem needing urgent attention. The tendency of householders to associate IAP health risks with non-adherence to cultural norms helps to prevent the health impacts associated with burning biomass fuels and inhaling wood smoke from being realised.

The cultural context examined in this chapter appears to be pivotal to unravelling the varying contentions of outsiders interacting with households living a communal way of life when attempting to make a change to their conventional lived lives. Cultural norms tend to prevent community members from receiving and accepting gifts from visitors, in order to discourage favouritism and jealousy amongst them. For this reason, interventions that would encourage the use of cleaner fuels need to be approved by community leaders and members. Allowing communities to choose and nominate participants using their individual strategies, beliefs, traditional norms and values can enhance the successful outcome of any form of intervention, reconcile any differences amongst the householders and can help to introduce cleaner fuels into households. At all times householders' needs must be adapted to the form of intervention and solution provided in alleviating the problem of indoor air pollution in peri-urban areas in Ado Ekiti. The next chapter summarises the findings of this research.

Chapter Eight

Conclusions

8.1 Introduction

This final chapter discusses and summarises the key findings of this research in relation to the objectives originally identified in Chapter One. Section 8.2 discusses key findings and highlights socio-cultural perspectives about energy issues and limitations of the research. Section 8.3 reflects on the socio-cultural contexts that have implications for the uptake of cleaner technologies in the area. In Section 8.4, I draw conclusions from findings on energy issues in Ado Ekiti, Nigeria, while Section 8.5 points to possible area for further research.

This study set out to investigate the socio-cultural context of indoor air pollution in Ado Ekiti, Nigeria. In dealing with linkages between indoor air pollution and the use of biomass fuel, previous studies have focused on various interventions that involve improving or modifying energy sources, stoves and housing (Clark *et al*., 2010; Li *et al*., 2011; Malla *et al*., 2011; Bruce *et al*., 2000; Tsephel *et al*., 2009; Jin *et al*., 2006; Mestl *et al*., 2006; Barnes *et al*., 2004; Mehta and Shahpar, 2004). In all of these approaches, households had personal reasons (such as traditional cooking methods, food taste) for using biomass fuels, (even if they had access to cleaner fuels), which points to the fact that there is a strong preference for biomass fuel. This helps to explain why 'cleaner' fuels and technologies are not often used for domestic activities in developing countries. Although the socio-economic conditions of resource poor families have a major influence on fuel choice, improvements in their well-being often fail to significantly encourage the uptake of cleaner fuels.

Despite a wide range of hardware and software interventions seeking to ameliorate the impacts of indoor air pollution arising from the burning of biomass fuels, householders have often failed to embrace them. Intrigued by the limited impact of various interventions in encouraging householders to use cleaner fuels, this research considered the underlying cultural context surrounding the use of biomass fuels in developing countries in order to address energy needs in these areas and combat the problem of indoor air pollution in peri-urban communities in Ado Ekiti, Nigeria.

Based on the research findings, the socio-cultural context gave a better understanding of householders' perspectives of indoor air pollution and usage of biomass fuels. In the analysis of the data gathered, the local cultural context guided wood fuel gathering (such as sacred trees not being harvested for wood fuel), shaped cooking practices, and perspectives on indoor air pollution. The study established that poor housing conditions contributed to poor ambient air quality in the area, together with high levels of measured particulate matter in buildings, irrespective of whether cooking was done indoors or outdoors with biomass fuels. Householders perceived that non-adherence to traditional norms are the cause of the health problems and not poor air quality.

8.2 Major Conclusions from the Thesis Chapters

An overview of biomass fuel usage given in Chapter One of this thesis showed that its use continues to be on the increase, with users in the global South and Sub-Saharan Africa households having the highest percentages. This background information sets this study within the debate of energy issues in the global South by exploring the socio-cultural rationale for the use of biomass fuels amongst the resource poor. Nigeria was chosen as a case study mainly because of the present neglect of the domestic energy sector by the national government. At the same time, over 80 percent of the peri-urban population rely on biomass fuels in meeting their energy needs; consequently, it is relevant in investigating energy research issues in Nigeria. Though some countries in the global South have set policies and put interventions in place to reduce indoor air pollution, it appears that the resource poor use more biomass fuels for domestic activities in spite of the provision of cleaner fuels (Section 2.5). This research, therefore, attempts to address this gap in the literature by identifying the underlying socio-cultural contexts surrounding preferences for biomass fuels.

It was noted in Chapter Two that the derived advantage of using biomass fuels for traditional food preparation in developing countries appears to cause tension in adopting improved cookstoves and clean fuel interventions. Many of the different 'hardware' approaches failed to appreciate the value placed on traditional cooking methods. The 'software' approach (such as community acceptance, traditional cooking methods) was found to directly address the practicalities of how the rural poor live (Agbemabiese *et al*., 2012; Troncoso *et al*., 2007). Though cultural analysis has been undertaken in the literature to examine behavioural change (Section 2.5.1; Agbemabiese *et al*., 2012; Pine *et al*., 2011; Troncoso *et al*., 2007; Barnes *et al*., 2004), less has been done to analyse socio-cultural contexts shaping the harvesting of biomass fuels and perceptions about indoor air pollution within various ethnic groups in developing countries. The research specifically targeted this socio-cultural context in order to address this gap in the literature.

The distinctiveness of traditional norms amongst the different ethnic groups discussed in Chapter Three allowed various cultural contexts to be explored amongst peri-urban households in Ado Ekiti, Nigeria. Data gathered amongst the Ebira, Yoruba, and Tiv households allowed a diversified view about the use of biomass fuels for domestic activities, though responses are few among Yoruba and Tiv householders. As the focus of this research was not only on the cultural norms of the people, data were also collected on kitchen locations and the environmental risks stemming from the use of biomass fuels in the area. I also sought to demonstrate the practicalities of households living with indoor air pollution in their buildings.

An indication from the dwelling characteristics of householders as presented in Chapter Four highlighted the importance of ethnicity in choosing construction materials, kitchen locations, and architectural design. It was noted that householders replicate forms of social relations that connected them to their 'home' method of cooking with the use of '*aro meta*' (three hearthstone).

The chapter highlighted the complexity of peri-urban environments in developing countries where property development is individualised and does not require government control regarding the basic needs that households must provide in buildings. The study also found that the clustered layout of buildings and poor ventilation reduced air quality in the area. These contributed to poor quality as 98 percent of householders were using wood fuel for their cooking activities. As a result, measured levels of $PM_{2.5}$ in Irasa community indicated high average 24-hour readings found in buildings with both indoor and outdoor kitchens. This suggests that as the minimum standard of air quality in buildings (Table 2.1) is regularly exceeded householders will continue to be exposed to the risks associated with indoor air pollution with the use of biomass fuels for domestic activities. Furthermore, the clustered layout of buildings and the density of communities allowed IAP to penetrate inside the buildings despite people cooking outside. Although these results are significant, it is important to note that air pollution monitoring data were only collected in one community and the results may differ in other communities depending on the various cooking practices householders adopt.

Other factors contributing to the high levels of poor air quality in the area included the tendency for most people to cook at the same time and allow wood to smoulder throughout the day and night, thereby allowing wood smoke into buildings through eaves even when cooking was not taking place. This created background particulate matter in buildings and contributed to poor air quality. Household and community (neighbourhood) levels of air pollution simultaneously affected building air quality and exposed householders to levels of particulates higher than the recommended minimal levels in buildings. This was regardless of where kitchens were located in the community. Undoubtedly, inhalation and exposure to wood smoke have health impacts. According to Zhang and Smith (2007), the combustion of biomass fuels is a key source of indoor air pollution that contributes to the burden of ill health experienced in developing countries. The chapter noted that women and children have tended to be identified as being most vulnerable to the impacts of indoor air pollution (see Kraai *et al*., 2013; Murray *et al*., 2012; Dasgupta *et al*., 2009; Rehfuess *et al*., 2009; Schel *at al*., 2004; Bruce *et al*., 2000; Smith *et al*., 2000a), but this study indicates that the practicalities of using biomass fuels for cooking has health implications for all householders.

The analysis in Chapter Five suggested that higher socio-economic status did not necessarily translate into the use of cleaner fuels for cooking in the study area. Even those who had relatively high incomes (above ₦20000/month[38]) would not be able to sustain the use of cleaner fuel because of factors such as a large family size and other competing needs

[38] Which is approximately £80

that took priority in the home. Though the number of high-income earners was low in the study, their responses gave some insights into their fuel choice decisions. They indicated that improvements to the household income status as proposed in the energy ladder, does not necessarily translate into a shift from the use of biomass fuels to cleaner fuels; rather householders use multiple fuels in the study area. Free access to biomass fuel coupled with cultural perspectives on its use (notably the perception that it represents a faster means of cooking) and limited access to cleaner fuels contribute to its continued use.

An evaluation of householders' priorities regarding the provision of basic infrastructure in their homes found little emphasis on energy fuels. In some ways, the emphasis placed on other household needs has encouraged householders to rely on free fuel wood from the forest so as to discount energy expenses on school fees, food, transport and other expenses. If households had to pay for cooking fuel, they would have less financial resources available for these priorities. The 'free' access to energy fuels in the study area, though not clean, is depended upon by householders in meeting their energy needs, and has acted as a 'cultural-economical' way of providing for domestic energy needs. It has been found that the economic situation of the householders cannot only be relied upon to help them climb the energy ladder without understanding the underpinning cultural context. It is perhaps not surprising, as noted in Chapter Six, that socio-cultural factors have significantly shaped energy use in the area.

For communities in the study area, diseases are culturally contextualised as discussed in Chapter Six, and ill-health is often attributed to non-conformity with traditional norms that stipulate households must not harvest sacred trees as wood fuel. Whenever there are incidences of ill health, they are first 'culturally-diagnosed' regardless of whether the person's activities (burning wood fuel) might be connected with exposure to indoor air pollution. According to householders, the 'proven' health implications of harvesting sacred trees for wood fuels have shaped their perspectives and beliefs regarding the causes of diseases in the area. Perhaps not surprisingly, householders made no linkage between potential health impacts and the burning of biomass fuels. Ethnicity is vital to local realties as indicated by the association of the use of 'forbidden' trees and the convulsions of a child from the Ebira ethnic group.

In tending the hearth, cultural practices are strictly observed during cooking. As such, when cooking in open spaces, neighbours are forbidden from tampering with the fireplace by trying to heat up any metal object. A dedicated fireplace is used for the preparation of traditional medicine and cannot be used for other purposes. In addition, after cooking, cultural practices require that wood used for cooking must be spread apart. The contravention of any of these taboos associated with cooking practices was believed to have health repercussions. This emphasized the complexities of socio-cultural structures in communities especially where the 'cultural-diagnosis' of diseases was usually disconnected from any form of medical-diagnosis or assessment. In essence, the socio-cultural context dominated householders' thinking about the causes of disease, which revolved around adherence to traditional norms and observance of taboos.

The scientific interpretation of the causes of poor ambient air quality resulting from the burning of wood fuel contrasted with householders' socio-cultural explanation of it. Air pollution was premised on the belief that natural ventilation blew wood smoke into their buildings. These cultural interpretations of indoor air pollution are significant in understanding householders' view on the impacts of IAP. Householders' cultural structures obscured considerations of how wood fuel burning can cause poor ambient quality in buildings or have negative impacts upon their health.

Another dimension to the use of sacred trees in the study area was in attending to health needs. Extracts from leaves are used for the treatment of snakebite. Traditional medicine is widely practised by resource poor households and is based on the belief that it can act as an alternative to allopathic medicine.

Householders also considered the use of wood smoke as an effective way of sustaining their small-scale businesses. Perishable items, especially meat and fish, are usually smoked in order to preserve them. The infiltration of wood smoke into buildings was also believed to be a means of strengthening and prolonging the life of mud blocks that formed the structure of buildings. These claims further bring to light cultural contexts influencing medical treatment and technology, which emerged out of traditions handed through generations with an obligation to pass the same traditional knowledge to their children. However, if there had been access to western medical facilities in communities, householders may have been more aware of the health impacts of exposure to indoor air pollution. These cultural values governing cooking practices, businesses and living conditions have the tendency to influence householders' decisions in making a change to how they have lived for many years.

