UNIVERSITY OF GLOUCESTERSHIRE

AN ASSESSMENT OF THE IMPACT OF PESTICIDE USE BY URBAN CULTIVATORS IN OYO STATE, SOUTH-WESTERN NIGERIA.

A thesis submitted to University of Gloucestershire in accordance with the requirements of the degree of Doctor of Philosophy in the School of Natural and Social Sciences

By

Adewunmi I. Bodede

January 2020

Word Count: 69912

Author’s declaration

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas. Any views expressed in the thesis are those of the author and in no way represent those of the
University.

Signed

Date 27/01/2020

doi: 10.46289/SW96EE38

Abstract

This study is an investigation into pesticide use amongst urban agriculture practitioners in Ibadan, South-Western Nigeria. It explores pesticide use in urban agriculture within the broader context of sustainable development and its dimensions, namely; the environment, economy and society in sustainable agriculture. This study is significant as no single study in Nigeria has looked at how pesticide use in urban agriculture impacts on broader developmental issues using both methods from natural and social sciences. Furthermore, there are conflicting data on the extent of UA in Ibadan City and all previous work carried out has been purely descriptive and no recent work on pesticide presence in the environment.

This research adopted an interdisciplinary approach to developing a methodology that combines natural and social perspectives as there exist relationships amongst people, profit and planet. Therefore, this investigation utilised both a positivist and interpretivist paradigm in adopting a mixed methods approach in answering the research questions on historical and current pesticide contamination in environment; and evaluating the extent of pesticide use by UA farmers in Ibadan and explore farmers' knowledge concerning good practice, farmer awareness of the environmental impacts of poor practice, and farmer motivations with respect to the socio-economic drivers that determine pesticide use.

These methods included quantitative natural science methods of soil, sediment, and diatom analysis; and quantitative and qualitative social science methods of questionnaires, interviews and focus group discussions. The results from soil and sediment analysis showed pesticide residues, including banned organochlorine pesticides such as Dieldrin, DDT, Endosulfan, and Endrin. Further investigations to establish long-term contamination using biological and radioactive indicators yielded limited results and therefore, historical contamination of the study area could not be established.

However, quantitative analysis of pesticide use conducted via SPSS software showed a high incidence of pesticide use amongst farmers but no significant relationships between its use and farmers' characteristics such as age, gender, educational level and land tenure status. Despite no significant relationships between pesticide use and socio-economic variables, qualitative analysis of interviews and focus group discussions indicated an awareness of the harmful effects of pesticides by farmers and continued pesticide use is a precautionary strategy. It also suggested farmers willfully ignore impacts of pesticides on the environment and their health with little understanding of the long-term implications for their livelihoods.

Though pesticide residues in soil and sediments in this study are in low quantity, this study revealed new insights into farmers' limited knowledge on long-term impacts of pesticide use on the three dimensions of sustainable development as farmers' trade good agricultural practice, knowledge and awareness for livelihood and economic considerations. With the country committed to the sustainable development goals, the insights generated in this study emphasise the need for policy redress that can tap into the potentials of urban agriculture, especially in the education of farmers regarding pesticide use as a last alternative in their agricultural production. Also, a resuscitation of the country's existing law on pesticide monitoring and enforcement should be encouraged.

Word count: 490

Dedication

This work is dedicated to God almighty and the memory of my late sister, Adedoyin; you are sorely missed!

Acknowledgements

I give thanks to Almighty God for His goodness towards me and my family throughout this research. It can only be God who has brought me this far!

I am most grateful to my supervisors: Professor Kenny Lynch, Dr. Julie Ingram, Dr. Julia Webb and Dr. Liz Hamilton; without them, this research would not have been possible. Your coordination of my research program at making sure my training needs were promptly attended to is exemplary. Your timely pep talks are highly appreciated; they steadied me in the face of several struggles. I am also grateful to Dr. Lucy Clarke and Dr. Daniel Keech for helping with my examination preparations; your roles are instrumental to the viva outcome. I must appreciate Paul Kimber and all the laboratory staff for their support during my lab work. To Caro Mcintosh, thank you for supporting my GIS and cartography training. To my other research colleagues that we have crossed path one point or the other during this program to support one another, I say thank you.

I am especially grateful to Dr. Oluwatoyin Akintola for her moral, academic and financial support to make this research successful. Your help during the fieldwork is appreciated. To Dr. Olubode and Dr. Sowunmi of the University of Ibadan and Professor Soneye of the University of Lagos, thank you for all the support you provided. To Yemisi Olokeogun who helped with GIS mapping of sampling points during fieldwork, I am indebted to you. I must commend the effort of Israel, my hardworking and ever-available field assistant, thanks for making sure we stayed safe during our field visits. To my other field assistants (Kola, Justice and Mayowa); thank you for enduring the long hours spent visiting farmers and collecting data (it wasn't always easy). To Olaoluwa Adegoke, thank you for sparing time to help with some of the data analyses. To 'Lehin George, thank you for spending time to read my drafts and making suggestions to improve it. To Modupe Adebayo, Toyin Ojelabi and Adetayo Taiwo, thank you for continually pushing me and supporting me in every way you could.

I extend my gratitude to the farmers and key informants (retailers and extension officers) who provided me with vital information for this research. Special recognition of the Oyo state Horticultural association of Nigeria for mobilising their members in participating in the study, I am indeed grateful. To Mr Seth, thank you for providing valuable contacts that helped in the study.

I am indebted to my parents, especially my mother, Afolake Olatundun, for encouraging my academic pursuits and not giving up on me even when I doubted myself. This degree is to your credit. To my sister and brothers, Adetola, Adeyemi and Adefemi, thank you for your steady support and prayers; Adetola, thank you for pushing me towards the finish line. To my wonderful brother-in-law, Adedolapo, thank you for the gentle encouragement. To my darling grandmother, Susannah Anigele, thank you for your sacrifice of love, I love you. To the Akintola family, thank you for all the support, and I pray God’s continued blessing on you. To my Pastors and church family, I say thank you for your prayers and encouragement.

Finally, to my immediate constituent, my very own people, we did it together; my husband, Olufemi Johnson, your labour of love is appreciated; my son, Anjola Johnson and daughter, Desola Annabelle, thank you for all the prayers and understanding why mummy needs to be away from home on several occasions. I am so grateful to you all for standing by me through thick and thin; I love you guys.

Table of Contents

List of figures and boxes

List of Equations

List of Tables

List of Acronyms and Abbreviations

ATA	Agricultural Transformation Agenda
AU	African Union
CAADP	Comprehensive African Agricultural Development Programme
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
FMARD	Federal Ministry of Agriculture and Rural Development
IDRC	International Development Research Centre
IIED	International Institute for Environment and Development
MDGs	Millennium Development Goals
NAFPP	National Accelerated Food Production Programme
POPs	Persistent Organic Pollutants
POPSTAT	Population Statistics
PPE	Personal Protective Equipment
RUAF	Resource Centres on Urban Agriculture and Food Security
SA	Sustainable Agriculture
SD	Sustainable Development
SDGs	Sustainable Development Goals
SLU	Sveriges lantbruksuniversitet (Swedish University of Agricultural Sciences)
SPSS	Statistical Package for Social Sciences
UA	Urban Agriculture
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural organisation
WAAPP	West African Agricultural Productivity Program

WCED	World Commission on Environment and Development
WFS	Committee on World Food Security
UNCED	United Nations Conference on Environment and Development
UPA	Urban and Peri-urban Agriculture
UPAF	Urban and Peri-urban Agriculture and Forestry
UNFPA	United Nations Population Fund
UNWPP	United Nations World Population Prospects

Chapter 1

'*We won't have a society if we destroy the environment.*'

- Margaret Mead

Introduction

1.1 Introduction to study

This study is an investigation into pesticide use amongst urban agriculture practitioners in Ibadan, South-Western Nigeria. It explores pesticide use in urban agriculture (UA) within the broader context of sustainable development (SD) and its dimensions, namely the environment, economy and society. Pesticides, as production inputs, play a significant role in the production of food with almost one-third of global agricultural output produced using these products (Zhang, 2018). These compounds, in agriculture and by extension, UA, are relied on to control pests and diseases to reduce the industry's pre-harvest and post-harvest losses to pests and diseases (Oerke, 2006). However, concerns continue to abound on their adverse effects on the environment, society and economy as a result of their chemical composition, mode of action and methods of application by farmers (Arbeli and Fuentes, 2010; Mahmoud & Loutfy, 2012; Fenner *et al.*, 2013). When these pesticides accumulate in the environment from their overuse and misuse, volatility and persistence, they cause damage to agricultural land, fisheries, plant and animal organisms, unintentional killing of beneficial predators, illness and death in humans (Wilson and Tisdell 2001; Gavrilescu 2005; Arbeli and Fuentes 2010; Ochoa and Maestroni 2018). These problems not only cause environmental concern, but cause social and economic concerns.

Sustainable development is a concept defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: pg. 1). The definition emphasises the importance of managing our present social and economic needs within the limits of the environment in consideration of future generations. With pesticides contributing significantly to the provision of food by reducing pre and post-harvest losses to pests and diseases, which could be up to 36-40% loss of agricultural yield (Edwards, Thurston & Janke, 1993; Oliveira *et al.*, 2014), the rate at which these crop protection inputs are being used has increased in 20-fold globally (Popp, Neto and Nagy, 2013). These increase in use, with their following impact, has the potential to compromise the ability of future generations in meeting their own needs. Even though agriculture with pesticide use is being credited with alleviating food security crisis, it is still recognised as the highest contributor to environmental degradation (Fenner, 2013; Olaonipekun *et al.*, 2019) because of its use of pollutants that poses significant negative impacts on biodiversity, environment, food quality, human health and economic growth; a potential compromise of the ability of future generations to meet their own needs. To reduce this, sustainable agricultural practices are being encouraged.

Sustainable agriculture (SA) is agriculture that meets society's need for food without compromising the ability of future generations to meet their own needs (Pretty, 2007; Velten *et al.*, 2015). According to Kiraly (1996), a sustainable agricultural practice must have the potential to remain relevant for a period of time, preserve natural resources, protect the natural environment, and protect human health. This potential to contribute to SD is limited by pesticide due to its hazardous nature. This is most especially true for many developing countries in Africa that indiscriminately use these products, including the banned products (Quinn *et al.*, 2011). Given the significance of the reaching effects of pesticide use in agriculture, potential sustainable agriculture practices such as UA became encouraged as part of the drive to meet SD goals of bringing an end to hunger, achieving food security and improved nutrition and promoting sustainable agriculture.

Urban agriculture is defined as the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities (Brown *et al.*, 2002; Urban Agriculture Committee of the CFSC, 2003). It includes small-intensive urban farms, food production on housing estates, land sharing, rooftop gardens and beehives, schoolyard greenhouses, restaurant-supported salad gardens, public space food production, guerrilla gardening, allotments, balcony and windowsill vegetable growing and other initiatives (Mougeot, 2006; Redwood, 2008; Hou *et al.*, 2009). According to Hsin (1996) and Ackerman *et al.* (2014), UA is an exciting concept that can potentially contribute to SD because it promises self-reliance, community, and local economy while reducing many environmentally harmful practices from modern agriculture practices. However, its potential to positively contribute to SD is impaired by the use of pesticides and has been identified as one of the challenges to a successful practice of UA in African cities such as Ibadan (RUAF report, 2007).

With this limitation, its increasing popularity (UNDP, 1996) among urban residents and extensive implications for SD, there is a need for an exploratory study into UA pesticide practice, especially in developing economies such as Nigeria (Mok *et al.*, 2013; Lee-Smith 2010) where the practice of UA is gaining momentum as a livelihood strategy. The concept of urban farming and agriculture is rising and offers benefits to the citizens of urban areas (Carvalho *et al.*, 2017), especially in African cities. In developing countries such as Nigeria where UA is contributing to household incomes in response to worsening living standards, increased rural-urban migration (Bryld, 2003; Kutiwa, Boon and Devuyst, 2010; Thornton, 2010) and subsequent increase in urban population (Henderson, 2002), the rate at which pesticides are being used has grown exponentially despite available alternative crop protection methods (Pretty, 2007; de Bon *et al.*, 2014b). In some South-east cities of Nigeria, farmers produce various crops in their household gardens to fulfil their health and growth need but the adverse effects of using pesticides within their living vicinity can potentially affect the health of their family (Enete and Achike, 2008), hence a social concern.

Given the implications it has for social, economic and environmental goals, and overall sustainability from continued reliance on pesticides, this thesis is an investigation into pesticide use amongst urban agriculture practitioners in Ibadan, South-Western Nigeria within the context of SD. Findings from this study can inform on how UA could contribute to local and global food security within the principles of sustainable development (Coelho *et al*., 2018). This chapter of the thesis, therefore, introduces the subject of concern and states the aim and objectives of the research. It continues with the significance of the study and contribution to knowledge and outline of the thesis. The chapter concludes with an outline of the subsequent chapters of the thesis and a summary of this opening chapter.

1.2 Research aims and objectives

Trends and patterns in developmental studies (Basiago, 1999; Wilson & Tisdell, 2000) and policy narratives (Brundtland Report, 1987; Independent Group of Scientists appointed by the Secretary-General, 2019) point to the significant interactions and relationships that exist amongst the social, economic and environmental dimensions of sustainable development. One of these many interactions is the relationship that exists between agricultural practice and its impact on dimensions of SD (Martellozzo *et al.*, 2014). As pesticide use impacts on water, soil, air, and biodiversity (Petrescu-Mag *et al.* 2019), there are increasing global concerns about these impacts on the environment, society and economy. These impacts are significant because it affects the potential of UA to contribute to SD.

Given the potential multi-dimensional impacts of pesticide use in UA, the overall aim of this study is to adopt an interdisciplinary approach towards combining an investigation of these impacts, with an exploration of the extent of pesticide use and how these multiple dimensions are affected by farmers' decision to use or not use pesticide. The specific objectives for this study therefore are:

1. To develop a research framework for integration of environmental, economic and social perspectives on the use and impacts of pesticides in this exploratory study.

2. To identify suitable methods to quantify residual pesticides in soil and sediments.

3. To create a historical and current profile of pesticide use in Ibadan city from methods used in objective two.

4. To evaluate the extent which pesticide use by UA farmers in Ibadan and explore farmers' knowledge concerning good practice, farmer awareness of the environmental impacts of inadequate training, and farmer motivations concerning the socio-economic drivers that determine pesticide use.

A desk-study involving search and critical review of literature is carried out to develop a research framework that allows for an interdisciplinary study into pesticide use in UA and SD. Natural science methods are used to investigate the persistence of pesticides in soil and water, while social science methods were adopted to explore and explain the extent of pesticide use in UA. The study benefits from using quantitative data to tell us the extent of pesticide use and general knowledge, attitude and behaviours of farmers; and qualitative data to broaden our understanding of how farmers process the decision behind these factors. These culminate in a holistic approach towards fully identifying, understanding and explaining the extent of pesticide problem in UA.

1.3 Relevance and contribution of the study

As the world shift towards ensuring a society where the societal, economic and environmental impact of any given practice such as agriculture is minimized, the use of pesticide is a challenging occurrence that affects this delicate balance between human socio-economic needs and the environment. This delicate balance is so because these pesticides persist in the environment long after their application and potentially cause problems for the environment, society and economy. Although the role of agriculture is essential in meeting the basic physiological need for food, the continued demand for pesticides by farmers to control both the biotic and abiotic environment to meet socio-economic needs contradicts the principle of sustainability.

Despite several arguments made on the possibility of agricultural production without pesticides (Wilson and Tisdell, 2000; Pretty, 2007), these chemicals have been statistically shown in numerous studies (e.g. Edwards, Thurston & Janke, 1993; Oliveira *et al.*, 2014, Oerke 2006; Zhang, 2018) to considerably reduce the percentage of crop that are susceptible to pests and pathogens. This benefit the pesticides provide, by destroying those unwanted organisms that may threaten food production, subsequently minimise crop losses and increase profits for farmers. Their continued use and persistent presence in the environment, however, contributes to one of the many problems that impede sustainable development as a result of human failure to consider the long-term implications of their short-term benefits. These problems lead to both short and long-term damage such as soil and water contamination, pesticide poisoning, bioaccumulation in aquatic organisms, among many others.

Though UA is applauded as a solution to urban food security challenges, especially in low income countries (Dubbeling and de Zeeuw, 2010; Mougeot, 2011) and sub-Saharan countries like Nigeria (Lynch *et al.*, 2001 and Pasquini, 2006), Binns and Lynch (1998) expressed concerns that some published work on UA suggested that it was the panacea for solving urban food supply problems, without considering the wider implications of its impacts. Furthermore, Lynch *et al* (2001) suggested more research is needed to clarify issues such as impacts of UA on environment and health. With the misuse of pesticides identified as an impediment to its sustainable practice in Ibadan city, Nigeria (RUAF report, 2007), a study into this becomes imperative.

Pesticide misuse is a huge problem with lots of attendant effects despite the continuous research into producing safe-to-use chemicals (Taylor *et al*., 2007). The misuse of pesticide according to Asogwa and Dongo (2009) is rampant because of farmers', and even government trained agents', perception of increasing dosage beyond prescription (Adewunmi and Fapohunda, 2019) kills pests rapidly. One of such misconceptions is the mixing of different classes of pesticides, such as fungicides and insecticides, together so as to reduce application time (Ojo, 2016). The many conflicting data on the extent of UA in Ibadan makes it challenging to assess these pesticides since few studies have produced data that can be used to plan an assessment and investigation into the problem of pesticide misuse. For this reason, this study will collect and use its own primary information in ensuring data validity. By generating new primary data, they could be used in future research involving urban agriculture and sustainable development in the city.

This study is also significant due to limited information on pesticide use in UA in developing countries such as Nigeria, coupled with an absence of reliable empirical data on the scale and impact of pesticide use in UA in Ibadan city, Soth-western Nigeria (Brown, 2004; Djurfeldt, 2015; Stewart *et al.* 2013). Asogwa and Dongo (2009) and Brown *et al.* (2006) also revealed the nonexistence of detail research on impacts of pesticides due to a lack of consistent monitoring and evaluation process in Nigeria and other developing countries. This lack of monitoring and evaluation is in stark contrast to developed countries such as the United Kingdom (UK) where monitoring and assessment provide ample field-based information on impacts of pesticide use in urban agriculture. By adopting an interdisciplinary approach to developing a methodology that combines natural and social perspectives because of the influence of pesticide use in UA on sustainable development, this study will attempt to explore, in a single research, broader developmental issues surrounding pesticide use in UA in a Nigeria city.

This study is also significant in maintaining Nigeria's commitment towards achieving the Sustainable development goals (SDGs 2030) after failing to meet their Millennium development goals (MDGs) target in 2015. This is because environmental sustainability and an end to poverty are two inter-twined goals that are used as one of the many indicators of SD. Therefore, findings from this study can be used to inform national policy makers as the country work towards meeting its sustainable development goals targets by 2030 (discussed in chapter 2), which includes an end to hunger, achieving food security and improved nutrition, and promoting sustainable agriculture.

Furthermore, given the depth of research conducted on pesticide use in urban agriculture in developed countries, which are generally in temperate climes, there are fewer studies conducted in developing and tropical country like Nigeria. According to Ekeleme *et al.* (2008), the risk of pesticides is often higher in (sub) tropical climates than in temperate climates which could be due to different rates of pesticide dissipation under tropical and temperate conditions (Racke *et al.*, 1997) and this current study of pesticides in a tropical environment like Nigeria could provide significant insight into urban pesticide management.

Also, despite pesticide consumption in Africa to be 2-4% of the global pesticide market (Williamson *et al.*, 2008), the reported percentage of poisoning and damage to the environment is far higher in comparison to other continents. With limited research in Nigeria on farmer knowledge concerning good agricultural practice on pesticides (awareness, mastery of technical information etc.), farmer awareness of impacts of poor practice, and on farmer motivations concerning the socio-economic drivers that determine pesticide use (Wilson and Tisdell, 2000), this study is significant as it allows for an understanding of pesticide impacts within a dense and sizeable urban population like Ibadan, Nigeria.

Also, there is no previous study on the degree to which pesticides are being used in rapidly growing urban environments and the attendant problems associated with this, especially in a tropical climate as high temperatures have been established to influence the fate of their chemical constituents concerning soil. By exploring this gap, this thesis will contribute to the discourse on sustainable urban systems by informing policymakers on the significance and extent of pesticide use in the urban environment, which will help in designing programmes, and writing policies that will alleviate the pesticide problem.

Tracing the history of past and present use of pesticides in urban agriculture is also essential to urban agriculture studies as little information on pesticide contamination in the study area is available in the literature. This study plans to use both chemical and biological analyses to assess pesticide contamination, given the tropical characteristics of high temperatures in the study area, which may influence the persistence of pesticides in the environment. By coring recent lake sediments, the study can assess pesticide contamination in lake sediments and provide relevant insights to a history of pesticide use. This information will also help in providing monitoring and evaluation of pesticide use in our goal of making cities and human settlements inclusive, safe, resilient and sustainable for all inhabitants (Tabibian and Movahed, 2016).

This study will also contribute to the literature on the interdependence of economic, social and environmental factors in understanding factors driving pesticide use in urban agriculture. Such an understanding could be used in designing environmental educational programmes aimed at improving farmers' knowledge of pesticide and encouraging good agricultural practice. Overall, this thesis explores the evidence of the impacts of pesticide use in UA in a tropical city, as well as develop a methodology that can be refined and replicated in other similar urban settings.

1.4 Thesis structure

This chapter (one) provides a general background to the study, research aims and contribution to study. Chapter two presents the scope of research and conceptualisation of issues underlying the analysis. This chapter defined key terms and policy narratives on urban agriculture, pesticide use and sustainable development. These definitions allow for establishing the scope of research because UA is a broad topic touching on different aspects of social, economic and environmental factors. It creates a contextual justification for this study through an exploratory of historical and current pesticide use in UA, with focus on Ibadan City in Nigeria. This scope and context are used in formulating research questions and activities to achieve the study aim. It also includes the conceptual framework for the thesis. Conceptualisation of pesticide use in UA is discussed within the economy, society and the environment. This discussion establishes the interaction among the sustainability dimensions and how they impact one another in the practice of UA. It also explains the multidisciplinary nature of the research through diagrammatic representations of the research activities.

