INDOOR AIR POLLUTION AND ACUTE RESPIRATORY DISEASE MORBIDITY AMONG RURAL WOMEN IN GOMBI LOCAL GOVERNMENT AREA OF ADAMAWA STATE

BY

TAHIR MUSA TARFA

MSC/GY/07/0083

A THESIS PRESENTED TO THE DEPARTMENT OF GEOGRAPHY, MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY YOLA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL RESOURCE MANAGEMENT

2011

CERTIFICATION

This is to certify that this thesis on indoor air pollution and acute respiratory disease morbidity among rural women in Gombi local government area of Adamawa state, Nigeria, is an original work of Tahir Musa Tarfa M.Sc/GY/07/0083. Being submitted in fulfillment of the requirement for the award of Master of Science degree in environmental resource management to the department of Geography, School of environmental sciences, Modibbo Adama University of technology Yola. Copies of which are submitted for evaluation by the panel of examiners and subsequent oral defense by the candidate.

…….....	……
Head of department	Supervisor
Date…….	Date……

Having made the stipulated requirement, the dissertation has been accepted by the school of post graduate studies of Modibbo Adama University of technology Yola.

……

Dean school of post graduate studies

Date…….

APPROVAL PAGE

This thesis entitled indoor air pollution and acute respiratory disease morbidity among rural women in Gombi local government area of Adamawa state, by Tahir Musa Tarfa meets the regulations governing the award of Master of Science degree in environmental resource management from the Modibbo Adama University of technology Yola and is approved for its contribution to knowledge and literary presentation.

…….. …….

Dr. A.M. Mubi Date

Supervisor

…….. …….

Prof. A.L Tukur Date

Internal examiner

…….. ……..

Prof. Idris Audu Jaiyeoba Date

External examiner

…….. ……

Dr.A.M. Mubi Date

Head of department

…….. ……..

Prof. A.M. Nur Date

Dean, school of post graduate studies

DEDICATION

I dedicate this work in loving memory of my late parents Mallam Musa Habu Tarfa and Mallama Rhoda Musa Tarfa.

ACKNOWLEDGEMENTS

I wish to acknowledge the scholarly contribution of Dr A.M Mubi, Prof. A.L Tukur, Prof. A.A Adebayo and Dr. Helen Ray, thank you.

I also want to thank the following people for their support, Alh. Dauda Birmah (Sarkin Gabas Adamawa), Ricky M. Tarfa (SAN), Mrs. Ruth Madziga, Mrs. Martha Midala, Alex M. Tarfa, Leach M. Tarfa, Kenneth Umaru Tarfa, Mustafa M. Tarfa, Bishara M. Tarfa and Jamima Chiwari. Rebecca Mwajim Malgwi, Nuhu Bamare Bansi, Ibrahim Musa Dawah, Semen Jiddere, Kefo, Rufun Jauro, Dr Tendimadi, Musa Banu, Steven Warigon, Mark Behora, Solomon Midala, Musa Dauda Birma, Yusuf G. Malgwi, Solomon Garnvwa, Umaru Moh. Tarfa, Anjili Moh. Tarfa. My sincere appreciation goes to the entire staff of Geography department, Modibbo Adama University of technology Yola.

ABSTRACT

The aim of the study was to assess the awareness of Indoor Air Pollution (IAP) among the rural women and its relationship to acute respiratory disease morbidity among women and young children (1-6 years) in Gombi LGA. Four objectives were set out to help achieve this aim. Data were obtained through primary source and analyzed using descriptive and inferential statistical techniques. The results/findings of the analysis indicate that 99.8% of the respondents use fire wood for cooking while only 0.2% use kerosene. The availability of fire wood (42%) is the main reason for the use of fire wood among Respondents and this is followed by the cost of alternatives (32%), the lack of alternatives (13%) and cultural belief (12.3%). Based on analysis of IAP level indicators, a 24 hour mean exposure level of 33.1mg/m^3 of Carbon monoxide and 0.7mg/m^3 of Particulate Matter were established in the Study area. These are 3.1 times and 7.1 times higher than the 24 hour mean standards specified by (WHO 2005). 67% of the respondents are aware of the ills IAP and this awareness is influenced by age group and educational level of the respondents as well as the occupation of their spouses more than any other socio economic characteristics. 73% of the respondents and 80% of their children (1-6 years) have a high level of Acute Respiratory Disease Morbidity (ARDM). Acute Respiratory Diseases (ARDs) have been linked with prolonged exposure to IAP and six (6) out of the nine (11) IAP exposure level determining factors analyzed show significant association and relationship with ARDM among women and children in the Study area. This is arguably a strong indication of the link between IAP and ARDs. The restriction of kitchen stay was seen to be the most effective local intervention or mitigation measure against the effects of IAP as it reduced ARDM among women and children by an average of 42% instead of just by 25% with other mitigation measures. The evidence of relationships between IAP and ARDM witnessed in the analysis of the data obtained is convincing and indicative that IAP is a major factor influencing ARDM within the Study Area. The study therefore recommends a more pragmatic advocacy on the ills of IAP, the inculcation of bio mass pollution basics in the primary, secondary and tertiary education curricular, the involvement of the media in the advocacy efforts, the provision of improved stoves, alternative fuels and incentives as well as the strict implementation of legislation against indiscriminate forest exploitation.

TABLE OF CONTENTS

LIST OF TABLES

Tables **Page**

LIST OF FIGURES

Figures **Page**

GLOSSARY

ALRI	-	Acute Lower Respiratory Infection
ARDM	-	Acute Respiratory Disease Morbidity
ARDs	-	Acute Respiratory Diseases
ARIs	-	Acute Respiratory Infections
COPD	-	Chronic Obstructive Pulmonary Disease
IAP	-	Indoor Air Pollution
LGA	-	Local Government Area
NGO	-	Non Governmental Organization
UNDP	-	United Nation Development Program
UNEP	-	United Nation Environmental Program
USAID	-	United State Aid

USEPA	-	United State Environmental Protection Agency
VOC	-	Volatile Organic Compounds
WEC	-	World Economic Council
WRI	-	World Resource Institute
WWF	-	World Wide Fund

DEFINITION OF TERMS

- IAP levels- The level of concentration of smoke pollutants from fuel wood combustion indoors which is determined by fuel type and amount combusted (kg), kitchen size (m^3) and ventilation space (m^2), stove type and cooking time in hours as well as cooking habits (i.e. indoors or out doors).
- IAP exposure levels- The level or time spent by respondents in contact with pollutants from fuel wood combustion here determined by the awareness of IAP and local intervention, family size, practicing extra-curricular cooking and the all the listed IAP levels determining factors.

- Formal education- Official, prescribed or recognized education such as Islamic, Primary, Secondary or Higher education.
- Informal education- No form of official, recognized or prearranged education.

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Indoor Air Pollution (AIP) can be traced to prehistoric times when human's first move to temperate climates and it became necessary to construct shelters and use fire inside them for cooking, warmth and light. Fire led to exposure to high levels of pollution as evidenced by the soot found in prehistoric caves, (Albalak 1997).

Approximately half the worlds population and up to 80% of rural households in developing countries including 80% - 90% in some sub-sahara African countries still rely on unprocessed bio-mass fuels in the form of wood, dung and crop residues, (WRI, UNEP, UNDP and World Bank 1998). These are typically burnt indoors in open fires or poorly functioning stoves in which combustion is very incomplete, resulting in substantial emissions of smoke. This smoke in the absence of proper ventilation, produces very high levels of IAP, to which women, especially those responsible for cooking, and their young children (1-6 years), are most heavily exposed, (De koning *et al*. 1985). The smoke contains a large number of pollutants that are dangerous to health including Carbon monoxide (CO), Nitric oxide (NO), Nitrogen oxide (NO_2), and Nitrous oxides (N_2O). Others are Formaldehyde (CH_2O) and Polycyclic Organic Matter including Carcinogens such as Benzo [a] Pyrene ($C_{16}H_{10}$) and Benzene (C_6H_6) as well as particulates with diameters below 10 microns (PM_{10}), (De koning *et al.*1985).

The respiratory system specifically the lung is the most common site of injury by airborne pollutants and this may result to Acute Respiratory Diseases (ARDs) among the vulnerable population. Acute effects however, may also include none respiratory signs and symptoms, which may depend upon toxicology characteristics of the substance and host related factors such as nutritional or health status, (USEPA 1989). Nonetheless, the general signs and symptoms of ARDs includes cough with or without fever, blocked or running

nose, sore throat, ear discharge, phlegm, shortness of breath and other more advance complications such as air way inflammation and progressive lung tissue destruction, (WHO 2007). Recently, women have recorded a high level of ARD cases especially in developing countries and this might likely be due to their prolonged exposure to IAP from the use of biomass fuel for cooking while children (1-6 years) irrespective of sex also constitute a bulk of this statistics, (WHO 2007). Figures of disease diagnosis from the two main medical facilities in the study area indicates that Acute Respiratory Disease Morbidity (ARDM) among women and children continue to increase by an average of 3.4% annually from the year 1979-2008.

Evidence on the health effects of Indoor Air Pollution has grown in the last 10 years. Several studies such as those by Albalak (1997), Smith and Liu (2000) as well as Khin *et al*. (2005), have revealed a link between prolonged IAP exposure and a number of conditions including tuberculosis, prenatal mortality, low birth weight, asthma, otitis media, cancer of the upper air way and cataracts. But there is now a quite strong evidence that prolonged exposure to IAP increases the risk of ARDs especially Acute Lower Respiratory Infections (ALRI) in children and Chronic Obstructive Pulmonary Disease in Adults (COPD), (Smith 1987).

It is estimated that IAP was responsible for nearly two million deaths in developing countries and for some 4% of the global burden of disease in the year 2000, (Bruce *et al*. 2000). In addition to these direct health effects are other consequences arising from the use of household energy in conditions of poverty, including burns to children onto open fire, ingestion of kerosene stored in soft drink containers, restriction on income generating activity and opportunity cost for women of spending many hours collecting fuel wood as it becomes increasingly scarce, (WHO 2000).

Given the high level of IAP and the interaction of housing, household energy, and day to day household activities in determining exposure to indoor smoke in Developing Countries, research and development of effective remedies can benefit tremendously from the integration of methods and analysis tools from a range of disciplines in the physical, social and health sciences, (WHO 2000), hence the need for this research.

1.2 Statement of problem

Indoor Air Pollution is a major public health threat requiring greatly increased efforts in the areas of research and policy making, (Bruce *et al.* 2000). Prolonged exposure to IAP has been linked with respiratory diseases as components of smoke have been shown to adversely affect host defense against respiratory infections, (Khin *et al.* 2005). Acute respiratory diseases are among the most frequent causes of consultation and admission to hospitals and clinics in developing countries and are the leading cause of infectious disease morbidity and mortality in the world. According to WHO (2007), almost about four million people die from acute respiratory diseases each year. The mortality is particularly high among infants, children and the elderly in developing countries, (WHO 2007). While about 60% of the worlds population still rely on bio-mass fuels for domestic energy, in Nigeria, over 67% of the people still use biomass fuels with consequent 2.6 million Disability Adjusted Life Years (DALYs), 79,000 deaths as a result of Acute Respiratory Diseases and a 3.8% national burden of disease, all attributed to IAP in the year 2006, (WHO 2007).

In developed countries, modernization has been accompanied by a shift from biomass fuels to petroleum products and electricity. In developing Countries however, even where cleaner fuels are available, households often continue to use simple biomass fuel as a major source of energy, (smith 1987). Although the proportion of global energy derived from biomass fuels fell from 60% in 1900 to around 13% in 2000, there is evidence that their (biomass fuel) use is now increasing among the poor in developing countries, (Albalak 1997).

Although there are gaps in the knowledge of the health risk and most effective intervention against IAP, there is clearly enough evidence that current household energy use in developing countries presents a substantial public health risk that demands concrete global action. This action requires a combination of advocacy, policy, research to strengthen evidence base on health and other outcomes, a range of other basic and applied researches as well as the development of appropriate intervention strategies, (WHO 2002). This study examined IAP and exposure level indicators, the awareness of IAP from the use of fuel wood for cooking among the Rural Women in the study area and its relationship to ARDM, in order to be able to develop a locally appropriate and coherent framework of recommendations, for increased public awareness and Sustainable future mitigating measure, in a systematic manner.

Much of the studies carried out with regards to IAP from the use of biomass fuel for domestic house hold energy were project based and often donor-led, mostly concentrating on interventions at the source of pollution which could be temporary as evidenced by the study in South Africa, (Luvhimbi and Jawrek 1997), while neglecting interventions via advocacy which could be permanent because of its influence on user behavior. The large scale use of fuel wood witnessed in the Study area therefore calls for a more practical approach and permanent solution to the problem and as such the emphasis on advocacy. There has been awareness of the connections of IAP with health, but in practice this has not been prominent. In addition, very little of these works were coordinated and as a result did not bring about substantial change in policy, donor commitment or most importantly raise awareness of the ills of IAP which can bring about a change in user behavior in those countries and poor communities worst affected, (WHO 2OOO). IAP is not a recognized environmental hazard at policy level in developing countries, therefore, generally less efforts have been made in this regard, (WHO 2005). It is in view of the foregoing that this study is articulated.

1.3 Research questions

(1) What are the predominant types of household domestic energy in use among households and what factors influence their use?

(2) What are the characteristics of IAP and exposure level indicators?

(3) What is the level of awareness of IAP among rural Women in Gombi L.G.A?

(4) What is the frequency of occurrence of acute respiratory diseases (Acute Respiratory Disease Morbidity ARDM) among women and young children?

1.4 Aim and Objectives of the study

The aim of this research is to examine the awareness of IAP among rural women in and its relationship to acute respiratory disease morbidity among women and young children in Gombi LGA. To achieve this aim, the following objectives were pursued.

i. Examine the types of household domestic energy, and analyze the factors influencing their use.
ii. Assess IAP and exposure level indicators and there relationship to acute respiratory disease morbidity among women and children.
iii. Assess the level of Awareness of IAP and its relationship to acute respiratory disease morbidity among women and children.
iv. Examine the prevalence rate of acute respiratory diseases among rural women and Young children.

1.5 Guiding Hypothesis

The following hypotheses were tested to aid in achieving the aim and objectives of the study.

Ho_1 There is no significant relationship between the average family sizes found across the wards of the study area and average acute respiratory disease morbidity (ARDM) among women and children.

Ho_2 There is no significant association between awareness of IAP and

high ARDM among Women and children.

Ho_3 There is no significant relationship between average kitchen size (m^3) and average ARDM among women and children.

Ho_4 There is no significant relationship between average ventilation spaces (m^2) and average ARDM among women and children.

Ho_5 There is no significant relationship between average wood consumption (kg) and average ARDM among women and children.

Ho_6 There is no significant relationship between average cooking time and average ARDM among women and children.

1.6 Scope of the study

The study is limited to the ten wards comprising Gombi local government area from which samples were obtained proportionately. Indoor air pollution was assessed based on examination of IAP and exposure level determining factors or indicators, specifically from the use of fuel wood for cooking. Among the various pollutants present in the smoke emitted from fuel wood combustion, only carbon monoxide (CO) and particulate matter (PM) were considered in this research. This is because of their importance on health effect and IAP monitoring, as well as their relative concentration stability across different types of fuel wood combustion. Furthermore, their (CO and PM) concentration in homes that use fuel wood for cooking can be estimated based on an analysis of IAP level indicators thereby eliminating the need for expensive and high-tech instruments of measurement.

1.7 Significance of the study

The continuous use of biomass fuels as the major source of energy among rural dwellings in Developing Countries even where clean and relatively cheap fuels are available is an indication that the problem is multi dimensional involving both economic and social factors. By identifying the sources of domestic or household energy, pinpointing and deliberating on the factors influencing the use of the identified sources of energy, the study aided to

bringing out the salient factors involved in the use of simple bio-mass fuels as a major source of domestic energy. This facilitated the development of locally appropriate and coherent recommendations that could serve as basis for increased public awareness and sustainable future intervention. This can limit the use of biomass fuels as well as IAP on the one hand and mitigate the effects of the resultant pollution, on the other.

The estimated level of IAP from the use of biomass fuel for cooking as highlighted revealed the extent of the problem and therefore establishes the need for urgent action against the menace. This should in turn stimulate or act as a basis for the development of urgent and appropriate policies by the Authorities concerned.

The difference and relationship between ARDM among women and children and IAP exposure level determining factors as tested helped reveal the most important IAP factors influencing ARDs among women and children and therefore discloses the areas for direct intervention. It also helped solidify the numerous literatures linking prolonged exposure to IAP and ARDs among women and children (1-6 years).

The findings of this study have revealed the level of awareness of IAP among the rural women in Gombi L.G.A and can therefore be a useful tool in creating awareness about the subject matter. There is no doubt that raising awareness about the ills of IAP will not only improve the health and living standards of the population, but might in the long run discourage deforestation and air pollution, thus, improving environmental quality. The utility of public environmental awareness in shaping desirable environmental management practices and effective control can not be overemphasized, a successful policy on environmental control hinges on the exigencies of politics, and demands effective articulation of public opinion and support. Furthermore, the degree of public support for environmental programs depends on the extent of individual and group awareness of environmental problems, (Chokor 1985). Greater

awareness of indoor air pollution can raise public consciousness; stimulate appropriate behavioral changes which could redirect efforts in tackling the problem. It could also be administratively expedient, effective and cost saving as the expected attitudinal change following awareness of the risks and hazards of IAP would not only minimize its effect but reduce the need for costly interventions at the source of pollution.

Finally, this study has helped to consolidate experience of local interventions, encourage the evaluation of future interventions in a systematic and comparable way, in so doing building local capacity, and promoting the dissemination of experience in ways that are accessible locally and internationally.

1.8 Justification of the study.

In any indoor air pollution study, monitoring or measuring IAP levels is particularly important given the differences in housing, kitchen, fuel type, stove type, personal behavior and ventilation characteristics which are the main factors that determine IAP levels, (Smith *et al.* 2005). However, when monitoring or measurement is not feasible, the Questionnaire-based IAP assessment provides for an alternative, (Rehfuess and Pennise 2005). The choice of method depends on the context (purpose, capacity, finances) of the study and all methods require data management, quality assurance and control.