Within the emerging socio-cultural contexts of attempting to provide interventions in peri-urban areas in Ado Ekiti, Chapter Seven revealed some of the things to bear in mind in improving access to cleaner fuels and technologies to householders' in the area. Households live a communal life, which allows neighbours to have access to one another's homes and be aware of one's material acquisitions. Such intimacy was seen to foster free interaction and encourages sharing belongings with others as this links to wider cultural customs focused around not oppressing or exploiting those in need amongst them. In order not to breed jealousy amongst householders in the community, it is important to avoid a situation whereby outside experts (seen as 'visitors') work with particular 'favoured' households in an attempt to disseminate clean energy technology. To overcome this challenge, it is better to liaise with nominated householders that have been approved by the community leaders. In this way such initiatives are more likely to be culturally exempt from repercussions (in the form of sickness) associated with accepting offers or gifts from visitors.

At other times, local initiatives can represent a key driver in accepting 'new technologies' as described in Chapter Five with regard to the manufacturing of alternative forms of lighting from used CDs. When technology development involves end-users, appropriate technologies are more likely to be developed to meet challenges in the study area. This 'socio-technology' initiative provided a platform for householders to first identify their lighting preferences and at the same time enable them to develop a sustainable option. Understanding the wider socio-cultural context amongst householders for strategies in addressing energy issues in the area would complement experts' intervention strategies. Although this research has achieved the objectives detailed in Section 1.3, great care should be exercised in generalising the results because of the limitations discussed in the next section.

8.2.1 Limitations of the Study

Although the methods of data collection used for this research enabled the research objectives to be met, it must be noted that this research has its limitations.

The absence of a sample frame to facilitate the selection of householders' may have reduced the number of households that participated in the survey as the process used to select householders and communities was very time consuming. In communities and amongst ethnic groups with small sample sizes, householders' responses could have either been overestimated or underestimated in ways that did not reflect the majority of household responses.

As no health records were available for the study, it was not possible to access additional information on patterns of diseases, which could have been useful in analysing linkages between indoor air quality with ill health. Furthermore, there was no scope in this thesis to investigate the chemical composition of trees so there was no way to balance cultural information with scientific information.

Stakeholders' interviews are limited to a few organisations and key members of staff. If more government organisations, NGOs, and staff had participated in the study, it would have given wider perspectives on environmental problems/concerns in the study area. This would have also allowed richer data to be gathered on environmental problems/concerns in the study area.

For air quality levels in the study area, comparisons could not be made with other communities as air quality measurement was only carried out in one community (Irasa). As air quality monitoring was carried out only during the wet season, with none during the dry season, the results might not reflect the activity pattern of households throughout the year.

Due to the limitations of this research, there must be caution in generalising the results. However, this research has enabled the collection and analysis of site-specific and ethnic-specific data that address the objectives of this study (Section 1.3). Although the results of the air quality monitoring might not be representative for all the communities, it gave an indication of pollution levels in buildings irrespective of the kitchen location.

8.3 Lessons from Socio-Cultural Contexts to Energy Issues in the Global South

Ultimately, the study's efforts to 'see through the eyes of the people' and investigate the various complex social interrelationships in Ado Ekiti, Nigeria has been useful in interpreting some of the key energy-related issues affecting poor households. It is clear that energy choices and perceptions of indoor air pollution in the global South are not based solely on socio-economic issues or responses to the health risks of IAP as discussed in Chapter Two. Indeed, the socio-cultural context is one of several critical factors that contribute to the use of biomass fuels in the area. What, therefore, are the implications of the findings in this study for addressing energy issues in the global South? Drawing from both energy/fuel sources and building materials used by the householders, it can be concluded that low cost domestic energy and building materials that are within householders' financial reach are most preferred, suggesting that locally sourced materials are prioritised by the householders for livelihood sustenance in Ado Ekiti, Nigeria. Further, findings from the study revealed that having a relatively high income did not encourage householders to switch to cleaner fuels as the energy ladder suggests. Instead, householders frequently opted to use multiple fuels. It therefore seems insufficient to rely on the economic status of the householders in understanding energy choice, as households in the global South frequently do not make a complete transition to cleaner fuels. Instead, they stack fuel and/or leapfrog when adopting cleaner fuel and technology.

The decisions of each family unit regarding the fuel type used for domestic activities in Ado Ekiti as discussed in Section 6.2 has indicated that gender roles are able to influence fuel choices. This decision making process, which starts from the family unit (as illustrated in Figure 8.1) sets the geographical space and framework within which culture, economics, and technology contribute to the choice of fuel used in households. On the basis of economic factors, the interrelationship between enterprise and energy issues (Section 6.4.1) seems to suggest that householders trade-off commercial fuels with 'free fuel-saving' ones for their businesses. 'Free fuel' is not only used for income generating activities, but also for domestic use irrespective of the level of income as discussed in Section 5.4. The cultural factors revealed values and norms shaping fuel choice within ethnic groups (see Chapter Six). The relevance of this study to understanding energy issues in the global South lies in the way it unfolds all these intertwining factors conceptualised in Figure 8.1. Though each local environment has its own particular context, it could be instructive for experts to develop encompassing strategies that consider all these factors in scaling up resource poor households to cleaner fuels and technology in developing countries.

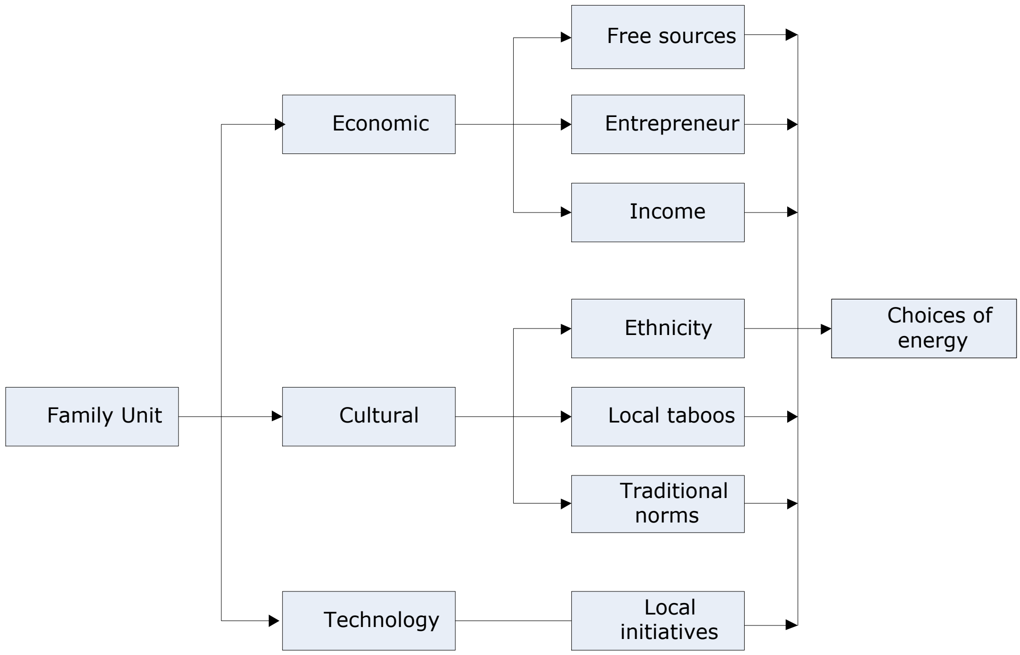


Figure 8.1: Conceptual model of fuel use decision making processes in Ado Ekiti
Source: Author

This study has established that households tend to solve their energy problems by relying on local technologies familiar to them. The basis for energy interventions in the global South must align with local household priorities for technology choices. Local citizens therefore, value 'hardware' found in their environment for the manufacturing of clean energy technologies. Analysis at this small spatial level has shed light into what needs to be done in initiating sustainable energy technologies in the global South.

To attain air quality within WHO limits, it appears that the socio-cultural contexts of indoor air pollution must be considered with the help of software approaches (Sections 6.3 and 7.4). It is interesting to note that householders believed that apart from sacred trees, all other types can be harvested as wood fuels without any cultural repercussions and/or implications. In this case, there is a socio-cultural complexity and contention between causes of health impacts associated with the burning of biomass fuels and the types of wood fuel used for domestic activities. Another aspect of the influence of the socio-cultural context revolved around cooking practices in which householders have to strictly adhere to behavioural taboos regarding fireplaces. Cultural views about indoor air pollution cannot be ignored as householders often attribute potential health impacts associated with exposure to wood smoke to contravening traditional norms, rather than to the reality of the health impacts associated with the burning of biomass fuels. Hence, cultural values frame both wood fuel harvesting and hearth behaviours, which in reality are fundamental to understanding energy issues in the global South. Therefore, incorporating socio-cultural perspectives into intervention programmes could enhance the uptake of cleaner fuels in the global South. However, it cannot always be guaranteed that householders would sustain the use of cleaner fuels because of cost issues.

Paying attention to householders' lived realities vis-à-vis poor ambient air quality in buildings brings contending logics together regarding householders' cultural perceptions of indoor air pollution and scientific approaches for determining air quality. Householders attributed the causes of indoor air pollution to natural weather blowing poor ambient air into their buildings, rather than to the use of biomass fuels used for cooking which produces wood smoke. Notably, householders did not consider their living environment to be polluted with wood smoke as they carried out their domestic activities. Householders' perceptions of indoor air pollution focus attention on climatic impacts and distances their social behaviour from IAP impacts. Indeed, Dodman's (2004) notion of individual perspectives and the construction of environmental problems allowed householders' cultural views to be more significant than experimental methods of assessing air quality.

In seeking to promote cleaner fuels and technologies in the study area, householders have demonstrated that the use of local technology (for example the local lamp initiative discussed in Chapter Four) designed by them has been able to address their priorities. Localised approaches to the development of clean energy technology that fits the needs of householders appear to be appreciated, valued, and used in the communities. However, there must be caution when introducing clean technology to communities as their communal way of life can be a drawback when neglected and when not everyone is included in the process. On the other hand, it could polarise relationships amongst householders as a result of selective participation in intervention programmes which can breed jealousy and resentment relating to who accepts and buys the technology. Promoters of such interventions must be aware that paying attention to the cultural norms of householders has the potential to establish locally acceptable forms of energy technology interventions. While this may be the case, community influences are also found to be interconnected with norms when relating with 'outsiders' in that 'gifts' cannot be accepted from them. This has significantly shaped their philosophies, and if development and health practitioners do not understand these cultural complexities, the uptake and use of energy technologies is unlikely to be viable.

8.4 Concluding Remarks

This research is central to debates surrounding energy issues in the global South where cultural issues, traditional norms, and shared cultural heritage are linked. Although the cultural values influencing the choice of energy fuel and perceptions of indoor air pollution might not be generalizable because of the small sample size taken from peri-urban communities in Ado Ekiti, Nigeria, this research provided some in-depth understandings that are relevant to other areas of the global South. In particular, it emphasises how culture shapes energy choices in the global South.

Masera *et al*. (2000) note that the use of cleaner fuels and technologies demonstrated increased socio-economic status which (Wickramasinghe, 2011) links fuel choice to income. However, as noted in Chapter Five, householders with relatively high incomes in the study area retain a preference for wood fuel, probably because of the easy access to 'free' wood fuel that they enjoy. In contrast to the energy ladder model, this indicates that increased income is not necessarily associated with a shift to using cleaner, more convenient and efficient fuels for domestic activities as Bailis (2004) suggests. Instead, households prefer to spend their incomes on other household expenses while continuing to take advantage of free biomass fuel. Fuel stacking is another popular energy use trend amongst resource poor households (Schlag and Zuzarte, 2008). This study found that 78 percent of householders used wood fuel alongside kerosene and did not abandon inefficient and polluting fuels in favour of clean fuels (Kowsari and Zerriffi, 2011) suggest.