Chapter Three is a review of key literature that shows the current state of knowledge and gaps in our understanding of pesticide use in urban agriculture, especially in a developing economy. This is followed by Chapter Four that entails the methodology employed in this study. It presents the research paradigm, the justification for using a combination of quantitative and qualitative methods and describes in detail the activities involved in conducting questionnaire survey, interviews and focus discussion. This chapter also explains the different methods used in the natural science research aspect of this study and the probable cause of the non-existent result generated from most of these methods. The conduct of data analysis, including laboratory analysis, were also described.

Chapters Five presents the results obtained from natural research methods such as coring activities, lead 210 dating, and soil analysis and diatom survey. It is followed by a discussion of findings and significance to study objectives. Chapter Six present the results from the social science research methods which includes the socio-economic background of respondents, factors informing pesticide use and themes developed from the analysis of the data generated from the social science methods adopted.

Chapter Seven discusses the results presented in chapter six, while chapter Eight brings together the interactions among results generated and discussed emerging themes on how they drive pesticide use in UA. It also presents a summary of key findings in the study and how it fulfils the objectives of the research. The chapter concludes with recommendations from current research for future research.

1.5 Conclusion

This chapter has given a brief introduction to this study, including the objectives and its relevance to the body of knowledge on pesticide use. The following chapter is in two parts: the first includes the scope of study which introduces and explores pesticide use in urban agriculture within the context of sustainable development and present sustainable development goals while the second part uses the context established in the conceptualisation of research issues.

Chapter 2

Scope of Study and Conceptualisation

2.1 Introduction

This chapter defines the extent of the research study and the context within which conceptualisation is situated. To reiterate the research aim highlighted at the beginning of the thesis, the objective of this study is to adopt an interdisciplinary approach by combining an investigation into the assessment of pesticides in soil and sediments in an urban ecosystem with the extent of pesticide use within an urban ecosystem and further explored by analysing how dimensions of SD are impacted on from continued pesticide use in UA practice. Given the depth of studies relating to the aim of research, the scope of this study is limited to pesticide issues concerning the urban ecosystem, urbanisation, urban challenge, food security challenge, urban agriculture, sustainable development and sustainable agriculture in developing countries and tropical environments like the study area, Ibadan city in Nigeria, sub-Saharan Africa.

The conceptualisation of research is a process of identifying underlying assumptions in a study (Srinidhi, 2013). This process is an essential component of a research thesis as it provides clarity in the research development process which helps in removing ambiguity and mapping out the key issues that are of interest in a research study (Srinidhi, 2013; Sequeira, 2014). This clarity further provides insights for understanding and analysing the phenomenon under investigation within the context of current knowledge. Sustainability/SD is a key concept used by social scientists interested in interactions between human society and the environment (Fahy & Rau, 2013). However, their multiple dimensions and inter-relationships provides a challenge in its conceptualisation as there is no established framework for this kind of study (Munda and Saisana, 2011). This is rather driven by concepts and methods specific to the subject of concern. Several issues that make it a challenge is the scoping of relevant concepts and components, given the interconnectedness that exists among the dimensions (Munda and Saisana, 2011). The conceptualisation of pesticide use in UA is therefore established in the latter part of this chapter within the concept of SD and its elements.

In this study, pesticide use is reviewed within the scope of urban agriculture's potential contribution to sustainable development. As such, the study looks at how pesticide use impacts on the three dimensions of sustainable development, namely; society, economy and the environment. To understand this subject of concern, this study assesses the presence and effect of pesticide use on environment, society and economy as dimensions of sustainable development. Urban farmers are also identified as primary consumers of pesticides and therefore, issues about their socio-economic characteristics, knowledge and attitude and how it influences their decision to use pesticides are explored.

This chapter of the study, therefore, contributes to this thesis by establishing the main concepts of interest, exploring wider issues on pesticide use and sustainable development, and providing a basic conceptual framework for this study.

2.2 Sustainable development/sustainability

As mentioned in chapter one, this study is concerned with pesticide use in UA and its impacts sustainable development. This provides background on developmental issues such as food security and urban poverty that drives UA in developing countries such as Nigeria. The proceeding sections will discuss UA and pesticide use within the context of SD.

2.2.1 The concept of sustainable development/sustainability

In the Eighties, global leaders mapped a new development concept that is aimed at protecting our world in totality. This concept, known as sustainable development (SD), was formally introduced in a document titled 'Our Common Future' by World Commission on Environment and Development (WCED) in 1987, also known as the Brundtland Report. The report was the synthesis of several policy efforts that recognised the finite characteristics of resources and how it concerns present and future generations' survival (Pearce *et al*., 1990). Sustainable development was defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: pg. 1). The definition of SD by the Brundtland commission recognises that resources we take for granted are finite and that if conscious steps at sustaining them are not encouraged, there will be fewer resources for future generations and therefore put them at risk. The report also highlighted our responsibility to remove compartmentalisation of human activities and effects within nations, sectors and general areas of concern (WCED, 1987; section 2:11).

Morelli (2011), defined sustainability as the ability of man to preserve the limited natural resources and not overuse these resources to the detriment of the future while Ben-Eli (2012) described it as a precise balance in the interface between a population and the carrying capacity of its environment which could be any population and any environment. Foy (1990) used the term sustainability interchangeably with SD to argue for environmental preservation on the premise that current economic and social activities should not place an excessive burden on future generations. These definitions of sustainability are synonymous to those used to describe SD in the 1987 Brundtland Report. However, some researchers criticised the ambiguity (Jacobs, 1994; Ben-Eli, 2012) in these two interchangeable terms because of their trivialisation, which for example in business is used as a corporate strategy that gives them grandstanding (Ben- Eli, 2012), as an ethical imperative (Pawlowski, 2008) and development projects (Jacobs, 1999).

Diesendorf (2000) expressed his criticism of the ambiguity by describing sustainability as the goal of a process called SD and therefore defined SD as a process that encompasses economic and social development which protect and enhance the natural environment and social equity. This study, therefore, adopts Diesendorf's (2000) distinction of both terms and will refer to SD in this study as a process and sustainability as a goal.

By adopting the definition of SD as a process in this study, three central components were derived from its definition, namely; environment, the economy and the society (Hallett, Hoagland and Toner, 2016). Each of these three dimensions is a complex, dynamic, self-organising and evolving entity in its own right and their overall sustainability relies on their capability to interact successfully with one another without jeopardising future needs (Spangenberg, 2005).

2.2.2 Dimensions of sustainable development

Since the emergence of SD, as a concept, and the three main dimensions: environment, society and economy; being used as its framework in studies involving sustainability, some authors has theorised additional dimensions in different contexts such as Seghezzo (2009) who included place, permanence and time; the United Nations Educational Scientific and Cultural organisation (UNESCO, n.d) included culture as a fourth dimension. All these theorisations confirm the dynamics of the three basic dimensions as foundational and are influenced by current issues, perspectives, and values (Brodt *et al*, 2011). However, for clarity, this study considers the environment, economy, and society as the main components, which is also referenced in the definition of SD. Also, given that the subject of concern is agriculture, a vital link between the society and the environment (Bacon *et al*.,2012), these dimensions are discussed within the scope of UA, the specific topic of interest.

Environmental sustainability is concerned with the protection and sustainable use of natural resources, especially water and soil resources without pollution or degradation (Liu and Zhang 2013). The field of sustainability as a dimension of SD gathered momentum to argue for environmental preservation and against environmental degradation from socio-economic activities because of its significant contribution to the society and economy (Everett *et al*., 2010). Attah (2010) and Morelli (2011) described the environment as our ‘natural capital’, which needs to be sustained in order to meet our socio-economic goals. Natural capital is a concept used in highlighting the importance of environmental systems via ecosystem services in influencing a country's economic output and social well-being (Constanza *et al.* 1997; EEA, 2015; Reed *et al.*, 2005; Ndimele *et al*, 2018). Ecosystem services are defined by Boyd and Banzhaf (2007) as "the benefits of nature to households, communities, and economies" which include provision of food and water purification; regulation of carbon sequestration; and support of nutrient cycles.

As explained by Sanchez-Medina *et al*. (2014), the environment is: responsible for supplying natural inputs upon which socio-economic success relies on; provides recreational services which are beneficial to the society; and also acts as a receptor of the wastes and residues such as pesticides which are generated in the production and consumption of goods for economic growth. The environment is therefore considered to play a crucial role in sustainability and often referred to as the bedrock of the tripartite relationship that exists amongst the three core dimensions of sustainability (EEA, 2015).

One of the ways environment is being degraded is the use of agrochemicals in the form of persistent organic pollutants and other pesticides in agriculture (Pimentel, 2005). Though pesticides are intentionally introduced into the environment, the impact of this willful action is significant to both social and economic dimensions of sustainability (Bacon *et al*., 2012). When these pesticides are used within the premise of environmental sustainability which includes practices and technologies that do not pose adverse effects on the environment and accessible and practical for farmers; their use can lead to improvements in food productivity with positive effects on environmental goods and services (Pretty, 2007). However, when these pesticides are misused, they may cause resource shortages due to extensive use, and environmental pollution is a side effect of pesticide overuse (Pretty, 2007). This pollution from pesticide inputs has consequences for both the social and economic dimensions of sustainability.

2.2.3 The Sustainable development goals: the policy context

The importance of global food security was recognised as central to the achievement of the eight MDGs (UN Millennium project, 2005; Sachs, 2012; see Box 2.1 for the MDGs) especially for developing economies like Nigeria with goal one aimed at reducing poverty by half between 1990 and 2015. Similarly, the SDGs has zero poverty and hunger as foundational goals for overall achievement. This is because an end to hunger contributes substantially towards economic growth and development (Timmer, 2004; WFP, 2016). The 17 SDGs (box 2.2) have been set in recognition of the interactions among the developments targeting the three main dimensions of SD, where an action in one area will affect the outcomes of others (UNDP, 2015).

However, the end report produced by the United Nations Development Program's (UNDP) in 2015 on Nigeria's MDGs progress, showed less than 45% of the target was met (weak). Also, the country's level of progress at ensuring environmental sustainability was reported as fair as 45-59% of targets was met. These shortcomings were adduced to the late commencement of MDGs in Nigeria in 2005 despite committing to it in 2000. With these shortcomings acknowledged, Nigeria transitioned into the SDGs as a continuation of MDGs and one of the ways she has demonstrated her commitment is through the Agricultural transformation agenda (ATA). It encourages farmers to increase agricultural productivity using sustainable practices (SDGs Nigeria, 2017).

BOX 2.1

The Millennium development goals (2000-2015)

Goal 1: To eradicate extreme poverty and hunger
Goal 2: To achieve universal primary education
Goal 3: To promote gender equality and empower women
Goal 4:To reduce child mortality
Goal 5: To improve maternal health
Goal 6: To combat HIV/AIDS, malaria, and other diseases
Goal 7: To ensure environmental sustainability
Goal 8: Develop a global partnership for development.

BOX 2.2

The Sustainable development goals (2015-2030)

Goal 1: No Poverty
Goal 2: Zero Hunger
Goal 3: Good Health and Well-being
Goal 4: Quality Education
Goal 5: Gender Equality
Goal 6: Clean Water and Sanitation
Goal 7: Affordable and Clean Energy
Goal 8: Decent Work and Economic Growth
Goal 9: Industry, Innovation and Infrastructure Goal
Goal 10: Reduced Inequality
Goal 11: Sustainable Cities and Communities
Goal 12: Responsible Consumption and Production
Goal 13: Climate Action
Goal 14: Life Below Water
Goal 15: Life on Land
Goal 16: Peace and Justice Strong Institutions
Goal 17: Partnerships to achieve the Goal.

With the recent transition to SDGs in 2015 and early commencement in most countries like Nigeria, national and continental commitment towards achieving these goals by 2030 is being exercised through a national, regional, and continental framework. For instance, the African Union (AU) on a continental scale has a blueprint for transforming Africa called the Agenda 2063, which came into effect in May 2013 during the 50th Anniversary solemn declaration (Africa union, 2013). The Agenda involves a plan to transform Africa into a global powerhouse and deliver on its goal for sustainable development in the next 50 years. Among its goals are building environmentally sustainable and climate-resilient economies and communities for a prosperous Africa based on inclusive growth and sustainable development through modern agriculture for increased proactivity and production that can radically transform African agriculture to feed the continent and become a significant player in food export. To achieve this, the Comprehensive African Agricultural Development Programme (CAADP) is one of the continental frameworks under Agenda 2063 that is designed to assist African countries to eliminate hunger and reduce poverty by raising economic growth through agriculture-led development as well as promoting increased national budget provision to the agriculture sector. CAADP also sets targets for reducing poverty and malnutrition, which will increase productivity and farm incomes, and for improvements in the sustainability of agricultural production and use of natural resources (Benin, 2016).

With the importance of food security crucial to the success of SDGs, pesticides in UA as a means to ensuring food security becomes an impediment. In this thesis, pesticides are conceptualised as having implications for sustainable development goals 1, 2, 3, 8, 11, 14 and 15 (see table 2.1) and are directly related to the objectives of this study. These are no poverty, zero hunger, good health and well-being, decent work and economic growth, sustainable cities and communities, life below water and life on land (SDGs, 2015). If there is no food security, poverty and zero hunger cannot be achieved;
good health and well-being are dependent on enough food, and only healthy people can work and contribute to economic growth. However, food produced with pesticides under bad agricultural practices contaminates the environment, leads to food poisoning, an unproductive workforce due to health-related issues and reduced economic growth. To promote sustainable urban areas and its communities (goal 11), the food security challenge as a result of rapid urbanisation needs to be evaluated within the purview of sustainable agriculture practice (goal 2).

Table 2.1: Impact of pesticides on SDGs 2030

Sustainable Development Goals (SDGs)	**Dimension of sustainable development**	**Impact of urban agriculture with pesticide use**	**Potential contribution of urban agriculture to sustainable development without pesticides**
Goal 1: End poverty in all its forms everywhere	Social dimension	Pesticide use in UA, especially with misuse leads to contamination of soil and water (environment), cause pesticide poisoning from residue in food (social). These contradicts the goals of ending poverty when food produced with pesticide is unwholesome.	Urban agriculture potentially contributes to food security even though the impact maybe small by making significant contributions to the urban nutrition, movement against hunger and poverty through self-reliance and improved livelihoods (Ferreira *et al*., 2018).Many urban dwellers (up to 70 percent of urban households) now engage in farming activities to meet their food needs which is a precursor to eradicating poverty (Zezza Tasciotti, 2010).
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Socialand environmental dimension		
Goal 3: Ensure healthy lives and promote well- being for all at all ages	Social dimension	The use of pesticides in UA leads to increased food poisoning from residues (Meharg, 2016), danger of pesticide inhalation.	UA potentially contributes to the nutrition of urban household (Boeing *et al*., 2012) through access to fresh produce such as vegetables and other highly perishables and thereby ensure healthy lives and well-being (Joye, 2007; Ulrich, 2006),
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Economic dimension	Its long-term impact on human health, animals and environment will lead to a decline in productivity. For example, pesticide resistance leads to more outbreak and reduced productivity.	UA contributes to livelihoods in Africa by improving income amongst poor households (Bryld, 2003; Thornton, 2008, Zezza and Tasciotti, 2010) and allows for an integration of multiple land use (Lovell, 2010).
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Social, economic and environmental dimensions	The presence of pesticides in the environment has been recorded to be an impediment to these services such as their impacts on wildlife and marine organisms. This makes city living	Several benefits of UA include the provision of ecosystem services (Armstrong, 2009; de Zeeuw *et al*., 2011), and fixation of atmospheric nitrogen and carbon (Herridge *et al*., 2008; Beniston & Lal, 2012); moderating air temperature (Susca *et al*., 2011; Qiu *et al*., 2013); regulation of local microclimate and hydrology (Oberndorfer *et al*., 2007); improving the quality of cities (Frumkin, 2003; Turner *et al*., 2004).
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Environmental and economic dimension		
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Environmental dimension		

2.2.4 Sustainable Agriculture

Sustainable development is achievable when modern societies promote agricultural practices that is required to meet our present and future nutritional requirements whilst ensuring protection of our environment and growth of the economy. According to the definition by the United States Farm bill (1990) in Velten *et al.* (2015), sustainable agriculture is an:

"integrated system of plant and animal production practices having a site specific application that will, over the long term: (a) satisfy human food and fiber needs; (b) enhance environmental quality; (c) make efficient use of non-renewable resources and on-farm resources and integrate appropriate natural biological cycles and controls; (d) sustain the economic viability of farm operations; and (e) enhance the quality of life for farmers and society as a whole."

In Lehman *et al*. (1993), it was simply defined as agriculture that is economically viable and meet people's need for safe and wholesome food, while conserving and enhancing the natural resources and quality of the environment. These definitions and several others such as MacRae *et al* (1989) and Pretty (1997), are all built around the concept of sustainability/SD discussed in earlier sections of this chapter. However, conventional agricultural practices that rely on inputs such as pesticides which on the long-term do not only negatively impact the environment through contamination and pollution but also affect the wellbeing of farmers and society and diminishing economic viability of the industry to contribute to livelihoods. These conflict with sustainable agriculture principles and therefore, the use of pesticides is not suitable in the goal of promoting sustainable development (Kiraly, 1996). UA has been proposed as a potential sustainable agriculture practice given its many benefits to the urban ecosystem (section 2.3.4), but its use of pesticide has been recorded which conflicts with the principle of sustainable agriculture.

However, according to McDougall *et al*. (2019), this issue could be mitigated through several interventions.

2.2.5 The food security challenge

The challenge to produce food towards the eradication of poverty in an environmentally and socially sustainable way while ensuring economic prosperity is crucial to meeting the sustainable development (SDGs, 2015). Food security, a significant element of development, is a goal of international, continental, and national governments. Internationally, world leaders are committed to eradicating hunger and achieving food security by the year 2030 through its sustainable development goals (SDGs) program. On a continental scale, Africa's Agenda 2063 is aligned to SDGs to eradicate poverty on the continent while national programs such as Agricultural transformation agenda (ATA) in Nigeria revolves around employment generation, food security and poverty reduction. These programs and policies highlight the importance attached to food security as a foundation for SD (Brooks, 2016). Though most food production practices appear to be beneficial, they are not environmentally sustainable with subsequent effect on social and economic sustainability. This challenge is prominent in low and middle countries such as Nigeria where pesticides are continued to be used in protecting crops and animals (Leon, 2008). Therefore, this section explains the food security challenge in an urban ecosystem within the context of the three dimensions of SD as a pathway towards meeting the SDGs in a developing country such as Nigeria.

According to the World Food Summit (WFS) in 1996, food security was described as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious foods that meets their dietary needs and food preferences for a healthy life" (Barrett, 2010). It is also described as secure access by households and individuals to nutritionally adequate food, which is procured by conforming to human aspirations and dignity. These definitions address multiple components of food security in terms of availability, access, utilisation and stability (Clay, 2002) as it is an essential component of social welfare and development which must be safeguarded and sustained by the world, nations, districts, villages, households and individuals (Dijk and Meijerink, 2014). This means that to individuals and families, nutritionally adequate food must be readily available, secured and consumed while conforming to human rights to dignity. This summation shows a direct relationship between sustainable development and achieving food security because food security cannot be classified as sustainable if pesticides are being relied on to boost agricultural productivity.

The key phrase in defining food security is 'secured access to food', which according to Maslow's hierarchy of need is a basic physiological need (Wahba and Bridwell, 1976; Lester, 1990) and pivotal to a healthy population required to drive a sustainable society. However, despite continued efforts by international institutions and national governments to ensure food security, it remains a challenge, especially in developing countries, which include the majority of African countries. This challenge is exacerbated by factors which include poor infrastructure, global climate change, poor agricultural systems, and lack of political will. Low-income urban residents amongst other groups of people has been cited to be vulnerable food insecurity. According to the food and agriculture organisation (FAO) statistics in 2015, an estimate of about 815 million people of the 7.6 billion people in the world (10.7%) were suffering from chronic undernourishment. Almost all the hungry people live in lower-middle-income countries within Africa, with only 11 million people undernourished in developed countries (FAO 2015).

The current food security challenge, especially in developing countries and the least developed countries, has become heightened with climate change (IIED, 2013). Climate change has influenced the distribution and persistence of crop pests and their natural enemies (Shabani *et al*., 2018) despite the use of pesticides. The consequences that are associated with this is seen in massive agricultural losses to insect pests (Hari, Sharma and

Prabhakar, 2014) as a result of frequent pest outbreaks. The food security challenge for both rural and urban residents is also exacerbated by low agricultural production arising from rural-urban migration. Within the scope of this study, urban food insecurity is also as a result of the high rate of urban poverty brought about by rising urban growth, especially in developing countries such as Nigeria. This is because most urban dwellers are consumers and barely survive on low or insufficient income that characterises the urban poor. In Sub-Sahara Africa, food insecurity linked to prevalence of undernourishment is around 21.35% of the total population while Nigeria is around 13.4% (FAO, 2017). Figure 2.1 shows Africa's proportion of undernourishment as at 2017 is 21.35%, lower by 6.14% as compared to 2000 while Nigeria has been experiencing a sharp rise in food insecurity since 2007. This food security challenge results in poverty, a major social problem and has been described by Baer *et al*. (2015) and Roncarolo & Potvin (2016) as a precursor for ill health and therefore, a need to classify it as a significant public health problem.