Measuring IAP levels requires the use of specialized equipments and real-time data logging devices which are both fragile and highly expensive. Although these equipments provide relatively accurate data, they are of new technology not traceable to national standards, require recalibration and are mostly of one-time use which increases the quantity needed and therefore the costs. They also give generally much variation in single household during short-term measurements and therefore require longer or continuous monitoring which is capital intensive, consumes much time and require large manpower,

(Smith *et al*. 2005). The equipments also give little or no information about personal behavior (time spent cooking) which is a necessity in this study.

Given these short-comings, assessing IAP levels through questionnaires currently used by WHO (2005) provides for a suitable alternative method of study. The questionnaires were developed in such a way that suits the needs and conditions of the study and therefore limited the drawbacks of insufficient information through the inclusion of questions on housing, kitchen, fuel type, daily consumption, stove type, personal behavior, ventilation characteristics as well as local experiences which allowed for adequate estimation of pollution levels through a comparison with the experimental data of Smith and Pennise (2005) currently in use by the World Health Organization (WHO).

1.9 The Study Area

1.9.1 Location and Extent

Gombi local government area (The Study area) is located in the north central part of Adamawa State and lies approximately between latitude $9^{O}7'$ and $10^{O}2'$ north of the equator and longitude $12^{O}3'$ and $12^{O}9'$ east of the green-which meridian, (World atlas, Encarta encyclopedia 2009). Gombi LGA is one of the 21 L.G.A's that make up Adamawa State. It (Gombi L.G.A) has total land area of 2,232.63km^2, (Adebayo 1999), and a population of 146,429 people, (National Polpulation Commission NPC 2007). Gombi LGA shares boundary with Song L.G.A in the south, Hong L.G.A. in the east, Shelleng L.G.A. in the west and Hawul L.G.A. of Borno State in the north, (Adebayo 1999).

Gombi LGA is made up of four (4) districts and ten (10) wards; Fig.1.1 shows the study Area, the districts and the wards.

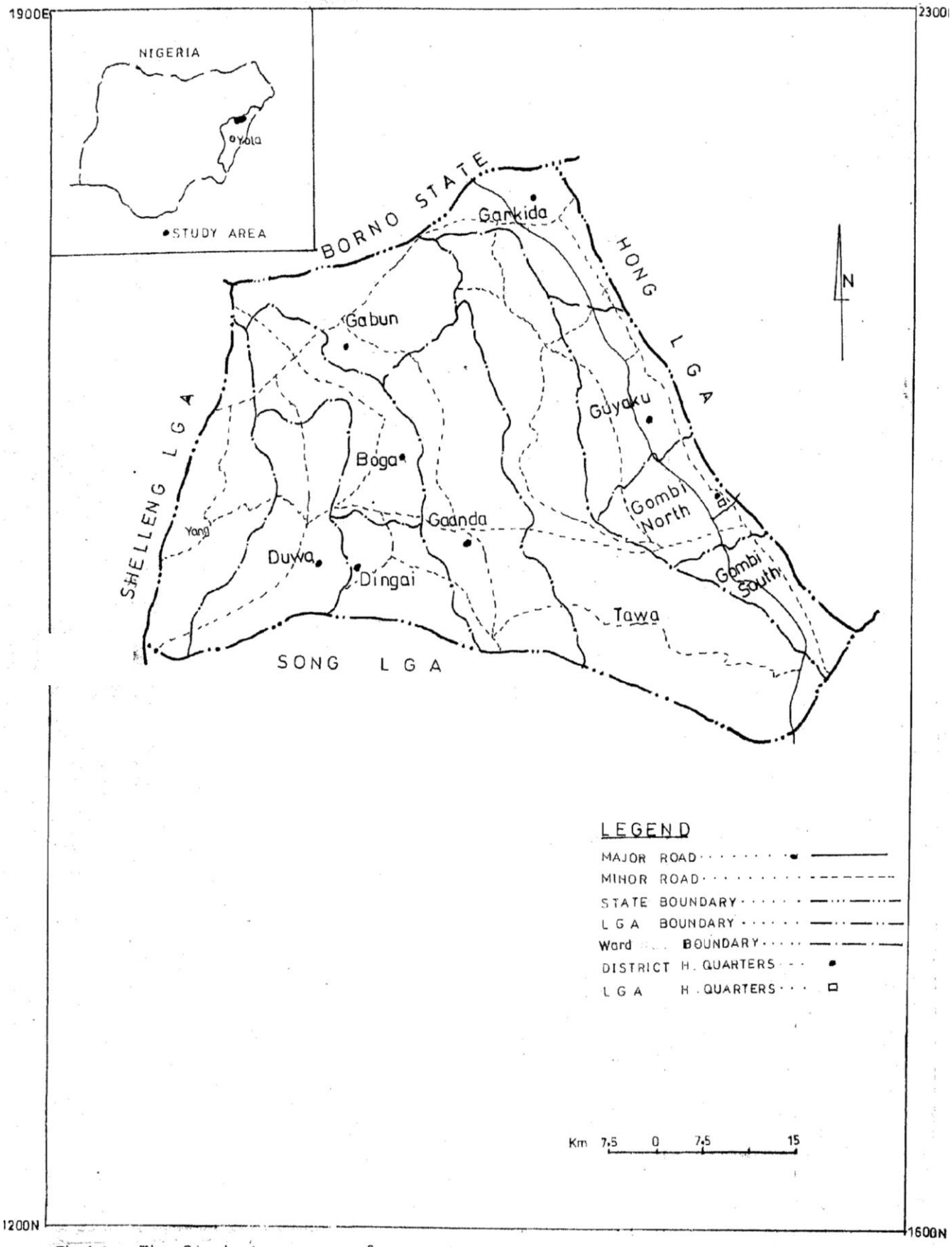

Fig 1.1: The Study Area Source Ministry of Works, Yola

1.9.2 Relief and Drainage

Gombi LGA lies on an upland plain with an average height of about 350m above sea level. Several inselbergs and hills of residual and granitic origin litter this expansive plain giving a picturesque open undulating country, (Tukur 1999).

The study area is drained ' he river Hawul to the north and river Kilange to the south, both of whicn eventually drain their waters into the Benue drainage system, (Adebayo and Umar 1999).

1.9.3 Geology and Soil

The geology of the study area is made up of mainly the hard crystalline cratonic Basement Complex with overlying sedimentary deposits. Several outcrops of granitic and sedimentary origin are littered across this gentle undulating landform which around some locations, are so dissected that they occur as plateau surfaces, (Tukur 1999).

The soil of the study area comprises mainly the Plinthic luvisols, however small areas of Lithosol occur at the central and northern parts of the L.G.A. Both of these soils are derived from the basement complex underlying the geology of the study area and are broadly classified as tropical ferruginous soils. These types of soil are defined often generally as having a marked differentiation of horizons and an abundance of free iron oxides usually deposited as red or yellow mottles or concretions, (Ray 1999).

1.9.4. Climate and Vegetation

The study area is characterized by a distinct dry and rainy season which is influenced by the seasonal movement of the Inter Tropical Discontinuity (ITD) which is the major factor controlling rainfall in the state and country in general. The dry season lasts for 5 months from November to April while the rainy season lasts for 7 months from May to October. During the dry season, the study area is under the influence of the dry continental and relatively stable air mass from the north-east (north-east trade winds or Harmattan) and during the

rainy season, the moist tropical maritime air mass from the south (south westerly's) dominates the study area. With an average annual rainfall of about 900mm, Gombi L.G.A comprises a warm climate with a mean annual temperature of 27^0c and a relative humidity of between 20% and 80% depending on the season, (Adebayo 1999).

The vegetation of the study area is of the northern guinea savannah type with interspersion of thickets, tree savannah, open grass savannah and fringing forests in the river valleys. Several woody plant species predominate in this zone including *Afzelia africana, Vitellaria paradoxa, Terminalia laxiflora, Terminalia glaucescens, Annona senegalensis* and the likes while grass species include *Hyparrhenia, Bracharia and Aristida, (*Akosim *et al.* 1999).

It is however important to note that deforestation have left large areas within this vegetation type with few indigenous woody plant species especially areas close to settlements where *Neem* and *Eucalyptus* trees dominate. The continuous savannah grass cover has also been distorted by pockets of expanding agricultural land, (Akosim *et al.* 1999).

1.9.5 Population and Land use

According to the 1991 population census, Gombi L.G.A. has a total population of 88,635 people comprising 43,585 males and 45,050 females in 16,974 households, (NPC 1991). The 2006 population census figure reveals a total of 146,429 people with 71,223 males and 75,206 females in 28,088 households, (NPC 2007). This indicates a 65.2% increase in population during this period (15 years).

The study area is made up of four (4) districts namely Guyaku, Ga'anda, Lala and Garkida districts, comprising several settlements and localities. These settlements and localities have been aggregated to form ten (10) political wards. Out of these wards, Guyaku district has four wards namely Guyaku, Tawa, Gombi north and Gombi south wards respectively; Ga'anda district has two (2) wards namely Ga'anda and Gabun, and shares one ward "Boga-dingai" with

Lala district which also has two (2) wards in Duwa and yang. Garkida district represents one political ward, (P.H.C. Gombi L.G.A. 2006). Table 1.1 shows the 2006 population and household distribution figures by wards and districts.

Table 1.1 Population and household figures by districts and wards.

s/no	DISTRICTS	WARDS	POPULATION	SEX		HOUSEHOLD
				Male	Female	
1	GARKIDA	Garkida	8,519	3859	4660	1633
2	GUYAKU	Guyaku	12,177	5661	6456	2324
		Tawa	20,039	9622	10417	3444
		Gombi North	25,040	12121	12919	3288
		Gombi South	17,135	8170	8965	3288
3	GA'ANDA	Ga'anda	8,731	3968	4763	2076
		Gabun	11,955	5580	6375	2293
		Bogadingai	17,409	8307	9102	3338
4	LALA	Yang	10,908	5056	5852	2091
		Duwa	14,576	6890	7686	2796
TOTAL			146,429	71,223	75,206	28,088

Source: Primary Health Care (P.H.C) Department, Gombi L.G.A 2006.

Just like many other rural settlements in Adamawa state, agriculture persists as the major land use or economic activity of the people of Gombi L.G.A, (Sajo and Kadams 1999).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter deals with the review of relevant literature on the main components of the study, these include; the nature of air pollution, the meaning, origin, rationale and scope of Indoor Air Pollution (IAP), sources of IAP, impact of IAP, Acute Respiratory Diseases (ARD) in developing countries, the link between poverty, domestic energy, IAP and health.

2.2 The nature of air pollution

It is difficult to give a simple comprehensive definition of pollution. The word comes from the Latin pollute, which means made foul, unclean, or dirty. According to the Macmillan world gazette and geography dictionary (2008), pollution is the introduction of any substance which causes an undesirable change in the physical, chemical or biological characteristics of the natural environment. The encyclopedia of public health (2008) defines the term pollution as a chemical or physical agent in an inappropriate location or concentration while the Encarta encyclopedia (2009), described pollution as the contamination of earths environment with materials that interfere with human health, the quality of life or the natural functioning of ecosystems.

All the three (3) definitions seem to emphasize on an adulteration of the earths environment. This means that pollution is an infection in all or part of the circumstances or conditions that surround an organism or group of organisms. These circumstances or conditions consist of both the physical and socio-cultural phenomenon that affects an individual or a community. Air is an important component of the physical environment therefore; air pollution can be regarded as a change or distortion in the natural characteristics or quality of air. The World Health Organization (WHO, 2005) defined air pollution as an Atmospheric condition in which certain substances like gasses, particulate matter, radioactive materials etc are present in such a condition that they can

produce undesirable effects on mankind and his environment, WHO (2005). Some authors such as Boehm (1995) limit the use of the term to damaging materials that are released into the air by human activities (anthropogenic sources). There are, however, many natural source of air quality degradation which includes volcanic eruptions that spew out ash, acid mists, hydrogen sulfide and other toxic gasses, sea spray and decaying vegetation, storms as well as volatile organic compounds (VOC) like Trepenes and Isoprene emitted from trees and bushes. Human induced air pollution is important because some materials in the atmosphere are considered innocuous at naturally occurring levels, but when humans add to these levels, overloading of natural cycles or disruption of essential processes can occur. air pollution is generally the most wide spread and obvious kind of environmental damage, (Cunningham *et al.* 2003).

The agents that induce undesirable changes in the air can broadly be classified into primary and secondary pollutants. Primary pollutants are those released directly from the source into the air in a harmful form, a typical example is the burning of biomass fuel for energy. Secondary pollutants by contrast are modified to a hazardous form after they enter the air or are formed by chemical reactions as components of the air mix and interact under the influence of solar energy, (Cunningham *et al.* 2003). The U.S clean air act of 1990 designated seven major pollutants (sulfur dioxide, carbon monoxide, particulates, hydrocarbons, nitrogen oxides, photo chemical oxidants and lead) for which maximum ambient air levels are mandated. These seven (7) conventional or criteria pollutants contribute the largest volume of air quality degradation and are also considered the most serious threat of all air pollutants to human health and welfare, (Cunningham *et al*. 2003).

2.3 Meaning, origin, rationale and scope of indoor air pollution

Indoor Air Pollution is simply a contamination of indoor air. Areas that are considered indoors include all enclosed or build up spaces in which humans

inhabit, (Chen *et al*. 1990). The World Health Organization (WHO) defines indoor air as "air within a building occupied for a period of at least one hour by people of varying states of health". Covered by this definition are buildings such as homes, schools, hospitals, restaurants, public buildings, residential institutions and offices. Work place covered by occupational health standards such as industries are not included in this definition, (WHO 2005).

Indoor air pollution can be trace to prehistoric times when human's first move to temperate climate and it became necessary to construct shelters and use fire inside them for cooking, warmth and light. Fire led to exposure to high levels of pollution as evidenced by the soot found in prehistoric caves, (Albalak 1997).

Approximately half the words population and up to 90% of rural households in developing countries still rely on unprocessed biomass fuels in the form of wood, dung and crop residues. These are typically burnt indoors and as a result, there are high levels of air pollution to which women especially those responsible for cooking, and their young (0-6 years) are most heavily exposed, (WRI, UNEP, UNDP, World Bank 1998).

In general, the types of fuel used becomes cleaner and more convenient, efficient and not always costly as people move up the energy ladder. This is because it is known that the price of fuel wood and kerosene can be on the par in certain localities in developing countries where the combination of rapid population growth and deforestation has resulted to the scarcity and therefore the hiking in prices of fuel wood, (Smith *et al.* 1994). Animal dung on lowest rung of this energy ladder is succeeded by crop residues, wood, charcoal, kerosene, gas and electricity. People tend to move up the energy ladder as socio-economic conditions improve but this has not been the case, especially in developing countries were poverty and the slow pace of development has resulted to over dependence on simple fuels, (Smith *et al*. 1994).

In developed countries, modernization has been accompanied by a shift from biomass fuels such as wood to petroleum products and electricity. In developing countries however, even where cleaner and more sophisticated fuels are available, households often continue to use simple biomass fuels, (Smith 1987). Although the proportion of global energy derived from biomass fuels fell from 50% in 1900 to around 11% in 2005, there is evidence that their use is now increasing among the poor, (WHO 2006). Poverty is one of the main barriers to the adoption of cleaner fuels; the slow pace of development in many developing countries suggests that biomass fuels will continue to be used by the poor for many decades, (Albalak 1997). Estimates suggest that wood provides around more than 70% of energy in developing countries and in 13 countries it is over 90%. Moreover, as the prices of alternatives such as kerosene and bottled gas have increased, the use of biomass fuel has also increased, (WHO 2000). The majority of households in developing countries burn biomass fuels in open fire places, consisting of such simple arrangements as three rocks, a U-shaped hole in a block of clay, or a pit in the ground, or in poorly functioning earth or metal stoves, (Smith 1987). Combustion is very incomplete in most of these stoves, resulting in substantial emissions which in the presence of poor ventilation, produces very high levels of indoor air pollution, (WHO 2000). Indoor concentrations of substances and particles principal among which are carbon monoxide, nitrous-oxides, formaldehyde, polycyclic organic matter including carcinogens such as benzo [a] pyrene and particulates (Particulate Matter, PM) with diameters below 10 microns (mostly conventional or criteria pollutants), usually exceed guideline levels by a large margin while high exposure levels of 3-9 hours have been recorded in rural households in developing counties, (Dekoning *et al.* 1985). The United State Environmental Protection Agency (USEPA) Standards for 24 hour average PM_{10} and $PM_{2.5}$ concentration are 0.75 ppm and 0.025 ppm respectively (ppm- parts per million). The standard for 24 hours mean carbon monoxide concentration is 0.4

ppm while that of nitrogen dioxide is 0.05 ppm, USEPA (1997). The 24 hours mean PM_{10} and $PM_{2.5}$ levels in homes that use biomass fuels as household domestic energy are typical in the range 0.1 – 1.5ppm and 0.05 – 0.75ppm and may reach 15ppm and 6ppm respectively, or more, especially during periods of cooking. A 10-50ppm have been reported as the 24 hour mean levels of carbon monoxide in homes using biomass fuels in developing countries while 1 – 5ppm of nitrogen oxides have been recorded, (Martin 1991). In line with WHO ``Biomass Pollution Basics'' (2005), based on material prepared by Professor Kirk R. Smith and David Pennise of the environmental health sciences department, university of California-Berkeley, two (2) pollutants are of primary interest for both health effects and IAP monitoring: Particulate matter (PM) and Carbon monoxide (CO). According to Rehfuess *et al.* in collaboration with WHO (2005), combustion of 1kg of wood in a typical open fire stove without chimney or hood, per hour, produces about 37.5kg of carbon monoxide (CO) and 2kg of particulate matter (PM). In an experimental kitchen $40m^3$ in diameter and $4m^2$ total ventilation space, this results to a typical concentration of $150mg/m^3$ of carbon monoxide (CO) and $3.3mg/m^3$ of particulate matter (PM) per hour. The typical standards to protect health (24 hour mean standard) are $10mg/m^3$ and $0.1mg/m^3$ per hour of CO and PM respectively, WHO (2005). Therefore the research focused on these two pollutants (PM and CO) in order to be able to make comparison with the results from the experimental kitchen.