As discussed in Chapter Six, the socio-cultural context not only influences householders' perceptions of indoor air pollution, it also guides the choice of wood fuel to be harvested for domestic activities. This brings to light the way in which behaviour can be embedded in householders' cultural norms, which tend to have a greater influence on biomass fuels use in the global South than the economic factors and housing conditions identified in the literature (Akpalu *et al*., 2011; Quagraine and Boschi, 2008; Ouedraogo, 2006). The focus of much of this work has been on the cultural practices associated with traditional food preparation and space allotment for cooking areas in buildings. However, as highlighted in Chapter Six, traditional norms informed wood sourcing behaviour. The identification of important social values relating to indoor air pollution (WHO, 2002), may help to reduce its health impacts. In effect, there is a 'causal behavioural factor' that is culturally contextualised and bequeathed on householders by their forbears, which constrains the harvesting of scared trees for fear of negative health impacts. This reinforces Jewitt and Baker's (2012) point that the complexity of understanding spatial risks make it difficult for the rural poor to realise the 'cause and effect' of burning biomass fuels and that there is a time lag for its health impacts to materialise (Section 2.3). The reliance on the experiences and discoveries of previous generations usually informs social customs that guide how social environments are lived (Zimmerman, 2013). It is in view of this that the resource poor give attention to traditional norms in carefully choosing wood fuels. As such, householders become subservient to traditional norms despite the scientific context, which frames the health outcomes from the burning of biomass fuels.

Not only this, in their health seeking behaviour, most rural households in Nigeria often seek relief from traditional, complementary, or alternative medicine rather than allopathic orthodox medicine. The same cultural beliefs householders have in keeping to traditional norms regarding wood fuel are also held while seeking medical attention for their ailments. As such, as Bickerstaff and Walker (2001) suggest, it is important to understand the social construction of problems and solutions in particular local environments.

This seems to explain why the cultural contextualisation of indoor air pollution could not be linked with the burning of biomass fuels irrespective of the wood type, as measured particulate matter levels discussed are high in the buildings. However, as the air quality dataset was created from scratch, and householders' were unable to keep accurate records of activity patterns, this added some levels of uncertainty to measured pollution levels at Irasa community. On the other hand, the research shows that there are wide gaps between WHO guideline values and the real air quality in buildings in the community as households subsist on biomass fuel for domestic activities. The $PM_{2.5}$ levels (Section 4.2) recorded in this study reinforce previous studies in the global South that biomass burning is a key source of indoor air pollution (Herrin *et al*., 2013; Colbeck *et al*., 2010; Begum *et al*., 2009; Fullerton *et al*., 2009; Nweke and Sanders, 2009; Bruce *et al*., 2000; Smith, 2000a). Air quality levels were found to be poor in buildings regardless of whether cooking was done indoors or outdoors as discussed in Chapter Four. With the majority of householders cooking at the same time in an area with a clustered building pattern, both household and neighbourhood pollution levels adversely affect air quality, which is a significant aspect of spatial risks. Although Zhang and Smith (2007) argue that outdoor kitchens reduce indoor air pollution, households with outdoor kitchens in this study recorded particulates higher than the prescribed WHO limit for buildings (Section 2.2.1).

With the reality of indoor air pollution as shown from the measurements discussed in Chapter Four, it is necessary to provide clean energy technology that aligns with the cultural beliefs of the householders. The discussion in Chapter Seven suggests that while communal life is beneficial to the householders, it also raises issues of 'jealousy' and 'favouritism' when individuals are singled out to participate in intervention programmes. This echoes Gadenne *et al*.'s (2011) findings that social norms within the community have a strong influence on the adoption of technology in an environment. Although debates on tensions between local culture and the adoption of cleaner technologies are not particularly new (see Troncoso *et al*., 2011; Wüstenhagen *et al*., 2007; Bickerstaff, 2004), this study has shed light on how such tensions play out in an area characterised by a range of different ethnic groups; each with their own variations in cultural background. As most energy policies target specific populations (Section 2.5), this study shows that all households in a community should be targeted for intervention in an area. This is because the communal way of life of the householders can promote or hinder the adoption of cleaner technologies depending on the approach taken.

In conclusion, there are interconnections between energy issues and socio-cultural contexts in the global South. In engaging with communities rather than first addressing indoor air pollution with a 'hardware' approach, the 'software' approach will highlight lived realities that are of utmost priority to communities experiencing such problems. This study has established that socio-cultural contexts underpin the use of biomass fuels and largely contribute to the uptake of cleaner technologies in the area. Although, three ethnic groups (Yoruba, Tiv, and Hausa) could not be studied in detail because of access, the few responses integrated in the empirical chapters provided diverse views on energy issues in the study area. Nonetheless, it is always necessary to consider and uncover cultural values in an environment before responding to problems and proposing solutions.

8.5 Further Research

The present study investigated ambient air quality in buildings, excluding weather data. As robust meteorological data could not be collected in the area, it was not possible to relate and draw relationships between the weather and households' energy use patterns (in which cooking was done by most households at the same time in the study area, thereby constituting neighbourhood pollution). Experimentation is therefore needed that would enable better evaluation of ambient air quality and ventilation in Ado Ekiti, Nigeria. Data gathered from such measurements would provide information on how weather variables combine to influence air quality in the area.

This thesis has demonstrated the key role that socio-cultural complexities play in energy choice, usage and perceptions about the impact of indoor air pollution in Ado Ekiti, Nigeria. Further investigations, however, are necessary to explore householders' cultural disposition to the implementation of clean energy interventions in the area. Due to time constraints, the development of local energy technologies that fit into the lived reality of householders' traditional norms could not be initiated although further research on this topic might facilitate clearer understandings of the set of contexts it could have produced. The findings of such a study would aid understanding of how 'software' approaches could be used in disseminating energy technologies especially for households in sub-Saharan Africa. Data gathered from the study would guide experts on specific 'hardware' approaches and strategies to resolve energy problems that vary in the global South.

If future research is carried out in this area, there is scope to collect comparative urban household energy information that was omitted from this study. This would enable better evaluation of factors determining fuel choice particularly among various income earners. In addition, the study would be useful in analysing household energy use patterns in urban areas and this information would be useful in evaluating the most suitable interventions to enable householders to alleviate the problem of indoor air pollution. Further, it would be useful to ascertain the impact of population trends and patterns of urban growth on household energy use particularly among householders in the peri-urban areas of Ado Ekiti.

It would also be useful to analyse stakeholders’ strategies in alleviating indoor air pollution when new programmes are launched. It would be particularly interesting to ascertain the impact of their approach to solving the problem amongst the resource poor who had not experienced the ‘trickle-down’ effect of government oriented projects. The dissemination pattern of stakeholders would serve as a platform for understanding the influence of institutional structures in promoting clean technologies to resource poor households in Ado Ekiti, Nigeria and evaluate how householders will cooperate for its implementation. In addition, it would be worthwhile investigating the impact made by international organisations and NGOs in alleviating indoor air pollution in other parts of Nigeria. A comparison is also needed with other peri-urban communities where clean fuel interventions have been introduced to further ascertain the place of socio-cultural factors as identified in this research.

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Appendix 1: Air Quality Monitoring

Consent for monitoring

Air quality sampling will be taking place in some homes in this area. This can take up to 24 hours. In measuring the air quality, samplers will be placed in houses before cooking. The monitor is safe and runs on batteries, it will not have any effect on house occupants, however, some noise could be noticed when the air quality is above the minimum standard. Participation is voluntary; you can choose to have the monitor removed at any time

It would be appreciated if you participate in this survey.

Thanks.

Signature of interviewer: ....

Field monitoring data form

Monitoring of respirable particulates in homes

Household ID: ....

Date of monitoring: ....

Kitchen type: ....

Air temperature: .... Relative humidity: ...... Wind direction and speed........

Type of sampling (i.e. area, personal): ....

Size of sampling ($PM_{2.5}$)...

Additional sampling measurements (CO)..

Location of monitor (i.e. height from the floor) ....meters

Sample start time: ....

Sample stop time: ....

Monitoring duration: ....

What type of weather condition(s) occurred during monitoring period? ....

Field Notes: (i.e. house type, ventilation, location of kitchen in relation to living area, etc)

Sketches of kitchen type

Appendix 2: Household Questionnaire

Dear Resident,

A survey is being carried out to study indoor air pollution in this area. This questionnaire is designed to gather information on indoor air pollution in homes and factors determining the use of biomass fuel for cooking and lighting.

It would be appreciated if you could spend a little time in answering this questionnaire. All the information provided will be used strictly for academic purposes.

Thank you for your kind assistance.

Part 1: Section A

Household characteristics

1. Identification No...
2. How long have you lived in this area? Years....... Months........
3. Gender......................
4. Kindly tick (√) appropriately to the following questions

Educational Qualification	Tick (√)	Age (years)	Tick (√)	Income/per month	Tick (√)
Primary school		Below 20		below ₦5, 000	
Secondary school		21 – 30		₦5,001 – 10,000	
NCE/OND		31 – 40		₦10,001 – 15,000	
HND/BSC		41 – 50		₦15,001 – 20,000	
Other		51 and above		above ₦20, 001	

5. How consistent is the above income in a year? ....
6. Number of children less than 5 years old in this house.....................
7. Number of adults in the house? ....

8. Source(s) of income..(please indicate all)

9. Ethnic group...

10. State of origin..............................Town...........................

****

Part 2: Section A

Housing characteristics

11. House ownership? (a) rented [ ] (b) family building [ ]

(c) personal [ ] (d) others (please specify)..................

12. Type of house structure

House type	**Tick (√)**
Single room	
Room and parlour	
Flats	
Other (please specify	

13. Type of building materials

Material	**Tick (√)**
Mud & thatched leaves roof	
Mud & corrugated iron sheet roof	
Mud/cement block & corrugated iron sheet roof	
Cement block & corrugated iron sheet roof	
Other (please specify)	

14. Type of window

Material	**Tick (√)**
Wood	
Louvre blades	
Corrugated iron sheet	
Open space	
Other (please specify)	

15. What is the approximate age of this building?........................years

16. Type of flooring...

17. Type of ceiling materials used in this house..................................

18. Are there open eaves (gaps) between walls and roof of the building? ....

    If yes .... (Approximate size in meters inside)

    .... (Approximate size in meters outside

19. Kitchen type

Kitchen type	**Tick (√)**
Inside	
Open space	
Attached to the external building wall	
Others	

20. Type of stove

Stove type	**Number**
Three stone fire	
Metal sawdust/residue	
Charcoal	
Kerosene stove	
Others (please specify)	

21. Source of cooking materials

    Please indicate your cooking location? Outside ....Inside...........

Cooking material (Fuel)	**Tick (√)**	How many days will this fuel last?
Agricultural residue		
Firewood		
Sawdust		
charcoal		
Kerosene		
Others (please specify)		

22. Do you ever buy fuel?

    (a) Yes[ ] if yes, go to **23**

    (b) No [ ] if no, go to **26**

23. How much did you pay for the last fuel you bought?

Cooking material (Fuel)	**Quantity**	**₦**
Agricultural residue		
Firewood		

Sawdust		
Charcoal		
Kerosene		
Others (please specify)		

24. How often do you buy fuel? ....

25. Why did you buy this fuel?

(a) Convenience [ ]

(b) Cleanliness [ ]

(c) Time [ ]

(d) Availability [ ]

(e) Others (please specify)...

26. Do you gather fuel?

(a) Yes [ ] if yes, go to **27**

(b) No [ ] if no, go to **31**

27. What type of fuel do you gather? ....

28. How long does it take you to gather these fuels?

Fuel type	**Quantity/ month/ week/day**	**Time taken**	**Distance to location**	**Who collects fuel?**

29. On a scale of 1 (lowest) – 5 (highest), can you rank the level of difficulty associated with fuel gathering?

Fuel type	**Ranking**

30. How adequate are the quantities that you gather?

Scale	Wet season	Dry season
Very sufficient		
Sufficient		
Just enough		
Scarce		
Very scarce		

31. Source of lighting

Lighting material	Number
Local lamp (indicate the type)	
Candle	
Kerosene lamp	
Electricity	
Others (please specify)	

****

Section B

Determining socio-cultural factors for fuel use

32. Kindly tick your cooking location during this period:

Location	Wet season	Dry season
Within building		
separate building outside		
within and outside building		
open shed/space		
others (please specify)		

33. Who cooks the food? ....

34. What type of food do you cook? List all

....

....

35. Which type of food takes most cooking time?

....

....

36. Does your stove type determine your cooking method or food type?

(a) Yes [ ] ....explain

(b) No [ ]

37. Do you think smoke affects the taste of your food?

(a) Yes[ ] ....explain

(b) No [ ]

38. In a good way or bad way?..explain

39. Which cooking method do you prefer? ....

Why? ....

.