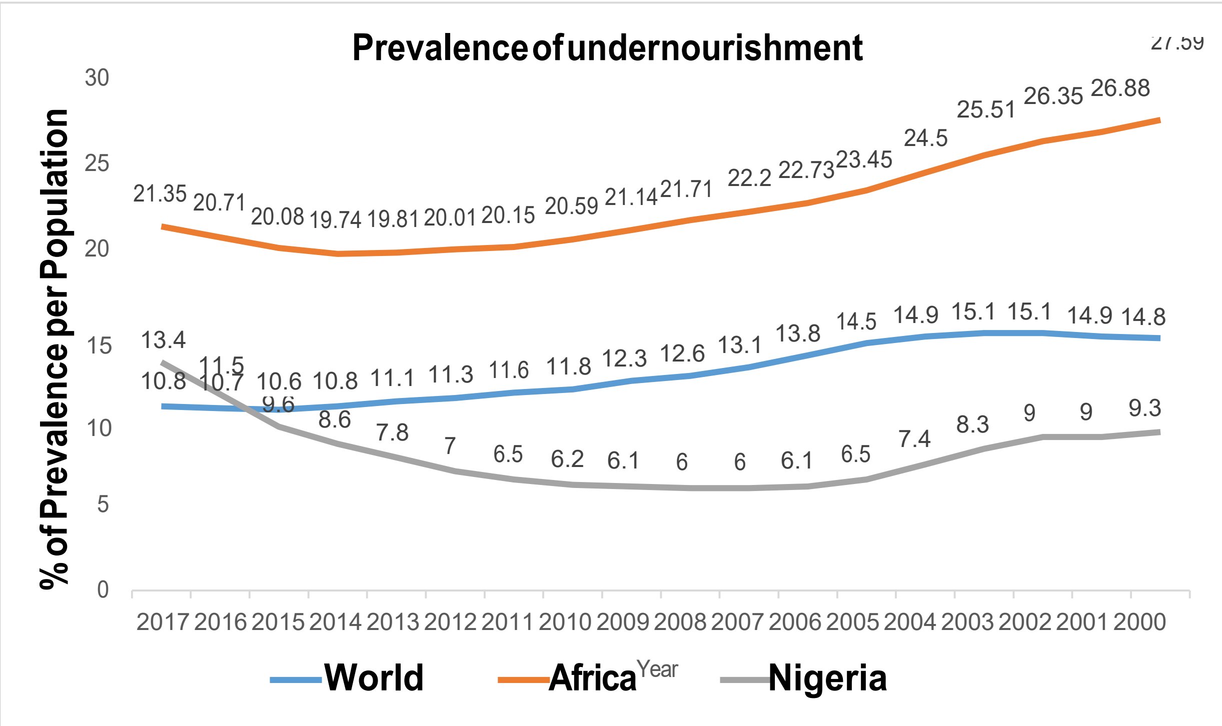


Figure 2.1: Prevalence of food undernourishment as an indicator of food insecurity (*Data sourced from Worldbank data)*

According to the United Nations report on the sustainable development goals, a high proportion of the over 795 million hungry people in the world live in developing countries (UN, 2015). This is an indication of a large population in great need which becomes alarming because one-quarter of the developing countries' population lives in urban areas (Zezza and Taciotti, 2010), meaning urban areas harbour the highest number of the world poorest. This problem becomes more important and goal-oriented in light of world leaders' commitment to achieving zero hunger by the year 2030 (SDGs, 2015) and a possible driver for pesticide use.

2.2.6 The urban ecosystem

An urban ecosystem is a component of the ecosystem, a broad term used in defining the spatial extent of the total natural environment (Francis and Chadwick, 2013) at different levels of biological organization, organisms and communities (Rebele, 1994). An understanding of the different spatial degrees to which an ecosystem can exist allows for describing the urban ecosystem as a component of the ecosystem, which includes the natural environment, the built environment and the socio-economic environment (Clark, 2009), where living things interact with non-living things within an urban landscape.

Though a sub-set of the ecosystem, the urban ecosystem is different from other ecosystems as it is characterised by the hybridisation of natural and human-made elements (examples include rivers, lakes, the species that live in them, the assemblages, buildings, walls, roads, parks and gardens (Francis and Chadwick, 2013). These interactions are not only being driven by the natural environment, but also by culture, personal behaviour, politics, economics and social organisation (Hernandez and Blazer, 2006; Kinzig *et al*., 2013). This suggests that urban ecosystem components are connected entities with direct and indirect impacts on immediate (local) and wider environments (the totality of the ecosystem).

With urban ecosystem continuing to be the centres and drivers of commercial, scientific, political and cultural life, with far-reaching influence on countries as a whole (Leon, 2008), they create opportunities for economic and social development and therefore make them important for economic growth, innovation, and employment (Cohen, 2006). These opportunities in the urban ecosystem have the added benefits of more jobs and potentially higher wages and created a pull effect that led to the rapid urbanisation of the urban ecosystem. This rapid urbanisation is accompanied by urban poverty and increasing food challenge in many African cities, such as Nigeria, especially where the infrastructure to accommodate this growth is lacking. The following section narrows down to urbanisation as a predicate to urban food security crisis and urban poverty. These two components are identified as a driver for pesticide use in pesticides in urban agriculture.

2.2.7 Urbanization

Urbanization and city growth are driven by several pull factors such as rural-urban migration, natural population increase, and annexation (Cohen, 2006). For the scope of this study, rural-urban is explored in line with its direct influence on rising urban poverty and food insecurity. Demographically, urbanisation is defined as the increase in the proportion of a nation's population living in urban areas (Satterthwaite *et al*., 2010; McGranahan & Satterthwaite ,2014). In other words, urbanization is a direct consequence of people moving away from a rural area. Owing to this mass migration, the population of people living in towns and cities in the developing world are growing rapidly.

Urban areas are defined by population size, which varies from country to country. Nigeria, for example, adopts a threshold population of 20,000 people as a criterion for defining an urban centre (Sunday and Ajewole, 2006; Ofem, 2012) while Ghana statistically define an urban centre as any settlement with a population of 5,000 or more people (Songsore, 2003 and Engstrom *et al*., 2013). The Republic of Benin classifies areas with 10,000 residents and more as urban while other African countries like Angola and Ethiopia has a benchmark of 2000 people to define urban areas. These disparities are to be considered when comparing urban agriculture practices and characteristics amongst countries because of locational and criterion differences.

As of 2017, the current world population of 7.6 billion was estimated to reach 8.6 billion and 9.8 billion in 2030 and 2050, respectively (UN DESA, 2017). Several studies have pointed out that the world will require between 70-100% more food by the year 2050 (Godfray *et al*., 2010 and Rayfuse & Weisfelt, 2012). This huge population explosion, alongside the significant food security challenges that may arise, places more burden on more developing countries such as Nigeria. Among the ten largest population in the world, Nigeria is the one experiencing the most rapid growth, has a projection of surpassing that of the United States in 2050, and will subsequently become the 3rd largest country in the world (UN DESA, 2017). With this kind of rapid growth, UA will help alleviate the burden of food insecurity that has been a threat owing to the stagnancy experienced in rural population growth which has traditionally been the primary producers (United Nations, 2008).

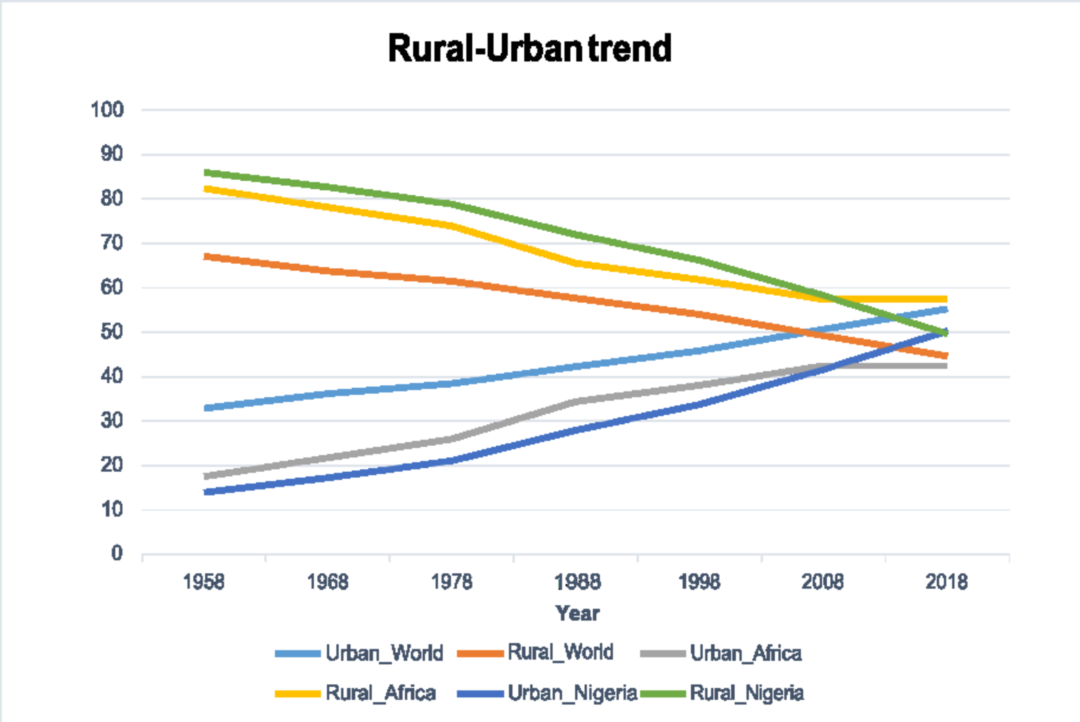


Figure 2.2: Rural-Urban trends across the World, Africa and Nigeria

Data sourced from United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision

2.2.8 The urban challenge

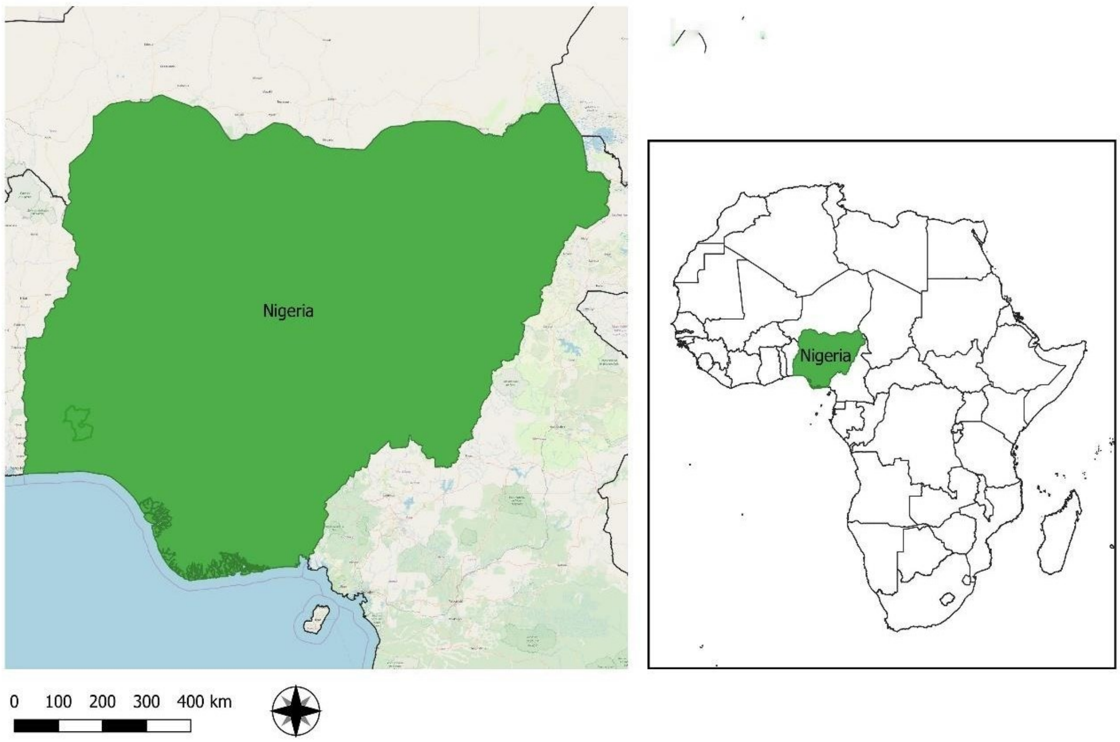
Following decades of a continuous increase in the proportion of the global population living in urban areas, the urban population was reported to have exceeded the rural population in 2008 (FAO, 2009). This led to an unprecedentedly high number of people living in large cities (Henderson, 2002), with the growth predicted to continue as FAO (2009) estimates 60 per cent of the world's population will be living in cities by 2030. This alarming rise in urban population, especially in developing countries like Nigeria and majority of her African neighbours, presents its unique challenges such as an increase in urban poverty and food insecurity as the bulk of the urban poor cannot afford the rising cost of food commodities.

Conceivably, this urban challenge is exacerbated by migration of rural agricultural households to cities, thereby leading to a shortage of farm labours and a subsequent reduction in agricultural productivity (Pendleton, Crush and Nickanor, 2014). This influx of people into the cities to pursue other activities aside from agriculture that could enhance their wages (Henderson, 2003; Goldsmith, Gunjal and Ndarishinkanye, 2004) skewed the scale of the balance of economically active population towards industry and services (Satterthwaite, McGranahan and Tacoli, 2010). Subsequently, there is an increased abandonment of farmland, a return to subsistence farming and a shortage of agricultural production from rural areas to feed the ever-increasing urban population (Qian *et al*., 2016).

The population of Nigeria in 2016 stood at 186 million people (UN DATA, 2015) out of which nearly 50% live in urban centres which are similar to the trend in Cameroon with more than 70% of its population expected to live in the cities by 2030 (De Bon, Parrot and Moustier, 2010). The country (Fig. 2. 2) is administratively divided into 36 states alongside the Federal Capital Territory, Abuja. The states are divided into 774 local government areas which imply there are only 774 urban centres' (since legally; the headquarters of these local government areas are established urban centres) in a nation of 186 million people. For Nigeria, the criterion for defining urban centres is ambiguous given that towns in rural areas of the country have a population size far higher than the threshold of 20,000 people provided for urban centres (Mabogunje, 1990 and Ofem, 2012). Nigeria also has five of the 30 largest urban settlements on the continent which include Lagos, Kano and Ibadan, with population figures of 13, 904, 000; 3, 906, 000 and 3, 464, 000 million respectively (POPSTAT, 2019).

2.3 Urban agriculture

With annual global population growth rate reported as 1.10% in 2018 (World bank data, 2018), world population increased from the 6.1 billion in 2000 to 7.7 billion in 2019 (UN WPP, 2019), UA presents an opportunity for a rapidly increasing population like Nigeria to increase/augment food supply and accessibility, which in turn improves health conditions,



boost local economy and encourage social integration. UA, in playing its role to augment

Figure 2. 3: Map of Nigeria

food security, especially for the urban population, use pesticides as part of its agricultural inputs, and therefore unintentionally contribute to environmental problems which have impacts on long-term food security, economy and people.

The state of food security, especially for the low-income group in urban areas has led to a renewed awareness and practice of UA to meet the dietary requirements of this population subset. The two-decades-old global statistics that are still used to highlight the number of people involved in UA is the 800 million figures estimated by Smit *et al*., (2001) in 1996 UNDP report and cited by many urban researchers (Redwood 2008, Lee-Smith 2010, Mougeot 2005 & 2011, Duchenim). Not only does this figure described the total population engaged in UA as at 1996 when the figure was established, but it also includes the 200 million people who are market producers and a labour force of 150 million (UNDP, 1996). However, with the continued increase in urban population, and a subsequent increase in UA practitioners, the figure would have increased exponentially.

2.3.1 Defining urban agriculture

Despite variations in defining UA or UPA according to the SLU Global Report of 2014, its definition keeps evolving to reflect the context in which it is discussed. Therefore, several definitions will be explored in this section to situate one that best describes the scope of this study. The term Urban Agriculture has been used interchangeably in different kinds of literature with Urban and Peri-Urban Agriculture (UPA) and Urban and Peri-Urban Agriculture and Forestry (UPAF), with all fundamentally referring to the same thing – the cultivation of productive plants and animals in and around cities (Mougeot, 2000). However, for the sake of consistent, the term Urban Agriculture will be used in this thesis.

Smit *et al*. (1996, p3 and 2001: p 1) defined UA as 'an industry that produces, processes and markets food and fuel, largely in response to the daily demands of consumers within a town, city, or metropolis, on many types of privately and publicly held land and water bodies found throughout intra-urban and peri-urban area, applying intensive production methods, using and reusing natural resources and urban wastes to yield a diverse array of land, water, and air-based fauna and flora, contributing to the food security, health, livelihood, and environment of the individual, household and community'. A simplified yet comprehensive definition was also given by Guendel (2002) as agricultural (including livestock) production, and processing and distribution activities within and around cities and towns, with the main motivation being personal consumption and income generation, and which competes for scarce urban resources of land, water, energy, and labour that are in demand for other urban activities.

These definitions show that UA offers a wide-ranging benefit which includes; contribution of significant amounts to the proportion of food consumed in the city; crisis management when markets are not working; strategy to overcome cash shortages or even for commercial purposes; as well as improving food security and nutrition, and creating employment for the jobless (Lynch *et al*., 2001 and Pasquini, 2006). Food production and income generation, as highlighted in the definition of UA, shows its important role in meeting the goals of the social and economic dimensions of sustainability. UA, according to Mougeot (2000) is characteristically different from rural agriculture because of how it is integrated into the urban economic and ecological system. This is because UA is agricultural production, regardless of where it is being practised, has its very own set of problems such as pest and disease infestation, UA, therefore, relies on the intensive use of pesticides to increase food production for the teeming urban population and cut losses accruing from pest and disease attack (Carvalho, 2007).

The first working definition was 'food and fuel grown within a city or peri-urban area, produced directly for the market or home consumption and frequently marketed by the farmers themselves or their close associates'. The definition emphasises UA role in producing food is mainly for local consumption, and there is the direct involvement of farmers themselves. As at the time Smit *et al*. presented this definition, UA was only seen as a means to augment agricultural production, which is heavily reliant on rural agriculture. It can, therefore, be said that UA was initiated to enhance food security which is central to its definition. Armar-Klemasu (2000) referred to UA as agriculture practices, formal or informal, within and around cities, which raises, processes, and distributes food from fisheries, horticulture and livestock. This definition by Armar-Klemasu (2000) makes UA accessible to all categories of farmers, especially with the formal and informal labels.

The main function of UA reflected in its several definitions revolve around the provision of one of the three basic human needs- food and income generation. These two provisions; food and income generation matches some social and economic objectives of sustainability. However, in the bid for UA to meet its social and economic objectives, its increasing reliance on pesticides coupled with lack of good agricultural practices has necessitated the need to shed more light on this developmental phenomenon. According to Nilsson *et al*. (2013), establishing multiple perspectives on the inter-relationship among well-being, profit and environment will help in attaining the long-term goal of sustainability. Mok *et al*., 2014 and Goldstein *et al*., 2016 in their papers also cautioned that food production should not be realised at the expense of the environment and that consequences of this practice need to be recognised and dealt with.

2.3.2 Urban agriculture: global context

In the year 1996, Smit *et al*. in its UNDP (1996) report made a conservative estimate of 800 million UA practitioners, with 200 million of this number producing food for the urban market, thus providing 15-20 per cent of the world's food supply. Surely, this amount has grown considerably since then, as urban agriculture is increasing in cities in developed as well as in developing countries (Van Veenhuizen, 2006; Corbould, 2013; Dieleman 2016). Today it is practised in almost all parts of the world. In Hanoi, Vietnam, 80 per cent of fresh vegetables and 40 per cent of eggs are produced by urban and peri-urban agriculture. In Ghana's capital Accra, around 90 per cent of all the fresh vegetables consumed are coming from production within the city (Corbould, 2013). To assess the state of urban and peri-urban agriculture in Latin America and the Caribbean, the UN Food and Agriculture Organization

(FAO) conducted a survey in 2013 in 23 countries in that region, concluding that urban agriculture is widespread.

It is practised, for example, by 40 per cent of households in Cuba, and by 20 per cent of the households in Guatemala while in 16 of the 23 countries surveyed; people earned some income from this activity (FAO, 2014). In North America, UA initially developed as a response to poverty created by economic depression and war. During the economic depression of the late 19th century, the mayor of Detroit stimulated the unemployed to use vacant lots to grow their vegetables and potatoes. The city invested $3000 in the program and realised already in the first year a harvest worth of $12,000. Over several years, thousands of families participated in the urban gardening program in both Detroit and Buffalo, and the initiative set the stage for urban agriculture in difficult times ever since, such as during World Wars I and II (Duran *et al*., 2005; Dieleman, 2016). During World War I, the US Department of Agriculture formed a committee to help plant a million new backyard and vacant lot gardens, so-called victory gardens as they were supposed to contribute to winning the war (Tucker, 1993; Dieleman 2016). The nineteen-sixties of the previous century saw the birth of community gardens that consist of small lots for family use on pieces of land that were either public property or privately owned and managed in collective ways. Even though UA as a concept, is portrayed as having no adverse effects on the environment, but some of its practices relating to pesticide use suggest the opposite. Urban agriculture has become the new solution to food security, and hence, it is crucial to assess the impacts that could arise from this 'new developmental project'.

2.3.3 Urban Agriculture: Nigeria

Nigeria, the most populous African country, with a population of 195.9 million people (UNFPA, 2018), was once included as one of the six fastest-growing countries in the world (World Bank, 2012). It currently has a population growth rate estimated at 2.6 per cent per annum between 2010 and 2018 (UNFPA, 2018). Despite that agriculture is the base of the Nigerian economy that provides a means of livelihood for majority of its teeming population (FAO1), the increasingly growing population brings about its own attendant problems of urban poverty (Baharoglu and Kessides, 2002) and food insecurity because food production increases do not commensurate with population growth (FMARD, 2016).

The country has thirty-six states including the federal capital territory Abuja. The country is administratively divided into 36 states alongside the Federal Capital Territory, Abuja. The states are further divided into 774 local government areas which imply there are only 774 urban centres' (since legally; the headquarters of these local government areas are established urban centres) in a nation of 186 million people. For Nigeria, the criterion for defining urban centres is ambiguous given that towns in rural areas of the country have a population size far higher than the threshold of 20,000 people provided for urban centres (Mabogunje, 1990 and Ofem, 2012). Nigeria also has five of the 30 largest urban settlements on the continent, including Ibadan, and is estimated to have the biggest urban population on the continent.

Nigeria like most developing countries are net food buyers (FAO, 2008) and because of its population size and developmental challenges, has always sought to achieve food security by creating policies such as operation feed the nation, adopting global programmes aimed at reducing poverty and hunger such as sustainable development goals (SDGs), enabling agricultural programmes such as FADAMA and exploring new agricultural concepts that promote food security such as urban agriculture. Examples of past programmes include Farm Settlement Scheme (FSS), National Accelerated Food Production Programme (NAFPP), Operation Feed the Nation (OFN) and the, (Iwuchukwu and Igbokwe, 2012) which were aimed at increasing food production as well as bringing about economic and national development, among other objectives (Agber *et al*., 2013). Present policies to achieve food security include the Country programming framework for Nigeria and National Fadama Development Project as supported by food and agricultural organisation (FAO, 2019) and World Bank. Most of these programmes encouraged the use of inputs such as fertilisers and pesticides (Agber *et al*., 2013).