Acute respiratory infections are among the leading cause of the Global burden of disease and have been casually linked with exposure to pollutants from domestic biomass fuel in developing countries. Components of smoke have been shown to adversely affect host defense against respiratory infections, (Khin *et al*. 2005). The respiratory system specifically the lung is the most common site of injury by airborne pollutants, acute effects may however include non respiratory signs and symptoms, which may depend on toxicology characteristics of the substance and host related factors such as health status,

allergies as well as living standards, (USEPA 1989). Several studies such as those by Robin *et al.* (1996) and Morris *et al.* (1990) on the navajo women and children of indian americans have revealed a link between prolonged iap exposure and a number of conditions including tuberculosis, prenatal mortality, low birth weight, asthma, otitis media, cancer of the upper air way, and cataracts. But there is now a quite strong evidence that exposure to IAP increases the risk of Acute Respiratory Diseases (ARDs) especially acute lower respiratory infections (ALRI) in children and chronic obstructive pulmonary diseases (COPD) in adults, (Smith *et al*. 1987). Recently, women have recorded a high level of ARDs cases especially in developing countries and this might likely be due to their prolonged exposure to IAP from the use of biomass fuel for cooking while children (1-6 years) irrespective of sex also constitute a bulk of this statistics. The children's high susceptibility to ARDs which have been linked to IAP exposure is likely as a result of the delicate, sensitive and relatively low resistant nature of their respiratory systems, (Khin *et al.* 2005).

2.4 Sources of indoor air pollution in developing countries.

The burning biomass fuel for energy is responsible for over 90% of indoor air pollution in developing countries, (Martin 1991). Other sources of indoor air pollution in developing countries include smoke from nearby houses from the burning of household waste, the burning of forests and agricultural land, the use of kerosene lamps, and industrial and vehicle emissions in homes near urban centers, (McCracken *et al*. 1998). indoor air pollution in the form of environmental tobacco smoke can be expected to increase in developing countries because of the large and growing statistics of young smokers, (WHO 2000). It is worth noting that fires in open hearths and the smoke associated with them often have considerable practical value, for instance in insect control, lighting, the drying of food and fuel and the flavoring of foods, but contribute to indoor air pollution, (Smith 1987). Women and their young children in developing countries are most at risk to iap as they are mostly at home and

responsible for domestic activities especially cooking, (WHO 2005). The situation is further multifaceted in the study area (Gombi LGA) as a considerable number of the women get involved in economic activities like the brewing of local beer (Burkutu) and frying delicacies such as beans cake, yams and potatoes, where biomass fuel in the form of wood is extensively used.

2.5 Environmental health impact of indoor air pollution

The health impact is the most important direct impact resulting from indoor air pollution produced by the burning of biomass fuels (wood, dung and crop residues) in simple stoves with inadequate ventilation, (WHO 2000). A health effect is determined not just by the pollution level but also, and more importantly, by the time people spend breathing polluted air, i.e. the exposure level. Variations in cooking habits between seasons have implications on exposure levels especially in sub Sahara Africa where there is a marked distinction in rainy and dry seasons. Information on such patterns is very important for understanding the dynamic relationship between levels of pollution and behaviors. As pollution levels are reduced it is possible that people will spend more time indoors or near source of pollution. If this happens a reduction in ambient pollution will not necessarily result in a proportionate decrease in exposure and there will be important implication for interventions, (Lioy 1990).

Another wider environmental impact is the contribution to green house gasses, although developing countries global output is small. in 2002, per capita carbon dioxide production was estimated at less tan 3 tones for developing countries, compared to 15 tones for developed countries and 20 tones for USA alone, (WHO 2006).The main issue for developing countries however is not the output of pollutants but the deforestation associated with the use of biomass fuel for energy. Tropical forests serve as store houses for carbon dioxide (Carbon sequestration) and deforestation was estimated to be at 0.8 – 2% per annum in tropical Africa, that is about 5 – 20 million hectares per

annum, (Cunningham 2003). Destruction of these forests means a reduction in the carbon storage capacity, hence greater contribution to green house gasses.

Many of the substances in biomass smoke can damage human health, the most important are particles with diameters below 10 microns (PM_{10}), and particularly those less than 2.5 microns ($PM_{2.5}$), they can penetrate deeply into the lungs and appear to have the greatest potential for damaging health, (USEPA 1997). Formaldehydes and polycyclic organic matter such as benzo [a] pyrene are highly carcinogenic substances found in biomass smoke, (USEPA 1997). Carbon monoxide binds to hemoglobin to form carboxyhaemoglobin and reduces the oxygen carrying capacity of the human blood, (Cunningham 2003). This has serious implications especially for those subjected to prolong exposure like women and their young children. The implications might be in form of reduced birth weight, still birth, tuberculosis, asthma, cancer of the upper air way, cataracts and most importantly Acute Respiratory Infections (ARI) prominent among which are Acute Lower Respiratory Illness (ALRI) and Chronic Obstructive Pulmonary Disease (COPD), (WHO 2007).

2.6 Acute respiratory diseases (ARDs) in developing countries

Acute Respiratory Diseases (ARDs) are upper or lower respiratory tract illness usually infectious in etiology, which can result in a spectrum of illness ranging from asymptomatic or mild infection to severe and fatal disease, depending on the causative pathogen, environmental and host factors such as immune status, (USEPA 1989). Some of the environmental factors affecting the prevalence of ARDs in developing countries include climate variability and seasonal weather variation as well as the geographical location of the area of residence, (Naumova 2006).

Acute respiratory diseases are the leading cause of infectious disease morbidity and mortality in the world likewise they (ARD) are among the most frequent cause of consultation and admission to hospitals and clinics in

developing countries. almost four million people die from acute respiratory diseases each year, with 98% due to ALRI and COPD, (WHO 2007).

ALRI is any combination of upper respiratory infectious (URIs) such as cough with or without fever, blocked or running nose, sore throat and ear discharge, (Khin *et al*. 2005); while COPD is a group of lung disease that are characterized by cough, phlegm and shortness of breath due to air flow and air way inflammation and progressive lung tissue destruction, (WHO 2007). these symptoms and other human infections combine to form more advanced and severe cases of acute respiratory infections such as bronchitis, pneumonia, emphysema, asthma, tuberculosis, otitis media, bronchiectasis, dyspnoea, oedema, lung fibrosis and a host of other respiratory and pulmonary diseases, (WHO 2000).

Given current quantitative knowledge, ALRI and COPD are the leading cause of mortality and burden of disease due to exposure to iap from solid fuel use in developing countries. conservative estimates of global mortality due to iap from solid fuels show that in 2000, between 1.5 million and 2 million deaths were attributed to this risk factor while in 2007, almost about 4 million people died from ARDs, (WHO 2007). This accounts approximately to 4 – 5% of the total mortality world wide, almost on the par with HIV/AIDS, (Smith *et al* 2000). Approximately 2.5 million of these deaths were due to childhood ALRI, with the remainder due to other causes, dominated by COPD and lung cancer, (WHO 2007).

According to WHO-IAP National burden of disease estimates, about 67% of the population in Nigeria rely on solid fuels for energy with consequent 79,000 deaths, 2.6 million disability adjusted life years (DALYS) and a 3.8% national burden of disease. Out of the 79,000 deaths, 70,390 deaths are as a result of ALRI while 8,570 deaths are from COPD, WHO (2007).

Notwithstanding the significance of exposure to IAP and the increase risk of Acute Respiratory Infections, the health effects have been some what neglected by the research community, donors and policy makers, thus the continuous use of biomass fuel, (Chen *et al.* 1990), therefore the need for this Study.

2.7 The relationship between poverty, domestic energy, indoor air pollution and health

Poverty remains the greatest barrier to reducing the enormous global inequalities in health that still exist and which in some countries are worsening. There is now greater awareness of the inter-relationships between household energy, health and poverty. Poverty is the main barrier in the transition to modern fuels, while reliance on such fuels holds back development due to the health burden, and the loss of time and direct health impact of IAP from solid fuel use, lack of access to modern fuels and appliances does limit the quality of life in a variety of ways which includes:

- Lighting may be restricted and provided only by fire, candles, or simple kerosene wick lamps which can be a significant source of pollution.
- Lack of light restricts activities in home, including children's home work, reading and opportunities for income generating activities.
- Lack of access to electricity restricts the use of a wide range of appliances that can contribute to food safety (refrigerators) communication/ education, leisure (radio, TV) and economic activity, WHO (2000).

There is also evidence that, over time the cost of using cleaner fuels is not necessarily higher, but that poverty prevents people from taking advantage of this fact as they generally find it difficult to invest money up-front to obtain the appliance needed for using kerosene (particularly for pressurized stoves), gas or electricity, or to buy the fuel in sufficient quantity to benefit from lower unit prices. As a result, poor people spend a higher proportion of income on fuel for

domestic or household purposes than those who are better off, WHO (2000). The succeeding figure (Figure 2.1) is a hypothetical diagram describing the link between poverty, household energy, IAP and health in developing countries.

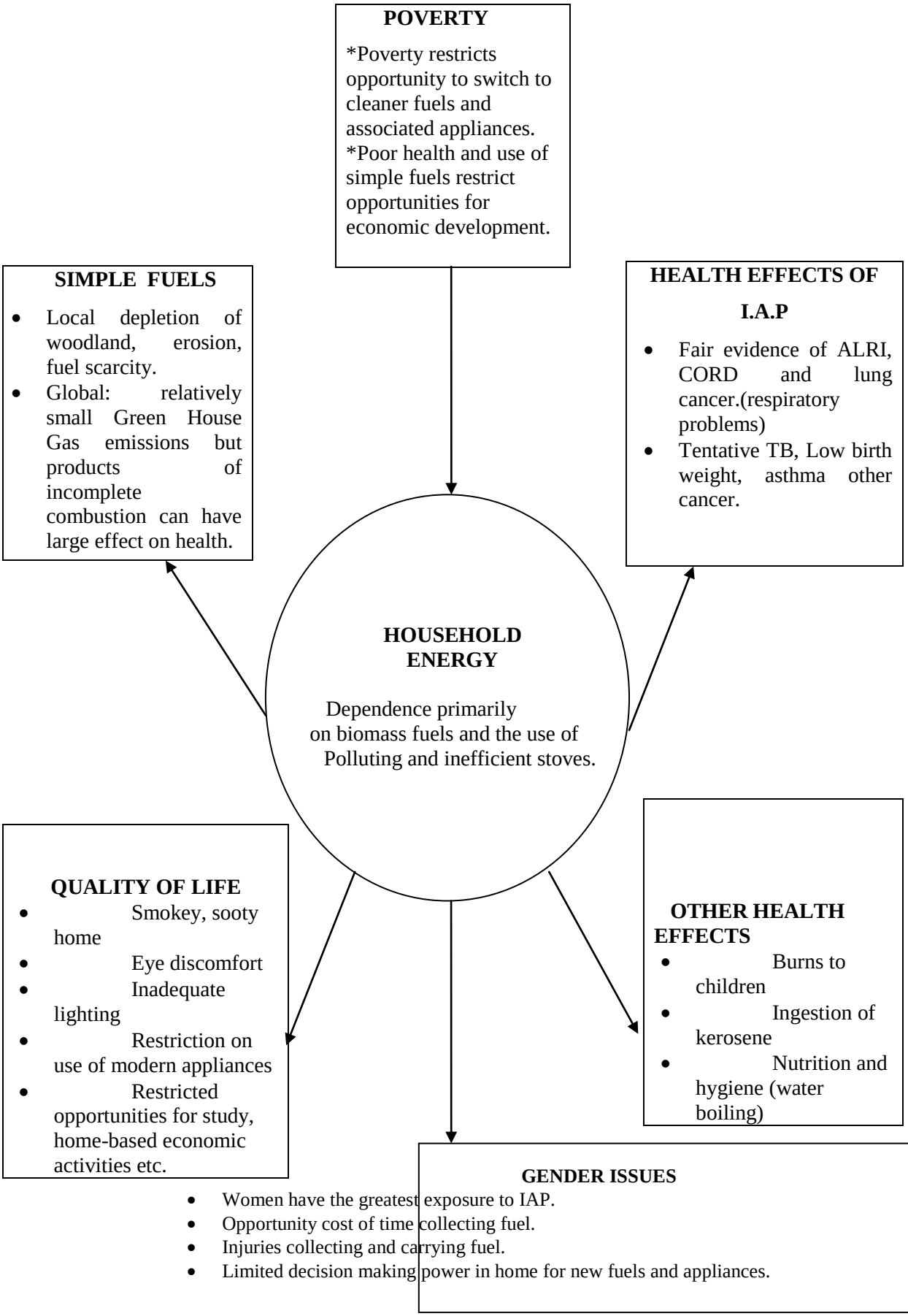

Fig 2.1: The link between Poverty, Household Energy, IAP and Health in Developing Countries
Source: WHO, (2000).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the methodology and approaches adopted in the study. Among the items discussed are; types and sources of data, data collection procedure, as well as the method of data analysis.

3.2 Types and Sources of data

The study made use of primary and secondary data. The primary data was sourced through the use of a structured questionnaire administered to women between the ages of 15 – 65 years and above in randomly selected households across the four (4) districts comprising study area. The questionnaires sought information on socio-economic characteristics of the respondents, sources of domestic household energy and factors influencing the use of such domestic household energy, daily fuel wood consumption in kg, kitchen sizes in m^3, ventilation sizes in m^2, cooking habits (i.e indoor/outdoor) and time spent cooking daily, awareness of IAP and local remedies among the respondents, as well as the frequency of occurrence of acute respiratory diseases (acute respiratory diseases morbidity - ARDM) among women and young children (1-6 years). The secondary data comprises 2 sets of 30 years (1979-2008) record of acute respiratory disease diagnosis among women and children (1-6 years) in the study area. There are about 40 government health facilities in the study area but only the General hospital and the Adamawa sate dermatological hospital where there is a program on leprosy and tuberculosis control both in Garkida, handle serious cases of acute respiratory diseases, (primary health care department (PHC), Gombi LGA 2006). Most of these health facilities refer severe or serious respiratory cases to these two hospitals and a few private hospitals of which because of poverty, only a few people in the study area can afford to access. Furthermore the two hospitals (Adamawa state dermatological hospital and the General hospital Garkida) have a more reliable and

comprehensive data, therefore the secondary data was acquired from these hospitals.

3.3 Data collection procedure

The women of Gombi LGA form the population while the households of constitute the sample frame for this research. All the ten (10) wards that make up the four (4) districts in the study area served as sample units from which households were selected as samples. This is to ensure a rational representation of the four (4) districts in the study area. Households are used as sample frame because it is the only logical place from which the much needed information on domestic household activities such as cooking can be generated. The use of political wards as sample units instead of the conventional village, community or locality is due to the unavailability of recent (2006) breakdown of household census figures by village, community or locality and therefore the 2006 household figures by ward as provided by the national population commission (2006) was used.

The total number of households in the ten (10) wards is 28,088 from which a 1% sample was taken, this amounts to about 281 households. This implies that 281 questionnaires was administered to women between the ages of 15-55 years and above in randomly selected households in the ten (10) wards within the four (4) districts of the study area. However, the questionnaires were allocated to each ward using Cochran's (1977) proportional allocation technique with the formula:

$$Nh = \frac{nh}{N} \times n$$

Where Nh = number of questionnaires for each ward.

nh = number of households in each ward.

N = Total number of household in the ten (10) wards.

n = Total number of questionnaires.

Therefore, the calculation for the number of questionnaires allocated for the first ward (Garkida) is shown below:

Garkida= $\frac{1633}{28088} \times 281 = 16$

This means that 16 questionnaires were administered in Garkida Ward. Similar produce was applied in calculating for the number of questionnaires administered in each of the remaining wards. Table 3.1 shows the distribution of questionnaires for each of the ten (10) wards.

Table 3.1 Allocation of questionnaires according to wards.

S/NO	WARD	NO. OF HOUSE HOLDS	NO. OF QUESTIONNAIRES TO BE ADMINISTERED
1	GARKIDA	1633	16
2	GUYAKU	2324	24
3	GABUN	2293	23
4	DUWA	2796	28
5	TAWA	3444	34
6	GA'ANDA	2093	22
7	GOMBI NORTH	4806	48
8	GOMBI SOUTH	3288	32
9	YANG	2074	21
10	BOGADINGAI	3338	33
TOTAL		28,088	281

In order to stay in line with the principles of probability sampling, the first household was selected randomly from where one household was selected as sample after every four (4) households counted for the administration of questionnaires. This continued until the required number of households was achieved. Personal interview aided in explaining some of the questions in the questionnaire perceived as difficult to comprehend by the respondents. The 50 meter tape was used to obtain data on kitchen and ventilation size in meters, while the weighing balance was used for measuring the daily fuel wood consumption in kilograms, in fuel wood consuming households.

3.6 Method of data analysis

Both descriptive and inferential statistics were employed in analyzing the data collected. A simple descriptive statistics of frequency and percentages was employed in the analysis of the primary data such as socio-economic characteristics, acute respiratory diseases morbidity (ARDM) and IAP exposure level determining factors among which are kitchen (m^3) and Ventilation (m^2) characteristics, Types and sources of domestic household energy, daily fuel wood consumption (kg), cooking habits and time spent cooking, awareness of indoor air pollution (IAP) as well as local interventions or remedies. The secondary data was also summarized using percentage to obtain the annual percentage increase in acute respiratory diseases among women and children in the study area.

Some of the IAP exposure level determining factors and the frequency of occurrence of respiratory infection (ARDM) among Women and Young children were further analyzed using inferential statistics. The Chi squared analysis (X^2) was employed to test for hypothesis two (Ho_2) while the Pearson's product moment correlation analysis (PPMC) was used to test for hypothesis one, three-six (Ho_1, Ho_3-Ho_6). All tests were conducted at 95% significance level. The formulas for both of the statistical tests are shown below.

Chi squared (X^2) test

$$X^2=\frac{\sum(O-E)}{E}$$

Where X^2 = chi squared test
O = observed frequencies of ARDM
E = expected frequencies of ARDM

PPMC Analysis

$$r=\frac{\sum(x-x)(y-y)}{\sqrt{\sum(x-x)^2(y-y)^2}}$$

Where r = correlation coefficient
x = independent variable (IAP exposure level indicators)
y = dependent variable (acute respiratory disease morbidity ARDM)
y and x = mean of dependent and independent variables

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis of data obtained from the field. The analysis was carried out with respect to the aim and objectives of the study, aspects of which includes types of household cooking fuel and factors influencing their use, estimated level of indoor air pollution from the use of fuel wood for cooking, awareness of IAP, local intervention and acute respiratory disease morbidity among women and children (1-6 years).