40. How long do you spend cooking each day?...................Total hours

41. How many meals do you cook each day?..............................Total

42. Does anybody smoke inside your house? Yes[ ] No[ ]

If yes, how many people smoke? .... How many stick(s) per day? ....

43. Do you have generator? Yes [ ] No [ ]

****

Section C

Knowledge, Information and Education about indoor air pollution

44. What are the major environmental problems/concerns in this area?

....

....

45. On a scale of 1(lowest) – 5 (highest), rank your concerns for this area

(a) Malaria [ ]

(b) Sanitation [ ]

(c) Drinking water [ ]

(d) Cooking smoke [ ]

(e) Others (specify)............[ ]

46. Have you noticed any health problem during cooking? ....

47. What is the air quality close to your house on a scale of 1(lowest) – 5 (highest)? ....

48. What sorts of discomfort do you experience while cooking?

....

.

49. If so, what causes it? ....

50. Is there any other source of smoke from outside or nearby kitchen influencing the pollution levels inside your house? ....

51. Do you think cooking smoke is bad?

Yes [ ]

No [ ]

Don't know [ ]

If Yes, why? ....

52. Who do you consider most vulnerable/exposed to the cooking smoke? ....

Why? ....

53. What are the benefits of smoke in your own opinion?

....

....

54. What are the main causes of ill health in your community?

Kindly list and rank them on a scale of 1 (lowest) – 5 (highest)

Ill health	**Ranking**

55. Have you received any information about smoke from the burning of wood used in cooking in the last year?

(a) Yes [ ]

(b) No [ ]

56. Through which source(s)? ....

57. Are you considering making any changes to

(a) Cooking fuel? If yes [ ] Please give details.............................

If no, go to **b**.

(b) Lighting fuel? If yes [ ] Please give details.............................

If no, go to **c**

(c)Cooking stove? If yes [ ] Please give details...........................

If no, go to **58**

58. What factors (if any) would persuade you to change your cooking fuel?

....

....

59. What factors (if any) would persuade you to change your lighting fuel?

....

....

60. What factors (if any) would persuade you to change your cooking stove?

....

....

Thank you for your time!

Appendix 3: Interview guide with Householders

Details of the interview

Number: .... *Date: ....*

Time: .... (Start)............ (End) *Venue: ....*

1. What do you consider to be the major problems affecting this community?
2. Do you have any concern/complains about cooking smoke?
3. What do you perceive causes smoke (indoor air pollution) in houses?
4. Does the cooking smoke pose any problem in this community?
5. Do you have knowledge or information about the health impacts of burning fuel wood indoors?
6. How best do you think information about cooking smoke (indoor air pollution) should be disseminated to people in this community?
7. Are there any benefits of cooking smoke?
8. Are there any traditional beliefs associated with cooking smoke and fuel wood in this community?
9. What possible changes are you likely to undertake in reducing smoke in your home?
10. What factors will you consider in making the above changes?
11. Any further comments?

Appendix 4: Interview guide with Stakeholders

Details of the interview
Number: ....
Date: ....
Time: .... (Start)............ (End)
Venue: ....

1. Name of institution/organisation?
2. What is the main function and responsibility of your organisation/institution?
3. What do you consider to be the major problems in this area?
4. What are the main environmental and health problems? (rank the answers on a scale of 1 (lowest) – 5 (highest)
5. On what problems or issues do you focus mainly?
6. Is your organisation/institution aware of the health impacts of indoor air pollution from the burning of biomass fuel?
7. Why do you think people use biomass fuel for cooking?

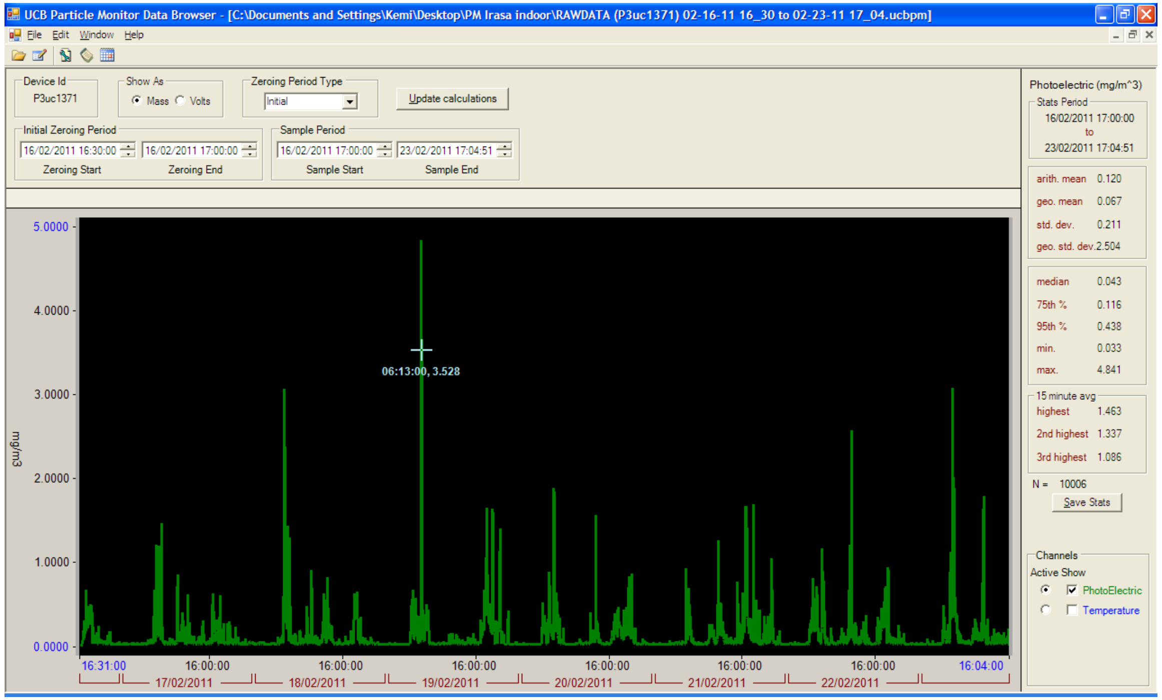
   (b) Lighting?
8. Is there information for the people in this area about the danger of indoor air pollution?
9. Who have you targeted? .... Why? ....
10. Which area? .... Why? ....
11. How best can the information be disseminated to the people?
12. Have you put any plans in place about indoor air pollution?
13. If yes, what plans and or policies have you put in place to eradicate this problem?
14. How will you achieve these plans and policies?
15. What steps can be taken to encourage clean energy fuel (e.g. biogas, ethanol)?

    (b) What about clean stoves?
16. What do you think might be the barriers for adopting clean energy and clean stoves?

    (a) Economic..
    (b) Social..
    (c) Cultural...

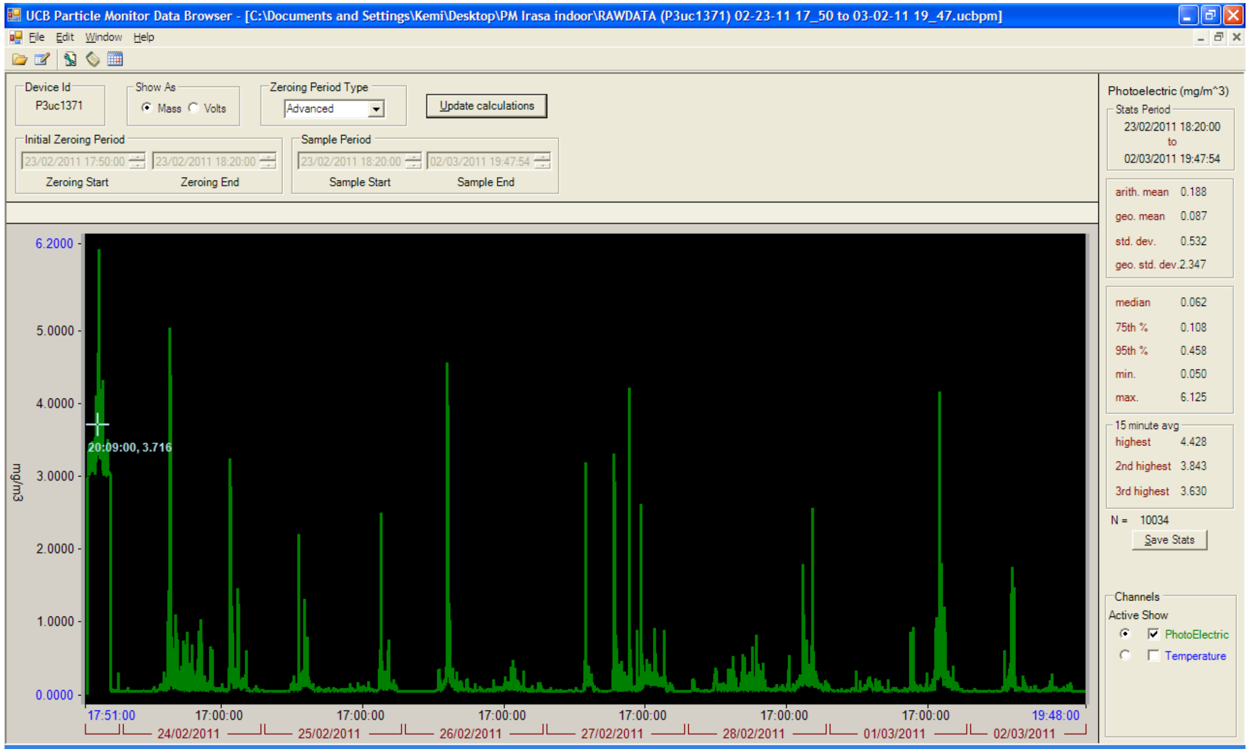
17. What do you think should be the role of government, private organisations and individuals in combating problems of indoor air pollution in this area?
18. How best would you prefer the problem of indoor air pollution to be solved in this area?
19. Any further comments?

Appendix 5: Irasa air quality data for buildings with indoor kitchen



Monitoring of $PM_{2.5}$ in Building 1 (HH1) with indoor kitchen at Irasa community

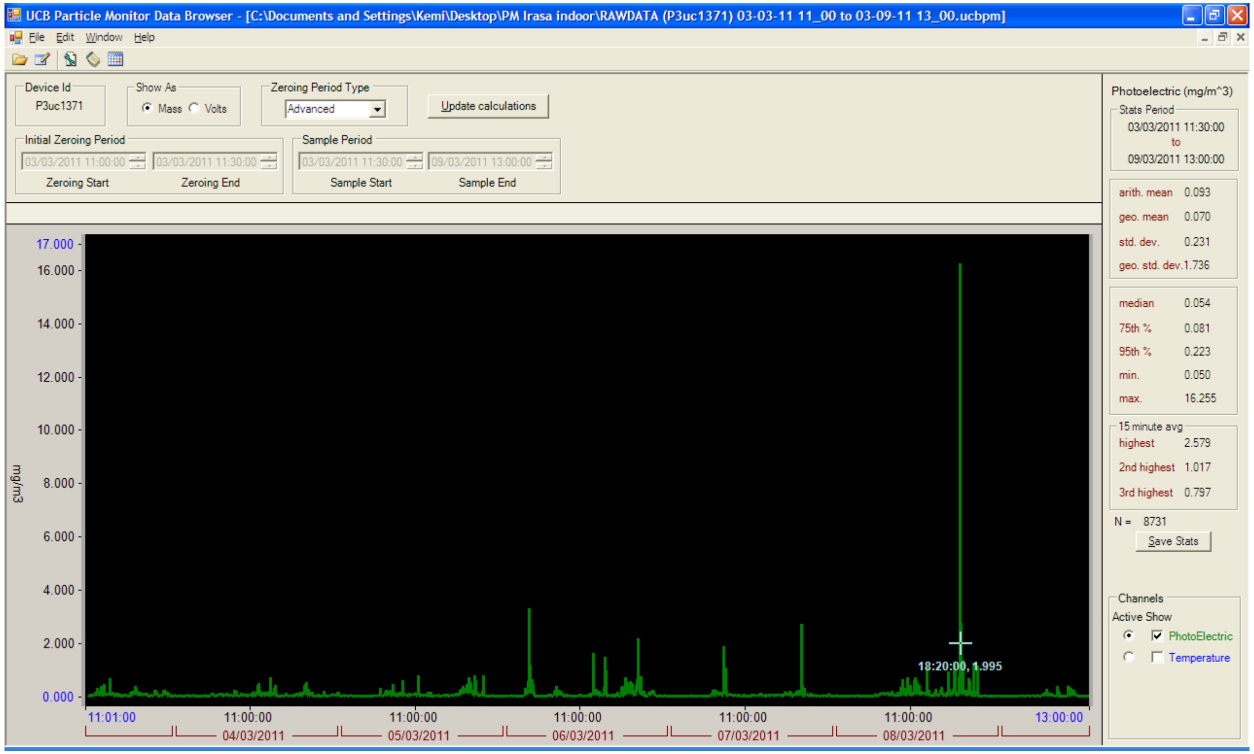
Week 1: 16/02/2011 – 23/02/2011



Monitoring of $PM_{2.5}$ in Building 2 (HH2) with indoor kitchen at Irasa community