Among these many concepts, tools and policies, urban agriculture, a fairly new concept, which is informally adopted mainly as a strategy for achieving food security (Adedeji and Ademiluyi, 2009; Samuel *et al*. 2012) in a developing country such as Nigeria. With 47.8% of Nigeria population living in cities (UNDATA, 2015), 70% of total population (both urban and rural) live below the poverty line due to the high rate of urbanisation (Wahab, *et al*, 2018), weakened purchasing power, high incidence of poverty, retrenchments in public and private sector and high unemployment rate. Furthermore, a high percentage of income (an average of 50-80%) is spent on food (NBS, 2006), UA has become a popular option for most urban dwellers to produce their food. It is therefore not surprising that most UA practitioners in Nigeria prioritise vegetable cultivation and highly perishable crops for consumption and as a source of income (FAO, 2010). Urban agriculture in Nigeria is practised either in an open-space area, mostly undeveloped lands and Government-owned lands or subsistence gardening in backyards of high-value products (Dreschel &Dongus 2009). According to Adelekan *et al* (2014), UA in Ibadan city is practised by people from different socio-demographic groups with vegetables, cereal, and root crops as predominant crops.

According to Cohen and Garrett (2010), about 20 million households in West Africa provides 60–100 per cent of their cities' fresh vegetables. In Nigeria for instance, the demand for a variety of vegetables such as lettuce, cabbage, and carrots, by the expatriate community largely based in Lagos and Ibadan, has influenced the practice of UA as a commercial enterprise (Cofie, 2009). In Ibadan, two-thirds of urban farmers also over half of their produce within the city and its neighbours. This is the same in many African cities such as Dakar and Banjul, where 60% and 80% of vegetables, are supplied through urban agriculture. Similarly, in Accra, Ghana, urban farmers produce much of Accra’s fresh vegetables for the wealthy population (Appeaning-Addo, 2010). Also, vegetables and fruits from urban agriculture are important commodities of export in some cities, such as Lome (Cofie, 2009). Most African diasporans in developed countries such as the UK have been estimated to spend £1 million daily on fresh fruits and vegetables from Africa (MacGregor and Vorley, 2006).

To sustain this huge demand for vegetables, most urban farmers rely heavily on pesticide use to protect their crops from pest and diseases. This move has been reported to be an anticipatory and precautionary method of protecting their crops and livestock as lots of farmers borrow to finance these ventures. As pests and diseases are unwanted development in farmer's quest to maximise profits, pesticides are necessary to maintain and sustain production. Intensification of farming year in year out to meet the rising demand for farm products is also an invitation to pest infestation.

Though UA is not formally recognised by policy makers (Egbuna, 2007), the rise in the number of UA practitioners in Nigeria major cities such as Lagos, Kano, Ibadan and Abuja, policy shows the appreciation the populace has for it in alleviating poverty and reducing food insecurity. Nigerian agriculture has always been rural-based, but because of the downward shift in rural population as a result of mass migration to the city, it comes with a downside for the nation's agriculture sector through the loss of manpower. Even though the manpower for rural agriculture has declined, the report provided by Central Bank of Nigeria (CBN) in 2012 showed the country's agricultural sector contributed about 42% tothe GDP and remained the highest employer of labour with about 60% of the working population. This shows how significant agriculture is in Nigeria, especially with its contribution to the three dimensions of sustainable development, namely: economy, society, and environment.

2.3.4 Benefits of UA

Within the context of food security and sustainability, urban agriculture (UA) has long been recognised for the role that it plays like an urban survival strategy in cities (Van Veenhuizen, 2006). Urban Agricultural activities are diverse as it includes the cultivation of vegetables, medicinal plants, herbs, spices, mushrooms, fruit trees, ornamental plants, and other productive plants, as well as the keeping of livestock for eggs, milk, meat, wool, and other products (Lovell, 2010). All these make it benefits far-reaching one which includes a role in supplementing the domestic food budget, in helping to ensure food security, and serving as a source of income by encouraging livelihood diversification (Altieri *et al*., 1999; Mougeot, 2000; Asomani-Boateng, 2001; Hubbard and Onumah, 2001; Zezza and Tasciotti, 2010; Smart *et al*., 2015).

With the adoption of UA, its potential for increasing household income was realised by its practitioners, and most of them appreciated UA as an enterprise that could improve their finances and hence, reduce poverty. This is evident in the amplified definition by Guendel (2002) and Van Veenhuizen (2007) which defined UA as agricultural (including livestock) production, and processing and distribution activities within and around cities and towns, with the main motivation being personal consumption and income generation, and which competes for scarce urban resources of land, water, energy and labour that are in demand for other urban activities. This definition is similar to that provided by Hovorka *et al*. (2009) which is the production of foods (such as, vegetables, fruits, meat, eggs, milk, fish and non- food items such as fuel, herbs, ornamental plants, tree seedlings, flowers) within the urban area and its periphery; for home consumption and the urban market, and related small-scale processing and marketing activities.

UA contributes to food security and nutrition by providing food for family self- consumption, thus contributing to a healthy diet and allowing for saving on food expenditures. Evidence suggests that urban agriculture can make a significant contribution to ensuring food security, particularly amongst poor households, as well as providing work in situations where there are high rates of unemployment (Smart *et al*., 2015). It is clear that the main role played by UA is enhancing food security. According to van Veenhuizen's (2007) description, UA plays a complementary role in rural agriculture, but its practice has continued to expand. This expansion could be attributed to continued rural-urban migration (Tacoli *et al*., 2015) and its adaptability and mobility compared with rural agriculture (Ademiluyi and Adedeji, 2009). This is evident in the scale at which it is practised in both developing and in the industrialised countries (Gbadegesin, 1999; Mlozi, 1997).

Urban agriculture also developed as a means of reducing seasonal gaps in fresh foods for urban dwellers (Mougeot, 2000 and Egal, Valstar and Meershoek, 2001). Food availability is particularly important for fresh foods such as horticultural plants, fruits, eggs, milk and poultry, which can be in the street, markets or local stores. These products are also produced for home consumption, for example, green leaves (Salau and Attah 2012). Also, staple foods such as maize, cocoyam and sweet potato are produced in many towns for home consumption (Foeken, 2006). According to Salau and Attah (2012), urban agriculture (UA) is said to have become a recent issue, with increasing popularity, most notably in developing economies such as Nigeria because it is valued as a viable intervention strategy to combat poverty. According to Jacobi *et al*. (2000), It is described as a response to food crisis and a coping strategy for the poor UA is a practice widely used in the past and is still in common use in many urban areas around the globe with it making substantial contributions to the food produced in many cities of the world but with the rapid growth of urban population and food insecurity, there is a motivation to use pesticides to enhance food security.

Aside documented evidence that UA is undertaken by farmers for three reasons: cash (mainly vegetables and livestock); food subsistence (including savings on food expenditure); and as a survival or risk buffering strategy (e.g. Armar-Klemesu & Maxwell, 2000; Nugent, 2001), UA can play a role in environmental conservation, since energy can be saved by reducing the distance between the points of production and consumption and thereby increase savings on storage and transport (Adedeji & Ademiluyi, 2009). This also increases the amount of food available and enhances the freshness of perishable foods reaching urban consumers.

Urban agriculture is also reported to contribute directly towards improving the urban environment by improving the micro-climate, CO2 balance and biodiversity within cities, by preventing erosion and flooding through planting bare lands and steep slopes (disaster mitigation) and by using urban (organic) wastes (solid waste and waste water) as a productive resource (Adedeji and Ademiluyi, 2009; Dubbeling *et al*., 2019). In a study conducted by Adedeji and Ademiluyi (2009), they opined that UA does require higher technological and organisational precision than rural agriculture. Risks are technically manageable and depend on cities making better use of prevention and mitigating measures. UA is said to have grown in recent years compared to rural agriculture, part of the reason ascribed to this growth in UA is its adaptability and mobility compared with rural agriculture (Ademiluyi and Adedeji, 2009).

Furthermore, UA has had a lot of impact on the standard of living and economic life of the masses by contributing to poverty reduction (Ntow, 2013). Urban agriculture is used as a strategy by many urban dwellers to improve their livelihoods and overall well-being (SLU Global Report, 2014). Despite many technological and mechanical improvements in food production, hunger and malnutrition remain central issues as poverty continues to be prevalent in many cities around the world, a report by FAO in 2012 estimated 40% of urban inhabitants live on less than US$1 a day including Nigeria, while simultaneously 70% are living on US$2 a day. Similarly, impoverished urban households are estimated to spend 60–80 per cent of incomes on food, making them more vulnerable to food price volatility (Baiphethi & Jacobs, 2009; Cohen & Garrett, 2010; SLU Global Report, 2014).

Although UA in developed countries is adopted more as a social tool to provide measurable improvements to human health and wellbeing (Joye, 2007; Ulrich, 2006) by connecting urban residents with natural systems from which they have been separated (McClintock, 2010; Turner, 2011), the overall selling points for UA in a developing country as Nigeria is the suggestion that it can help alleviate poverty (van Veenhuizen & Danso, 2007; Zezza & Tasciotti, 2010), increase market resilience to fluctuations and climate change (de Zeeuw *et al*., 2011) and serve as a source of agricultural knowledge (Koohafkan & Altieri, 2010), encourage new agricultural technologies (Despommier, 2010). Understanding the potential role UA has to play in alleviating poverty and improving the economic profile of small-scale farmers may contribute to our understanding of pesticide use, which when combined with poor agricultural practices and lack of infrastructure to assess and monitor these chemicals in Nigeria, may impact on the delivery of national and continental goals of food security.

2.4 Pesticides

With current trends and patterns showing a direct relationship between rising population, high rates of poverty and an enduring food crisis, the continued reliant on agro-inputs such as pesticides to increase food production and achieve food security amidst a rapidly- growing population, are being used in increasing amount (Gill and Garg, 2014). Though pesticides do not have a direct contribution to increased agricultural yield (Schreinemachers & Tipraqsa, 2012), they were encouraged as part of food production programmes geared towards intensification of agriculture such as Green revolution (GR) on a global scale and Operation Feed the Nation (OFN) in Nigeria on a national scale between the sixties to the turn of the 21st century (Conway and Barbier, 1988; Dhaliwal *et al*., 2010; Oliveira *et al*., 2014).

The continued use of these chemical inputs in present-day agricultural practices, however important their contribution to producing food for our growing population is, raise concerns about the prospects of agricultural sustainability because of their adverse effects on environmental services, human health and possible long-term impact on productivity (Pretty, 2007; Oliveira *et al*., 2014). This is because pesticide misuse and overuse, followed by pollution has increased (Pimentel, 2009; Zhang, 2019).

The Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) in the International code of conduct handbook on pesticide management (2014) defines pesticides as '*any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest, or regulating plant growth'*. Therefore, the purpose of pesticides is to destroy certain living organisms, as well as constituting a particular group of biocides that can reach a wide lethality. They are poisons which are intentionally released into the environment to control these pests. In Agriculture, their release is aimed at the destroying population of pests and weeds that affects or may affect agricultural productivity (Rother, 2011). Their use, however, comes at a cost to the environment, society and long-term economic prosperity.

The environmental cost of pesticide use includes the destruction of beneficial natural predators and parasites in both natural and agricultural ecosystems (Pimentel, 2005; Aktar *et al*., 2009). For instance, many predators and parasites species which help control plant- feeding arthropod populations are adversely affected by pesticides (Ruberson & Roberts, 2005). These natural beneficial species make it possible for ecosystems to remain "green". According to Hairston *et al*. (1960) and Pimentel (1988), parasites and predators help keep plant-feeding populations at low levels, with only a relatively small amount of plant biomass removed each growing season by arthropods. Aside its cost to the environment, pesticide poisoning result in long term health impacts like cancer, damage to reproductive organs, birth, and neurological defects and many others. Infertility, sterility, and stillbirth are some types of most common reproductive harms

(Zougmoré *et al.*, 2016). The human studies related to leukemia and lymphoma explain that pesticides are used in numerous treatments which as a result, cause some harms to human bodies which include brain cancer, and problems regarding breast and ovaries, prostate, and testes.

Since the mid-1940s, over 200 basic chemicals have been created for use in killing insects, weeds, rodents, and other organisms described in the modern vernacular as 'pests' (Balaram, 2003); and they are sold under several thousand different brand names. These agrochemicals (pesticides) are intensively used to maintain farm production with the advent of agricultural intensification. They have been recovered from most of the major river systems and streams of groundwater flowing unseen through the Earth (Veerle, 2008). Residues of these chemicals linger in the soil to which they may have been applied a dozen years before (Veerle, 2008).

Pesticides are classified according to their target organisms which include insecticides, fungicides, herbicides, rodenticides, and fumigants. Each of these class are further classified according to their chemical nature. For instance, insecticides which kills insect pests is further classified according to chemical type as Organochlorines, Organophosphates, Carbamate Esters, Pyrethroids and Botanical pesticides.

Organochlorine pesticides such as DDT, aldrin and dieldrin, lindane, parathion, now classified as persistent organic pollutants, were one of the earlier pesticides used in agriculture but banned because of their persistence in the environment and ability to accumulate in fatty tissues and increase in concentration and bioaccumulate in the food chain (Gavrilescu, 2005; Wang *et al.*, 2007). They have been found to contaminate most protein-sourced foods such as milk, animal fats, fish and eggs and heightened concerns about their carcinogenic effects in human health (WHO, 1999). These pesticides are extremely hazardous and can cause tremors and seizures.

They try to accumulate in the tissues and can enter the human body by food over which pesticides are used. Residues of organochlorine pesticides are even found in human breast milk.

The chemical properties of organochlorine pesticides such as low water and high fat solubility, stability to photo-oxidation and low vapour pressure are the main elements not only in the efficacy of these compounds as pesticides but also in their persistence in the environment. The Stockholm Convention established standards for the control and elimination of twelve Persistent Organic Pollutants (POPs), famously called the dirty dozen: eight of them are pesticides (Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Mirex and Toxaphene). Although the use of many types of organochlorine pesticides have been severely limited in many countries after the Stockholm Convention was agreed upon, they have been reported to be in use in several developing countries despite their residues having an impact on the ecosystem (Kim & Smith, 2001). According to Graziosi *et al.* (2017), some banned organochlorine pesticides were reported to have been found to be in use in some parts of California, USA. Also, a lot of farmers in developing countries like Nigeria still unofficially use these products in substantial amount despite its ban (Osibanjo, 2003). Several studies have reported their use by farmers in Nigeria (Nwankoala & Osibanjo, 1999; Osibanjo, 2003; Williams *et al*., 2016; Unyimadu *et al*., 2019) and in other developing countries such as Ghana (Ntow, 2001; Fosu-Mensah *et al*., 2016; Okoffo *et al*., 2016), Mexico (Rodriguez *et al*., 2014) and India (Aktar *et al*., 2009; Awathi & Awathi, 2019) because of their low cost, easy availability, their effectiveness as pest and vector control, and coupled with inadequate regulation and management on the trade and use of these chemicals (Wahab *et al*., 2018; Awathi & Awathi, 2019).

Organophosphate pesticides, though less persistent in the environment as compared to organochlorine pesticides, they have been reported to be far more toxic to both animals and humans (Aktar *et al*., 2009). They include Dimethoate, DDVP, Diazinon, Malathion, Parathion, Phosphamidon and Methamidophos. These insecticides are classified by the world health organization as highly hazardous with Parathion, Parathion methyl, Fenthion, Phosphamidon and Methamidophos included in the Rotterdam Convention's Prior Informed Consent (PIC) procedure (ECHA, 2012). The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides was adopted in 1998 and in similar fashion to the Stockholm convention, is intended to help prevent the unwanted import of extremely hazardous pesticides and other chemicals to developing countries. These organophosphates were developed as byproducts of nerve agents developed during World War II, containing neurotoxins that can attack the nervous system. Exposure to these chemicals has been reported to cause dizziness, vomiting, seizures, paralysis, loss of mental function, and death.

2.4.1 Pesticide use in Nigeria

Across the African continent, an estimated 50,000 tonnes of obsolete stockpiles of pesticides and seriously degraded soils are leaking into the environment, contaminating soil, water, air, and food sources. Having accumulated over the past 40 years, these persistent organic pollutants (POPs) and other pesticides pose serious threats to the health of both rural and urban populations, especially the poorest of the poor, and contribute to land and water degradation. Today, Chemicals formulated or produced in Nigeria are those for use in agriculture such as fertilizers and agro-chemicals and industrial chemicals like Sulphuric Acid, Alum, Linear Alkyl Benzene, Carbon Black etc.

POPs pesticides were used for pest control until the 1980s/1990s in food crops and export crops as well as malaria vector control. POPs pesticides are still available for sale in the informal market “under cover’’. The Nigerian Federal Ministry of Health indicated that aldrin, dieldrin, chlordane, DDT and endrin are POPs pesticides used for control of arthropods of medical and veterinary importance and their use was stopped in 2002.

The Nigerian experience from available research shows that major POPs contamination of air, soil and water arises basically from the use of pesticides. Pesticides use in Nigeria includes certain chemicals that for environmental reason have been partially or completely banned in developed countries. However, such chemicals continue to find their way into Nigeria for pest control mainly through illegal traffic. Of the nine POPs pesticides, only seven are known to have been used or are in use in Nigeria. Mirex has never been reported to have been used in Nigeria. The seven pesticides are Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor and Toxaphene. Aldrin and Dieldrin have widely been used as insecticides in cash crops protection such as cocoa, rubber and cotton. Heptachlor, Chlordane and Dieldrin have been used for termite control in many parts of Nigeria. However, the current general response by most stakeholders is that all POP substances are no longer in use in Nigeria but reports by some experts have revealed that Nigerian farmers still prefer some of these banned POPs because of their potency and relatively cheaper cost than their non-POPs alternatives. The most commonly used pesticide is Lindane (Gamma BHC) on Kola-nuts (cola nitida) for protection against kola-nut weevils (Balanogastris Kolae). It is also widely used by fishermen to kill fish for commercial purposes in Nigeria. Fenthion (an insecticide) is an effective avicide and is used mostly in northern part of Nigeria against bird pest. DDT and Gammalin-20 a rodenticide that has been outlawed but they are still illegally used in some parts of Nigeria.

The need to rely heavily on pesticides in Nigeria is partly driven by the need to achieve food self-sufficiency and sustained livelihoods through commercialisation of agricultural produce to consolidate the nation's economy. Once a mainstay of the country's economy before the oil boom of the 1950s' (Glick, 2009), Agriculture is making a comeback especially in the face of dwindling oil prices which plunged the country into recession in 2015. Nigeria is blessed with a huge amount of agricultural land which encompasses about 81.8% of the total land area

(91,077,000ha) with an estimated 44.6% (FAO, 2016) of the labour force involved in farming (Fig. 2.4 dominated by smallholder farmers with little knowledge on modern farm practices, low capital and limited access to infrastructure (Wilson & Tisdell). However, laudable the drive for self-sufficiency in food security, the intentional release of deleterious chemicals into the environment has a long-term impact on the current success achieved.

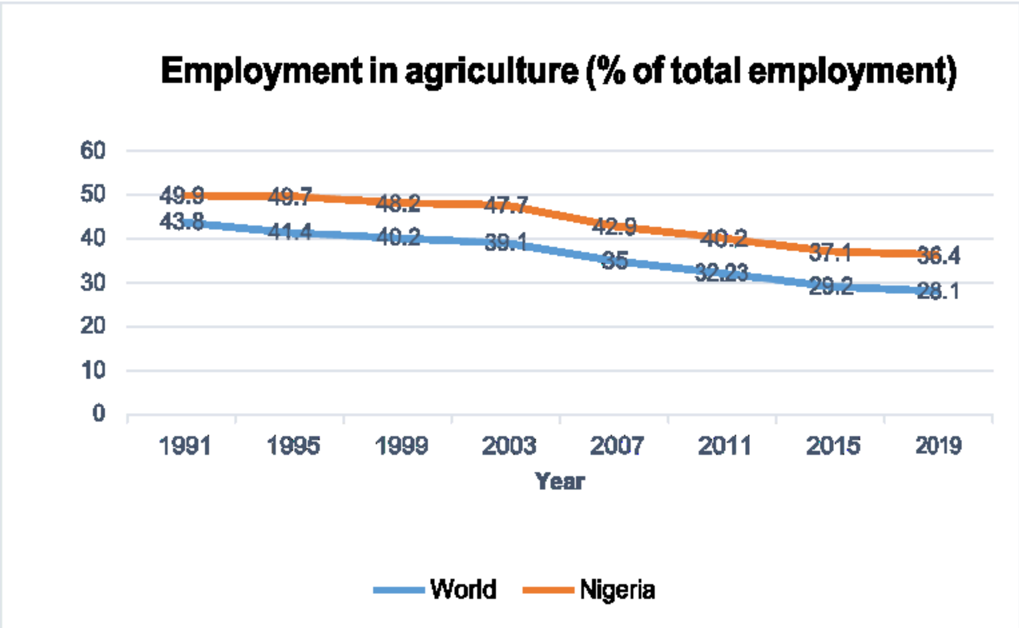


Figure 2.4. Employment in Agricuture
Data sourced from FAOSTAT, 2016

Chemicals are used for crops and seeds protection and are widely used in both developed and developing nations to improve their crop yield and therefore ensure their food security. In Nigeria, there are currently about 124 registered crop protection chemicals officially sanctioned by NAFDAC and its Directorate of Registration responsible for the registration of all chemicals regulated by law. Nigeria's consumption of fertilizer per hectare is the lowest in the world at about 10kg/hectare/annum which is less than 5 percent of the best practice rate of 210kg. Therefore, due to the low-level of chemical use in agriculture in Nigeria, it may be possible that stockpiles of obsolete pesticides may not be significant. The FAO in 2002 estimated that Nigeria had only about 22 tonnes of obsolete stock of 40 assorted pesticides in

55 different sites. The FAO source also revealed that pesticides accounted for most POPs contaminations in Nigeria.

Agrochemicals are not manufactured in Nigeria but imported mostly from developed countries such as France, the United Kingdom and Japan (PAN, 2007). This is because formulation plants for pesticides, owned by multinational companies, which existed in Lagos, Kaduna and Port Harcourt, were shut down in the late 1980s and early 1990s when the Federal Environmental Protection Agency Regulations in 1990 banned the importation and production of persistent organic pollutants pesticides in response to international concern about POPs and their effects (PAN, 2007). Today, over 95% of all pesticides are imported as finished pre-packed products imported mostly from developed countries like France, United Kingdom, Japan, and China among others. These include pesticides, industrial chemicals, fertilizers, and consumer chemical products.