4.2 Types of household cooking fuel and factors influencing their use

Two types of fuel are found to be used among the Respondents. Fire wood is used by 99.3% of the Respondents while 0.7% of them found mainly in Gombi north ward use kerosene for cooking. This finding conforms with WRI, UNEP, UNDP and World Bank (1998) that "approximately half the worlds population and up to 80% of rural household in Developing Countries including 80%-90% in some sub-Sahara African countries still rely on unprocessed biomass fuels in the form of wood, dung and crop residues". Five main factors were found to influence the use of the identified sources of energy; Table 4.1 shows the distribution of the factors responsible for the use of the fuel types among the Respondents.

Table 4.1 Types of fuel, sources and factors influencing their use among respondents

s/no	Wards	fuel types		Source of fuel				Factors influencing the fuel use									
		K	w	buy	%	fetch	%	a	%	b	%	c	%	d	%	e	%
1	Garkida	-	16	4	25	12	75	2	13	7	44	6	37	1	6	_	_
2	Guyaku	-	24	2	8	22	92	10	42	2	8	9	37	3	13	_	_
3	Tawa	-	34	5	15	29	85	10	29	3	9	7	21	14	41	_	_
4	Gombi .N	2	46	39	81	9	19	1	6	13	27	30	62	2	4	2	1
5	Gombi .S	-	32	28	87	4	13	1	3	5	16	22	69	4	13	_	_
6	Ga'anda	-	22	-	-	22	100	14	64	2	9	4	18	3	9	_	_
7	Gabun	-	23	-	-	23	100	10	43	3	13	7	30	3	14	_	_
8	Bogadingai	-	33	-	-	33	100	31	94	_	_	2	6	_	_	_	_
9	Yang	-	21	-	-	21	100	13	62	1	5	3	14	4	19	_	_
10	Duwa	-	28	-	-	28	100	26	93	_	_	2	7	_	_	_	_
Total		2	279	78	-	203	-	118	-	36	-	91	-	34	-	2	-
Percentage %		0.7	99.3	28	-	72	-	42	-	13	-	32	-	12.3	-	0.7	-

Key:- fuel types- k=kerosene, w=wood. Factors of fuel use-a=availability, b=lack of alternatives, c=cost of alternatives, d=cultural belief, e=convenience.

Table 4.1 suggests that the availability of fire wood is the factor with the largest proportion of Respondents (42%) that use fire wood for cooking, which seems like an indication of the abundance of forest resources (fire wood) in the Study area. 100% of the Respondents in Bogadingai and Duwa wards fetch their fire wood from the surrounding environment and these two wards have the largest proportion of Respondents that use fire wood for its availability (94% and 93%). Gombi north and Gombi south wards record the smallest proportion of Respondents that use fire wood for its availability (6% and 3% respectively) and here, 81% and 87% of the Respondents buy their fire wood. Akosim *et al*. (1999) are of the opinion that deforestation especially around major settlements has left large areas with few indigenous trees and that may be why Gombi north and Gombi south (major settlements) record the smallest proportion of Respondents that use fire wood for its availability and some of the largest proportion of Respondents that buy their fuel wood perhaps because of its

scarcity. A look at figure 1.1 (the study area) shows that both Bogadingai and Duwa wards are located in the remote parts of the Study area where there are no major roads and fire wood will probably be abundant, which may be why 100% of the Respondents indicated that they fetch their fire wood. Ilesanmi (1999) is of the view that only Gombi town (Gombi north and south wards) is considered a third order core urban settlement while the rest of the wards are all rural settlements. The remote and rural nature of the settlements with the exception of Gombi town might therefore be responsible for the relative abundance and the use of fire wood because of its availability. This finding suggests that 42% of the Respondents will use any readily available fuel provided it is affordable.

About 13% of the Respondents indicated the lack of alternatives as the main reason for the use of fire wood for cooking. The largest proportion of this group can be found in Garkida ward (44%), Gombi north (27%) and Gombi south ward (16%) while the smallest proportion can be seen in Bogadingai and Duwa wards with 0% of Respondents each. This is not surprising considering the proposed availability or abundance of fire wood in both Bogadingai and Duwa wards (remote settlements) which may result to a lack of the need for any alternative fuel. Nevertheless, this finding implies that 13% of the Respondents will be willing to switch to other alternative fuels even at relatively higher costs provided they are available.

The cost of alternatives is the main reason for the use of wood among 32% of the Respondents. Gombi north and Gombi south wards (62% and 69% respectively) share the largest proportion of Respondents with economic reasons despite being relatively better off (urban settlements in terms of living standars) than Bogadingai and Duwa wards who share the smallest proportion of Respondents with economic reasons (6% and 7%). This may be as a result of lack of fire wood and therefore the relatively higher costs around urban settlements (Gombi town); and the ignorance about the costs of alternatives in remote or rural settlements (Bogadingai and Duwa wards) because of the

availability of fire wood. Nevertheless, 32% of the Respondents may be willing to change to alternative fuels provided they are cheaper than fire wood.

About 12.3% of the Respondents indicate that the use of fire wood is a cultural heritage which means that there is no need for alternatives. This group is predominantly found among respondents in Tawa ward (41.5%) and Guyaku /Gombi south ward (13% each). A pragmatic advocacy about the effects of IAP from the use of fire wood for cooking targeted this group can break the rigid cultural belief especially when affordable alternatives are provided.

Only 0.7% of the Respondents found in Gombi north ward use kerosene for its convenience. This may not be surprising in Gombi town because it is a semi-urban settlement and it has been put forward by Smith *et al.* (1994) that "the types of fuel used in rural areas of Developing countries becomes cleaner, more convenient and efficient as people move up the energy ladder". Animal dung on the lowest rung this ladder is succeeded by crop residues, wood, charcoal, kerosene, gas and then electricity. People tend to move up the ladder as socio economic conditions improve. This finding suggests the importance of socio economic development as a pre-requisite for the switch to a more convenient and efficient alternative fuel higher than fire wood on the energy ladder.

4.3 Estimated level of indoor air pollution from the use of fuel wood for cooking

According to the World Health Organization (2005), the main factors important in the assessment of IAP levels through questionnaires includes fuel type, stove type, amount of fuel consumed or combusted, kitchen size, and ventilation characteristics. Table 4.2 shows the IAP level determining factors across the Study Area.

Table 4.2 Indoor air pollution level determining factors

s/no	Wards	Stove type		Daily Wood consumption (kg)		Kitchen size (m^3)		Ventilation space (m^2)		Cooking habits		Cooking hours		Extra curricular cooking	%
		A	B	Tt	P/p	Tt	Av	Tt	Av	In Door	In/out Door	Tt	Av		
1	Garkida	16	_	241.9	2.4	242.5	15	22	1.4	9	7	49.3	3	7	44
2	Guyaku	24	_	392.4	2.6	242.4	10	28	1.2	6	18	61.3	2.3	7	30
3	Tawa	34	_	553	2.1	666.6	19	34	1	19	15	108	3	14	41
4	Gombi .N	48	_	685.9	2.0	709.1	15	67	1.4	23	25	269.3	5.3	22	46
5	Gombi .S	32	_	568	2.4	393.2	12	46	1.4	18	14	137.3	4	15	47
6	Ga'anda	22	_	250.6	1.8	243.4	11	29	1.3	2	20	58.3	2.3	10	45
7	Gabun	23	_	224.3	1.6	248.5	11	31	1.3	3	20	53	2	10	43
8	Bogadingai	33	_	473.8	2.2	370.4	11	45	1.4	12	21	82.3	2.3	10	31
9	Yang	21	_	266.4	2.0	224.8	11	28	1.3	4	17	50	2	6	28
10	Duwa	28	_	383.2	2.3	306.3	11	37	1.3	8	20	66.3	3	6	21
TOTAL		281	_	4008	21	3647	_	367	_	104	177	936.3	30	107	-
PERCENTAGE %		100	_	_	_	_	_	_	_	37	63	_	_	38	-
AVERAGE		_	_	14.2	2.1	13	_	1.3	_	_	_	3	3	-	-

KEY- stove type-A=open fire stove without chimney, B=open fire stove with chimney, Tt=total, P/p=per/person, Av=average.

The typical 3 stone open fire stove without chimney or hood which is according to Smith and Pennise (2005), the most common stove type found in rural areas of developing countries is the only stove type in use among the respondents. This means that 99.2% of the respondents that use fuel wood for cooking are subjected to varying degrees of smoke (pollutants) emitted from the burning of fire wood in simple stoves. An average daily wood consumption of 14.2kg per household and an average per person daily wood consumption of 2.1kg was discovered in the study area. The average per person daily wood consumption varied across the ten wards with Guyaku ward showing the largest average at 2.6kg and Gabun ward showing the smallest average at 1.6kg. An average kitchen size of $13m^3$ and $1.3m^2$ average ventilation size was established among the respondents. However different average kitchen and ventilation sizes were found across the wards of the study area. Tawa ward has the largest kitchen size of $19m^3$ while Ga'anda, Gabun, Bogadingai, Yang and Duwa all share the smallest kitchen size of $11m^3$. Garkida, Gombi north, Gombi south

and Bogadingai ward have the average ventilation size of 1.4m^2, while Tawa ward has the smallest ventilation size of 1m^2. About 37% of the respondents cook strictly indoors while 63% cook both in and outdoors for an average of 3 hours. However, different average cooking time was found across the wards with Gombi north ward having the longest cooking time of 5hours 30minutes and Gabun/Yang sharing the shortest cooking time of 2hours each. About 38% of the respondents engage in extra curricular cooking, Gombi south ward recorded the largest number of these respondents (47%) while Duwa ward has the smallest number at (21%).

These IAP levels determining factors listed above (i.e. fuel type, stove type, amount of fuel combusted in kg, kitchen size in m^3 and ventilation space in m^2, average daily cooking time and percentage of respondents that engage in extra curricular cooking) are hereby utilized with respect to the model in Smith and Pennise (2005), to assess the estimated level of IAP from the use of fuel wood for cooking in Gombi local government area.

According to Smith and Pennise in collaboration with WHO (2005), combustion of 1kg of wood in a typical open fire stove without chimney or hood, per hour, produces about 37.5kg of carbon monoxide (CO) and 2kg of particulate matter (PM). In a 40m^3 kitchen with 4m^2 total ventilation space, this results to a typical concentration of 150mg/m^3 of carbon monoxide (CO) and 3.3mg/m^3 of particulate matter (PM) per hour. The typical standards to protect health (24 hour mean standard) are 10mg/m^3 and 0.1mg/m^3 per hour of CO and PM respectively, (WHO 2005).

In an average family of 6.5 found across the study area (Table 4.3), which falls within the range of common family units found in Adamawa state as provided by the national population commission (1991), and an average per person daily wood consumption of 2.1kg; The average fuel wood consuming rural Woman using the typical open fire stove without chimney or hood within the study area burns about 13.65kg (at 2.1kg per person) of fuel wood daily.

This amounts to a daily emission of about 511.9g of CO and 23.7g of PM. In a typical kitchen ($40m^3$ and $4m^2$) with dimensions equal to that specified by Smith and Pennise (2005), the emission of 511.65g of CO and 23.7g of PM will result to a concentration of $2047.5mg/m^3$ of CO and $45.045mg/m^3$ of PM daily. In a local kitchen ($13m^3$ average kitchen size and $1.3m^2$ average ventilation size) both of which are about 3.1 times smaller than the experimental kitchen, the concentration will equally be 3.1 times higher than the assumed or experimental kitchen at $6347.3mg/m^3$ of CO and $139.6mg/m^3$ of PM daily. This is equivalent to an hourly mean of $264.5mg/m^3$ of CO and $5.8mg/m^3$ of PM daily. These figures concur with Mccracken and Smith (1998), Robin *et al* (1996), Ellegard (1996) and USEPA (2000), that the 24 hour mean concentration levels are typical in the range 50-$300mg/m^3$ of CO and 3-$10mg/m^3$ of PM, and may reach up to $3000mg/m^3$ of CO and $30mg/m^3$ of PM during cooking hours in homes that use biomass fuels for cooking in simple stoves with inadequate ventilation.

However, women in the study area only cook for an average of 3 hours, and this means the respondents will be exposed to a total of $793.5mg/m^3$ of CO and $17.4mg/m^3$ of PM daily, and a 24 hour mean pollution level of $33.1mg/m^3$ of CO and $0.73mg/m^3$ of PM daily. This finding agrees with Armstrong and Campbell (1991) that IAP levels in households that use biomass fuels as sources of domestic energy are sometimes 5-20 times higher than the international guideline levels. The typical standard to protect health is 10mg/m3 of CO and 0.1mg/m3 of PM daily, (WHO 2005), and as such IAP levels within the study area is 3.1 times higher for carbon monoxide and 7.3 times higher for particulate matter than the 24 hour means standards.

The figures above concerning the level of IAP might seem negligible especially when viewed in connection with the cooking habits of Respondents (only 37% cook strictly indoors while 63% cook both in/out doors thereby reducing exposure levels); however the cumulative effect of the exposure levels

can prove fatal to women and young children (1-6 years) that are most heavily exposed. Considering the slow pace of development in Developing countries which suggest that biomass fuel will continue to be used for many years, (Bruce *et al.* 2000), the poor nutritional status among rural dwellers in developing countries, (Albalak 1997), which reduces their resistance to infectious diseases, and the percentage of women (38%) subjected to additional exposure from extra-curricular cooking, there is no doubt that the level of IAP in Gombi LGA is worth urgent consideration.

4.4 Factors of awareness of indoor air pollution and local interventions among respondents

Some socio-economic variables were considered important at influencing the awareness of IAP and local intervention among respondents; they include age group of the respondents, educational level of the respondents and their spouses and occupation of the respondents and their spouses.

4.4.1 Age groups, awareness of indoor air pollution and local interventions among respondents

Table 4.3 shows the distribution of the awareness of IAP and local interventions based on the various age groups found among respondents in the study area.

Table 4.3 Awareness of indoor air pollution and local interventions among different age groups of respondents

s/no	Age groups	No. of Rsp	%	Awareness of IAP				Local interventions			
				aware	%	Not aware	%	Intervene	%	No intervention	%
1	15-24	69	25	34	49	35	51	33	48	36	52
2	25-34	85	30	50	59	35	41	46	54	39	46
3	35-44	49	17	43	88	6	12	38	76	11	24
4	45-54	51	18	36	71	15	29	32	63	19	37
5	55&above	27	10	26	96	1	4	26	96	1	4
Total		281	100	189	-	92	-	175	-	106	-
Percentage %		100	100	67	-	33	-	62	-	38	-

Key :- Rsp = respondents

Information in Table 4.3 revealed a progressive increase in the awareness of IAP and local interventions from the youngest age group (15-24) towards the oldest age group (55 years and above). This simply means that both awareness of IAP and local interventions seem to develop as the respondents grow older, become more mature and conscious and therefore gain more experience of their environments. This statement conforms to the work of Boulding (1956), who suggested that over time individuals develop mental impressions of the world through their everyday contacts with the environment and that these impressions (awareness) act as the basis for behavior (interventions). Nevertheless, the age influence on the awareness of IAP and interventions measures was not fully reflected in the two wards (Yang and Guyaku wards) with the highest and the lowest awareness of IAP and intervention measures respectively (Table 4.4).

Table 4.4 Ward, age group, awareness of indoor air pollution and local interventions among respondents

s/no.	Wards	Age groups					Awareness of IAP				Local intervention			
		A	B	C	D	E	Aware	%	Not aware	%	intervene	%	No intervention	%
1	Garkida	6	4	2	2	2	11	69	5	31	11	69	5	31
2	Guyaku	5	7	6	6	2	13	54	11	46	9	37	15	63
3	Tawa	7	7	8	8	6	23	67	11	33	22	79	12	21
4	Gombi south	7	19	9	9	2	32	66	16	46	27	56	21	44
5	Gombi north	8	9	6	6	3	20	62	12	48	19	59	13	41
6	Ga'anda	7	5	4	4	2	16	73	6	27	12	54	10	46
7	Gabun	4	6	5	4	4	17	74	6	26	16	69	7	31
8	Bogadingai	11	10	3	7	2	24	73	9	27	24	73	9	27
9	Yang	5	7	3	4	2	16	76	5	24	17	81	4	19
10	Duwa	9	9	5	3	2	17	61	11	39	18	39	10	61
Total		69	85	49	51	27	189	-	92	-	175	-	106	-
Percentage (%)		25	30	17	18	10	67	-	33	-	62	_	38	-

KEY-(AGE GROUPS) A=15-24, B=25-34, C=35-44, D=45-54, E=55 and above. %=percentage

From Table 4.4, it is clear that Yang ward has lesser population of respondents in the older age groups (35-44 and 45-54) than Guyaku ward, but almost doubles its percentage of awareness of IAP at 76% against Guyaku's 54% and doubles Guyaku wards (37%) percentage of local interventions at 81%. It is only at the oldest age group (55 years and above) that Yang ward

exceeds Guyaku ward in proportion of respondents and even at this age group, the margin (1%) is somewhat small as to be held accountable for such wide variation in the awareness of IAP and local interventions between the two wards, Yang and Guyaku. This is however contradicted in the ward with the second highest and second lowest awareness of IAP and local interventions (Gabun and Duwa wards respectively). Table 4.4 indicates that Gabun ward has a larger proportion of older respondents in all the age groups except the youngest (15-24) age group than Duwa ward and that may be why Gabun ward has a high level of awareness of IAP and local intervention at 74% and 69% respectively than Duwa ward at 61% and 39% respectively. This is because in Table 4.3, it is obvious that older age groups of respondents are better aware and undertake more local interventions than younger age group of respondents and as such, even though there are differences in the influence of age on awareness of IAP and local interventions across the study area, a general trend of consciousness and behavioral development or greater awareness from younger to older generation has been established among the respondents.

4.4.2 Educational level of respondents

An examination of the educational level of the respondents shows that 49% had either Islamic or Informal education, which is unfortunately according to Aghlor (1993), forms or levels of education with little or no emphasis on environmental education, not to talk of issues like IAP; which is not a recognized environmental hazard at policy level in developing countries. Table 4.5 shows the educational level distribution of the respondents across the study area.

Table 4.5 Educational level of the respondents across the different wards

s/no	Wards	Educational level									
		A	%	B	%	C	%	D	%	E	%
1	Garkida	4	25	3	19	3	19	4	25	2	12
2	Guyaku	8	33	2	8	10	47	2	8	2	8
3	Tawa	20	59	2	6	8	23	3	9	1	3
4	Gombi north	17	35	10	21	13	27	7	15	1	2
5	Gombi south	8	25	8	25	10	31	3	9.5	3	9.5
6	Ga'anda	9	41	2	9	8	36	3	14	_	_
7	Gabun	9	39	1	4	8	35	5	21	_	_
8	Bogadingai	11	33	4	12	11	33	7	21	_	_
9	Yang	7	33	2	9	7	33	4	19	1	5
10	Duwa	9	32	1	4	15	54	2	7	1	4
Total		102	-	35	-	93	-	40	-	11	-
Percent %		37	-	12	-	33	-	14	-	4	-

KEY-(Educational level)-A=informal, B=Islamic, C=primary, D=secondary, E=higher. Rsp=respondents.