Week 2: 23/02/2011 – 02/03/2011

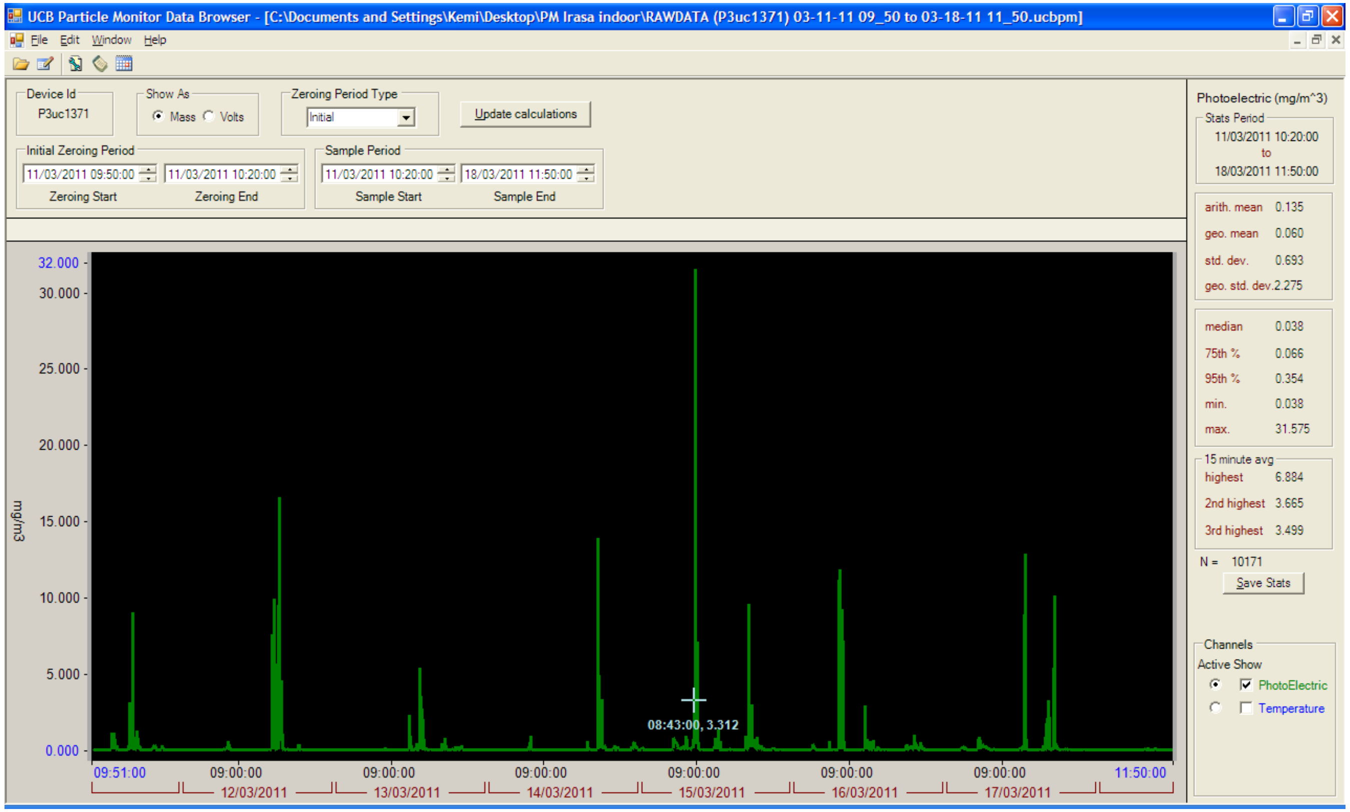
(Note: limit of detection not within ≥30µg/m^3 and ≤75µg/m^3, adjusted to 50µg/m^3)



Monitoring of $PM_{2.5}$ in Building 3 (HH3) with indoor kitchen at Irasa community

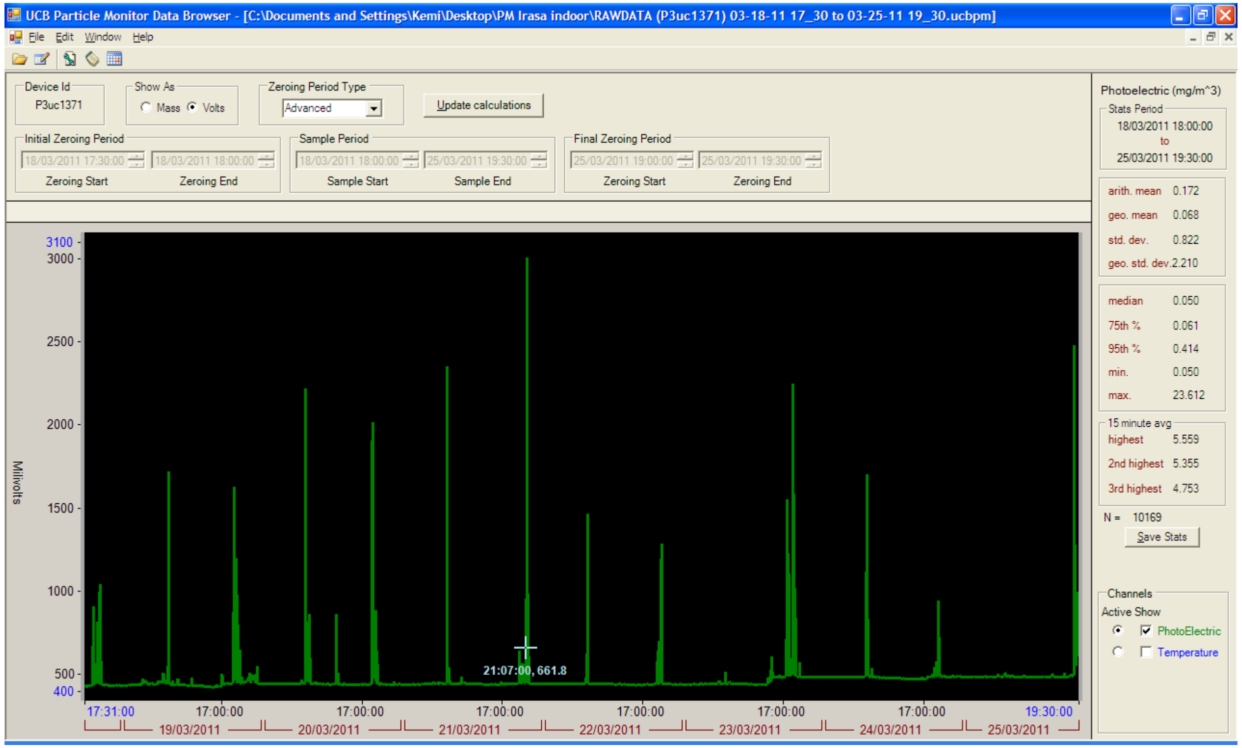
Week 3: 03/03/2011 – 09/03/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 4 (HH4) with indoor kitchen at Irasa community

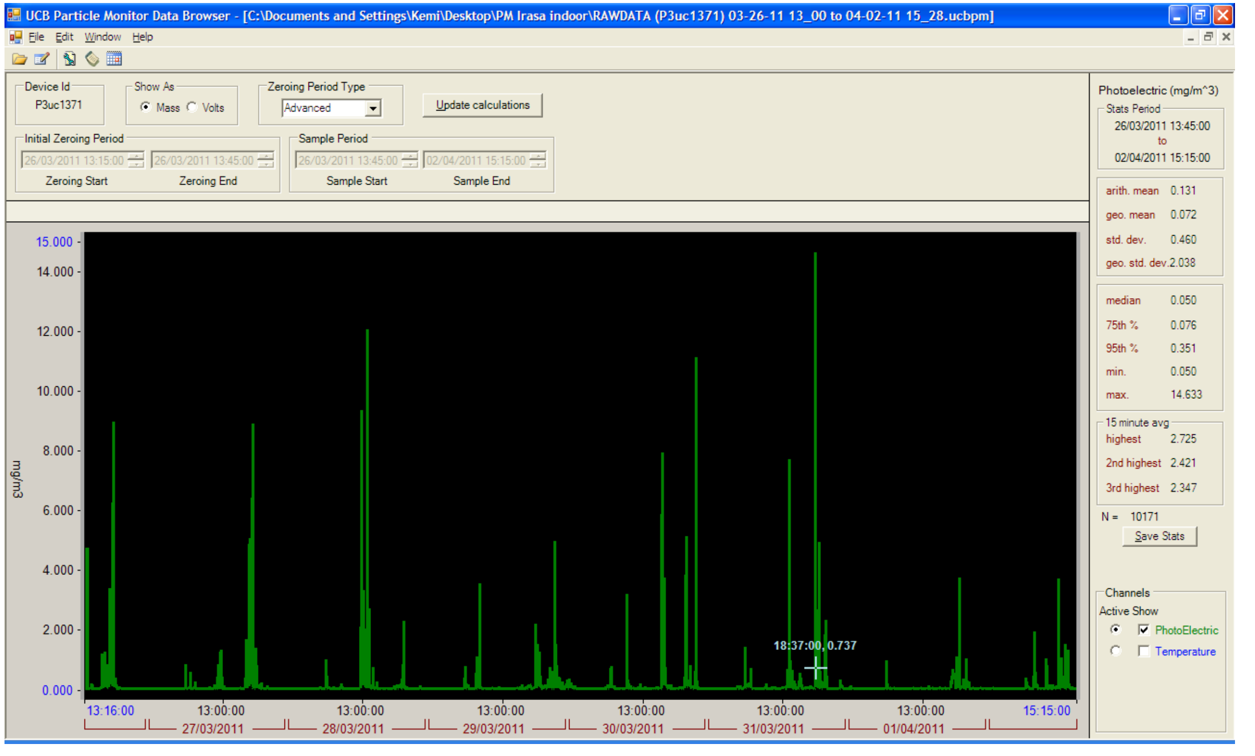
Week 4: 11/03/2011 – 18/03/2011



Monitoring of $PM_{2.5}$ in Building 5 (HH5) with indoor kitchen at Irasa community