Pesticide use in Nigeria includes certain chemicals that for environmental reason have been partially or completely banned in developed countries because of its soil degrading attributes (PAN-2007), despite developed countries banning many of the older pesticides due to potential toxic effects to man and/or their impacts on ecosystems, in favour of more modern pesticide formulations cheap compounds, such as DDT, HCH and lindane, that are environmentally persistent still remain popular in developing countries (Carvahllo 2006) and continue to find their way into Nigeria for pest control mainly through illegal traffic (PAN, 2007). In developing countries, some of the older pesticides remain the cheapest to produce and, for some purposes, remain highly effective as, for example, the use of DDT for malaria control. Developing countries maintain that they cannot afford, for reasons of cost and/or efficacy, to ban certain older pesticides. The dilemma of cost/efficacy versus ecological impacts, including long range impacts via atmospheric transport, and access to modern pesticide formulations at low cost remains a contentious global issue.

2.4.2 Pesticide use in urban agriculture

With pesticides contributing significantly to the provision of food by reducing pre and post-harvest losses to pests and diseases, which could be up to 36-40% loss of agricultural yield (Edwards, Thurston & Janke, 1993; Oliveira *et al*., 2014), the rate at which these crop protection inputs are being used has increased in 20-fold globally (Popp, Neto and Nagy, 2013). These increase in use, with their following impact, has the potential to compromise the ability of future generations in meeting their own needs. Though agriculture supported with pesticide use has been adopted in agriculture intensification practices (Schreinemachers & Tipraqsa, 2012) and credited with alleviating food security crisis (Popp *et al*., 2013), it is still recognised as the highest contributor to environmental degradation (Fenner, 2013; Olaonipekun *et al*., 2019) because of its use of pollutants that poses significant negative impacts on biodiversity, environment , food quality, human health and economic growth (Aktar *et al*., 2009 Geiger *et al*., 2010; Popp *et al*., 2012; Mahmood *et al*., 2016) ; a potential compromise of the ability of future generations to meet their own needs.

It is no doubt that pests are a bane to food security and pest infestation, and the same way in which it affects rural agricultural productivity, so does it affect UA. With these massive attacks threatening productivity, pesticides have been increasingly used to reduce pest infestation. These chemical compounds are so used in UA to ensure productivity, an end to which it is promoted. The benefits of pesticides are unarguably attractive, but the impact of its use through a history of misuse cannot be ignored. In managing pests and diseases problem, most farmers, especially those in primary production such as crop and livestock farmers, rely on farm inputs such as pesticides (Popp *et al*., 2012). Pest infestations of farm crops and animals significantly reduce agricultural productivity when not carefully managed.

Despite lack of data on agricultural loss to pests in Nigeria, annual losses of cassava to cassava mosaic disease (CMD) in Africa is estimated at over US$ 1 Billion (Manyong *et al*., 2012) while Cedra *et al*. (2017) estimated high primary yield losses of 26% and higher secondary yield losses of 38% to pests and diseases in coffee. Also, in Nigeria, 30-35% of cocoa yield is lost to the cocoa pod disease (Adejumo, 2005) while fruits and vegetable loss to pest and disease has been reported to be a challenge (Ibeawuchi *et al*., 2015). In Nigeria, insect pests and plant diseases are major yield-reducing factors, threatening food security and farmers' incomes (Ndubuaku and Asogwa, 2006). Despite studies in the 90s' showing Nigerian farmers' awareness of the availability of several methods of pest control, including chemical, biological, and traditional cultural control methods (Alghali, 1991; Bottenberg, 1995), millennial farmers manage pests by relying primarily on chemical insecticides (Banjo *et al*., 2003).

In the case of African agriculture, the pest management challenge is impaired by the predominance of smallholder farmers who are characterised by low agricultural productivity due to constraints such as little knowledge on modern farm practices, low capital and limited access to infrastructure (Zhang *et al*., 2018).

2.4.3 Pesticide impacts

According to Pimentel (2007) and Carvalho (2017), pesticides in the environment are extremely dangerous to several organisms. Like pest populations, beneficial natural enemies and biodiversity (predators and parasites) are adversely affected by pesticides (Pimentel *et al*., 1993a). For example, the following pests have reached outbreak levels in cotton and apple crops after the natural enemies were destroyed by pesticides: cotton ¼ cotton bollworm, tobacco budworm, cotton aphid, spider mites, and cotton loopers; apples

¼ European red mite, red-banded leaf roller, San Jose scale, oyster shell scale, rosy apple aphid, wooly apple aphid, white apple aphid, two-spotted spider mite, and apple rust mite. Major pest outbreaks have also occurred in other crops. Also, because parasitic and predaceous insects often have complex searching and attack behaviors, sub-lethal insecticide dosages may alter this behavior and in this way disrupt effective biological controls.

These chemicals can hurt insects, spiders and non-targeted organisms like pigeons and rodents that pick the pesticides accidentally and as a result, they die. For instance, the herbicide oxadiazon, is toxic to bees which are pollinators (Hladik *et al*., 2018) and also destroy the food and shelter of different species (Thompson, 2014). Also, the presence of pesticides is a risk in drinking water (Adeyemo *et al.*, 2017). Water can be toxic under the surface, and its use can cause several problems (Bevans 1998). Pesticide-contaminated water can pose problems in irrigation and agriculture. Although, in most of the countries surface water is regularly checked for pesticides.

Pesticides are the chemicals used in agriculture, they can contaminate in the soil, above the ground, and under the ground surface. They can also leave residues in lakes, streams, and rivers. Different types of pesticides are used to increase the cultivation and to kill the different types of pests (Egendorf *et al.*, 2018). In urban agriculture, pesticides are used to a greater extent. On the other hand, pesticides specifically insecticides are the more toxic category of pesticides that also harm non-targeted organisms. Pesticides can contaminate into the surface water, and it is widespread all over the world. It is revealed by several geological surveys that, a heavy amount of pesticides, is present at the major river sinks.

Due to the use of insecticides, aquatic life is also endangered. Insecticides can contaminate in water for a long time that is harmful to life in water. The herbicides 2, 4-D, diuron, and prometon, and the insecticides chlorpyrifos and diazinon are the most common types of pesticides that are detected often across the world (Wahab *et al.*, 2018). These pesticides are more often used in urban agriculture and homeowners. According to Bevans (1998) it is predicted that Trifluralin and 2, 4-D is present almost in all the 19 samples out of 20 taken from the river's basins. The National Academy of Sciences for the protection of aquatic life has declared that an exceeding concentration of these insecticides like diazinon, and the weed-killers dichlobenil, diuron, triclopyr, and glyphosate are found most commonly in urban streams due to which, the life of water will be no more one day (Ajayeoba *et al.*, 2016). Pollution is found in groundwater because of pesticides as a worldwide problem. According to the US geological survey, about 22 transformations have been observed in groundwater. These transformations are because of different types of pesticides belonging to the major category of chemicals (Chepchirchir *et al.*, 2017). Once pesticides enter the groundwater, it can persist for a long time and cleaning when possible, involves a complex and costly process (Ben-Iwo *et al.*, 2017).

Pesticides and their transformation are divided into two classes (Atungwu *et al.*, 2018). The first class includes bioaccumulable, Hydrophobic and persistent pesticides that can strongly stick to the soil. Transformation products of organochlorine DDT, endosulfan, endrin, heptachlor, and lindane are some forms of pesticides that are included in first class (Wossen *et al.*, 2018). The second class contains; polar pesticides like herbicides including carbamates, fungicides, insecticides, and their transformation products. They can cause difficulty for the supply of drinking water by moving from the soil, running and leaching (Graziosi *et al.*, 2017). Different pesticides can remain in the soil for a different time period depending upon the nature of soil and class of pesticide.

Pesticides can also affect the fertility of the soil. Extra use of pesticides can increase the crop but it kills the necessary microorganisms. A great soil scientist Dr, Elaine Ingham said, if we kill both fungus and bacteria then the quality of soil also degrades. Moreover, the overuse of pesticides is as similar to the overuse of antibiotics to human. Consequently, it can be added that the use of pesticides can work for a few days or years but kills the necessary organisms that can hold the nutrients. For instance, the plant requires some microorganisms to convert nitrogen into nitrates, which is a necessary process for a plant to breathe. On the other hand, some pesticides which contain Glyphosate and 2, 4-D reduces the nitrogen level and affects the activity and growth of the plant. Nutrient uptake process is supported by Mycorrhiza fungi which grows with the roots of many plants (Egendorf *et al.*, 2018). Contaminated pesticides in the soil can damage these fungi also.

Contamination of pesticides in air, soil, and water effects the not targeted organisms and vegetation. While spraying pesticides, some non-targeted vegetation also suffers. Even though by using the ground equipment, some of the pesticide drift also occurs. According to Bevans (1998) about 2 to 25 percent of the chemicals, can spread into the environment, few, or several miles away from the target (Abtew *et al.*, 2016). Due to the volatile nature of the pesticide, 80 to 90 percent of the applied pesticide volatilised after few days of application. Besides the fact, that still limited research is done over this topic, but studies reveal that pesticides residues in the atmosphere. It is also added by the US geological survey, that pesticides were detected in every sampled area of the USA (Ifeanyichukwu *et al.*, 2018). Moreover, the presence of pesticides was also detected in the samples of rain, fog, smog or snow all over the globe. The concentration is at a higher level in the urban areas of Nigeria.

According to Bevans (1998) urban landscapes all around the globe which contain some contaminated pesticides. Numerous organisms like insects, plants, animals, fish, birds, and other wildlife are affected by the use of pesticides (Darkoh & Rwomire, 2018). It is revealed by studies, that Chlorpyrifos is a common contaminated pesticide noted in the stream of urban areas that are very harmful to the fishes. Due to this highly toxic chemical, dead fishes are found near the treated fields and buildings. However, herbicides are used over the herbs and plants, but the chemicals used are very toxic to fish also. A necessary ingredient of weed-killer like Trifluralin, is a killing agent for both cold and warm water fish. Herbicides also cause physical deformities in fish.

According to Bevans (1998) several cases behind the death of dolphins have been recorded because of pesticides. Dolphins residing in rivers are seriously the world's most endangered species. Due to the use of pesticides and different chemicals poured into the streams and rivers is dangerous for the health of fishes (Goyol *et al.*, 2017). The population of the rivers is facing a threat regarding extinction. This is a fact, which increased urban agriculture is making many species extinct. In addition to dolphins, fish and other marine life are endangered because of the over the use of pesticides and its contamination in water.

Chemicals like DDT (1, 1, 1-trichloro-2, 2-bis [p-chlorophenyl] ethane), PCBs and many other toxic contaminants are putting their adverse effects over the reproductive and immunological processes of the aquatic mammals (Zougmoré *et al.*, 2016). Fishes of the fresh water are reported as sensitive to pesticides contamination, especially in the areas of urban agriculture. Plants within the water are also endangered because of pesticides contamination. Some herbicides are also designed to kill plants in the water, but the chemicals within those pesticides can affect aquatic life also. Some pesticides are used to kill algae in the water, although it is part of the food chain in an aquatic system (Adekunle *et al.*, 2017).

2.5 Conceptualisation of research issues

UA's potential to contribute to long-term sustainability goals as discussed in section 2.3.2 may be hindered if limiting factors such as pesticide misuse is not holistically addressed within the perspective of SD. According to Hsin (1996) and Ferreira *et al*. (2018), UA practised within the principles of sustainable development promotes urban self-reliance, builds the local economy and reduce many environmentally harmful practices of modern agriculture such as pesticide use. The notion that pesticide use does not only have long- term consequences for the environment but the society and economy forms a conceptual basis for this research. It is imperative for this research to take the bottom-up approach in assessing pesticide presence and explore the influence of farmers' characteristics on decisions that drive pesticide use and ultimately shape the role of sustainable urban agriculture. To understand this idea, it is important to conceptualise sustainability, urban agriculture, farmers' characteristics, and pesticide use.

This section provides an understanding of the inter-relationships and inter-dependence of UA and sustainability issues from pesticide use. Though pesticides are used both in rural and urban agriculture, the shift of human population from rural areas to urban areas raised concerns on their environmental impact within the urban ecosystem, especially with rising urban poverty and food insecurity. The main focus of this study is pesticide use in UA because of the heterogeneous nature of social-economic factors that contribute to an urban area (Fall and de Zeeuw, 2001). For instance, urban agriculture practitioners in low-income households in Harare are under pressure to generate income and therefore have to maximise both time and resources (Kutiwa, Boon and Devuyst, 2010) because "urban households typically need higher cash incomes to avoid poverty than most rural households" (David Satterthwaite 2005). In some cities of Kwara state Nigeria, Adebisi and Tunde (2012) reported the female farmers in their studies were involved in UA initially to secure food because of the rising food costs experienced in the country, but now mainly engaged as a source of livelihood. This sort of pressure to increase income and avoid poverty further drive farmers' pesticide use.

Furthermore, UA's potential contribution to the principle of sustainability is a dynamic concept that keeps evolving due to the interactions of factors amidst changing urban land use. This dynamic characteristic is encompassed in the different scale and magnitude of urban agriculture practice.

Achieving food security is of utmost interest to the leaders and the inhabitants of this world, most especially with the unprecedented rising population we experience in this modern world. Urban

Agriculture is surely seen as a rescue tool to augment other traditional tools to attain this social goal. Aside this, improved livelihoods, enabled by urban agriculture, provides a much-needed income to small households which are translated into economic prosperity, meeting the sustainable development goals of ending poverty. It has also helped with the gender empowerment agenda such that marginalised female gender are encouraged to participate in UA as an enabling tool for women. Summarily, urban agriculture supports food security, create business opportunities for farmers, empower gender emancipation and foster community building.

However, increased pesticide use in urban agriculture is rampant because of its short-term efficacy in controlling pests, which are undeniably an impediment to agricultural productivity, and by extension, food security. For instance, Sharifzadeh *et al*. (2018) reported that experienced farmers favour pesticide use because of its performance and effectiveness. The use of these pesticides, despite providing an avenue for us to meet our immediate needs, comes with undesirable impacts on long term sustainable development. The steady rise in its use has been attributed to a lack of knowledge concerning alternatives to chemical pesticides (Oesterlund *et al*., 2014). From the land, soils, water, and air to micro-organisms, plants, animals and human beings, the subsequent challenges that arise from pesticide use perhaps negates its perceived benefits.

With the realization that resources are finite and the possible endangerment for future lives, world leaders and policy makers came up with the term sustainable development as a process to achieve sustainability which is to secure the totality of the environment in perpetuity for generations yet unborn. A sustained development will cater to the needs of the society, economy, and environment within a balanced system, even though trade-offs may exist in some instances. Economy, society, and environment are the main dimensions of sustainable development, and it is very important that holistic frameworks are designed and used to evaluate trade-offs and synergies between pesticide use in agriculture and their wider impacts on these dimensions. It is therefore within this concept of sustainability that this research was conceptualised by looking at how pesticides which are intentionally released into the environment, impacts on these dimensions of sustainable development environment, to provide an understanding of the factors that influence the pesticide use, knowledge, behaviour, and decisions of urban farmers, and subsequently inform policy makers and stakeholders on mitigating measures.

2.5.1. Urban agriculture and sustainable development

The task to produce food in an environmentally and socially sustainable way while ensuring economic prosperity has been a bane to truly attaining sustainable development in the area of agriculture. This element of agriculture, i.e., UA had been existing for centuries (Smit and Nasr, 1992) but only validated as a tool for achieving food security in the 90s' (Adelekan, Olajide-Taiwo, Ayorinde, Ajayi and Babajide, 2014). Despite this positive step in developing great urban cultivation schemes to achieve the goal of increasing opportunities for employments and livelihood strategies, the application of chemicals; most especially pesticides in the urban production process can result in environmental impacts. This is significant where cultivation is intensive near populations that solely rely on waterbodies for their ecosystems service's needs.

Urban agriculture (UA) has been described by some groups of researchers and reports (Binns & Lynch, 1998, FAO, 1999 and Guendel, 2002 as an interesting concept of sustainable development (since it is believed to address sustainability issues viz food security, self-reliance, and local economy while reducing many environmentally harmful practices from modern agriculture practices (Hsin, 1996). For instance, in Uganda, the increase in food prices has made it difficult for many low-income earners in Kampala to meet their daily food requirements, and therefore urban (peri) agriculture contributes to the general food supply of the city (Sabiiti & Katongole, 2014). Aside this, Sabiiti & Katongole (2014) reported that UA had become an important economic activity in the city. This, however, comes at a cost: increase in use of agrochemicals such as pesticides, insecticides, herbicides to protect the agricultural produce. This is not without its consequential effect, especially on the environment and man. Effects such a food poisoning from agrochemical use that has been absorbed into the human food chain has been well documented (Ekeleme *et al*., 2008), likewise land degradation and water pollution (Balaram, 2003).

2.5.2 Pesticide use in urban agriculture and the dimensions of sustainable development

The potential of urban agriculture to contribute to sustainable development cuts across social, economic and environmental services by enhancing food security for the ever- increasing urban population (Altieri *et al*., 1999; Asomani-Boateng, 2001; Hubbard and Onumah, 2001; Mougeot, 2006; de Bon *et al*., 2009; Pearson *et al*., 2010); contributing to human nutrition and subsequently reducing the risk of multiple chronic diseases (Boeing *et al*., 2012); improving livelihoods through income generation in developing countries amongst poor urban households (Bryld, 2003; Thornton, 2008; Zezza and Tasciotti, 2010); providing an opportunity for integrating multiple functions for land use in urban areas (Deelstra and Girardet, 2000; Lovell, 2010); reducing pressure on rural agriculture and decompensating land loss by using vacant spaces in cities (Eigenbrod and Gruda, 2014). Other UA contributions include consumption of nutrient-rich "waste" water and bio- solids/organic matter (Armstrong, 2009; de Zeeuw *et al*., 2011), and fixation of atmospheric nitrogen and carbon (Herridge *et al*., 2008; Beniston & Lal, 2012); moderating air temperature through increase in urban vegetation shading which helps in solar radiation absorption via evapotranspiration (Susca *et al*., 2011; Qiu *et al*., 2013); regulation of local microclimate and hydrology (Oberndorfer *et al*., 2007); improving the quality of cities (Frumkin, 2003; Turner *et al*., 2004); creation of habitat for pollinators and other wildlife (Goddard *et al*., 2010).

However, UA may introduce disease and agricultural pollutants to the urban ecosystem (Smit *et al*., 2001) especially with the increased reliance on pesticides, create conflicts over land use (Schmelzkopf, 1995), and add complicated, maintenance intensive systems to the urban infrastructure. The introduction of agricultural pollutants, especially from pesticides, could lead to an increase in food contamination (Meharg, 2016), particularly fruits and vegetables, which are in high demand from urban farmers. Pesticide use in agriculture and by extension, urban agriculture, is relied on to control pests and diseases to reduce the agricultural industry's losses to pests and diseases. These losses are reported to account for reduced productivity and threaten food security, especially in developing countries (Zakari *et al*., 2014).

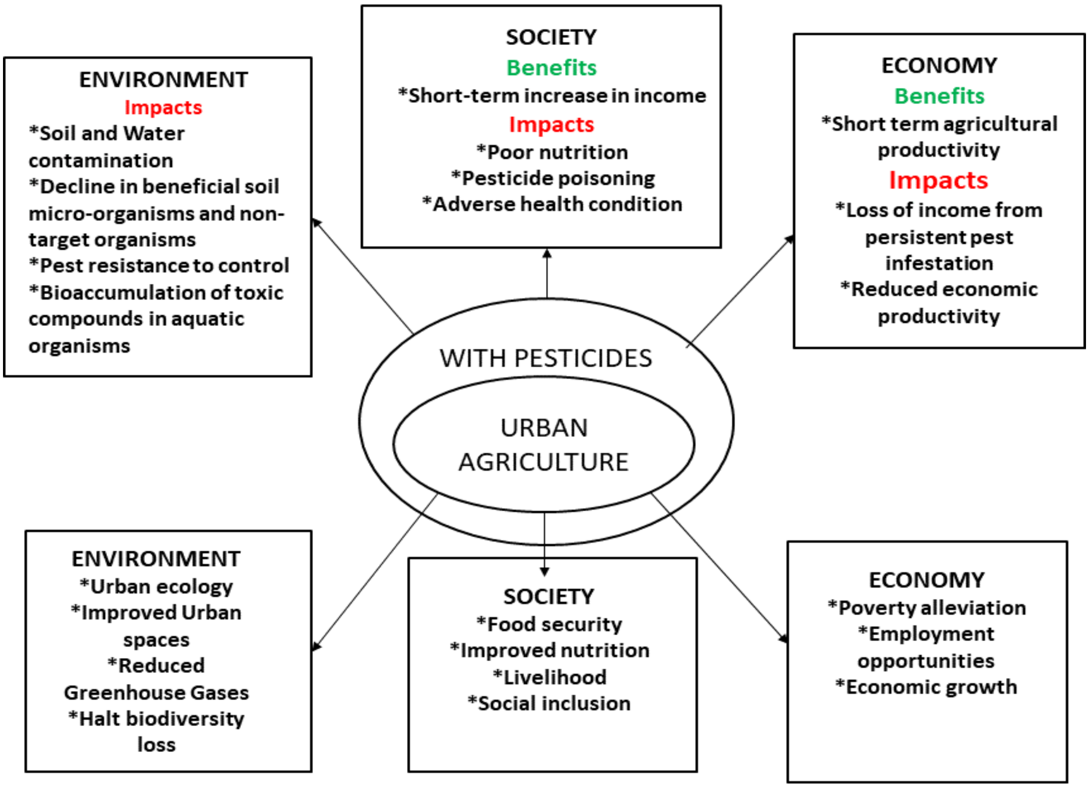


Figure 2.5: An illustration of UA potential with and without pesticides

In a world where population increases are synonymous with poverty and food shortage, food security has become a major element of development, therefore a goal for world leaders entrusted with the task of feeding the rising human population.

The balance between benefit and harm from pesticide use is complicated because it has been argued that the use of pesticides, broadly, has increased the quality and quantity of fruits and vegetables (Oerke, 2006) and consequently has improved public health, in spite of the potential adverse health effects (Bonner & Alavanja, 2017). Notwithstanding, the long-term damage to the environment from pesticide use could no longer be ignored as the state of the environment was brought to the forefront of developmental goals in the report 'our common future' (WCED, 1987) wherein it was argued that environmental health is a prerequisite for social and economic success due to the strong relationship between man's socio-economic activities with the environment (Sanchez-Medina *et al*., 2014).