About 51% of the Respondents had primary, secondary or higher education where according to Adara (1993), there have been efforts at introducing environmental education in the school curricular. However, even at this levels, there have been challenges which were not overcome and as a result, the ineffective inculcation of environmental principles, Adebayo and Olawepo (1997). This is compounded by the fact that the study area is predominantly a rural settlement with relatively low literacy level and inefficient access to information and therefore in need of a pragmatic approach to issues of both environmental and health concern. An examination of the awareness of IAP and local interventions based on educational level of the respondents can shade more light on the relationship between them. Table 4.6 shows the distribution of the awareness of IAP and local interventions based on the educational level of respondents.

Table 4.6 Awareness of IAP, local interventions and the educational level of respondents

s/no	Educational Level	No. of Rsp	%	Awareness of IAP				Local interventions			
				aware	%	Not aware	%	Intervene	%	No intervention	%
1	Informal	102	36	74	73	29	27	70	69	32	31
2	Islamic	35	12	25	71	10	29	21	60	14	40
3	Primary	93	33	48	52	45	48	45	48	48	52
4	Secondary	40	14	31	78	9	22	28	71	12	29
5	Higher	11	4	9	82	2	18	11	100	_	_
Total		281	100	189	-	92	-	175	-	106	-
Percentage %		100	100	67	-	33	-	62	-	38	-

Key :- Rsp=Respondents

From Table 4.6, it is clear that the educational level of the respondents significantly or positively influences awareness of IAP and local intervention measures especially at the secondary (78%) and higher (82%) education levels. This concurs with Onibokun (1972) and Onokerhoraye (1977) that better education enhances individual or group consciousness of environmental problems and as a result helps the development of management techniques. Nonetheless, the relatively high level of awareness of IAP and local interventions among respondents with informal (73% and 61%) and Islamic (71% and 60%) education both of which are considered lower levels of education based on western or scientific principles, somewhat contradicts the suggestion by Onibokun (1972) and Onokerhoraye (1977) but agrees with Chokor (1983), Egunjobi (1983), Odemerho (1984) and Omuta (1984) that ordinary people possess a substantial knowledge of the complexities of environmental problems besetting them and make efforts to articulate and adjust favorably to them. The primary education level records a relatively balanced proportion among respondents that are aware and those that are not aware of IAP (52% and 48% respectively) as well as those that undertake local interventions and others that don't (48% and 52% respectively). This is

somehow understandable because although environmental education starts at the primary level, it is of lesser emphasis compared with the secondary level in Nigeria, (Adebayo and Olawepo 1997). Primary education also ends at a younger age from which the pupils are less capable of articulating the complexities of environmental processes.

An examination of Table 4.5 shows that at the Islamic and secondary education level (which have both been seen from table 4.6 to significantly influence the level of awareness of IAP and local intervention), Yang ward (9% and 19%) exceeds Guyaku ward (8% and 8%) in proportion of respondents. This may seem to explain the variation in the level of awareness of IAP and local interventions between the two wards as shown on Table 4.4; but the balanced proportion of respondents with informal education (33%) between Yang and Guyaku wards and the larger proportion of respondents with higher education in Guyaku ward than in Yang ward although marginal (3%), disrupts the presumed superiority of educational level at influencing awareness of IAP and local intervention and as a result disagree with Onibokun (1972) and Onokerhoraye (1977) and encourages the multi-factorial effects or influence proposed or argued by Chokor (1983), Egunjobi (1983), Odemerho (1984) and Omuta (1984) that ordinary people possess a substantial knowledge of the complexities of environmental problems besetting them and make efforts to articulate and adjust favorably to them.

4.4.3 Educational level of the spouses of respondents

Table 4.7 shows the educational level distribution of the spouses of respondents in the ten wards comprising the study area.

Table 4.7 Educational level of the spouses of respondents

s/no	Wards	Spouses education level									
		A	%	B	%	C	%	D	%	E	%
1	Garkida	2	13	_	_	6	37	6	37	2	13
2	Guyaku	8	33	_	_	10	42	5	21	1	4
3	Tawa	8	24	4	12	13	38	9	26	_	_
4	Gombi .N	6	13	11	23	9	19	17	35	5	10
5	Gombi .S	5	16	7	22	8	25	8	25	4	12
6	Ga'anda	6	27	1	4.5	11	50	3	14	1	4.5
7	Gabun	6	26	1	4	9	39	5	22	2	9
8	Bogadingai	10	30	5	15	13	39	5	16	_	_
9	Yang	4	19	3	14	9	49	4	19	_	_
10	Duwa	7	25	3	11	11	39	6	21	2	4
Total		62	-	35	-	99	-	68	-	17	-
Percentage (%)		22	-	13	-	35	-	24	-	6	-

KEY-(SPOUSE EDUCATIONAL LEVEL)-A=informal, B=Islamic, C=primary, D=secondary, E=higher.

Table 4.7 shows that 78% of the spouses of respondents had formal education in Islamic, primary, secondary or higher education, while 22% had informal education. This implies that the spouses of respondents are relatively more literate (78%) than the respondents (63%).

The educational level of the spouses of respondents was considered an influencing factor in the awareness of IAP and local interventions among respondents. Table 4.8 shows the awareness of IAP and local intervention based on the different educational levels of the spouses of respondents.

Table 4.8 Awareness of indoor air pollution, local intervention and the educational level of the spouses of respondents

s/no	Spouses educational level	No.of Rsp	%	Awareness of IAP				Local interventions			
				aware	%	Not aware	%	Intervene	%	No intervention	%
1	Informal	62	22	40	65	22	35	34	55	28	45
2	Islamic	35	12	23	66	12	34	19	54	16	46
3	Primary	99	35	65	66	34	34	64	65	35	35
4	Secondary	68	24	45	66	23	34	43	63	25	37
5	Higher	17	7	16	94	1	6	15	88	2	12
Total		281	100	189		92	-	175	-	106	-
Percentage %		100	100	67		33	-	62	-	38	-

Key :-Rsp=respondents

Table 4.8 clearly shows that the higher educational level of the spouses of respondents greatly influence the level of awareness of IAP with 94% of the respondents aware of IAP and 88% practice local interventions while these variables remain relatively stable (between 55%-65%) across the other educational level of the spouses. This means that the different educational level of spouses of respondents exerts a moderate but stable influence on the level of awareness of IAP and local intervention among respondents except at the higher education level where the influence can be seen to be much higher. This finding is further explained in Table 4.7 where it can be seen that, Guyaku ward despite possessing a larger proportion of spouses with higher education (4%) (which is the most influential educational level of the spouses, in terms of awareness and intervention among respondents) than Yang ward (0%), has a much smaller percentage of respondents that are aware of IAP and undertake local intervention than Yang ward.

4.4.4 Occupations of the respondents

An observation of Table 4.9 indicates that the mainly housewives and the civil service housewives are proportionally larger in Yang ward (29% & 5%) than in Guyaku ward (12.5% & 0%) and this might be partly responsible for the larger percentage of respondents that are aware of IAP and undertake local interventions in Yang ward than in Guyaku ward. This is because in Table 4.10, both the mainly housewives and the civil service housewives show tremendous influence on awareness of IAP and local intervention; 70% of mainly housewives are aware of IAP and 100% for civil service housewives, while 63% of mainly house wives undertake local intervention and 100% for civil service housewives. Table 4.9 shows the occupational distribution of the respondents based on the different wards, with respect to the level of awareness of IAP and local interventions while Table 4.10 shows the different influence of the various occupations of respondents on the level of awareness of IAP and local interventions.

Table 4.9: Occupation of the respondents with respect to the level of awareness of indoor air pollution, local interventions, extra-curricular cooking and acute respiratory disease morbidity among women and children

		WARDS										Tt	%
		1	2	3	4	5	6	7	8	9	10		
Occupations of the Respondents	A	2	3	6	26	17	1	-	13	6	5	79	28
	%	13	13	18	54	53	5	-	39	29	18	-	-
	B	2	13	23	5	-	16	22	15	10	17	123	44
	%	13	54	68	10	-	73	96	45	48	61	-	-
	C	9	8	4	12	14	5	-	5	4	6	66	23
	%	56	33	12	25	44	22	-	16	19	21	-	-
	D	3	-	1	4	1	-	-	-	1	-	10	4
	%	19	-	2	8	3	-	-	-	5	-	-	-
	E	-	-	-	1	-	-	1	-	1	-	3	1
	%	-	-	-	3	-	-	4	-	4	-	-	-
Level of Awareness of IAP	High	11	13	23	32	20	16	17	24	16	17	189	67
	%	69	54	67	66	62	73	74	73	76	61	_	_
	Low	5	11	11	16	12	6	6	9	5	11	92	33
	%	31	46	33	46	48	27	26	27	24	39	_	_
Local interventions	Intv.	11	9	22	27	19	12	16	24	17	18	175	62
	%	69	37	79	56	59	54	69	73	81	39	_	_
	No	5	15	12	21	13	10	7	9	4	10	106	38
	%	31	63	21	44	41	46	31	27	19	61	_	_

Key:- (wards)-1=garkida, 2=guyaku, 3=tawa, 4=gombi north, 5=gombi south, 6=ga'anda, 7=gabun, 8=bogadingai, 9=yang, 10=duwa.

Source: Primary data 2010

Table 4.10 Awareness of indoor air pollution and local intervention based on occupation of respondents

s/no	Occupations	No.of rsp	%	Awareness of IAP				Local interventions			
				aware	%	Not aware	%	Intervene	%	No intervention	%
1	Housewife (HW)	79	28	55	70	24	30	50	63	29	37
2	HW/farmer	123	44	82	67	41	33	78	63	45	37
3	HW/business	66	23	37	56	29	44	36	55	30	45
4	HW/civil servant	10	4	10	100	_	_	10	100	_	_
5	HW artisan	3	1	2	66	1	44	1	44	2	66
Total		281	100	189	-	92	-	175	-	106	-
Percentage %		100	100	67	-	33	-	62	-	38	-

Key :- HW=Housewife, Rsp=Respondents

The influence of the respondents occupation on the level of awareness of IAP and local intervention is further expressed in the fact that the least influential occupation (housewife/business) as seen in Table 4.10 is proportionally larger in Guyaku ward (33%) than in Yang ward (19%) as seen in Table 4.9, and this might have helped reduce the level of awareness of IAP as well as local interventions in Guyaku ward than in any other ward within the study area.

Among the various occupations of the respondents, civil service exerts the most acute influence on the awareness of IAP and local interventions. This can be seen in Table 4.10 where 100% housewife/civil servants are aware of IAP and undertake local interventions. This is explicable because the civil service (a somehow more prestigious occupation) is characterized by better education and more access to information compared with the other occupations especially in rural areas like Gombi LGA. Table 4.10 also indicates that the mainly housewives show the second largest percentage of respondents that are aware of IAP (70%) and undertake local intervention (63%). This may be because of the housewives primary occupation of house management, from which they might have learned through experience of the ills of IAP, and as such may have developed mitigation strategies. The farming housewife comes third among the respondents occupation at influencing awareness of IAP (67%) and local intervention (63%) while the artisan housewife though fourth in percentage of respondents that are aware of IAP (66%), is the lowest at practicing local interventions (44%). These observations can be attributed to the general lack of information and the relatively low level of education among rural dwellers especially women. The business woman/housewife has the lowest percentage of respondents that are aware of IAP but a step higher than the artisan housewife at practicing local interventions and this might be as a result of the somehow tedious and engaging nature combining business with house management which leaves little or no time for unrelated matters.

These findings could prove valuable when planning for advocacy or awareness campaigns as the particular population, such as the businesswoman/housewife and the artisan/housewife with the smallest percentage of respondents that are aware of IAP and undertake local interventions can easily be deduced from the analysis and table provided.

4.4.5 Occupations of the spouses of respondents

Of the five main occupations found among the spouses of respondents, 58% are farmers, 18% businessmen, 10% civil servants, 13%artisans and only 1% are politicians. This is in line with Bashir and Raji (1999), that the population of rural settlements in Adamawa state is predominantly farmers. Table 4.11 shows the distribution of the occupation of the spouses of Respondents.

Table 4.11 Occupations of the spouses of respondents

s/no	Wards	Spouses occupations									
		A	%	B	%	C	%	D	%	E	%
1	Garkida	8	50	4	25	2	13	2	12	_	_
2	Guyaku	19	79	2	8	_	_	3	13	_	_
3	Tawa	25	74	6	18	1	2	2	6	_	_
4	Gombi .N	14	29	12	25	10	21	12	25	_	_
5	Gombi .S	6	19	14	44	6	19	4	13	2	5
6	Ga'anda	17	77	1	5	2	9	2	9	_	_
7	Gabun	16	70	2	9	2	9	2	9	1	3
8	Bogadingai	23	70	6	18	2	6	2	6	_	_
9	Yang	15	71	1	5	2	10	3	14	_	_
10	Duwa	20	71	2	7.5	2	7.5	4	14	_	_
Total		163	-	50	-	29	-	36	-	3	-
Percentage %		58	-	18	-	10	-	13	-	1	-

KEY-(SPOUSE OCCUPATIONS) - A=farmer, B=businessman, C=civil servant, D=artisan, E=politician.

The occupation of the spouses of respondents was considered a likely influencing factor on the level of awareness of IAP and local intervention among Respondents. Unlike the educational level of the Spouses, the

occupations of the Spouses of respondents seem to have a more pronounced influence on the awareness of IAP and the practicing of local interventions among respondents. Table 4.12 shows the awareness of IAP and local interventions among respondents based on the occupations of their spouses.

Table 4.12 Awareness of indoor air pollution and local interventions based on the occupations of the spouse of respondents

s/no	Spouse occupation	No. of respon-dents	%	Awareness of IAP				Local intervention			
				aware	%	Not aware	%	Intervene	%	No intervention	%
1	Farmer	163	58	112	69	58	31	105	64	65	36
2	Businessman	50	18	28	56	16	44	27	54	17	46
3	Civil servant	29	10	24	86	5	14	24	83	5	17
4	Artisan	36	13	23	58	13	42	18	56	17	44
5	Politician	3	1	3	100	_	_	1	33	2	67
Total		281	100	189	-	92	-	175	-	106	-
Percentage %		100	100	67	-	33	-	62	-	38	-

A look at Table 4.12 shows that the wives of civil servants are more aware of IAP and practice local intervention (86% & 83% respectively) than any other respondent. They are only exceeded by the wives of politicians who are all aware of IAP at 100%, but the wives of politicians fall short as only 33% practice local intervention. This could be explained by the argument that civil servants and politicians have more access to information and as such might have influence their wives towards a better perception of the subject matter. The wives of farmers also show a high level of awareness of IAP and local intervention (69% & 64%) as well as the wives of artisans (58% & 56%) respectively. These observations can be attributed to the findings in section 4.4.3 that the Spouses of respondents are relatively more literate than the respondents and as such might have influence their wives towards a favorable disposition about the subject matter.

Curiously, just like with the respondent's occupation, the wives of businessmen record the smallest percentage of respondents that are aware of IAP and undertake local interventions. Again this might be as a result of the busy or engaging nature of local businesses which allows for little or no time for unrelated matters.

A critical look at Table 4.11 will shade more light on the influence of Spouse occupation on the level of awareness of IAP and local interventions. Although politicians at 100% (who exert the strongest influence on their wives) are not found among the spouses of respondents in both Yang and Guyaku wards, civil servants who happen to exert the second strongest influence on their wives (86%) and artisans (58%) were found to be larger in proportion in Yang ward (10% & 14%) than in Guyaku ward (0% & 12%). On the other hand, businessmen who happen to exert the least impact on the level of awareness of IAP and local interventions (56%) on their wives were found to be proportionally larger in Guyaku ward (8%) than in Yang ward (5%). Therefore the occupation of the spouses of respondents is one of the major contributing or influencing factor to awareness of IAP and the practice of intervention in some wards than in others, among respondents.

4.5 Prevalence rate of acute respiratory diseases (acute respiratory disease morbidity ARDM) among women and children

Acute respiratory diseases morbidity (ARDM) among respondents and their children is recorded in the questionnaires based on the definition and symptoms provided by WHO (2007) and USEPA (1989), (refer to literature review 2.5). Table 4.13 shows the level of ARDM among women and children across the ten wards of the study area.

Table 4.13 Acute respiratory disease morbidity among women and children

s/no	Wards	No. of respon-dents	%	Acute Respiratory Disease Morbidity (ARDM)									
				Women (Respondents)					Children (1-6 years)				
				once monthly	twice monthly	Quarterly	1 in 6 Months	Av. ARDM	Once monthly	twice monthly	Quarterly	1 in 6 months	Av.ARDM
1	Garkida	16	5.7	11	1	4	_	14.3	9	_	5	_	10.6
2	Guyaku	24	8.5	17	3	4	_	24.3	13	_	6	_	15
3	Tawa	34	12	21	5	8	_	33.6	18	1	8	1	22.8
4	Gombi .N	48	17	21	14	7	6	52.3	28	9	8	1	48.8
5	Gombi .S	32	11	20	10	1	1	40.5	17	7	1	_	31.3
6	Ga'anda	22	8	18	_	3	1	19.1	12	4	2	_	32.6
7	Gabun	23	8.2	11	2	6	4	17.6	7	3	3	_	14
8	Bogadingai	33	12	16	2	15	_	25	25	_	4	_	26.3
9	Yang	21	7.5	10	_	11	_	13.6	6	5	5	_	17.6
10	Duwa	28	10	22	1	3	2	25.3	19	3	3	_	26
Total		281		167	37	62	14	266	155	24	47	2	245
Percentage %		100		60	13	22	5	_	66	14	19	1	_

Key-Av=average, ARDM=Acute Respiratory Disease Morbidity

About 60% of the respondents experience some sort of acute respiratory diseases (ARDs) at least once monthly while 13% experience ARDs twice monthly; 22% experience ARDs once in 3 months while only 5% are subjected to this disease once in 6 months. Among the 281 Respondents investigated, only 233 have children between the ages of 1-6years who are at this age group most vulnerable to IAP and its effect. Out of the 233 children, 66% suffer ARDs once a month while 14% are infected at least twice monthly. 19% of the children are subjected to ARDs quarterly while only 1% go through the disease once in 6 months. For better comprehension and further analysis, respondents and children that experience ARDs once or twice monthly will be regarded as having a high level of ARDM while those that suffer ARDs quarterly or once in 6 months are considered as having a low level of ARDM.