Week 5: 18/03/2011 – 25/03/2011

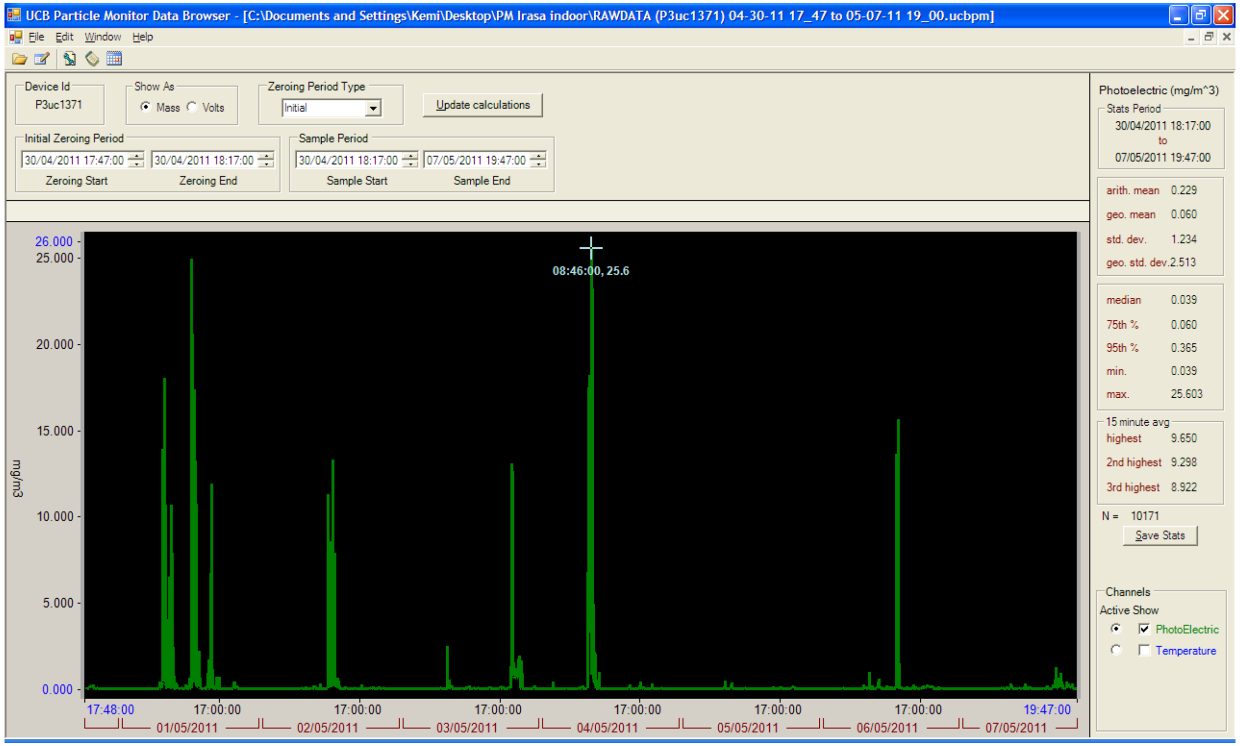
(Note: limit of detection not within ≥30µg/m^3 and ≤75µg/m^3, adjusted to 50µg/m^3)



Monitoring of $PM_{2.5}$ in Building 6 (HH6) with indoor kitchen at Irasa community

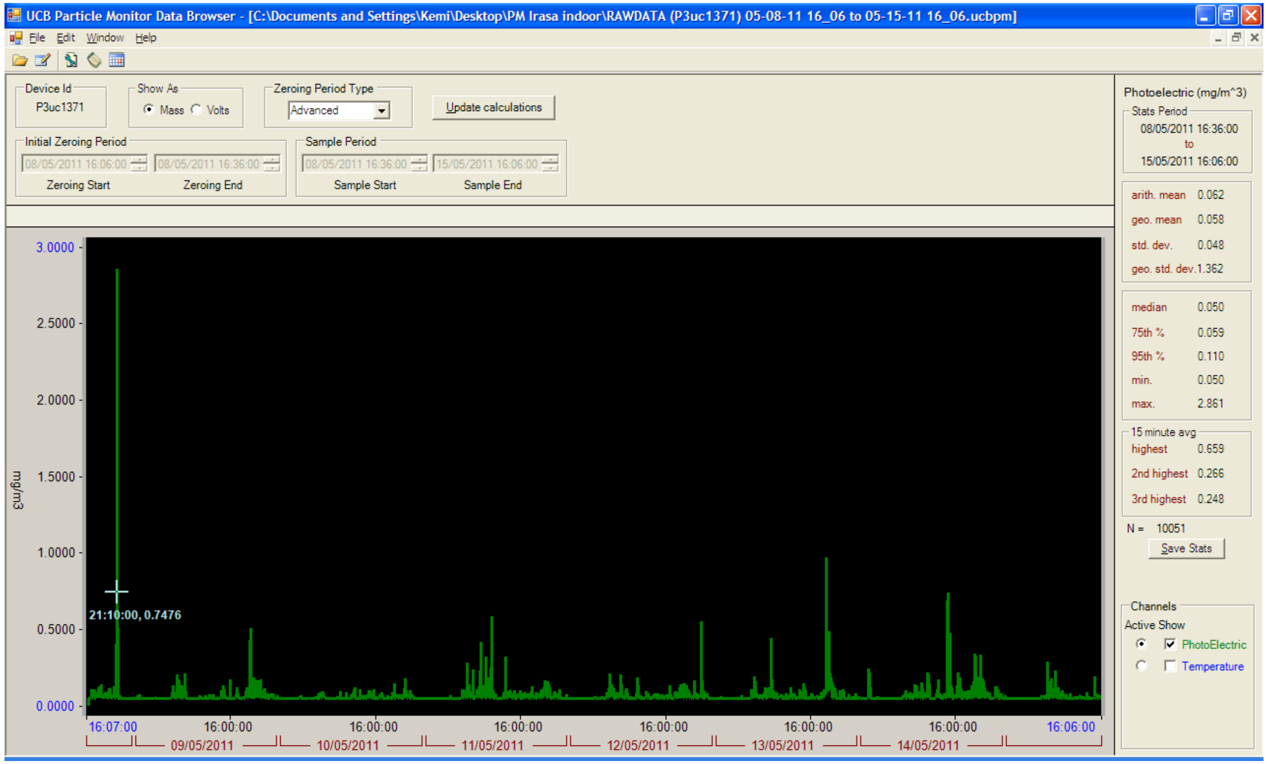
Week 6: 26/03/2011 – 02/04/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 7 (HH7) with indoor kitchen at Irasa community

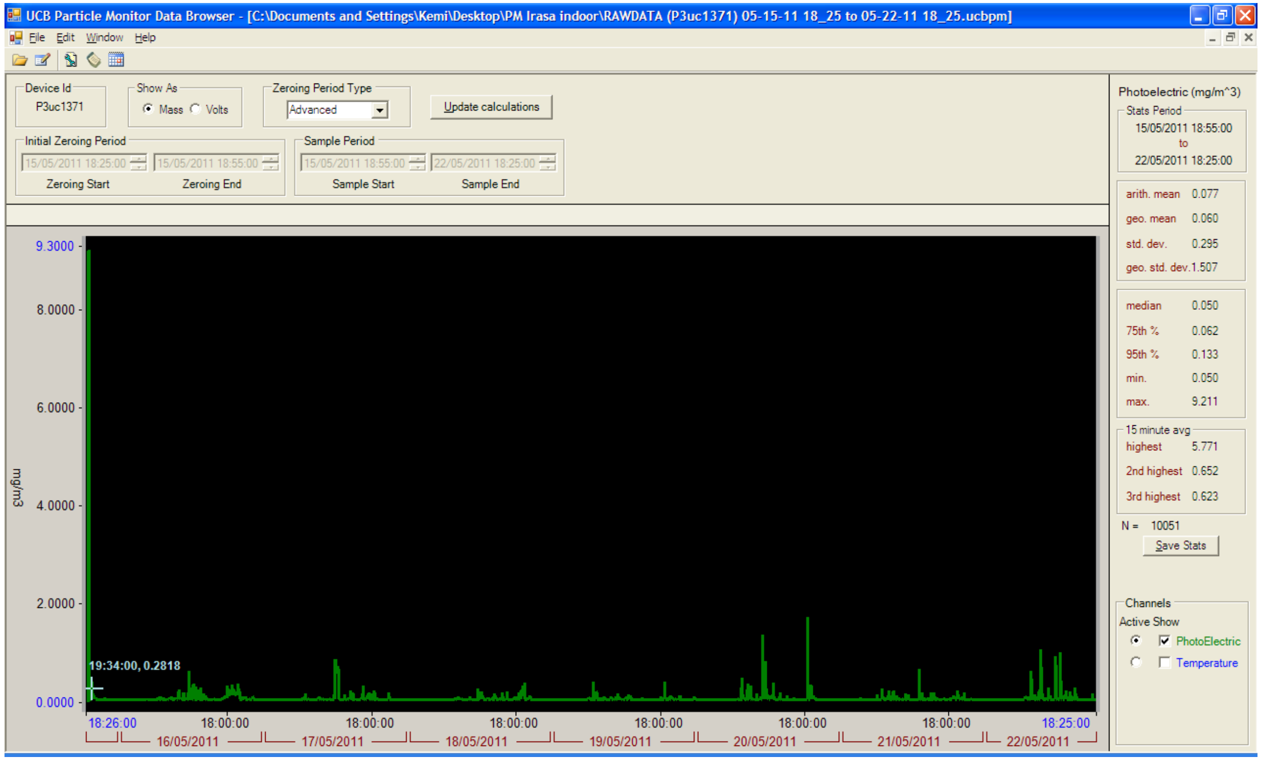
Week 7: 30/04/2011 – 07/05/2011



Monitoring of $PM_{2.5}$ in Building 8 (HH8) with indoor kitchen at Irasa community

Week 8: 08/05/2011 – 15/05/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)

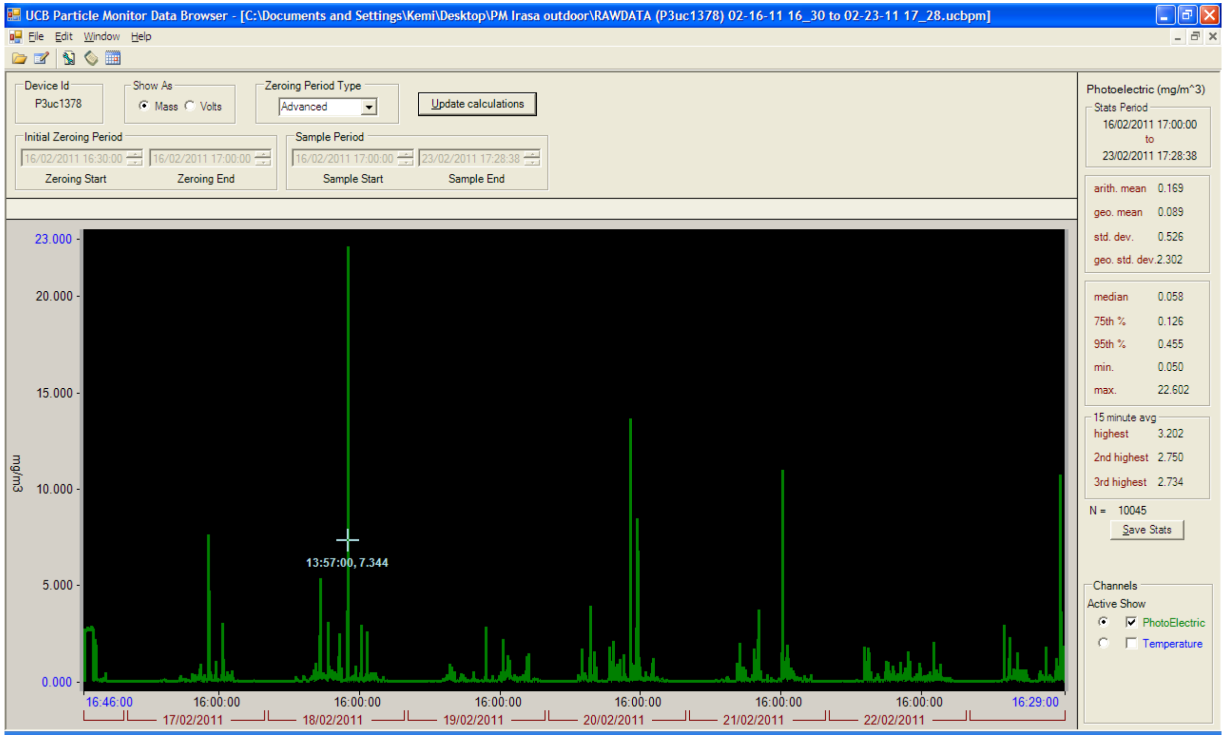


Monitoring of $PM_{2.5}$ in Building 9 (HH9) with indoor kitchen at Irasa community

Week 9: 15/05/2011 – 22/05/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)