Even though pesticides are intentionally introduced into the environment to control pests, a healthy environment plays a significant role in the success of both social and economic dimensions of sustainability. As explained by Sanchez-Medina *et al*. (2014), the environment is responsible for supplying natural inputs upon which socio-economic success relies on; provides recreational services which is beneficial to the society; and also acts as a receptor of the wastes and residues such as pesticides which are generated in the production and consumption of goods for economic growth. The damage to the environment from pesticide use, amongst many other causes is prioritised in the global development goals in the report 'our common future' (WCED, 1987) wherein it was argued that environmental health is a prerequisite for social and economic success if sustainable development is to be realised. This acknowledgement is due to the strong relationship between man's socio-economic activities with the environment (Sanchez-Medina *et al*., 2014). Subsequently, this study is designed on the premise that urban agriculture can contribute to sustainable development if pesticide use as one of the limitations to urban agriculture is minimised by seeking to understand both the socio-economic dimensions of pesticide use and simultaneously assessing its presence in the environment.

2.6 Conclusion

The conceptual framework considers pesticide use in urban agriculture practice, with a focus on farmers within the principles of sustainability. This approach is grounded in recognition of the potentials of urban agriculture to contribute to sustainable development and that an understanding of drivers for pesticide use can play a critical role in an enduring urban agriculture practice that promotes sustainability via food security, improved livelihoods, and environmental protection. The main concepts behind this research are urban agriculture and sustainability. These two concepts amongst other key-terms have been defined in this chapter, alongside food security challenges. This chapter has limited the scope of study to the research objectives and is used in chapter four to define the research framework for the methodological approach adopted in this study. The next chapter is a discussion of the literature on studies on subject of concern, especially on pesticide misuse, contamination, impacts and methods of assessing this in the environment.

Chapter Three

Literature Review

3.1 Introduction

Literature review is an important element of the research process as it provides a framework for relating new findings to previous findings in the discussion section of a dissertation (Randolph, 2009). It is described as a process that culminates in the summary and synthesis of previously recorded arguments and ideas on the topic of interest through identification and selection of sources that discuss the concept, and therefore a reference point for the current study (Micheli *et al*., 2018). This chapter therefore contributes to the overall thesis by reviewing the current state of knowledge from previous studies and frames the gaps this study attempts to fill.

The objectives of this study are: to develop a research framework for an integration of environmental, economic and social perspectives on the use and impacts of pesticides in this exploratory study; to identify suitable methods to quantify residual pesticides in soil and sediments; to create a historical and current profile of pesticide use in Ibadan city from methods; to evaluate the extent of pesticide use by UA farmers in Ibadan and explore farmers' knowledge concerning good practice, farmer awareness of the environmental impacts of poor practice, and farmer motivations with respect to the socio-economic drivers that determine pesticide use.

In Chapter two, the environmental, social, and economic implications of pesticides were highlighted as part of the underlying issues in this study. One of the recurring themes identified in the scope and conceptualisation of research is pesticide misuse, which has been cited as one of the challenges of UA, especially in Ibadan (RUAF, 2007). Also, significance of the persistent presence of these pesticides in the environment as it affects their primary target and indirectly affects non-targets such as animals, aquatic organisms, air and human was identified.

Therefore, one of the sections in this chapter will review current studies on factors that influence the misuse of these products, especially with farmers as primary consumers. This will further include review of studies on farmers' behaviours, attitudes and knowledge that influence their pesticide use and misuse. Other sections will review their movement in the environment, their presence as contaminants and methods of assessing them.

3.2 Misuse of pesticides by Farmers

Pesticide misuse was cited as one of the challenges of UA in Ibadan in a study on urban and peri-urban agriculture (RUAF, 2007). Although there appears to be no definite academic definition for pesticide misuse in literature, it can safely be defined according to the Oxford dictionary as the wrong or improper use of pesticides. The term 'misuse' has been used to describe farmers' poor agricultural pesticide practice in several studies on pesticide use, handling and its' impacts e.g., Palikhe, 2002; Ajayi & Akinnifesi, 2007; Rother & Hall, 2008; Asogwa & Dongo, 2009; Hou *et al*., 2010; Naidoo *et al*., 2010; Oesterlund *et al*., 2014; Mengistie *et al*., 2017 and Jallow *et al*., 2017. It is noticeable that most of these studies are in developing countries, especially the countries in Africa, where Agricultural practice is characterised by lack of knowledge and awareness of impacts of poor practice (Wilson & Tisdell, 2000).

Asogwa & Dongo (2009), in their studies on pesticide use in Cocoa production in Nigeria, described pesticide misuse in Nigeria as overdosage of pesticides to effect quick action and their use for purposes other than which they are manufactured for. Asogwa & Dongo (2009) attributed this problem of over-dosage to poor extension services, lack of proper calibration equipment, lack of safety measures and poor Government intervention. Some results, reported by Ugwu *et al*. (2015) from their studies into pesticide-handling practices among smallholder Vegetable farmers in Oyo state, Nigeria reported that 97% of their sample population use pesticides. This result was consistent with Asogwa &Dongo's (2009) summation on pesticide misuse in the country as a result of accessibility and increased use. For instance, 58.7% of Ugwu *et al*.'s sample population had no information or training on pesticide handling and safety measures.

Similar to Asogwa & Dongo (2008) in Nigeria, Palikhe (2002) identified the case of overdosage of pesticides in Nepal as misuse. Palikhe noted that farmers tend to overuse pesticides regularly, which leads to overdosage to achieve a same level of control when pests become resistant to the chemicals. Palikhe (2002) also identified the lack of knowledge on the side of the farmers at realizing the extent to which these chemicals are poisonous and hazardous to humans and environment when misused. Palikhe (2002) also noted that over 60% of farmers with over five years farming experience wait less than two weeks after spraying pesticides before harvesting the crop. He also listed aggressive marketing strategies, use of highly toxic pesticides, pattern of use (no knowledge of active ingredients, mixture of pesticides and outdated products).

Oesterlund *et al*. (2004) in their cross-sectional study on 'pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda' reported that farmers had poor knowledge about pesticide toxicity, and the majority did not use appropriate personal protective equipment (PPE) when handling pesticides. They reported no significant association between the number of times of spraying with pesticides and self- reported symptoms of pesticide poisoning. The only significant association was between blowing and sucking the nozzle of the knapsack sprayer and self-reported symptoms of pesticide intoxication. In this study, twenty-eight small-scale farmers did not know the name of the pesticide they used which could be highly hazardous chemicals.

Waandaat *et al*. (2015) reported misuse of pesticides among vegetable farmers in Tano South of Ghana. They described the high intensity of up to four times a week as misuse because farmers use these chemicals whenever they sight pest on their vegetable crops. This type of misuse was also reported by Abang *et al* (2013) in Cameroon where 83% of vegetable farmers did not use timeliness of operations, choice of growing season, and planting date as pest management strategies but rather use as many times as they want. Abang *et al* (2013) the absence of farmer training as a determinant for increase in vegetable production as most of the farmers were not aware of other less hazardous pest control methods.

Farmers' storage and disposal practices also contribute to pesticide misuse as Mengistie *et al* (2017) reported farmers in Ethiopia as using unsafe storage and disposal methods by ignoring the risks and safety instructions that accompany the labelling. This practice is common in other developing countries (Ngowi *et al*., 2001 and Murphy *et al*., 2002), including Nigeria where farmers in Oluwole and Cheke (2009) stored chemical pesticides in their homes and bedrooms, in close proximity to food and humans. This poses a hazard to children and increases the chance of pesticide poisoning through ingestion or inhalation Storing (Tijani, 2006). This danger may be determined by the pesticide's chemical makeup and formulation, its path into body, the amount that enters the body and the length of exposure. These stored pesticides may even expire or become outdated and no longer suitable for use. However, 80% of Oluwole and Cheke study participants reported that they mix expired pesticides with new ones and continued to use them. Their reason for such practice is attributed to the high cost of the new pesticide formulations which are less toxic in comparison to the obsolete and banned products. Poor disposal of pesticide residue, packaging and containers on farms, waterways, landfill, and their reuse as storage for food or water is also an act of misuse. Damalas *et al*. (2007) reported that 30% of farmers in their study sample dump and empty containers in the field or into waterways.

Pesticide misuse is also practiced by farmers when they ignore labelling instructions by concocting a cocktail of different kinds of pesticides before applying the mixture on the intended targets (Ngowi *et al*., 2007). Oluwole and Cheke (2007) reported that almost all farmers interviewed in their study mixed two or more pesticides before application as they believe that such practice increased the efficacy of the pesticide solution and therefore, increases the success rate of controlling the target pest. They also believed that mixing different pesticides saved time because they could apply more than one pesticide in a single spraying operation (Jallow *et al*., 2017). Mixing of pesticides cause interactions that may increase the health and environmental risk of pesticides (Sharafi *et al*., 2018). Other pesticide misuse includes the use of faulty equipment, lack of proper equipment operation and maintenance, and lack of the use of protective gear such as gloves and appropriate clothing such as Personal protective equipment (PPE) during the mixing and application of pesticides (Ibityayo, 2006).

This misuse, in however form it occurs, often leads to contamination of ground and surface water, pollution of soil and air, and cause an imbalance between insect parasites and predators which leads to pesticide resistance. Pesticides as contaminants are discussed in later sections of this chapter, however, studies such as Damalas *et al*. (2007), Oluwole and Cheke (2009), Oesterlund *et al*. (2004); Palikhe (2002) among several others have identified the need for improved efforts at training farmers for proper use of pesticides. This implies how important farmers' knowledge is to the safe use of pesticides.

3.2.1. Awareness, knowledge, and behaviour

An understanding of farmers' knowledge and learning processes is essential in the drive for sustainable agricultural practices. This study seeks to explore farmers' knowledge of pesticides and how it influences their behaviour because their level of knowledge can influence individual behaviour such that the higher the level of knowledge, the more likely the individual is expected to adopt and practice safe behaviours (Rezaei *et al*., 2017). A strong awareness and knowledge of pesticide will encourage good agricultural behaviour or practice and therefore reduce misuse, which is the mostly responsible for pesticide mishaps.

Knowledge, as defined by Davenport & Prusak, 2000 in Liew, 2007, is a mixture of organized experiences, values, information and insights offering a framework to evaluate new experiences and information. However, as described by do Paço & Raposo (2009), there appears to be a mismatch between the levels of knowledge, experience and education on the one hand and expected safe behaviours on the other. This according to Moore (2008) means that a high level of knowledge does not necessarily commensurate with decrease in pesticide use or an improvement in the safe use and handling of pesticides.

Farmers' awareness and knowledge of pesticide risks are reported to be crucial towards improving safety (Damalas, Spyridon and Koutroubas, 2018). This awareness and knowledge of pesticides has been linked to educational status in literature. For example, in Öztaş *et al*. (2018) study into 'knowledge level, attitude, and behaviours of farmers in Cukurova region of Turkey regarding the use of pesticides', farmers' awareness of

pesticides were found to be related to their educational status as educated farmers can read publications and access information through the Internet. Other studies reinforce this position in similar contexts (Atreya, 2007 and Rios-Gonzalez *et al*., 2013). In Öztaş *et al*. (2018), farmers' awareness of pesticides was found to be related to their educational status as educated farmers can read publications and access information through the Internet. They also identified age as an important socioeconomic factor that influence farmers' awareness on list of approved and banned products. This is similar to Mubushar *et al*., (2019) findings in a study on 'assessment of farmers' knowledge on pesticides and trainings on pesticide waste management in central Punjab – Pakistan' in which 69% of farmers rely on neighbours in. Yilmaz (2015) also reported a significant amount of information on pesticide use is received from pesticide dealers during their analysis of environmental awareness of farmers' decisions and attitudes in pesticide use in Turkey.

3.2.2 Motivations for pesticide use

Despite the problems associated with pesticide use in Agriculture, farmers have been reported to continually rely on these chemicals. Wilson and Tisdell (2001) explained farmers' reliance using the neoclassical theory. The theory suggests consumers' preferences are dependent on the benefits they enjoy from the current consumption of a product (Angner & Loewenstein, 2012). Wilson and Tisdell suggested farmers will continue to use pesticides if they enjoy benefits from its use. This agrees with Robinson *et al*. (2007). In their study on pesticide use motivations among Bangladesh farmers', Robinson *et al*. (2007) noted that pesticide use by the farmers was informed by their perceptions that pesticides provide more benefits and easy to purchase. Even though the Bangladesh farmers had received training on other pest management control measures aside pesticides, they chose to use pesticides because they are seen as less labour intensive, less risky and cheaper to adopt when compared to the non-chemical methods. Another reason for their continued pesticide use reported by Robinson *et al*. (2007) is its' use as a precautionary measure to prevent future and unexpected pest attacks.

Lagerkvist *et al*. (2012) in their study to understand farmers' motivations for pesticide use in leafy vegetables in Kenya reported that the demand by urban consumers for aesthetically acceptable vegetables and the need to reduce loss and waste influence farmers' excessive use of pesticides. According to their study, the opportunity provided by pesticide to meet consumers' demand for aesthetic quality increases the quantity of vegetables sold and therefore more income which is used to meet needs. This also confirms Wilson and Tisdell's position that farmers are likely to continue to use pesticides because of the benefits accrued from its' application. In a study by Rahman & Chima (2018) on determinants of pesticide use in food crop production in South-eastern Nigeria, farmers were reported as using pesticides as substitutes for labour and ploughing services. This indicated that farmers' pesticide use is motivated by the need to save on operational cost, and ultimately increase profit.

3.3 Pesticides as contaminants/pollutants

A chemical is classified as a pollutant when its presence has the potential to damage either the environment or human health (Briggs, 2003). It is well established that pesticides are dangerous chemicals deliberately introduced into the environment to kill pests in form of insects, weeds, parasites and pathogens (Djouaka *et al*. 2016). These pesticides include miticides, insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and several others which offer a number of advantages including protection of crops, preservation of foods or different materials, and control of diseases (Egendorf *et al*., 2018). However, a large fraction of these pollutants persists in the environment long after their initial application (Gavrilescu, 2005) through transport and transformation into more stable structures with far-reaching impacts on the soil, water, organisms, plants, animal and human health and wealth through the disruption of predator-prey relationships, loss of biodiversity and significant human health challenge (Fig. 3.1).

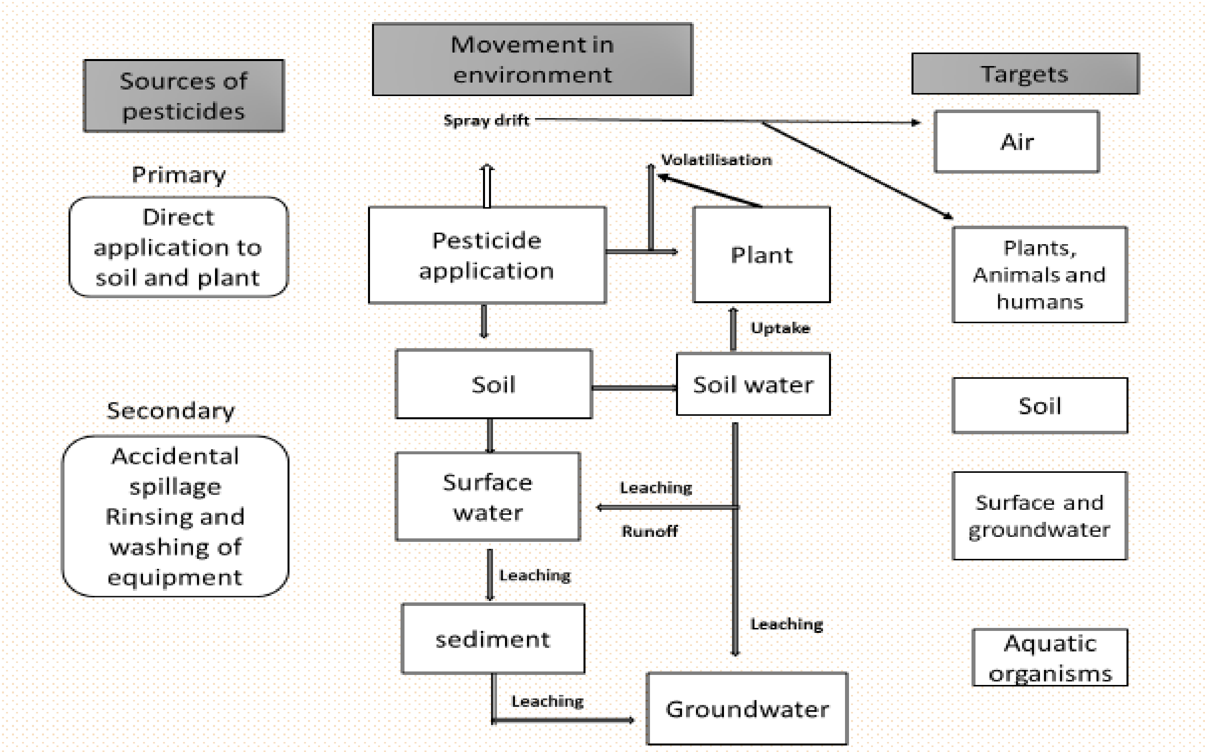


Figure 3.1: Graphical illustration of pesticide sources, movement and targets in the environment

Pesticides are a primary source of pollution in the environment but becomes classified as pollutants/contaminants when they are released into the environment either through point-source or non-point source (Racke *et al*., 1997; Vryzas, 2018). The soil, sediments, surface and groundwater become contaminated with varying amount of pesticide residues once these chemicals are released into the environment (Vryzas, 2018). A point-source contamination as described by Muller *et al*., (2002) is the discharge of pesticide from a discrete identifiable source such as during disposal, filling, and cleaning of spraying equipment within an immediate farm area. They also included washing off of pesticide residues from washing vegetable plants or from impermeable surfaces such as roadside and rail tracks (Carter, 2000a). For a non-point or diffuse contamination, it is defined as that which cannot be identified to a specific source such soil surface run-off, leaching and spray drift (Carter, 2000a; Muller *et al*., 2002). Soil and sediments are identified as the major storage area of pesticides from both types of contamination (Ochoas and Maestroni, 2018; Vryzas, 2018). Therefore, the next sections will discuss pesticide fate in soil and sediments. The section will highlight the maximum residue limits expected in these media and review current studies that will be used in discussing the findings of this study.

3.3.1 Pesticides in soil and sediments

Pesticides introduced into the soil, either through by direct or indirect application are potential contaminants/pollutants. Vryzas (2018) described soils as major sinks of pesticides once introduced into the environment since they are natural media for plant growth. Chaplain *et al*. (2011) described the soil as the interface between pesticides and other environmental compartments such as sediment, surface and ground waters. Soils become directly affected by pesticide application when they are introduced to increase agricultural output by reducing pest infestation of crops both in and out of season. A soil, according to Soil Taxonomy, is defined as:

> *'a natural body comprised of solids, liquid, and gases that occurs on the land surface, occupies space, and is classified by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment'* (Soil Survey staff, 1999, pg 9).

This ability of soil to transfer and transform energy and matter to support plant growth (Abrahams, 2002) is the same characteristic that is capitalised upon when for pesticide potency when formulated. This transfer and transformation of energy and matter shapes the fate of pesticides in the environment (Cyon and Piotrowska-Seget, 2006; Ochoa and Maestroni, 2018) as availability and persistence of these chemicals is required for pesticide formulations to be effective on their intended targets (Carter, 2000b).

The retention and mobility of a pesticide in soil is largely driven by the extent and strength of sorption reactions, which are regulated by the chemical and physical properties of the soils and pesticide used (Grant *et al*., 2009; Fenoll *et al*., 2011). These soil characteristics include environmental conditions such as pH and temperature and biological conditions such as soil organic carbon (Grant *et al*., 2009). This movement and persistence in the environment are also determined by type of pesticide once it is released, where some of these pesticides can become absorbed immediately or be transported through other soil processes (Arbeli and Fuentes, 2010).

3.3.1.1 Soil physico-chemical properties that affect pesticide movement in soil

Soil characteristics that affect pesticide movement in the soil include soil type and structure, organic matter content, clay content, pH, mineral ion content and microbial population (Edwards, 2005). Soil properties such as texture and size affect pesticide degradation by influencing the soil adsorption and cation exchange capacity (Ochoa and Maestroni, 2018). For example, clay soil adsorps pesticide because of the large number of exchangeable cations this particular soil type has (Lagaly, 2001; Ochoa and Maestroni, 2018). According to Lagaly (2001), these exchangeable cations in clay soils modify the absorbing capacity of these soils and therefore, influence the interaction between pesticides and clay minerals. The amount of exchangeable cations present in clay soils are as a result of its' high moisture content influenced by high temperature (Racke *et al*., 1997; Durovic *et al*., 2009; Ochoa and Maestroni, 2018). Pesticide adsorption thereby increases with high soil moisture content since water aids pesticide movement to sorption sites (Ochoa and Maestroni, 2018). High organic matter content also influence pesticide adsorption (Durovic *et al*., 2009, Ochoa and Maestroni *et al*, 2018). Also, the higher the soil pH, the faster the rate of pesticide process in soil (Cyon and Piotrowska-Seget, 2006).

Another characteristic is temperature. The rate of pesticide breakdown is highly influenced by temperature, with an increase in temperature leading to a faster rate of degradation (Pimentel and Edwards, 1982; Cyon and Piotrowska-Seget, 2006). This faster rate of degradation due to high temperature influence moisture condition, which in turn influence microbial activity. A high microbial activity from soil microflora influenced by high temperature, allows for low adsorption of pesticides to different soil particles, and therefore, a faster degradation process (Cyon and Piotrowska-Seget, 2006; Arbeli and Fuentes, 2010). High temperature is a characteristic of tropical environment and therefore this is significant to this study where historical and current profile of pesticides used Ibadan in UA, a tropical environment is being assessed. A tropical environment, according to Arbeli and Fuentes (2010), is defined as the land mass between the Tropics of Cancer and Capricorn and represents 40% of the world surface area. Though research on pesticide fates in tropical soils are limited, the faster degradation process that occurs in environment with high temperature means that tropical soils are less liable to long-term contamination of pesticides.

Organic matter content also influences pesticide movement in soil. The quantity of organic matter determines the adsorption rate of pesticides and their transformation products (Fenoll *et al*., 2001). Soil PH level also determines the rate of adsorption, the higher the pH level, the lower the adsorption is. For ionisable pesticides, adsorption can be increased by lowering the PH level (Zougmoré *et al*., 2016).

3.3.1.2 Pesticide characteristics that affect its' movement in soil

The characteristic of a pesticide type affects their movement in soil. These characteristics include solubility in water, soil adsorption and pesticide persistence (Gavrilescu, 2005, Ochoa and Maestroni, 2018). Pesticide solubility in water influences the ability of pesticide to adsorp to soil particles and hence, its persistence in the soil. Most pesticide compounds are produced in a form where they require water to m. Similarly, as explained in earlier chapters, pesticide movement in the environment, especially to their non-target organisms or earlier causes economic loss to farmers, poor pest control and environmental contamination (Tiryaki and Temur, 2010).