The data discussed above is in the form of counted data and can only be subjected to non parametric statistics. Thus, in order to achieve a measured data for subsequent parametric statistics, the average frequency of occurrence of acute respiratory diseases (ARDM) was obtained for both women and

children (1-6 years). The results are presented against the counted ARDM data on Table 4.13.

Table 4.14 Indoor air pollution exposure level determining factors and acute respiratory disease morbidity among women and children

IAP exposure level determining factors		Wards										Tt	%	Av.
		1	2	3	4	5	6	7	8	9	10			
Awareness of IAP	Aware	11	13	23	32	20	16	17	24	16	17	189	67	_
	%	69	54	67	66	62	73	74	73	76	61	_	_	_
	Not aware	5	11	11	16	12	6	6	9	5	11	92	33	_
	%	31	46	33	46	48	27	26	27	24	39	_	_	_
Local interventions	Intv.	11	9	22	27	19	12	16	24	17	18	175	62	_
	%	69	37	79	56	59	54	69	73	81	39	_	_	_
	No	5	15	12	21	13	10	7	9	4	10	106	38	_
	%	31	63	21	44	41	46	31	27	19	61	_	_	_
Cooking habits	Indoor	4	6	19	23	18	2	3	12	4	8	104	37	_
	%	56	25	56	48	56	9	13	36	19	28	_	_	_
	In/out	7	18	15	25	14	20	20	21	17	20	177	63	_
	%	44	75	44	52	44	91	87	64	81	72	_	_	_
Fuel types	K	_	_	_	2	_	_	_	_	_	_	2	0.7	_
	W	16	24	34	46	32	22	23	33	21	28	279	99.3	_
Source of fuel	Buy	4	2	5	39	28	_	_	_	_	_	78	28	_
	%	25	8	15	81	87	_	_	_	_	_	_	_	_
	Fetch	12	22	29	9	4	22	23	33	21	28	203	72	_
	%	75	92	85	19	13	100	100	100	100	100	_	_	_
Extra curricular cooking		7	7	14	22	15	10	10	10	6	6	107	38	-
%		44	30	41	46	47	45	43	31	28	21	-	-	-
Average Kitchen size (M^3)		15.2	10.1	19.6	14.7	12.2	11.1	10.8	11.2	10.7	11	126.6	_	13
Average ventilation space (M^2)		1.4	1.2	1	1.4	1.4	1.3	1.3	1.4	1.3	1.3	1.3	_	1.3
Average per person wood consumption (kg)		2.4	2.6	2.1	1.9	2.4	1.8	1.6	2.2	2.0	2.3	21.3	_	2.1
Average cooking hours		3	2.30	3	5.30	4	2.30	2	2.30	2	3	30	_	3
Average family size		6.1	6.2	7.7	7.2	7.2	6.0	6.1	6.3	6.1	6.0	64.9	_	6.5
Acute Respiratory Disease Morbidity (ARDM) among Women	High	12	20	26	35	30	18	13	18	10	23	205	73	_
	%	75	83	76	73	94	82	57	55	48	82	_	_	_
	Low	4	4	8	13	2	4	10	15	11	5	76	27	_
	%	25	17	24	27	6	18	43	45	52	18	_	_	_
Acute Respiratory Disease Morbidity (ARDM) among Children (1-6 years)	High	9	13	19	37	24	16	10	25	11	22	186	80	_
	%	64	77	68	80	96	89	68	82	69	94	_	_	_
	Low	5	6	9	9	1	2	3	4	5	3	47	20	_
	%	36	23	32	20	4	11	32	18	31	6	_	_	_

Key:- (wards)-1=garkida, 2=guyaku, 3=tawa, 4=gombi north, 5=gombi south, 6=ga'anda, 7=gabun, 8=bogadingai, 9=yang, 10=duwa.

It is quite clear that at 73% high level of ARDM in women and 80% high level of ARDM in children, there is a high level of ARDM among women and children within the study area and this argument agrees with WHO (2007), that ARDs are the leading cause of infectious disease morbidity and mortality in the world likewise they (ARDs) are among the most frequent cause of consultation and admission in hospitals and clinics in developing countries. But this morbidity can not solely be attributed to IAP exposure because of the confounding nature of respiratory infections which depends on the causative pathogen, environmental and most importantly host related factors such as nutritional and immune status, which with the exception of some environmental factors, do not fall within the limits of this investigation. Thus, the following analysis is being conducted not because IAP is exclusively responsible for ARDM in Gombi LGA, but in order to understand the role played by IAP exposure at influencing ARDs within the study area.

A look at Table 4.14 indicates that IAP exposure level determining factors are characterized by 2 distinct types of data in the form of counted and measured data. The counted data includes the level of awareness of IAP, local intervention, cooking habits, fuel types, sources of fuel and extra curricular cooking, while the measured data are the average kitchen size (m^3), ventilation space (m^2), per person wood consumption (kg), cooking time or hours as well as family size. Thus, ARDM was determined both as measured data at Table 4.13 and as counted data at Table 4.14. Hence, in order to understand the role played by both sets of data (i.e. counted and measured data) at influencing ARDM in women and children, the appropriate statistical test must be selected in each case to obtain a meaningful result and explanation. The following are results and discussion of such analysis.

4.6 Factor influencing acute respiratory disease morbidity among respondents and children

The main factors considered important at influencing acute respiratory disease morbidity among respondents include family size, the level of awareness of IAP, local intervention, cooking habits, fuel type, source of fuel, kitchen size, ventilationsize, daily wood consumption and cooking time.

4.6.1 Family size and acute respiratory disease morbidity among women and children

Table 4.14 indicates a general average family size of 6.5 and this falls within the range of average family units found in Adamawa State (6-7) as provided by the National Population Commission (1991). However, different average family sizes were found in the various wards comprising the study area. Tawa ward has the largest family size of 8 while Garkida, Guyaku, Ga'anda, Gabun, Bogadingai, Yang and Duwa wards showed the smallest family size of 6. It was assumed that a larger family size will mean greater consumption of fuel wood, a proportional increase in emission rates, higher IAP exposure levels and a likely increase in ARDM. But the data on Table 4.1 clearly indicates that Duwa ward, with the smallest average family size (6), has a greater wood consumption (2.3kg) than Tawa ward (2.1kg), which has the largest family size (8). This contradicts the assumption of the effect of family size on wood consumption but agrees with the effect of larger wood consumption on ARDM. This is because in Duwa ward, with a 2.3kg average per-person wood consumption, 82% of the Respondents experience a high level of ARDM while in Tawa ward, with a 2.1kg average per-person wood consumption, only 76% experience such high levels of ARDM. Nonetheless, it is important to note that both Tawa and Duwa wards with the largest and smallest family sizes respectively, share the same average cooking time of 3 hours which is thought to highly influence IAP exposure levels, a major factor in ARDM. This simply implies that family sizes do not generally influence the time spent cooking. This

is so because it is evident in some of the rural households, especially the polygamous households that each of the women or Respondents simply cooks for their blood offspring's and husband only and this reduces the time spent cooking for these women. Thus in other to understand the role of family size on IAP as well as ARDM, the average family size in each ward was used to test if there is a relationship between the average family sizes and average ARDM among women and children. Table 4.15 shows the result of the analysis.

Table 4.15 Relationship between average family size and average acute respiratory disease morbidity among women and children

Values	Women	Children (1-6 years)
'r' value	0.78,	0.657,
't' value	3.57	3.77
Remarks	Significant	Significant

Ho_1 indicates that "There is a relationship between family size and ARDM among women and children and this relationship is found to be significant at 95% confidence limit ". This is because both the 'r' and 't' values for women and children are greater than the table or critical value at the specified significance level. The positive and fairly strong relationship suggests that an increase in family size may likely be result to an increase in ARDM among women and children. This finding agrees with the general assumption that a large family size influences larger wood consumption consequently, high levels of IAP, exposure levels and as a result greater risk of acute respiratory diseases.

4.6.2 Awareness of indoor air pollution and acute respiratory disease morbidity among women and children

Figures in Table 4.14 shows that 67% of the respondents are aware of IAP and this is arguably a fairly high level of awareness of IAP. This is reflected in each of the ten wards. The fairly large percentage of respondents that are aware of IAP is almost equally reflected in local interventions (62%)

and these results are in line with the view of Chokor (1983), Egunjobi (1983), Odemerho (1984) and Omuta (1984), that ordinary people possess a substantial knowledge of the complexities of environmental problems besetting them and indeed make efforts to articulate and adjust favorably to these problems.

However, the generally fairly large percentage of respondents that are aware of IAP and practice local interventions are not without variations as can be seen in the difference between the ward with the largest proportion of respondents that are aware of IAP Yang ward (76%) and the ward with the smallest proportion, Guyaku ward (54%). This is not surprising as Yang ward has a larger proportion of respondents in the older age group (55 years and above) than Guyaku ward (9% and 8% respectively), and as revealed at 4.2.1, both awareness of IAP and local interventions are higher in older age groups. Table 4.9 and 4.11 also indicates that Yang ward has a larger proportion of respondents and spouses who are civil servants (5% and 10% respectively) than Guyaku ward (0% and 0% respectively) and this population is thought to have better access to information and might be more aware of the ills of IAP. These findings suggest that the age group and educational level of Respondents and the occupation of their Spouses affects the level of awareness of IAP among Respondents more than any other socio-economic factor. Coincidentally, local interventions are highest in Yang ward (81%) and lowest in Guyaku ward (37%) and may not be far from the reasons of the variation found at the awareness of IAP among respondents. A look at Table 4.14 shows that 67% of the respondents are aware of IAP while 33% are not. ARDM is higher or worst in Gombi south ward (94%) and lower or least in Yang ward (48%). The corresponding figures in the awareness of IAP shows that Yang ward has a larger percentage of respondents that are aware of IAP (76%) than Gombi south ward (62%) and this might partly be the reason for the disease (ARD) disparity between the two wards (Yang and Gombi south wards). A look at the ARDM of the ward with the largest percentage of respondents that are aware of IAP (Yang

ward) and that with the smallest (Guyaku ward) will shade more light on the influence of the awareness of IAP on ARDM. Respondents of Yang ward with the largest percentage aware of IAP (76%) experience a lower level of ARDM (48%) than respondents of Guyaku ward who have the smallest percentage that are aware of IAP (54%) and a very high level of ARDM (83%). Gombi south and Duwa wards again show the highest level of ARDM among children at 96% and 95% respectively while Garkida ward at 64% experience the lowest level of ARDM among children. This can also be explained by the relatively large percentage of respondents that are aware of IAP in Garkida ward (69%) than in Gombi south ward (62%) or Duwa ward (61%). This trend is only disrupted in Bogadingai ward where there is a large proportion of respondents that are aware of IAP (73%) than in Garkida ward (69%) and a higher ARDM in Bogadingai ward, but to the contrary, Garkida ward still possess a lower ARDM than Bogadingai ward. To further clarify the argument, the association between the of awareness of IAP and ARDM in women and children was tested. The result of the chi-squared (X^2) test for hypothesis two (Ho_2) is shown in the table below.

Table 4.16 Association between awareness of indoor air pollution and high acute respiratory disease morbidity in women and children

X^2 value for women **17.46**	Remarks
	Significant
X^2 value for children **18.55**	Significant

The calculated value for women and children are both greater than the critical values at 95% confidence limit, the null hypothesis is hereby rejected while the alternative is accepted. Hence, Ho_2 suggests that ``there is an association between the awareness of IAP and ARDM among women and children and this association is found to be significant at 95% confidence limit. These findings underline the importance of advocacy in effective environmental and health management and as such concur with Chokor (1985) that the utility

of public environmental awareness in shaping desirable environmental and health management practices and effective control can not be over emphasized.

4.6.3 Local interventions and acute respiratory disease morbidity among women and children

Table 4.14 indicates that 175 Respondents (62%) undertake local interventions. Out of this number (175), the highest proportion can be found in Yang ward (81%) and the lowest is found in Guyaku ward (37%). Correspondingly, the level of ARDM is lower in Yang (48%) than in Guyaku ward (83%). Furthermore, part of the reason for Gombi south recording the highest ARDM (96%) while Yang ward recorded the lowest (48%) might not be far from the large difference in the proportion of respondents that undertake local interventions between the two wards (22%). Garkida ward also exceed both Gombi south ward and Duwa ward in the proportion of respondents that undertake local interventions and this might partly be the reason for a lower ARDM among children in Garkida ward (64%) than in either Gombi south ward (96%) or Duwa ward (95%). Table 4.17 shows ARDM among women and children with respect to the different local interventions practiced by respondents.

Table 4.17 Acute respiratory disease morbidity among women and children based on the different local interventions

Local intervention	No. of rspndts	%	Acute Respiratory Disease Morbidity							
			Women				Children			
			High	%	Low	%	High	%	low	%
A	37	21	24	64	13	36	32	86	5	14
B	57	33	28	49	29	51	38	67	19	33
C	81	47	54	67	27	33	67	83	14	17
Total	175	100	106		69		137		38	
Percentage %	100	100	61		39		78		22	

Key: (local interventions), A=opening window during cooking, B=restricting kitchen stay, C=reducing firewood.

Results in Table 4.17 reveals that restricting kitchen stay (B) provides the most effective remedy or local intervention against IAP and this is followed by the opening of windows (A), then the reduction fire wood during cooking (C). The evidence lies in the Table (Table 4.17) where it can be seen that respondents that restrict their kitchen stay during cooking, experience relatively low ARDM (49%) than respondents that open their windows (64%) and those that reduce fire wood during cooking (67%). This trend further persist in ARDM of children at 67%, 86% and 83% for restricting kitchen stay, opening windows and reducing wood respectively. It can be seen that local interventions have successfully reduced the level of ARDM by 39% among women and 22% among children (Table 4.18) in contrast to only 26% in women and 18% in children in the general distribution comprising respondents that do not undertake any local intervention (Table 4.14). This finding point to the role a reduction in cooking hours could play in mitigating the effects of IAP and therefore serve as a clue towards developing mitigation measures. This is because the restrictions of kitchen stay during cooking which have been seen from the above table to reduce ARDM more than any other intervention means a reduction in exposure level or time.

4.6.4 Cooking habits and acute respiratory disease morbidity among women and children

Table 4.14 shows that only 37% of the respondents cook strictly indoors while 63% of them cook both indoors and out doors. An examination of the cooking habits indicates that the highest proportion of respondents that cook strictly indoors (56%) can be found in Garkida, Tawa and Gombi south wards while the lowest proportion at 9% is found in Ga'anda ward. However, the corresponding ARDM in all these wards seems relatively high (75%, 76%, 94% and 82% among women and 64%, 68%, 96% and 89% among children in Garkida, Tawa, Gombi south and Ga'anda wards respectively) despite the low proportion of cooking strictly indoors in Ga'anda ward. A low proportion of

respondents cooking strictly indoors is suppose to lower the exposure levels and therefore ARDM in the ward concerned by the reduction of uptake among the respondents and children through the influence of diffusion on reducing concentration of smoke pollutants outdoors. The case of Yang ward which shows a low proportion of women cooking strictly indoors (19%) and the lowest level of ARDM is exceptional as many factors have been attributed to this manifestation among which are the high level of awareness of IAP and local interventions (76% and 81% respectively), small proportion of respondents engage in extra curricular cooking (28%) as well as the relatively short cooking hours (2 hours). Thus, the result obtained from table 4.14 on cooking habits and ARDM among women and children has proven contrary to assumption (that outdoor cooking might reduce concentration of pollutants and limit exposure levels, hence ARDM) and this point to the ineffectiveness or inefficiency of encouraging increase in kitchen size or ventilation characteristics as a mitigation strategy against the effects of IAP. But this insinuation might be misleading especially when one considers the relatively large proportion of respondents in Ga'anda ward engaged in extra-curricular cooking, low local interventions and the relatively small size of kitchens as well as the influence of confounding factors (causative pathogen and host related factors).

4.6.5 Fuel type and acute respiratory disease morbidity among women and children

A look at Table 4.14 shows that about 99.2% use fire wood for cooking and only 0.8% found mainly in Gombi north use kerosene strictly for cooking. This means that 4% of the respondents in Gombi north ward use kerosene strictly for cooking, but that has not help much in lowering the level of ARDM among women and children as Gombi north ward records one of the highest level of ARDM (73%). Notwithstanding, the role of cleaner fuels in lowering pollution can not be down casted by this eventuality because so many factors like the relatively large proportion of women engage in extra-curricular cooking

(46%) as well as the long cooking hours (5.30 hours) evident in Gombi north ward and the fact that only 4% of the house holds in Gombi north use kerosene strictly for cooking. This population is too small a fraction to make the difference in ARDM in Gombi north ward. All these factors mentioned above have therefore played important roles in heightening the level of ARDM in Gombi north ward.

4.6.6 Source of fuel and acute respiratory disease morbidity among women and children

Table 4.14 indicates that about 28% of the respondents buy their fire wood while 72% fetch their wood from the surrounding environment. The buying of fire wood is practiced only in five wards namely Garkida, Guyaku, Tawa, Gombi north and Gombi south wards. Gombi south and north have the largest fraction of respondents that buy their wood (87% and 81% respectively). 100% of the respondents in the remaining wards namely Ga'anda, Gabun, Bogadingai, Yang and Duwa wards fetch their fire wood from the surrounding bush or environment. The buying or fetching of fuel wood will indirectly affect ARDM in the sense that respondents that easily fetch their wood will probably be wasteful and over use the fuel thereby resulting to higher emission rates or pollution level than Respondents that use their hard earned money to buy and this may reflect in ARDM. However, the level of ARDM is higher in Gombi south ward (96%) in which 87% buy their fuel, than in any other ward that easily fetch and may overuse their fuel. Thus, since the buying or selling of fuel is only suppose to increase or decrease fuel consumption, the relationship between fuel consumption and ARDM among women and children which is dealt with in 4.6.9 will aid in clarifying the issue concerning the buying or fetching of fuel wood.