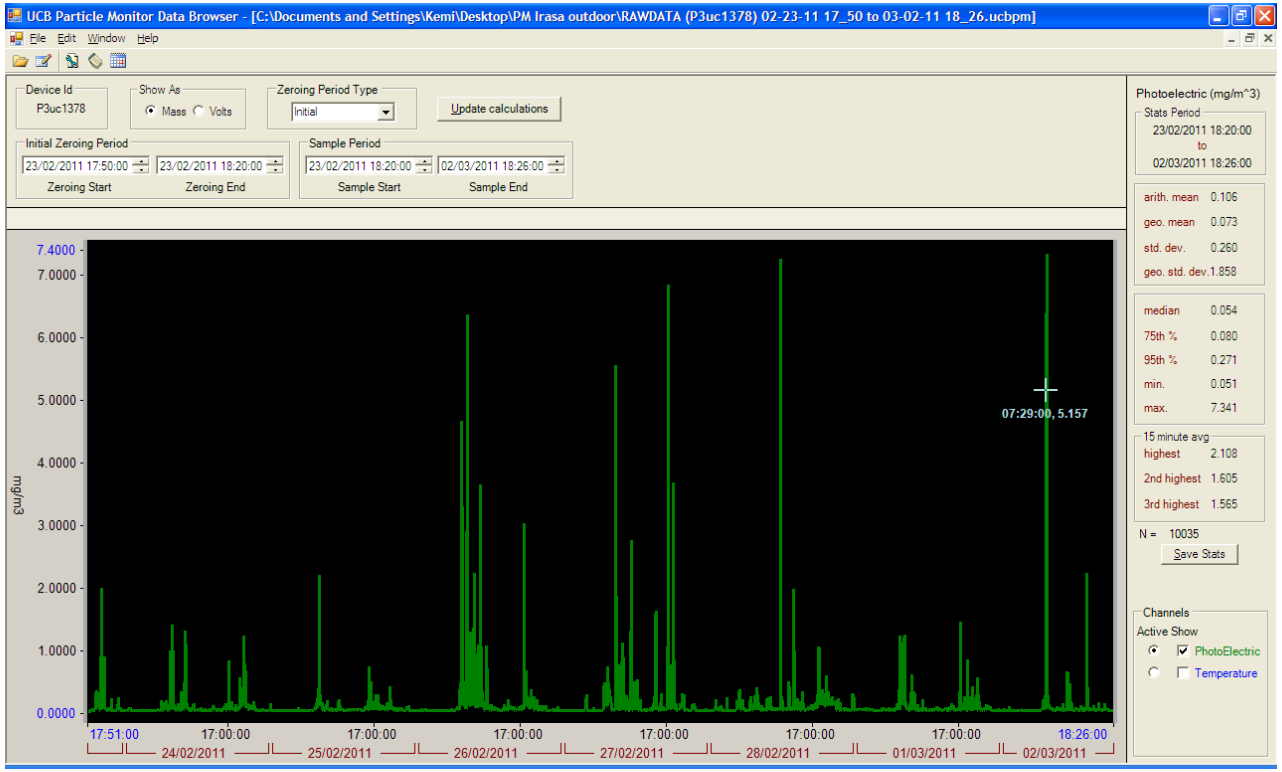
Appendix 6: Irasa air quality data for buildings with outdoor kitchen



Monitoring of $PM_{2.5}$ in Building 1 (HH1) with outdoor kitchen at Irasa community

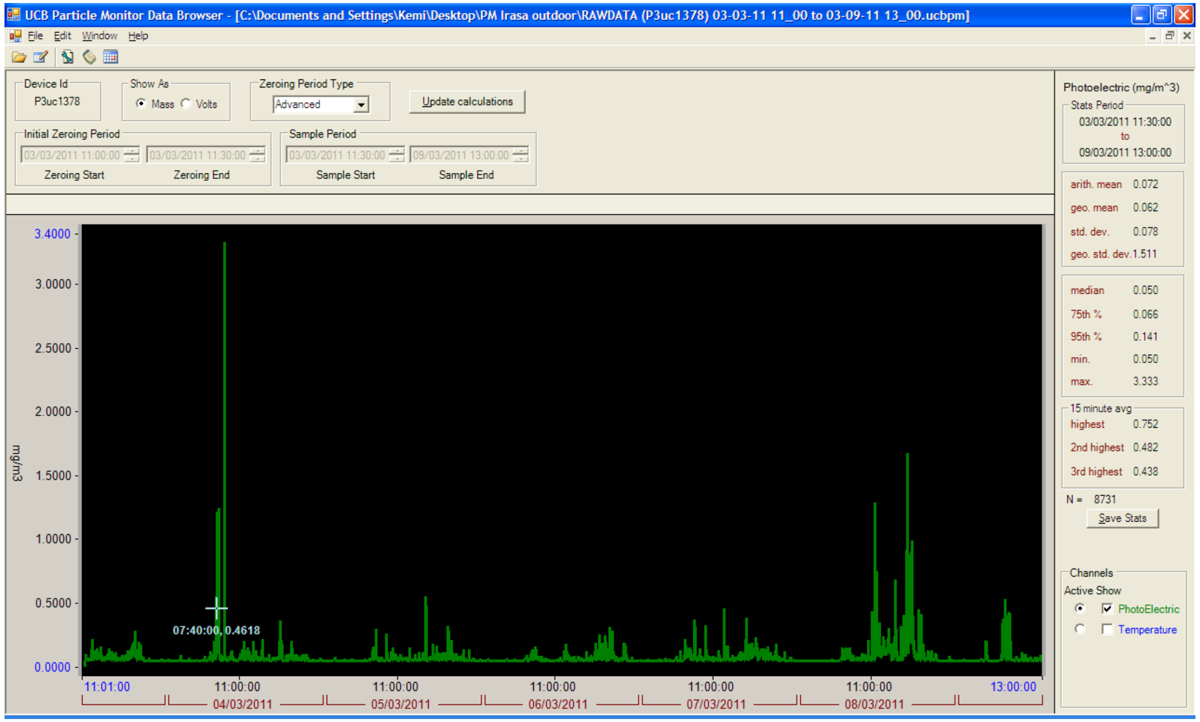
Week 1: 16/02/2011 – 23/02/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 2 (HH2) with outdoor kitchen at Irasa community

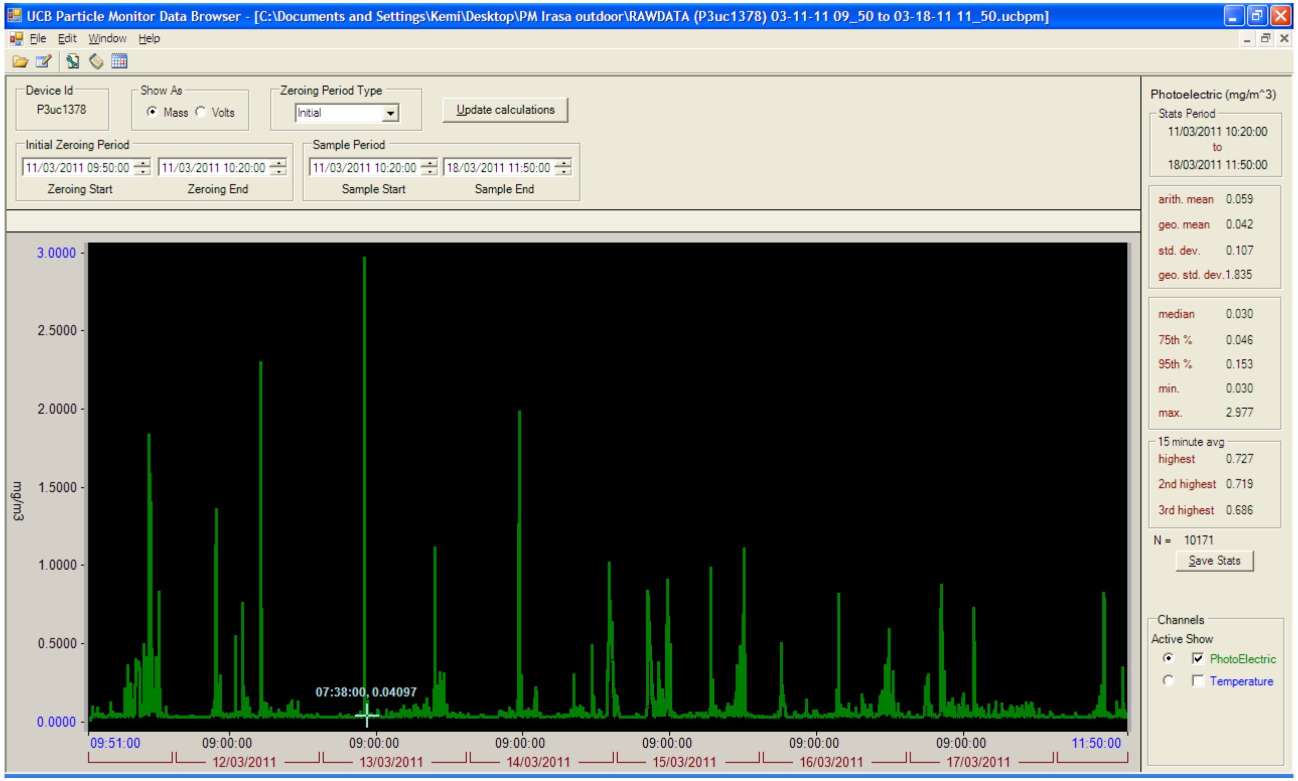
Week 2: 23/02/2011 – 02/03/2011



Monitoring of $PM_{2.5}$ in Building 3 (HH3) with outdoor kitchen at Irasa community

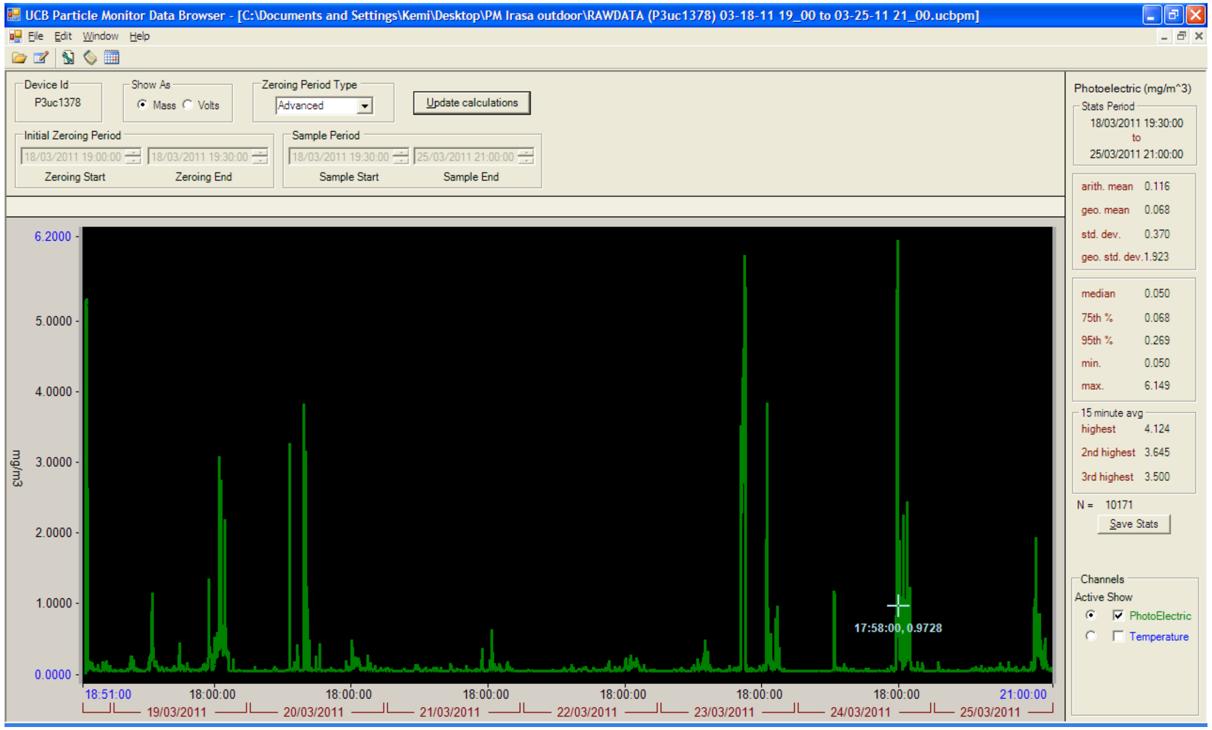
Week 3: 03/03/2011 – 09/03/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 4 (HH4) with outdoor kitchen at Irasa community