Pesticide persistence, also refer to as half-life is the number of days required for half of the initial pesticide quantity to break down in the soil (Gavrilescu, 2005; Tiryaki and Temur, 2010). The longer the half-life, the greater the potential for pesticide movement (Gavrilescu, 2005). Persistence is important in assessing pesticides because it signifies a causal relationship between pesticides and the environment long after its' application (Edwards, 2002). This is exemplified by the continued persistence of organochlorine pesticides in the environment long after they have been banned. Persistence indicates an impactful causal relationship that extends into the future because persistent chemicals that are present now will also be present to a certain extent after a considerable number of years (e.g., 25% after 10 years if the degradation half-life is 5 years). Pesticides can be divided into three categories based on half-lives: non-persistent pesticides with a typical soil half- life of less than 30 days, moderately persistent pesticides with a typical soil half-life of 30 to 100 days, or persistent pesticides with a typical soil half-life of more than 100 days (Kerle *et al*. 2007).

3.3.1.3 Pesticide degradation in soil and sediments

As mentioned in earlier sections, soil and sediments are the major sinks of pesticides after application and therefore the sites for degradation. Degradation is often used in predicting fate of pesticides in soils through laboratory and field dissipation studies and therefore a process worth mentioning. Pesticide degradation occurs when these chemical compounds are transformed into simpler compounds such as water, carbon dioxide, and ammonia during chemical reactions such as hydrolysis, photolysis, and biodegradation (Ochoa and Maestroni, 2018). These degradation processes and amount of pesticides left in soil and sediments are subjected to physical, chemical and biological factors which may be influenced by prevailing environmental conditions that control soil temperature and moisture content (Kah *et al*., 2007;

Vryzas, 2018). Temperature

3.4 Methods of assessing pesticide contamination in the environment

To assess pesticide contamination in the environment, it is imperative to consider the chemical, physical, biological, and hydro-meteorological factors that affect their presence and persistence. This has been discussed in the earlier section of this chapter. These factors affect their transport, degradation and uptake by plants and organisms when applied in farms (Gevao *et al*., 2000; Ochoa and Maestroni, 2018). Due to the various factors that influence pesticide movement and hence, the degree of contamination, different methods can be employed in assessing pesticide contamination.

3.4.1 Direct measurements

One of the most reliable ways of assessing pesticide contamination is use of direct measurements in field experiments. This is so because it provides realistic assessments on the presence and effect of pollutants in soil, sediments, water and organisms (Racke *et al*., 1997). Furthermore, it is used to provide region-specific information on pesticide fate in different soil types, usage, regional- and climatic-dependent variables (Racke *et al*., 1997; Edwards, 2003). Direct measurements include collecting sample of interest in form of surface water, soil and sediment directly from sample sites, preserving and transporting them to the laboratory for toxicity bioassays and (chemical) pesticide residue analysis. The sample preparation process and instrument determination are crucial to pesticide assessment because determination of pesticide residues in an extensive variety of conditions is challenging as a result of the small quantities of analytes and huge amounts of interfering substances that may affect the quality of the result (Tuzimski, 2012; Zhang *et al*., 2012). The type of instrumentation to be used determines the sample preparation method (Zhang *et al*., 2012).

Pesticide residue analysis of field samples are carried out after extracting the analytes through a cleaning up process and can be spiked due to low levels of pesticides that may be present in the environment (because of the pesticide transport system). The pesticide residue analysis process may involve spectrometry methods or the adapted QuEChERS (quick, easy, cheap, effective, rugged, and safe) method (Schenck *et al*. 2009).

The traditional gas/liquid chromatography-mass spectrometry methods were developed for rapid multi-residue determination of OP insecticides in fresh fruits and vegetables at the 1-ng/g level (Anastassiades *et al*. 2003). This method entails acetonitrile extraction of food samples with magnesium sulfate and sodium chloride, followed by a solid-phase dispersive cleanup using graphitized carbon black and primary secondary amine solid-phase extraction sorbents and the addition of toluene. Extracts were evaporated almost to dryness under a nitrogen stream at 50°C and reconstituted in toluene for determination of OP and pyrethroid pesticide residues. The OP residues were determined using a gas chromatographic method with pulsed flame photometric detection, flame photometric detection, and mass spectrometry with limits of detection (LODs) ranging from < 1.0 to 10 ng/mL. The pyrethroid insecticide residues were determined using a gas chromatography method with halogen-specific detectors and/or mass spectrometric detectors, with LODs ranging from 5.0 to 25 ng/mL (Wong *et al*. 2010). They are however expensive and labor- intensive.

3.4.2 Measurement by indicators

Even though direct measurements are the best assessments for contaminations, indicators can be deployed when it is not possible to obtain direct measurements (Burrows & Edwards, 2002). Indicators are variables which provide information on other variables which are difficult to understand and may be a complex system (Beketov *et al*., 2008; Schriever *et al*., 2008). They are used to synthesize data, display current state of assessment, demonstrate the achievement or non-achievement of objectives; and finally communicate current status to users for management decisions (Bockstaller *et al* 1997). This is especially useful when monitoring for pesticides in surface waters which can be problematic due to the large number of different compounds potentially present, the rate of diffusion and transient nature. These substances are generally diffuse and transient pollutants and are often present at low concentrations.

3.4.2.1 Biological indicators

One of the bio-indicator methods is the development and use of soil enzymes as bio- indicators of soil quality (Floch *et al*., 2011). Soil enzyme bio-indicators were developed with the aim of creating sensitive and appropriate indicators of soil contamination from pollutants such as pesticides based on the assumption that the biological properties of soil, such as enzyme activities, can be used as earlier indicators of soil degradation than chemical or physical parameters. Due to the sensitivity of these soil enzymes to pollution, they are therefore used as a measurement of soil degradation (Trasar-Cepeda *et al*., 2000). Another positive characteristic is that they are relatively simple, rapid, and cost-effective. Also, many soil enzyme assays are ideal for this purpose, being relatively simple, rapid, and cost effective. Furthermore, soil enzyme bio-indicators are specific to specific active ingredients in pesticide (lock and key mechanism pesticides may directly interact with soil enzymes by binding with the active groups of the proteins and consequently affect their catalytic activities However, they have only been used under laboratory condition and in single pesticide studies at different incubation times.

Results of studies that have tried this bio-indicator revealed that soil enzyme activities differ in their sensitivity to pesticide addition, producing both significant positive and negative responses, in soil microcosms. During the experimental approach, microcosms were particularly useful to investigate a wide range of pesticide effects on soil enzyme activities. However, numerous factors encountered in the natural environment were not included; moreover, soils are generally subject to multiple pesticide contaminations instead of a single contamination. It can be also assumed that commercial formulations with additives other than pesticides will have different effects on soil microbial functions than pure active ingredients.

Another bio-indicator is the use of aquatic organisms. Studies reveal that diatoms can help to indicate pesticide contamination. However, soil algae are present in all kinds of soil. On the top few centimetres of the soil layer these little microorganisms are concentrated (Adekunle *et al*., 2017). Algae are organized in the layers depending upon the type of soil, farming methods, and application of pesticides used over these photosynthetic microorganisms. Contaminated pesticides are difficult to assess that is why the concept of diatoms are used. In biomonitoring, there is a great interest in using morphological aberrations. Overall use of abundance teratology is an excellent tool for identification and determination of contaminated and non-contaminated pesticides (Ben-Iwo *et al*., 2017).

According to Schnurrenberger *et al*. (2002), lakes play a dynamic role of integrating environmental effects into a continuous, high-resolution archive of local and regional change. This archival system is achieved through the continuous sedimentation process of the lake right from their formation be it natural or man-made. Lakes accumulate sediments continually, a process that has been ongoing since their formation, in many cases for several thousand years or even longer. The sediment consists of biological remains from the lake itself and its surroundings, as well as soil particles and other non-biological material originating from the lake catchment and also the atmosphere. Hence, the sediment sequence in each lake is a continuous environmental archive, which contains information about the history of the lake and its surroundings.

Sediment analysis serves a reconstruction tool to create a historical timeline of pesticide use in an agricultural ecosystem (Weston *et al*., 2007; Sabatier *et al*., 2014) since sediments act both as a sink and as a source of pollution and sources of pollutants to surface water and biota (Somparn *et al*., 2017). In the case of this study, it allows for assessing incidence of continuous pesticide use amongst urban farmers in Ibadan, South-Western Nigeria. For example, Sabatier *et al*, 2014 in their studies using sediment analysis to validate pesticide use in a local vineyard were able to produce results showing how farming practices affect pesticide transfer dynamics. They discovered that introduction of short stay post- emergence herbicide glyphosate led to a release of long-term immobilised DDT pesticide.

Studies reveal that diatoms can help to indicate pesticide contamination. Diatoms act as biological indicators. However, soil algae are present in all kinds of soil. On the top few centimetres of the soil layer these little microorganisms are concentrated (Adekunle *et al*., 2017). Algae are organized in the layers depending upon the type of soil, farming methods, and application of pesticides used over these photosynthetic microorganisms.

Contaminated pesticides are difficult to assess that is why the concept of diatoms are used. In biomonitoring, there is a great interest in using morphological aberrations. Overall use of abundance teratology is an excellent tool for identification and determination of contaminated and non-contaminated pesticides (Ben-Iwo *et al*., 2017). In modern times, identification of diatoms is based on the morphological characters like symmetry, physical shape, density, and many others. Diatom contains outer cell walls composed of two valves that are made up of amorphous silica that is gone through polymerization. The frequency of deformities occurrence is mostly low but are commonly noted in diatom assemblages. Because of physical or chemical stresses cell division in cellular processes and the formation of a valve can be altered (Graziosi *et al*., 2017). The diatom cell density is a very simple metric that does not require any taxonomic knowledge. Under the conditions of contaminated stress, algal growth is observed as a result of lower call counts are expected. However, numerous other factors like water discharge and grazing pressure have an impact on biomass and algal extension (Ifeanyichukwu *et al*., 2018). Difficulties in monitoring for pesticides makes attributing any observed changes in a biological community to pesticide contamination complicated. An indicator that would allow us to diagnose pesticide contamination at a site would be very useful (Beketov *et al*. 2008).

3.4.2.2 Use of Lead (Pb) 210 Dating to Assess Pesticides

Lead-210 (210Pb) is a valuable tracer/indicator radioactive isotope for carrying out environmental investigations (Mabit *et al*., 2014). It is used for dating, tracing, and modelling biogeochemical cycling in ecosystems in the field of natural and physical sciences (Mabit *et al*., 2014). Lead-210 is a naturally occurring radioactive element, an element of Uranium radioactive series, the elements of this series have a countless half-life. Natural radiation consists of cosmic radiation and the radiation derived from the decay of naturally occurring radionuclides (NRC, 1999).

Primordial radionuclides exist as left-overs from when the earth was created, are the major contributors to our radiation environment (Shahbazi-Gahrouei *et al*., 2013). These natural radionuclides include the primordial radioactive elements in the earth's crust such as, their radioactive decay products, and radionuclides produced by cosmic-radiation interactions. Therefore, it is present in earth's crust with an unchanging concentration over time. The concentration of uranium varies in different places, but it is present in almost all sediments and soil. These elements keep decaying continuously. By the time Uranium -238 decays into Uranium-234, which then decays to Uranium-230, and then into Radium-226 (Basu *et al*., 2016). This way, the chain of reproductive elements decays continuously. However, the radioactive concentration remains the same as it was in uranium before. This is because of the natural process called secular equilibrium and therefore an indication that radium- 226 is found everywhere in soil at low levels (Carvalho *et al*., 2017).

The method of 210Pb is a chronological framework that was established by measuring short-lived radionuclide elements. A calculation is based on some constants and parameters. The first constant is sedimentation rate constant, the second constant is of the flux of excess 210Pb to the sediment-water interfacing constant (Abtew *et al*., 2016). The third parameter is post-depositional migration of the radionuclide and the fourth is the activity of 210 Pb by the aid of 226Ra in the sediments that is independent of deepness. By considering these parameters, the dating 210Pb helps to assess the pesticides contamination and sedimentation (Ameh *et al*., 2017). The basic equation of radioactive decay helps to understand the lead 210- dating. Radioactive decay can be defined as in the unstable isotope elements the number of atoms decreases with time. In this equation "N" shows a number of unstable elements. And lambda refers to the radioactive decay constant (Ameh *et al*., 2017).

$$\boxed{-\int_{N_0}^{N_T} \frac{dN}{N} = \int_{N_T}^{N_0} \frac{dN}{N} = \int^{T} \lambda \, dt}$$

Equation 3.1: Basic Radioactive Decay Equation

Pb-210 dating is a technique that can be used for pesticides contamination. It is an isotope of Pb or leads that is formed by the decaying sequence of Uranium-238 (Basu *et al*., 2016). Sediments and soil contain an already existed level of Pb-210 that is formed due to the decay of Radium, which is incorporated into sediments due to rocks erosion. As soon as the former PB-210 is lost the new Pb-210 creates by the continuous decay of Ra-226. An excess of unsupported Pb-210 is also present in the young sediments. In order to analyse how Pb-210 helps in determining and assessing the pesticides, a model of equations is used.

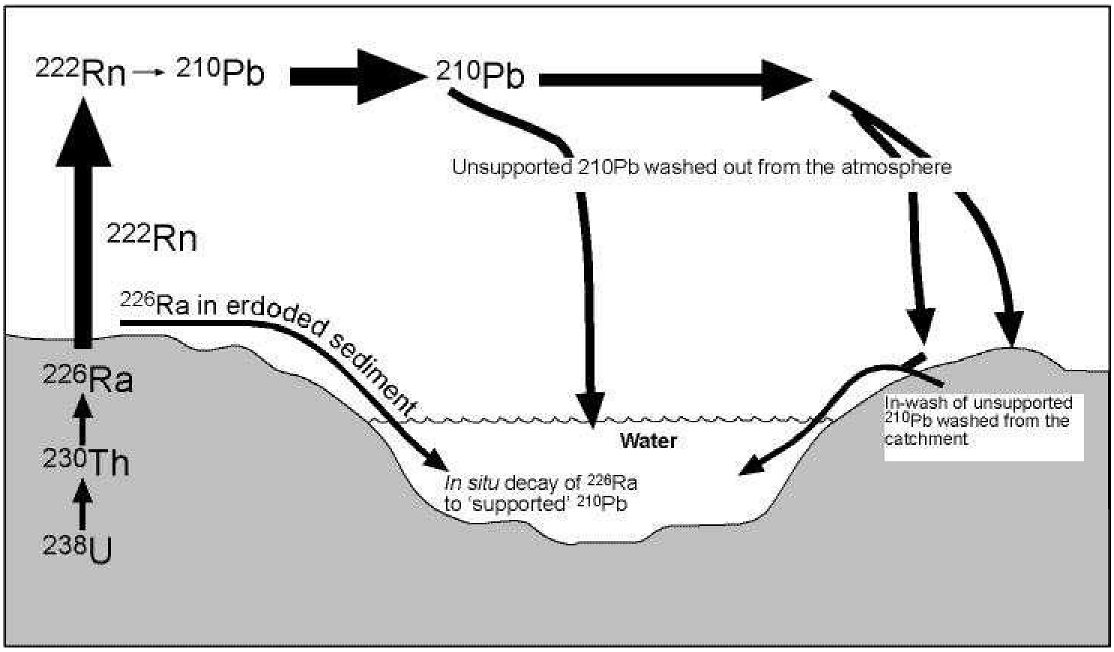


Figure 3.2: An illustration of Radiometric Dating

Source: (www.ocean.washington.edu)

Steps behind the Pb-210 dating to assess pesticides are described below.

- Identification of previously existed radioactive material. Where the value should be taken at larger depths that is constant there.
- Subtraction of the previously existed value from the new observed at lower depths.
- Take the natural logarithm on observed values.
- Plot the graph of depth z against the log of previously observed values.
- Measure the slope in the mid region. It should be negative.
- To get the sedimentation and contamination rate of pesticides, multiply the minus slope by radioactive decay constant. The constant value of lambda is (λ= 0.0311 yr- 1).

This method is limited to certain situations like where it is not applicable where the sedimentation rate varies with time (Egendorf *et al*., 2018).

The Pb-210 method helps to estimate the age, accumulation rate of the sediment from a specific depth within the sediment column. For pesticide assessments, the accumulation rate of sediments in lakes, oceans, streams, rivers, and several water bodies can be determined by using the Pb-210 dating method (Alam *et al*., 2016) to study the depth profile of historical pesticide residues in an environment (Pandit *et al*., 2014). This method helps in quantifying the amount of erosion and sediment accumulation in agriculture water wells. At the watershed scale, this method is effective to assess the effectiveness of soil conservation. When radioactive element decays it produces the radioactive gases, called inert gases. Radon is among the inert gases, it can outflow into the atmosphere before decaying to the next radioactive element (Darkoh and Rwomire, 2018). This is possible only in a condition if the gas is produced in soil, where soil and air interfere. Before applying this technique, it is assumed that the sediments of lake and streams are receiving a continuous input of Pb-210 from the atmosphere. If Pb-210 that was integrated into the sediments about 22.2 years ago will remain only 50 percent radioactive as it was initially added (Wossen *et al*., 2018). That is why this process is used to calculate the sediment age and accumulation rate of sediment.

In this study, the use of Pb 210 is adopted for assessing the contamination of pesticides. Pesticides and sediments are continuously accumulating for several years. In order to assess the accumulation rate and save the various species, it is important to measure the depth of accumulation. Krishnaswami *et al*. (1971) introduced a model to determine the presence of Pb 210. During the last several decades, agricultural pesticides are used at a higher rate around the world. In addition to this, long term storage and dynamic transformation of pesticides are changing our environment drastically. A number of dangerous pesticides have been banned but due to persisting nature, the molecules of these pesticides can remain in the soil, sediments, underground water and ice (Wahab *et al*., 2018). This method presents an approach to monitor and determine the micropollutants and the long-term transfer and diffusion of herbicides, fungicides, and insecticides. The use of post- emergence herbicides (glyphosate) increases soil erosion and sedimentation. There are various other hazardous chemicals used in agricultural pesticides that are behind the changing in the environment.

According to Egendorf *et al*. (2018), samples that were under 1700 m of rocks were analysed by the dating method in the Laboratory Souterrain de Modane. The radioactive elements used include 210Pb, 226Ra, 228Ra, 228Th, 234Th, 241Am, 137Cs, 7Be. By selecting low activity materials and the dominance of cosmic radiation, the lessening of the crystal was obtained. For measurement, the detector sensitivity was allowed for the reduction in sample mass at the same time. This helps to measure both less radioactive levels and small weights as well. Using the Gamma rays exhibited by their short-term descendants about 40K levels were analysed and measured by the gamma emission at 1460 Ke V (Darkoh & Rwomire, 2018).

3.5 Conclusion

This chapter has reviewed literature on pesticide misuse, awareness, knowledge, and behaviour of farmers who are the primary consumers of pesticides, the process of pesticide contamination and methods of assessing their presence in the environment. Previous studies on these subjects are used in designing the questionnaire survey, which is discussed in detail in the next chapter.

Chapter Four

Research Methodology

This is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits

-Rachel Carson, Silent Spring

4.1 Introduction

The quote above aptly summarizes the motivation for this study which is situated on the premise that pesticide use in modern agriculture, with particular focus on urban agriculture has both direct impacts on the environment and indirect ones on the society and economy. These impacts- discussed in chapters 2 &3- are not in isolation of one another and as such requires an interdisciplinary approach. As the practice of agriculture involves a complex interaction of technologies within the social, environmental, and economic dimensions, unilateral approaches are no longer sufficient to resolve research problems that cuts across other sustainability dimensions (Zinsstag *et al*., 2011). Taking cognizance of todays' fast-changing landscape with the heightened impacts of our activities on climate change, the challenge presented by pesticide reliance in urban agriculture need to be tackled within the perspective of other factors beyond environmental issues. For instance, aside from measuring presence and persistence of pesticides from environmental point of view, this study acknowledges the need to explore the social and economic dimensions that is driving pesticide reliance.

Following the conceptualisation of the potentials of UA to significantly contribute to SD (chapter 2), and that an understanding of drivers for pesticide use can play a critical role in it's practice, therefore promoting sustainability via food security, improved livelihood and environmental protection, this chapter presents the justification for combining social and natural science methods in this interdisciplinary approach to answer research question, including how it fits into the research paradigm adopted for this study. It will discuss the strength and weaknesses of methods used and adapted in the inquiry process. In summary, this chapter will be in two parts with the first part focused on research philosophical issues including the research methodology, research paradigm and justification for interdisciplinary approach; while the second part will present the study area and quantitative and qualitative methods adopted from both natural and social science research paradigms. The chapter concludes with a section on ethical decisions and considerations taken in the course of the study.

4.2. Research methodology

Research methodology is the overall action plan as regard the choice and use of specific methods and linking the choice and use of these methods to the expected outcomes (Crotty, 1998). Olsen (2004) also defined it as a set of proposed techniques in combination with ontology (underlying assumptions about the world) and epistemology (assumptions about how to establish true statements about the world). It therefore situates the scope of research, likely problems and steps taken to minimize their impacts on the interpretation of findings, and subsequently, the overall research (Crotty, 1998; and Daryl, 2014). This research's methodology therefore involves an interdisciplinary approach, combining an investigation of the impacts of pesticides on soil and sediments over time, using natural science methods, with an exploration of the extent of pesticide usage and small-urban farmers' knowledge on environmental impacts and best practice in Ibadan Nigeria, using social science methods.

To fully grasp the philosophy behind the research, this section shall also explore research paradigms and the limitations of the research. It also explains the process and rationale behind the research design and what influence this may have on the overall conclusion of the entire thesis.

4.2.1 Research philosophy

This section describes the research philosophy and paradigm underlying this study; justification for interdisciplinary research; and the ethical considerations in designing the study.

Research philosophy is important as philosophical ideas influence the research design and practice of research. A research design is a framework that guides or sign-post the collecting and analysing of data evidence in such a manner that makes it possible for the research questions to be answered (Ragin, 1994; Bryman, 2004). The research design should have capacity to create conditions which enable a contribution to theory (Gerson and Horowitz, 2002). The choice of research design is influenced by the dimensions and priority of the research, examples being, establishing causal relationships, generalising with respect to a larger population, understanding behaviour and its meaning within specific contexts and understanding interconnections of social phenomena within specific time (Bryman, 2004).