4.6.7 Kitchen size (m^3) and acute respiratory disease morbidity among women and children

Various kitchen sizes were found across the study area with a mean kitchen size of $13m^3$. A large kitchen size is suppose to induce better diffusion of IAP pollutants and hence a lower pollution and exposure level which could reflect in level ARDM among women and children who are most at risk to IAP. Thus, Guyaku ward has the smallest kitchen size (10.1 m^3) and a higher ARDM than Tawa ward which has the largest kitchen size (19.6 m^3) as shown on Table 4.14. Thus in order to clarify the interaction between kitchen size and ARDM among women and children, the Pearson's product moment correlation analysis (PPMC) was used to assess the relationship between these two variables. Table 4.18 shows the result of the analysis.

Table 4.18 Relationship between average kitchen size (m^3) and average acute respiratory disease morbidity among women and children

Values	Women	Children (1-6 years)
'r' value	**0.61**	**0.57**
`t' value	**2.17**	**1.98**
Remarks	Not significant	Not significant

Ho_3 indicates that "there is no significant relationship between the kitchen sizes and ARDM among women and children at 95% confidence limit". This is because both the 'r' and 't' values for women and children are less than the critical values at the specified confidence limit. This shows that kitchen size plays a less prominent role at influencing exposure levels which is a known IAP health effect determining factor. This finding conforms to the argument at 4.6.4 concerning the ineffectiveness or inefficiency of an increase in kitchen size or ventilation space as an IAP mitigation measure.

4.6.8 Ventilation size (m^2) and acute respiratory disease morbidity among women and children

Just like the kitchen sizes, different sizes of ventilation size were discovered in the kitchens of the households investigated. The ventilation size is as well supposed to enhance diffusion and therefore reduce the concentration or pollution levels during cooking. A reduction in concentration of pollutants means a reduction in unit uptake and this may likely reflect by a decrease in exposure levels, thus a low ARDM. The smallest average ventilation size can be found in Tawa ward ($1m^2$) while the largest is seen in Garkida, Gombi north, Gombi south and Bogadingai wards with $1.4m^2$ average ventilation size each. At the same time, some of the highest levels of ARDM can be found in the wards with the largest average ventilation size (e.g. Gombi north ward) and this has proven contrary to the logic. Therefore the PPMC analysis was again used to assess the strength of the relationship between the specified variables. The result is shown in Table 4.19.

Table 4.19 Relationship between average ventilation space (m^2) and average acute respiratory disease morbidity among women and children 1-6 years

Values	Women	Children (1-6 years)
'r' value	**0.54**	**0.48**
't' value	1.8	1.5
Remarks	Not significant	Not significant

The result of the PPMC concerning the relationship between average ventilation size and ARDM among women and children shows that "there is no significant relationship between average ventilation size and ARDM among women and children in the study area'. This is further indicated by the relatively weak correlation coefficients (0.54 for women and 0.48 for children).

4.6.9 Wood consumption (kg) and acute respiratory disease morbidity among women and children

Table 4.14 indicates a 2.1kg total average fuel wood consumption (per person), however different average fuel wood consumption can be found across the study area, this difference can result to different emission rates. This means that a large quantity of wood consumption (per person) in a particular ward might result to higher emission rates with consequent higher exposure levels, and this can reflect in ARDM among women and children in the study area. It is against this argument that the fifth hypothesis will be tested to see if there is any significant relationship between the average per person wood consumption (kg) and the average ARDM among women and children. Table 4.20 shows the result of the Pearson's product moment correlation analysis (PPMC) for hypothesis five.

Table 4.20 Relationship between average wood consumption (kg) and average acute respiratory disease morbidity among women and children

Values	Women	Children (1-6 years)
'r' value	**0.65**	**0.779**
't' value	**2.41**	**3.44**
Remarks	Significant	Significant

Ho_5 suggests that the relationship between average wood consumption and average ARDM among women and children was found to be significant at 95% confidence limit because both the `r' value and the `t' value calculated for women and children are greater than the corresponding critical or table value. The findings point to the importance of total emission rates (because wood consumption is directly proportional to emission rates) as a factor influencing high levels of IAP and therefore exposure levels consequently, high levels of ARDM.

4.6.10 Cooking time in hours and acute respiratory disease morbidity among women and children

Table 4.14 shows a 3 hours general average cooking time and several different averages ranging from 2-6 hours across the study area. This finding concurs with Engel *et al* (1998) that people in developing countries are commonly exposed to very high levels of IAP from the use of biomass fuel for cooking for periods of between 3-7 hours daily over many years. The longest cooking time of 5.30 hours can be found in Gombi north ward and this is followed by 4 hours in Gombi south. Coincidentally between these two wards is found the highest ARDM among women and children which is explainable because of the long cooking hours. The shortest cooking time of 2 hours can be found in Gabun and Duwa wards which expectedly portray the lowest levels of ARDM among women and children. This finding agrees with Bruce *et al.* (2000), that a health effect is determined not just by pollution levels, but also and more importantly by the time people spend breathing polluted air (exposure level). Thus the time spent cooking is one of the most important factors determining IAP exposure levels, and exposure levels ultimately defines the effects of IAP on the most vulnerable victims (i.e. women and children). This means that respondents with longer cooking hours will probably have a higher ARDM than respondents with short cooking hours because of the longer exposure levels. This argument was subjected to the PPMC analysis and the results are shown on Table 4.21.

Table 4.21 Relationship between average cooking time in hours and average acute respiratory disease morbidity among women and children

Values	Women	Children (1-6 years)
'r' value	**0.89**, r^2 = 0.7921 = **79.21%**	**0.88**, r^2 = 0.7744 = **77.44%**
't' value	**5.49**	**5.30**
Remarks	Significant	Significant

Ho_6 suggests that "There is a relationship between cooking time and ARDM among women and children and this relationship is found to be significant at both 95%". This is because both of the calculated values for women and children are greater than the critical values at the specified significance levels. This means that a unit increase in cooking time may likely be directly proportional to a unit increase in ARDM among women and children.

4.6.11 Extra curricular cooking and acute respiratory disease morbidity among women and children

Table 4.14 shows that about 107 Respondents representing 38% of the sampled households engage in extra curricular cooking across the ten wards comprising the study area. Gombi south ward provides the largest proportion of respondents that engage in extra curricular cooking (47%) while the smallest proportion can be found in Duwa ward (21%). The research assumption is that extra curricular cooking activities among the respondents will increase the level of exposure to IAP and will therefore reflect in ARDM among the women involved and their children. However, the research finding revealed that ARDM is almost equal among women and children in the two wards with the largest and smallest proportion of respondents that engage in extra-curricular cooking (Gombi south ward - 94% and 96% high ARDM and Duwa ward - 93% and 95% high ARDM for women and children respectively) despite the difference in the proportion of respondents that engage in extra curricular cooking between the two wards. This divergence from assumption can be explained by a look at the same table where it can be seen that Gombi south ward has a larger kitchen size ($14.7m^3$) and ventilation size ($1.4m^2$) than Duwa ward ($11m^3$ and $1.3m^2$ kitchen size and ventilation size). The larger kitchen size as well as ventilation size lessens the smoke concentration in the kitchen and therefore lowers the IAP exposure levels, hence a relatively low or equal level of ARDM in Gombi south ward as in Duwa ward. This is supported by the personal observation that most

of the extra-curricular cooking is done outdoors and as a result, increased ventilation during cooking, lower exposure levels and relatively lower risk of ARDs. However, the divergence is corrected in the wards with the second and third smallest proportions of respondents that engage in extra curricular cooking (Yang 28% and Guyaku 30%) where it can be seen that the level of ARDM among women and children is relatively lower than in Gombi south ward which has the largest proportion of respondents engage in extra curricular cooking as well as the highest level of ARDM among women and children.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION.

5.1 Summary of research finding

The study aimed at assessing the awareness of IAP among women and its relationship to acute respiratory disease morbidity among women and children in Gombi LGA of Adamawa state. This is in order to be able to develop a locally appropriate and coherent frame work for increased public awareness and sustainable future interventions against the effect of IAP, in a systematic manner. Four objectives were set out to achieve this aim.

Both primary and secondary data were use in the Study. The primary data was sourced from a 28 item questionnaire administered to 281 women (15 years and above) in randomly selected households across the ten wards of the study area while the secondary data was obtained from the records of health centers within the Study area. The data obtained were analyzed using both descriptive and inferential statistical techniques of means, percentages, chi square and correlation analysis respectively.

Findings from the primary data indicated that 67% of the respondents are of aware of IAP while 33% are not aware. The age group and educational level of respondents as well as the occupation of their spouses were found to be important factors influencing the aware of IAP among the respondents. On the other hand, the occupation of the Respondents and the educational level of their spouses showed a limited influence on awareness of IAP among the respondents.

About 8 factors were considered important indicators of IAP levels in the study area, these include fuel type and stove type, amount of fuel consumed (kg), kitchen size (m^3) and ventilation size (m^2), cooking habits (in/out doors) and time (hours) as well as the percentage of respondents engaged in extra curricular cooking activities. 99.8% of the respondents use fire wood for

cooking while only 0.2% uses kerosene. All of the Respondents that use fuel wood for cooking utilize the typical 3 stone open fire stove without chimney or hood with a 2.1 kg average daily per person wood consumption. A 13m^3 average kitchen size with 1.3m^2 average ventilation size were discovered in the households surveyed. 37% of the respondents cook strictly indoors while 73% cook both in and out doors and only 38% of the respondents engage in extra curricular activities. These factors or variables were used (with respect to the result of the work by Smith and Pennise in collaboration with the World Health Organization 2005) to obtain an estimated 24 hour mean IAP levels of 33.1mg/m^3 of CO and 0.73mg/m^3 of PM. The 24 hours mean international standards are 10mg/m^3 and 0.1mg/m^3 for CO and PM respectively.

From the data analyzed, 73% high level of ARDM and a 27% low level were found among the respondents while 80% high and 20% low level of ARDM were found among their children (1-6 years). Prolonged exposure to IAP has been linked to ARDs in victims, thus several factors were considered as IAP exposure level determining factors. These include the level of awareness of IAP among respondents, local interventions, family size and all the indoor air pollution level determining factors mentioned in the preceding paragraph. Of these factors, awareness of IAP, local interventions, amount of wood consumed, family size and time spent cooking were seen to have the most significant association with ARDM among women and children. The restriction of kitchen stay was seen to be the most effective mitigation measure against the effects of IAP as indicated by the 42% average low level of ARDM among women who practice it and their children (1-6 years). The opening of windows during cooking and the reduction of wood only show a 25% average low level of ARDM among the women who practice it and their children. Cooking habits (in/out doors) showed an insignificant association with ARDM whiles the significance of fuel types and sources were discussed there in (4.6.5 and 4.6.6)

and are reflected in the analysis of wood consumption which is here summarized. The average kitchen size (m^3) and average ventilation size (m^2) both showed insignificant relationships with average ARDM.

The availability of fire wood (42%) was found to be the main factor influencing the use of fire wood for cooking and this is preceded by the cost of alternatives at 32%. About 13% of the Respondents indicated the lack of alternatives as the reason for the use of fire wood for cooking, 12.3% indicated that it is a matter of culture while 0.7% who use kerosene said it is a matter of convenience.

The secondary data showed that acute respiratory disease morbidity is increasing at a rate of about 3.4% among women and children in the study area.

5.2 Conclusion

The following conclusions were drawn based on the results and findings of the study:-

- There is a fairly high level of awareness of IAP among the respondents and this fairly high level is influenced by age group and educational level of the respondents as well as the occupation of the spouses of respondents more than any other socio economic characteristic.
- There is also a high level of IAP from the use of fire wood for cooking within the Study area. This is justified by the 24 hour mean pollution levels of 33.1mg/m3 of CO and 0.73mg/m3 of PM common in the house holds surveyed; which are 3.1 times and 7.1 times higher than the 24 hour mean standards of 10mg/m3 of CO and 0.1mg/m3 of PM specified by WHO (2005).
- There is a high level of ARDM among women and children (1-6 years) as substantiated on Table 4.14 where 73% of the women and 80% of the children have a high level of ARDM.
- Six (6) of the eight (11) exposure level determining factors analyzed showed significant association and relationship with ARDM among

women and children, this is arguably a strong indication of the link between IAP and ARDs in women and children.

- The restriction of kitchen stay during cooking has proven to be the most effective local intervention or mitigation measure as it has successfully reduced ARDM among women and children by an average of 42% while the opening of windows and the reduction of wood during cooking only reduce ARDM among respondents that practice it and their children by an average of 25% each. A reduction of kitchen stay during cooking means a reduction of cooking time or hours and this may be why a strong and positive relationship was found between cooking time and ARDM among women and children (4.5.10). This finding also suggests a strong link between IAP and ARDs in women and children.
- The availability of fire wood (42%) as the main reason for its use indicates a general lack of effective restriction and legislation against indiscriminate forest exploitation while the cost of alternatives (32%) as the second reason for the use of fire wood suggests poverty and a lack of incentives among the respondents. The lack of alternatives among 13% of the respondents shows that 13% of them might be willing to switch to cleaner or more efficient cooking methods or alternative fuels if provided with incentives while 12.3% might not be willing to switch to other fuels because of their cultural inclination toward cooking with fire wood in simple stoves. 0.7% indicated convenience as the reason for the use of kerosene for cooking and this shows that they may be willing to change to even more convenient fuel types no matter the costs provided they are convenient.

5.3 Recommendations

It is of vital importance to note that IAP is not a recognized environmental hazard at policy level in developing countries including nigeria and therefore the need to integrate it at the policy level. This is in view of the verity of IAP as

not just a health issue but also a developmental and environmental problem. Coupled with this effort should be a sustained proactive multi sector approach towards prevention and mitigation as well as advocacy of its (IAP) harmful effects on the health of the individual as well as the environment. To achieve this, a number of measures are imperative, among which are the following:

(1) The effects of IAP should be inculcated in every facet of Government, NGO, and other agencies environmental, sanitary, hygiene or health campaigns owing to its high level in the study area and its links to respiratory disease morbidity.

(2) The awareness or advocacy programs should focus on:

- The mechanism towards which IAP weakens the human immune systems resistance against respiratory infection.
- The most vulnerable group (i.e. women and young children 1-6 years)
- The evidence that on the long run, upfront investment in cleaner fuels (kerosene and gas) might be cheaper, profitable and beneficial (in terms of medical costs) and environmentally sound than the use of wood for cooking.
- On the short term and as a matter of urgency, encourage the use of face mask during cooking as a means of reducing exposure.

(3) Provision of the necessary loans and incentives for upfront or bulk acquisition of cleaner fuels and the provision of these fuels in the remote and rural areas of the state.

(4) Policy decisions in the national, state and local government on environmental matters should emphasize on ways of providing access of the poor to cleaner fuels.

(5) Provision and encouraging the use of more efficient and effective stoves like the closed fire stove with chimney/hood in place of the commonly found open fire stove without chimney/hood can go a long way in reducing emission rates, hence reduced uptake or exposure.

(6) Encouraging the enlargement of kitchen sizes including larger windows to provide for adequate ventilation and reduced concentration of pollutants within the kitchen.

(7) The provision of IAP monitoring kits in educational/research institutes as well as government ministries/parastatals in charge of the environment will increase IAP monitoring options, extend possible areas for investigation and strengthen research based evidence.

(8) In realization of the importance of the media in effecting public consciousness, IAP and its effects should be integrated into all environmental correspondence of all mass media (radio, television and news paper).

(9) Strict implementation of legislation against indiscriminate forest exploitation may discourage the use of fire wood thereby limiting deforestation and desertification which is becoming a major scourge especially in the northern parts of Adamawa state and the study area in particular.

(10) IAP and its effect should be integrated into the environmental education curriculum of primary, secondary and tertiary institutions. This can be administratively expedient, effective and cost saving, because it can motivate and instill from young age, the basic behavioral change necessary for the effective control of IAP through embracing cleaner fuels, thereby discouraging deforestation. This will improve the health and living standards of the population as well as enhancing environmental quality.

Finally, it is important to keep in mind the close interrelationship between poverty which is prone in rural areas of developing countries (e.g. Gombi LGA) and dependence on polluting fuels, and consequently the importance of socio economic development, which should be at the core efforts to achieve healthier households and environments.

REFERENCES

Adara O.A (1993) Environmental education in the formal sector: problem and prospects, paper presented at the first national conference on environmental education, Lekki conservation center, Lagos.

Adebayo AA. (1999) Climate 1 & 2 in Adebayo AA and Tukur AL (eds). *Adamawa state in maps*. Paraclete, Yola, Adamawa state Nig.p 20 – 26.

Adebayo A. and Olawepo J.A (1997) Integration of environmental education in social sciences curricular at the secondary school level in Nigeria: problems and prospects. *Environmental education research*. vol 3.

Adebayo AA, Umar AS. (1999) Hydrologya nd water resources in Adebayo AA and Tukur AL (eds). *Adamawa state in maps*. Paraclete, Yola, Adamawa state Nig.p 17 -19.

Aghlor R.N (1993) Environmental education in the non formal sector, paper presented at the first national conference on environmental education, Lekki conservation center, Lagos.

Akosim C, Tella I0, Jatau DF. (1999) Vegetation and forest resources in Adebayo AA and Tukur AL (eds).). *Adamawa state in maps*. Paraclete, Yola, Adamawa state Nig.p 32-35.

Albalak R. (1997) Cultural practices and exposure to particles pollution from indoor biomass cooking: effects on respiratory health and nutritional status among the aymara indians of the Bolivian highlands (Doctoral disertation). University of Michigan.

Amstrong JR and Campbell H. (1991) Indoor air pollution exposure and lower respiratory infections in young gambian children. *International journal of epidemiology*. Vol. 20: p 424 – 429.

Bashir .A and Raji .M.M (1999) Rural Settlements in Adebayo AA and Tukur AL (eds). *Adamawa state in maps*. Paraclete, Yola, Adamawa state Nig.

Boehm RG. (1995) *World Geography: A Physical and cultural approach*. Glencoe mcgrawhill, USA.

Boulding J. (1956) in Adebayo AA. (1989) Man environment relations: The Geographers view point. P15. (Unpublished lecture notes).

Bruce N, Perez- Padilla R, Albalak R. (2000) Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the world health organisation* WHO Press, Geneva. Vol 78: p 1078 – 1092.

Chen BH, Martin KS, Collins DA (1990) Indoor air pollution in developing countries. *World health statistics quarterly*. Vol 43: pp 27 -138.

Chokor BA. (1985) "A humanistic philosophy for environmental management. context and constraints" paper presented to the departmental seminar, geography and regional planning, University of Benin.