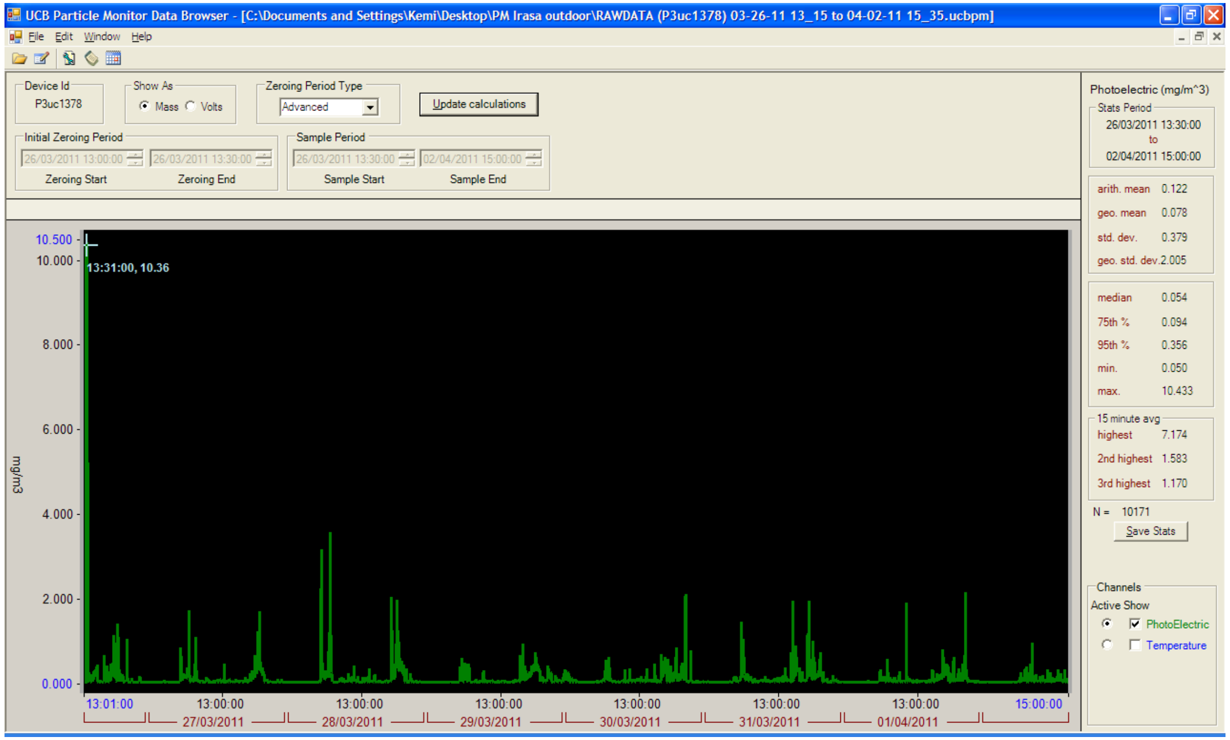
Week 4: 11/03/2011 – 18/03/2011



Monitoring of $PM_{2.5}$ in Building 5 (HH5) with outdoor kitchen at Irasa community

Week 5: 18/03/2011 – 25/03/2011

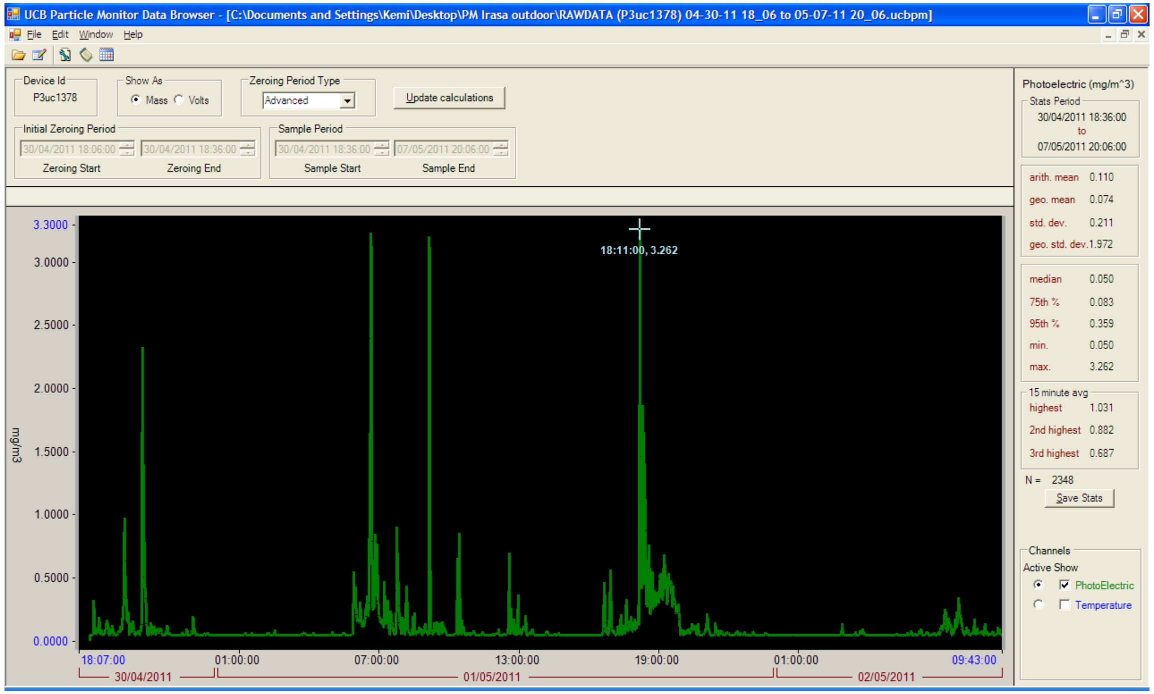
(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 6 (HH6) with outdoor kitchen at Irasa community

Week 6: 26/03/2011 – 02/04/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)

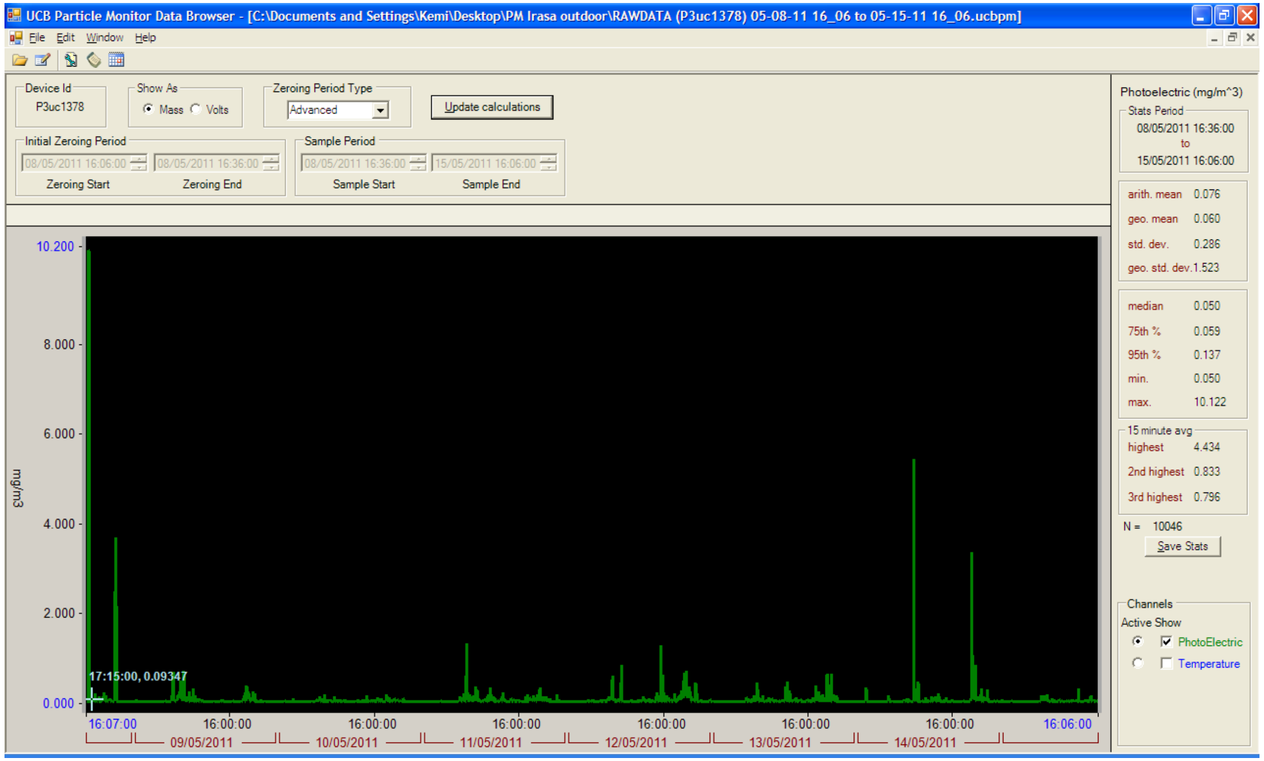


Monitoring of $PM_{2.5}$ in Building 7 (HH7) with outdoor kitchen at Irasa community

Week 7: 30/04/2011 – 07/05/2011

(Note: limit of detection above ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)

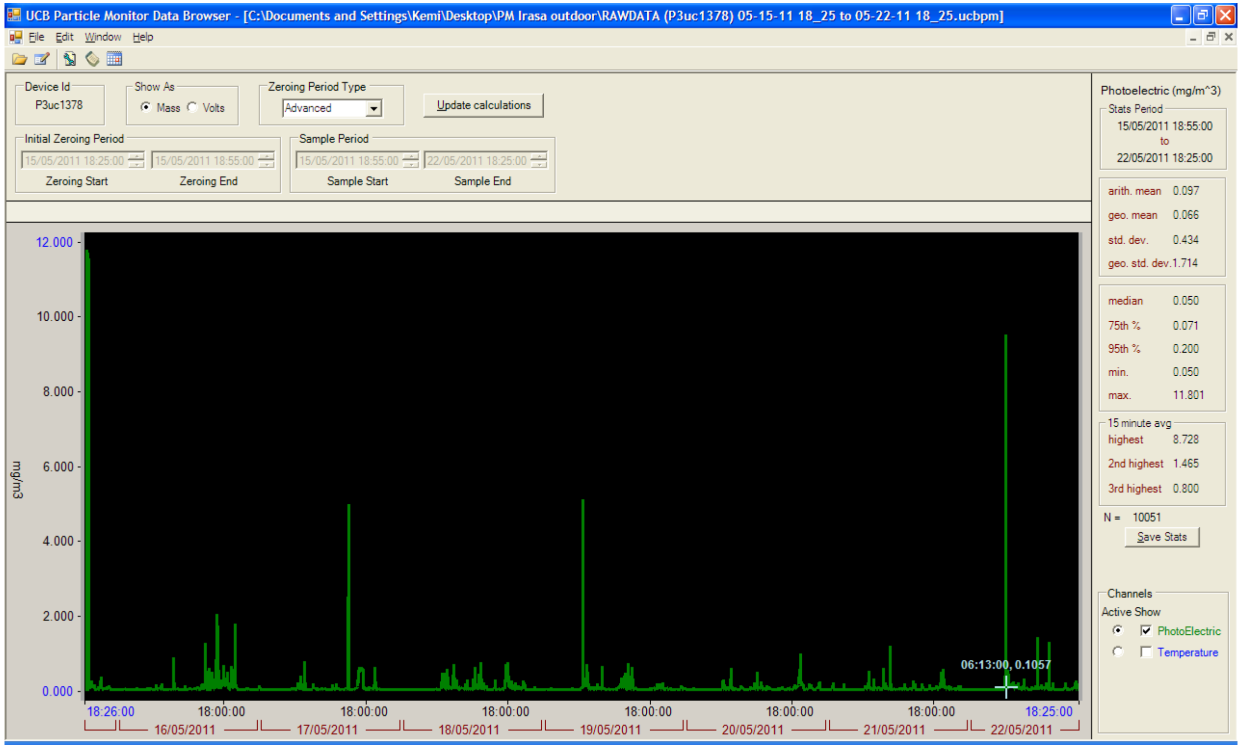
(Incomplete data, battery stolen midway of measurement)



Monitoring of $PM_{2.5}$ in Building 8 (HH8) with outdoor kitchen at Irasa community

Week 8: 08/05/2011 – 15/05/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)



Monitoring of $PM_{2.5}$ in Building 9 (HH9) with outdoor kitchen at Irasa community

Week 9: 15/05/2011 – 22/05/2011

(Note: limit of detection not within ≥30μg/m^3 and ≤75μg/m^3, adjusted to 50μg/m^3)