Chokor BA. (1983) ``The sense of place: A study of Environmental experience and place consciousness and planning in Ibadan, Nigeria'' Phd thesis, University of London.

Cokhran WG (1977) *Sampling techniques*, 3rd edition, John Wiley and Sons Newyork.

Cunningham WP, Cunningham MA, Saigo BW. (2003) *Environmental science: A global concern* 7th edition. Macgraw Hill, Newyork, USA.

De Koning HW, Smith KR, Last JM. (1985) Biomass fuel consumption and health. *Bulleting of the world health organization*. Vol. 63: p 11 – 26.

Egunjobi L. (1983) *Perception of Environmental problems: A pilot study centered on the city of Ibadan.* NISER. Ibadan.

Ellegard A. (1996) Cooking fuel smoke and respiratory symtoms among women in low income areas of Maputo. *Environmental health perspectives.* Vol 104: p 980 – 985.

Encarta encyclopedia (2009) microsoft encarta 2009 (dvd).Redmond WA. microsoft corporation, USA.

Encyclopedia of public health (2008) microsoft encarta 2009 (dvd). Redmond WA. microsoft corporation, USA.

Engel P, Hurtado E, Ruel M, (1998) Smoke exposure of women and young children in highland guatemala: predictions and recall accuracy. *Human organization.* Vol 54:p 408-417.

Ilesanmi FA. (1999) Urban settlements in Adebayo AA and Tukur AL (eds). *Adamawa State in Maps*. Geography dept. FUTY, Adamawa State Nig. Pp 104 -106.

Johnson AW and Aderele WI. (1992) The association of household pollutants and socio-economic risk factors with the short term outcome of acute lower respiratory infections in hospitalized pre-school Nigerian children. *Annuals of tropical paediatrics*. Vol 12:pp 421 – 432.

Khin MT, Han W, Ohnmar, Aung KZ, Thuzar M, Khin KMS, Sandra K, Than L. (2005) Indoor air pollution: Impact of intervention on acute respiratory infection (ARI) in under-five children. *Regional health forum.* vol 9.

Lin D. (1998) The development and prospective of bioenergy technology in China. *Bio-mass and bio energy.* Vol 15: p 181 – 186.

Lioy PJ. (1990) Assesing total human exposure to containants: a multidisciplinary approach. *Environmental science and technology*. Vol 24. p 938 – 945.

Luvhimbi and Jawrek H. (1997) Household energy in a recently electrified rural settlement in Mpumalanga, South Africa. *Boiling point*. Vol 38: pp 30 – 31.

Martin KS. (1991) Indoor air pollution in developing countries, *Lancet*, Vol 337. p 358.

McCracken JP and Smith KR, (1998) Emissions and efficiency of improved woodburning cookstoves in highland Guatemala. *Environment international.* Vol. 24: p 739 – 747.

Morris K, Pandey MR, Malik S (1990) woodburning stoves and lower respiratory tract infection in American indian children. *American journal of disease of children*. Vol 144:p105-108.

National Population Commission (1991) *Final result of the 1991 population census of Nigeria.* NPC, 1992.

National Population Commission (2007) *Preliminary result of the 2006 population census of Nigeria*. NPC, 2007.

Naumova E.N (2006) Mystery of seasonality: getting the rhythm of nature. *Journal of public health policy*. Vol 27 (1): 2-12.

Odemerho FO, (1984) ``the structure of urban problems as perceived in Warri, Bendel state, Nigeria''. *Journal of environmental management,* vol 19, pp 65-78.

Omuta GED (1984) ``territorial and Environmental problems in Auchi, Nigeria''. *Land use policy*. vol 1, 33041.

Onibokun GA. (1972) `` Nigeria strategies for urban redevelopment''. *Journal of the royal town planning institute*. vol 58, pp 51-56.

Onokerhoraye AG (1977) `` Public involvement in urban development planning: the case of environmental sanitation in Ibadan, Nigeria''. *Journal of administration overseas*. vol 16,pp 171-177.

Pandey MR, Basnyat B, Neupane RP (1985) Domestic smoke pollution and respiratory function in rural Nepal. *Tokai journal of environmental and clinical medicine.* Vol 10: pp 471-481.

Primary Health Care Department (PHC) (2006) Population and household distribution, Gombi L.G.A, Adamawa State of Nigeria.

Ray HH. (1999) Soils and Erosion in Adebayo AA and Tukur Al (eds). *Adamawa State in Maps*. paraclete, Yola, Adamawa state Nig.pp 37– 40.

Robin LF, Behera D, Dash S (1996) Wood burning stoves and lower respiratory illnesses in Navajo children. *Pediatric infectious disease journal* Vol 15: pp 859-865.

Rehfuess E and Pennise D (2005) *Addressing indoor air pollution through questionnaires.* African regional workshop on IAP and household energy monitoring, Kampala Uganda. WHO press, Geneva Switzerland.

Sajo AA and Kadams AM (1999) Food and cash crops in Adebayo AA and Tukur AL (eds). *Adamawa State in maps*. Paraclete, Yola, Adamawa state.p 37 – 40.

Smith KR. (1987) *Biomass fuels, air pollution, and health: A global review*. New York, Plenum press.

Smith KR, Shah N, Victoria CG. (1994) Air pollution and the energy ladder in Asian cities. *Energy.* Vol 19:p 587 – 600.

Smith KR and Liu Y. (2000) Indoor air pollution in developing countries and acute respiratory illness in children. *Thorax,* Vol 55: p 518 – 532.

Smith K, Naumoff K, Pennise D (2005) *Indoor air pollution measurement options.*Center for entrepreneurship in international health and development (CEIHD), University of California-Berkley.

Smith KR and Pennise D (2005) Biomass pollution basics. *Environmental health sciences*. University of California-Berkeley.WHO press Geneva Switzerland.

The Macmillan World Gazette and Geographical dictionary, (2008*).* Macmillan press England.

Tukur AL (1999) Land forms in Adebayo AA and Tukur AL (eds). *Adamawa State in maps*. Paraclete, Yola, Adamawa state Nig. p 14 – 16.

USEPA (1997) Revisions to the national ambient air quality standards for particles matter. *Federal register.* Vol 62: 38651 – 38701.

USEPA, Office of Air and Radiation, (1989) Assessment and control of indoor air pollution. *Report to congress on indoor air quality*. vol 2:, p 1, 4-14.

USEPA (2000) *Air quality guidelines for Europe*. Copenhagen, WHO regional office Europe.

WHO (2000) *Addressing the links between indoor air pollution, household energy and human health.* Based on the WHO- USAID global consultation on the health impact of indoor air pollution and household energy in developing countries (meeting report). WHO, Washington, DC. USA.

WHO (2002) *Addressing the impact of household energy and IAP on the health of the poor: implications for policy action and intervention measures*. Paper presented for the commission on macroeconomics and health, WHO press, Geneva Switzerland.

WHO (2005) *Situation analysis of household energy use and IAP in Pakistan*. discussion papers on child health. Department of child and adolescent health and development, WHO Press, Geneva Switzerland.

WHO (2006) *Fuel for life: household energy and health*. WHO Press, Geneva Switzerland.

WHO (2007) *Indoor air pollution: National burden of disease estimates*. WHO Press, Geneva Switzerland.

WHO (2007) *Infection prevention and control of epidemic and pandemic prone acute respiratory diseases in healthcare*. WHO interim guidelines. WHO press, Geneva Switzerland.

World atlas (2009) encarta encyclopedia, microsoft encarta 2009 (dvd). Redmond WA: Microsoft corporation, USA.

World Resources Institute (WRI), UNEP, UNDP, World Bank, (1998) *World Resources: A guide to the global environment*. Oxford University Press, England

APPENDIX I

FEDERAL UNIVERSITY OF TECHNOLOGY YOLA
(SCHOOL OF ENVIRONMENTAL SCIENCES)
DEPARTMENT OF GEOGRAPHY.

Dear respondent,

This is an Msc research questionnaire on the awareness of Indoor Air Pollution (IAP) among rural women in Gombi L.G.A. of Adamawa State. Kindly respond to the questions below by carefully and honestly providing answers, you are assured of the confidentiality of the information provided, please.

Yours Sincerely,

SECTION A
SOCIO-ECONOMIC CHARACTERISTICS.

(1) District …….
(2) Ward …….
(3) Family size ……
(a) (b) (c) (d) (e)
(4) Age group (15-24) (25-34) (35-44) (45-54) (55&above)
(5) Educational level.

Personal.	Husband.
(a) Informal education	(a)Informal education
(b) Islamic School	(b)Islamic school
(c) Primary School	(c)Primary school
(d) Secondary School	(d)Secondary school
(e) Higher Education	(e)Higher education
(f) Other specify…….	(f) Other specify…….

(6) Occupation

Personal	Husband
(a) Farmer	(a) Farmer
(b) Housewife	(b) business man
(b) Business woman	(c) Civil Servant
(c) Civil Servant	(d) Artisan
(d) Artisan	
(e) Other specify……	(f) others specify…….

SECTION B
SOURCES OF DOMESTIC ENERGY

(7) Kitchen size-.....

(8) Total ventilation space-.....

(9) What type of fuel do you use mainly for cooking?
(a) fuel wood
(b) Kerosene
(c) Electricity
(d) Gas
(e) Crop residue
(f) Animal dung
(g) charcoal
(h) Others Specify ……..

(10) If (a), what is the daily consumption in kilograms? …….

(11) Why do you use such fuel?
(a) Its availability
(b) Lack of alternatives
(c) Cost of alternatives
(d) Cultural belief
(e) Others specify……

(12) How do you source your fuel?
(a) Buying
(b) Fetching
(e) Others specify……..

(13) What type of cooking stove is used?
(a) Open fire/stove without chimney/hood
(b) Open fire/stove with chimney/hood
(c) Closed stove with chimney/hood
(d) Others specify……..

(14) How many hours do you spend cooking daily?.....

(15) How do you cook during rainy season?
(a) Indoors
(b) Outdoors
(c) Both

(16) How do you cook during dry season?
(a) Indoors
(b)Outdoors
(c)Both

(17) What other activity do you engage in that involves cooking with fuel wood?.....

SECTION C
AWARENESS OF INDOOR AIR POLLUTION (IAP)

(18) Do you or others burn things around this area? Yes/NO

(19) If yes, where do you burn these things?
(a) Indoor
(b) Outdoor
(c) Both

(20) What do you think are the effects of burning things?
(a) Health effects
(b) Sanitary effects
(c) Aesthetic effects
(d) Others specify……

SECTION D
LOCAL INTERVENTION

(21) How do you minimize the effect of burning things especially fire wood?.....

(22) Have you ever been contacted by anybody on how to minimize the effect of the smoke? Yes/No

(23) If yes, what was the mitigating measure? .....
……..

SECTION E
RESPIRATORY PROBLEMS

(24) Do you suffer from any frequent respiratory problems? Yes/No

(25) How frequent do you face this problem ? (a)once a week (b)once a month (c)once in 3 months (d)once in 6months (e)once a year (F)others specify……

(26) Do you have children between the ages of 1 – 6 years? Yes/No

(27) Do any of your children (1 – 6 years) suffer from respiratory problems? Yes/no

(28) How frequent do they suffer from this problem?(a)once a week(b)once a month(c)once in 3 months(d)once in 6months(e)once a year(o)others specify……

Thank You.

Appendix II

Acute Respiratory Disease diagnosis among Women and Young children in Gombi LGA of Adamawa State (1979-2008)

Years	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Total
1979	14	17	22	9	11	8	21	14	16	11	13	12	168
1980	12	19	13	19	11	14	15	21	11	9	15	14	173
1981	17	23	26	9	8	22	19	24	18	20	7	21	214
1982	23	18	18	23	19	21	17	21	16	27	19	20	242
1983	21	20	19	15	14	16	23	20	18	22	17	19	224
1984	19	23	21	19	25	17	18	24	21	23	16	20	246
1985	37	18	27	19	19	18	17	33	25	22	27	20	282
1986	28	27	22	16	21	19	27	25	30	32	29	31	307
1987	33	24	19	26	20	30	28	24	21	32	30	26	313
1988	37	33	30	20	24	32	39	31	23	30	27	29	355
1989	30	25	19	20	22	31	27	24	25	20	21	30	294
1990	12	27	22	16	21	33	35	34	36	39	37	29	341
1991	32	39	36	34	34	43	39	39	41	26	29	37	429
1992	30	28	27	24	40	14	37	31	33	28	26	28	346
1993	33	38	12	7	9	34	30	26	33	31	17	27	297
1994	32	31	25	20	20	38	27	25	31	14	18	29	310
1995	37	32	22	27	16	53	40	32	14	18	27	39	357
1996	35	31	41	40	48	17	43	39	31	12	53	37	427
1997	35	2	37	28	31	9	41	19	17	57	42	28	342
1998	25	22	20	17	14	20	7	16	39	15	13	9	217
1999	36	30	2	40	11	29	13	32	25	3	19	21	261
2000	31	20	22	27	20	7	30	18	6	11	21	19	232
2001	25	26	40	49	25	29	9	19	27	31	12	26	318
2002	36	26	25	5	29	41	30	32	36	19	24	27	330
2003	25	22	31	30	9	19	37	40	19	17	21	24	294
2004	53	19	43	47	17	36	37	41	39	16	19	40	407
2005	43	17	50	13	3	10	40	25	36	31	18	22	308
2006	30	27	25	20	39	67	37	7	19	10	52	30	363
2007	28	20	20	10	11	8	20	27	19	14	9	19	205
2008	39	21	43	36	41	19	40	41	43	39	67	43	427
Total	888	725	779	685	632	754	843	804	768	679	745	776	9,074

Source: Adamawa State Dermatological Hospital Garkida, Gombi LGA, 2009.

Appendix III

Acute Respiratory Disease diagnosis among Women and Young children in Gombi LGA of Adamawa State (1979-2008)

Years	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Total
1979	16	15	12	13	16	19	18	24	21	14	15	13	196
1980	22	16	13	12	21	23	19	25	16	15	14	17	213
1981	19	21	17	18	25	31	33	19	10	26	17	20	253
1982	15	10	13	20	17	19	19	21	16	14	17	20	201
1983	18	17	14	14	11	24	15	19	16	13	21	15	197
1984	22	20	22	18	23	17	16	21	19	17	16	23	236
1985	27	21	18	20	19	27	30	26	21	23	19	20	271
1986	30	33	40	26	22	29	31	28	19	20	31	37	346
1987	29	37	41	42	36	17	31	32	30	27	38	29	389
1988	31	23	19	28	40	17	24	37	22	18	27	26	312
1989	26	20	26	28	20	39	32	31	34	27	16	18	317
1990	34	29	26	37	41	47	36	32	40	38	20	28	408
1991	31	35	33	27	28	34	31	36	26	29	32	30	372
1992	30	36	27	33	36	28	37	32	24	26	22	31	365
1993	41	36	52	39	46	39	39	45	42	38	37	43	496
1994	42	40	48	43	38	47	41	47	50	39	36	40	511
1995	47	40	41	44	42	39	40	41	23	29	49	51	486
1996	46	33	26	26	29	20	30	34	32	41	37	43	397
1997	49	43	57	42	38	39	41	46	50	60	46	51	562
1998	69	63	58	64	47	61	49	57	67	43	54	69	701
1999	59	63	56	53	60	49	51	70	57	53	21	70	662
2000	55	57	60	40	56	66	58	61	51	48	59	60	671
2001	40	49	44	53	46	32	39	41	34	40	47	43	508
2002	47	35	34	39	40	37	48	49	29	57	47	50	512
2003	41	42	39	44	40	46	40	39	43	48	50	45	517
2004	46	50	55	49	35	31	48	50	29	43	37	44	519
2005	59	53	19	37	67	61	55	51	54	73	83	57	669
2006	61	78	63	51	60	33	57	60	71	42	43	59	678
2007	72	76	86	80	69	84	74	81	67	70	71	78	908
2008	58	51	67	66	63	47	54	52	66	69	49	61	703
Total	1182	1142	1126	1106	1131	1102	1136	1207	1079	1100	1071	1191	13,576

Source: General Hospital Garkida, Gombi LGA, 2009.

Appendix IV

Raw data for the hypothesis

Ho_1

s/no	Average family size	Average ARDM	
		Women	Children
1	6.1	14.3	10.6
2	6.2	24.3	15
3	7.7	33.6	22.8
4	7.2	52.3	48.8
5	7.2	40.5	31.3
6	6.0	19.1	32.6
7	6.1	17.6	14
8	6.3	25	26.3
9	6.1	13.6	17.6
10	5.9	25.3	26

Ho_2

s/no	Aware of IAP	High ARDM	
		Women	Children
1	69	75	64
2	54	83	77
3	67	76	68
4	66	73	80
5	62	94	96
6	73	82	89
7	74	57	68
8	73	55	82
9	76	48	69
10	61	82	94

Ho_3

s/no	Kitchen size (m^3)	Average ARDM	
		Women	Children
1	15.2	14.3	10.6
2	10.1	24.3	15
3	19.6	33.6	22.8
4	14.7	52.3	48.8
5	12.2	40.5	31.3
6	11.1	19.1	32.6
7	10.8	17.6	14
8	11.2	25	26.3
9	10.7	13.6	17.6
10	11	25.3	26

Ho_4

s/no	Average ventilation space (m^2)	Average ARDM	
		Women	Children
1	1.4	14.3	10.6
2	1.2	24.3	15
3	1	33.6	22.8
4	1.4	52.3	48.8
5	1.4	40.5	31.3
6	1.3	19.1	32.6
7	1.3	17.6	14
8	1.4	25	26.3
9	1.3	13.6	17.6
10	1.3	25.3	26

Ho_5

s/no	Average wood consumption (kg)	Average ARDM	
		Women	Children
1	2.4	14.3	10.6
2	2.6	24.3	15
3	2.1	33.6	22.8
4	1.9	52.3	48.8
5	2.4	40.5	31.3
6	1.8	19.1	32.6
7	1.6	17.6	14
8	2.2	25	26.3
9	2.0	13.6	17.6
10	2.3	25.3	26

Ho_6

s/no	Average cooking time in hours	Average ARDM	
		Women	Children
1	3	14.3	10.6
2	2.30	24.3	15
3	3	33.6	22.8
4	5.30	52.3	48.8
5	4	40.5	31.3
6	2.30	19.1	32.6
7	2	17.6	14
8	2.30	25	26.3
9	2	13.6	17.6
10	3	25.3	26