This research design, as described by Oppenheim (1992), is the basic outline of the research and the logic behind an assessment of pesticide use in UA within the context of sustainable development dimensions, which allows for formulation of explicit research questions that allows for valid conclusion to be drawn. Therefore, the research design used in this study is a combination of both quantitative and qualitative methods from natural and social science research respectively.

To plan a good research design according to Creswell (2009), three elements need to be considered. These are: the intersection of philosophy (ontology and epistemology), plans of inquiry, and specific methods (Creswell, 2009). Philosophy gives a snapshot into how a thesis imparts on the world beyond the abstract, which subsequently informs the plan and line of inquiry. The line of inquiry, which is how pesticide use in urban agriculture impacts on the environment, society and the economy, is therefore used in selecting specific methods that will be used to answer the research questions: assess the impact of pesticide use on soil and water; create both historical and current profile of pesticide use; and evaluate the extent of pesticide use; and explore farmers socio-economic and environmental considerations on pesticide use (Creswell, 2009).

Since philosophical assumptions are underpinned by an intersection of epistemology and ontology (Creswell, 2009), one may safely assume that understanding both the epistemology and ontology behind the research topic is necessary to identify the best research paradigm that embodies the methods needed to answer the research questions. According to Grix 2004: 58, "ontology and epistemology can be considered as the foundations upon which research is built." It is the researcher's ontological and epistemological assumptions that inform the choice of methodology and methods of research. King and Horrocks (2010) defined epistemology as the philosophical theory of knowledge while ontology is described as what reality exists (Crotty, 1998). This suggests that epistemology is knowledge that can be established adhering to a process (Crotty, 1998) to define how we know what acceptable knowledge is, what is to be gained from it, and how we communicate it (King & Horrocks, 2010).

4.2.2 Research paradigm

A research paradigm, as defined by Teddlie and Tashakkori (2009) is ''a worldview, together with the various philosophical assumptions associated with a particular point of view''. This definition is also in agreement with Creswell & Plano Clark (2007). Grix (2004) referred to paradigm as the understanding of what one can know about something and how one can gather knowledge about it. To understand the use of pesticide in urban agriculture, one requires a view that allows for both a glimpse and in-depth analysis of issues and patterns identified. Patton (2002) further expatiated the description of paradigm as a way of describing a world view that is informed by philosophical assumptions about the nature of social reality (ontology), ways of knowing (epistemology), and ethics and value systems (axiology).

Paradigm was a term adapted from the works of Kuhn (1962; 1970), allowing for researchers to define their epistemological stance along the research continuum of two traditional approaches of quantitative and qualitative research. A paradigm is an approach, or a research model adopted to conduct research. A paradigm must be verified and accepted by the research community and applied in research design for many decades. Morgan (2007) identified four different meanings of paradigm: a worldview; an epistemological stance; shared beliefs among a community of researchers and model examples of research. A paradigm therefore provides a backdrop against which we ask certain questions and use appropriate approaches to carry out a systematic inquiry. Ontology relates to whether we believe there is one verifiable reality or whether there exist multiple, socially constructed realities (Patton, 2002). Morgan (2007) accepted that the description of paradigm as an 'epistemological stance' is the most used meaning of paradigm in discussions of social science methodology and this is the position adopted in this research. Epistemology inquiries into the nature of knowledge and truth. It asks the following questions: What are the sources of knowledge? How reliable are these sources? What can one know? How does one know if something is true?

The main paradigms that evolved from the understanding of the 'not mutually exclusive' traditional approaches of quantitative and qualitative research include positivism, interpretivism, critical realism and post-positivism (see Table 4.1). In limiting the scope of this discussion, the two paradigms that situates the epistemological position of this research, are the traditional positivist and interpretivist approaches, will be briefly discussed and its contribution to the evolution of post-positivism, which is the main paradigm of this research.

The traditional positivist paradigm produces scientific knowledge through the process of objectivity and therefore is accorded a dominant role in conventional agricultural research methods (Ingram, 2004; Nuijten, 2011). This paradigm generates and portrays information objectively without considering the interplay of other factors that may not be clearly obvious (Onwuegbezie, 2000). This paradigm aims at explaining cause and effects in a study by explaining relationships (Creswell, 2009; Grix, 2004). Positivist methodology aims at explaining relationships and mostly characterised by experimental designs, hypotheses testing and verification by experiments between the independent and dependent variables (Creswell, 2009). It mainly thrives on homogeneity and therefore provides sectarian answers to research problems. This paradigm would have been solely adopted in this study if research questions are being asked in isolation of one another. However, the objective of this research is to assess pesticide use in a way that acknowledges the existent relationship among the three dimensions of sustainability and therefore, this line of inquiry will not fully meet the research objectives.

To support the positivist approach in fully answering the research inquiry, an interpretivist paradigm is adopted. This paradigm perceives reality as an interconnectedness phenomenon that requires meanings and understandings on social and experiential levels (Nguyen and Tran, 2015). According to Cohen *et al*. (2007), it is noted that interpretivist researchers discover reality through participant's views, their own background, and experiences. As this study involve human subjects as primary consumers of pesticides, a paradigm that allows for understanding the why of the pesticide use is required. This will contribute towards an understanding of farmers' role in deciding pesticide use and inform on providing mitigating measures towards reducing its use in UA.

For this study, research paradigm can simply translate to the framework required to know about incidence and impacts of pesticide use in urban agriculture by small-urban farmers through both quantitative and qualitative research methods. This means this paradigm in this research context is a way of describing pesticide use informed by increased use of pesticides by urban farmers within the principle of sustainability and measuring their incidence and impacts through both quantitative and qualitative methods. Furthermore, the interactions amongst the three main dimensions of sustainability are acknowledged and factored in the research process.

Table 4.1: Characteristics of positivist and interpretivist paradigms

Philosophical assumption		**Positivism**	**Interpretivism**
Ontology	Nature of inquiry	Objective, tangible and single.	Socially constructed;
	Goal of research	Explanation and strong prediction	Understanding and weak prediction
Epistemology	Focus of interest	Provides general, average and representative	Specific, unique and deviant;
	Knowledge generated	Laws, Absolute	Meanings are relative, based on time, context, culture and value.
	Subject/Researcher Relationship	Rigid separation	Interactive, cooperative and participative
Methodology	Desired information	How many people think and do a specific thing or have a specificproblem	What some people thinkanddo, whatkind of problems they are confronted with, and how they deal with them.

Adapted from Pizam and Mansfeld (2009)

4.2.3 Interdisciplinary approach

The extent of interdisciplinary and mixed methods studies in present-day academia suggests that multi-lateral approaches provide valuable insights to research problems (Archibald *et al*., 2015), especially in those that involves human and environmental issues (Popp *et al*., 2012). Given the relationship that exists between the environment and socio- economic dimensions of SD, such as issues involving pesticide use in UA where pesticide consumption is driven by social and economic needs of ensuring food security and sustaining livelihoods, the significance of interdisciplinary studies in integrating different theories, concepts and data from different traditional research methods becomes apparent (Schoolman *et al*., 2011; Spangenberg 2011). In this current study, issues such as pesticide use assessment cannot be addressed by one scientific discipline e.g soil analysis alone or questionnaire survey alone, but by combining other disciplines to understand drivers and interactions behind its use. For instance, while quantitative measurements in form of questionnaires and field measurements are needed to create a context for extent of pesticide use and presence in the soil, qualitative instruments such as interviews, focus group discussions and key informant discussions provides a depth to the analysis and evaluation of problem statement (Munda and Saisana, 2011). Therefore, to understand how pesticide use changes in the natural environment and farmers' knowledge on pesticide use, awareness of its' impacts and motivations for its use, a research methodology that allows for heterogeneity of factors of interest is required.

This methodology is adopted by acknowledging that adverse environmental impact from pesticide use are influenced by economic and social decisions which subsequently limit the actualization of sustainable agriculture, and subsequent sustainable development. By acknowledging this relationship, the objectives of this study include assessing pesticide in the environment and its incidence, which involves natural science data collection and analysis and social science methods for understanding factors from the farmers' perspectives that drive pesticide (quantitative and qualitative analysis).

As presented in Figure 4.1, this research is designed as an interdisciplinary one, to help better understand pesticide use and impact amongst small-urban farmers using a combination of social and natural sciences research methods. An interdisciplinary approach is a means of solving problems and answering questions which cannot be satisfactorily addressed using methods or approaches from a single discipline (Borrego and Newswander, 2010). In this study, three distinct, yet overlapping factors are involved in the theoretical framework; environment, social and economy; and each can only be measured/assessed using approaches from different disciplinary foundations.

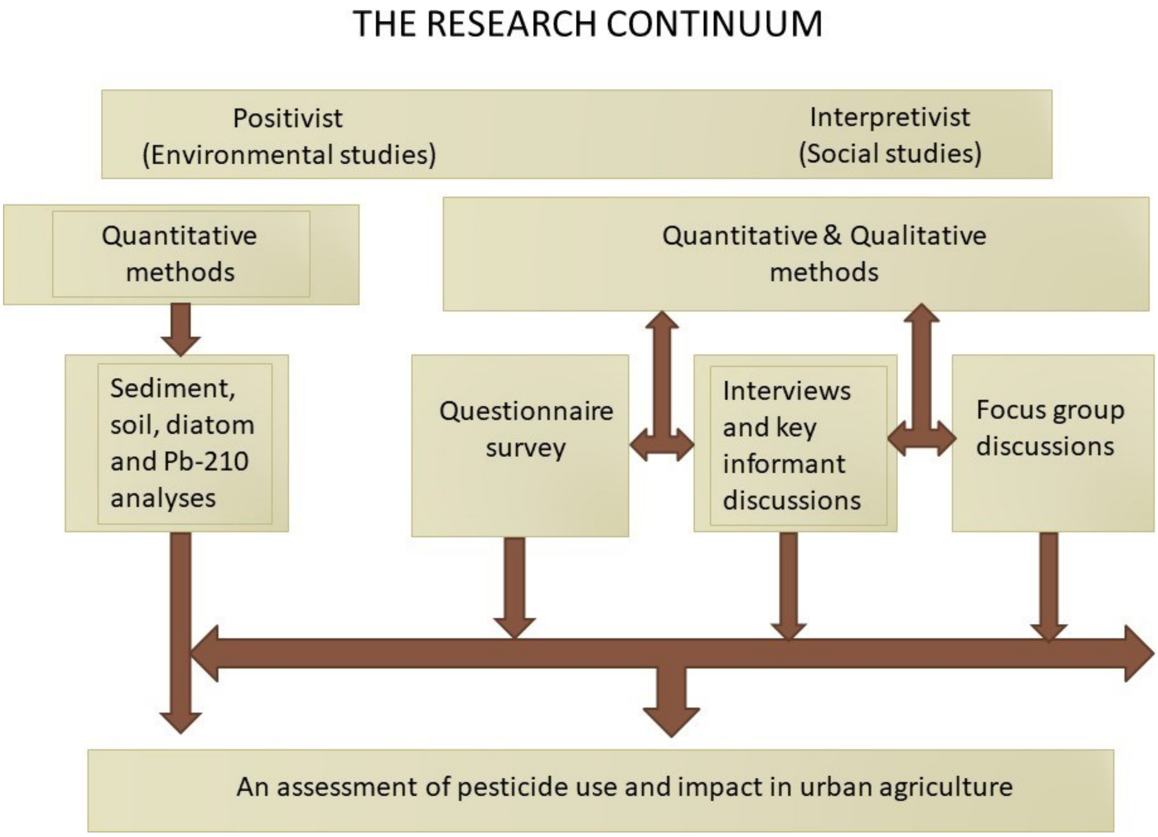


Figure 4.1: Graphical representation of the research paradigm in an interdisciplinary study

This approach, which is defined by both positivism and interpretivism paradigm, is adopted to provide an integrated understanding of pesticide incidence in the environment and farmer behaviour not only from the accounts of the users i.e., the urban farmers but also with respect to soil and sediment analysis. It allows for combining methods from both natural and social science disciplines which can be quantitative and qualitative. This interdisciplinary approach provides the opportunity to assess pesticide contamination from urban agriculture, and simultaneously understand social and economic factors responsible for it, with a subsequent goal of providing a robust solution to pesticide misuse in urban agriculture. It combines a natural science method of both chemical and biological analysis of sediments and soil samples to assess both historical and current environmental contamination from pesticide use and a social science instrument of questionnaire survey and interviews and focus groups to provide an overview of pesticide incidence, knowledge and behavior in UA.

A combined approach, drawing on a mix of natural and social science (quantitative and qualitative) approaches in this study, will help to bridge the gap between natural science research into environmental impacts of pesticides and its social and economic implications in urban agricultural practice by small-holder practitioners (Becker and Bryman, 2004). As such this study attempts to fill a gap in existing knowledge by carrying out an integrated research in a single study.

4.3 Study area

This section provides an overview of the study area within a geographical and administrative context. A profile of Nigeria as country which include its administration and geographical divisions and how the country's food security challenge might have influenced pesticide use in urban agriculture had been presented in chapter two. The country's food security challenge had also been discussed in chapter two under the scope of study and research context. This section will therefore provide an overview of Oyo state as one of the thirty-six states of the country and its contribution to agricultural production. This is followed by a much more detailed description of Ibadan city as the primary study area is provided to show the importance of urban agriculture with reference to pesticide use.

4.3.1 The profile of Oyo State

Figure 4.2 presents the map of Nigeria, showing the geographical position of Oyo state. The State is located in the rainforest vegetation belt of Nigeria between latitude 20 381 and 40 351 east of the Greenwich meridian in the south-west zone of Nigeria. It is bounded in the south by Ogun State and in the north by Kwara State, in the west by the Republic of Benin, while in the east it is bounded by Osun State (formerly part of Oyo State). Oyo state exhibits the typical tropical climate of averagely high temperatures, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October.

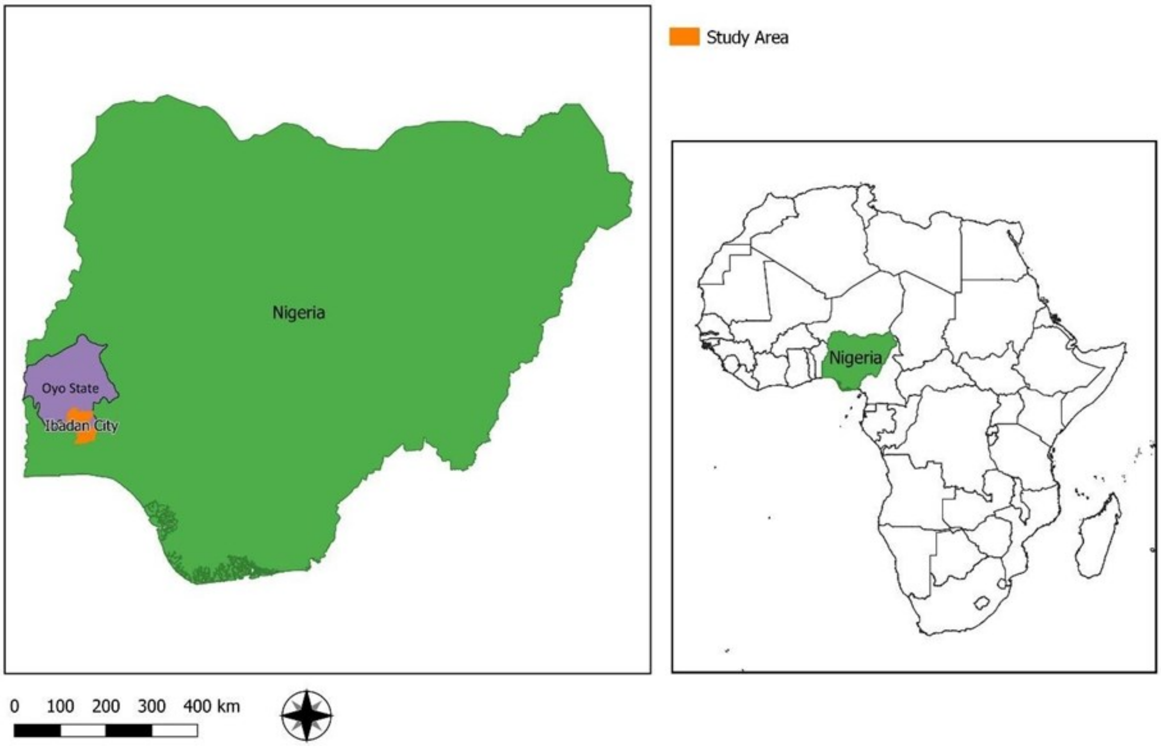


Figure 4.2: Map of Nigeria showing the sample area

It consists of thirty-three (33) Local Government Areas and covers an area of 28,454 square kilometres. Out of the thirty-three local government area, Ibadan the capital city (sample area) comprises eleven local government areas. The state has an estimated population of over 5,591,589 million people (N.P.C, 2006). The state residents are mainly engaged in Agriculture (both rural and urban) with small-scale traditional farming system predominating in the area cultivating a variety of food and cash crops, such as vegetables, yam, maize, cassava, millet, plantain, banana, rice, and fishing, which is favoured by the tropical nature of the climate, which has an average temperature and rainfall figures of 27.1^{0}C and 1313.13mm respectively (Adewuyi *et al*., 2015).

4.3.2 The profile of Ibadan city

Ibadan, the capital city in Oyo state and its economic capital is reputed to be the third largest city in Africa and not left out in the current trend of human population growth (Figure 4.2). It has a population of 3,565, 108 million people (UNDATA, 2015) from 100,000 recorded in 1951 (Onibokun and Faniran, 2011). This population increase is attributed to the urban sprawl that has expanded from 36-kilometre square in the 1950s' to over 400 kilometre square it occupies today (Onibokun and Faniran, 2011).

There are eleven (11) Local Governments in Ibadan Metropolitan area consisting of five urban local governments in the city and six semi-urban local governments in the less city. Local governments at present are institutions created by the military governments but recognised by the 1999 constitution and they are the third tiers of government in Nigeria. The fiscal federalism approach treats local government as a subordinate tier in multi-tiered system and outlines principles for defining the roles and responsibilities of orders of governments. Hence, in most federations as in Canada, the United States and Nigeria, local governments are extensions of state governments.

Local governments Councils consist of the Executive Arm made up of the Executive Chairman, the vice chairman, the secretary and the supervisory councillors. The legislative arm consists of the councillors representing the 127 political wards, each headed by a leader and supported by other house officials while the Director of Personnel Management (DPM) serves as the clerk of the house. There are six major departments in each local government which in turn are made up of divisions and sections. Various departments execute the policies and directives of the Executive. The senior staff members are employed and disciplined by the Local Government Service Commission (LGSC). The administrative departments are headed by a Director and include Personnel Management; works, Housing and Survey; Finance and Supply; Educational and Health and environmental Services and Agriculture.

4.3.2.1 Geographical profile

Ibadan is geographically situated within the tropical hinterland climate zone (about 150–240km northwards from the coast) with 1000 to 1500mm annual rainfall, temperature range of 21–25°C and relative humidity range of 50–80%. The city enjoys two distinct seasons namely, the rainy season between April to October and dry season between November and March. The rainy season is characterised by high rainfall with a mean annual rainfall of about 1237mm (Olayinka *et al*, 1999). The dry season is also characterised by dry dust laden winds originating from the Sahara' desert and experiences occasionally low rainfall. Average temperature reaches a peak of 28.8^0C in February and reaches a low of 24.5^0C in August.

The dry season range from 4–5 months between November to March, with December- January characterized by NE-SW dry, cold, and dusty harmattan trade wind, from the Sahara Desert. The city is characterized by bush, herbs, shrubs, trees, grasses, palm vegetation and comparatively high temperature and rainfall throughout the year. Most of the precipitation is received during the wet season and all the streams are perennial in nature.

The city is drained by three important rivers- River Ogunpa, River Ona and River Ogbere. The River Ona directly feeds into Eleyele Lake. The economic activities in the city include agriculture, commerce, handicraft, manufacturing, and service industries. Despite a decline in the city's farming practitioners, agricultural activities still remain an important industry in Ibadan with local government areas involved in subsistence farming, commercial farming and settlement farming (Odewumi *et al*., 2013).

4.3.2.2 Agricultural profile

During the colonial period (end of the 19th century – 1960), the Nigerian economy depended mainly on agricultural exports and on proceeds from the mining industry. Small- holder peasant farmers were responsible for the production of cocoa, coffee, rubber and timber in the Western Region, palm produce in the Eastern Region and cotton, groundnut, hides and skins in the Northern Region. The major minerals were tin and columbite from the central plateau and from the Eastern Highlands. In the decade after independence, Nigeria pursued a deliberate policy of import-substitution industrialisation, which led to the establishment of many light industries, such as food processing, textiles, and fabrication of metal and plastic wares. These were financed by revenue derived from exports of agricultural products. During this period, the Gross National Product grew at a rate of about 3.2 per cent per annum.

4.3.2.3 Geological and topographical profile

Ibadan lies mostly on lowlands influenced by rocky outcrops and series of hills. These crops are mainly granitic. Three major land forms of hills, plains and river valleys dominate the whole landscape of the region. The average elevation is 230m above mean sea level. The metropolis is drained by three major rivers, Ogunpa, Ona and Ogbere alongside their several tributaries which include Omi, Kudeti, Alaro and Alapata. These combinations of hills and river valley provide a good drainage for the city, but it has suffered a lot of mishap due to blockages of the water course by solid waste coupled with the construction along the river course and sometimes right within the course itself. Ibadan is underlain with basement complex rocks which are mainly metamorphic rocks of Precambrian age with granite, quartzite and migmatite as the major rock types. This city was purposively selected for this study because of its importance in UA practice in Nigeria.

4.3.3 Sample area

The main objective of the study is to assess pesticide use in urban agriculture in Ibadan so as to contribute to knowledge on why pesticide misuse remains a threat in developing countries such as Nigeria. In Ibadan, Urban agriculture has reduced the influence of farm- gate sellers and middlemen and therefore protect the profit of the farmers as transportation costs, storage cost and daily commission are removed from the production cost and therefore leading to high amount of profits. To assess pesticide use amongst urban agricultural practitioners, a sample of Ibadan city population is drawn for survey (see Fig. 4.3 for map). The sampling frame was purposively designed to select five local government areas from the city's administrative areas. This purposive sampling was adopted so that local government areas close to Eleyele Lake were included in the study.

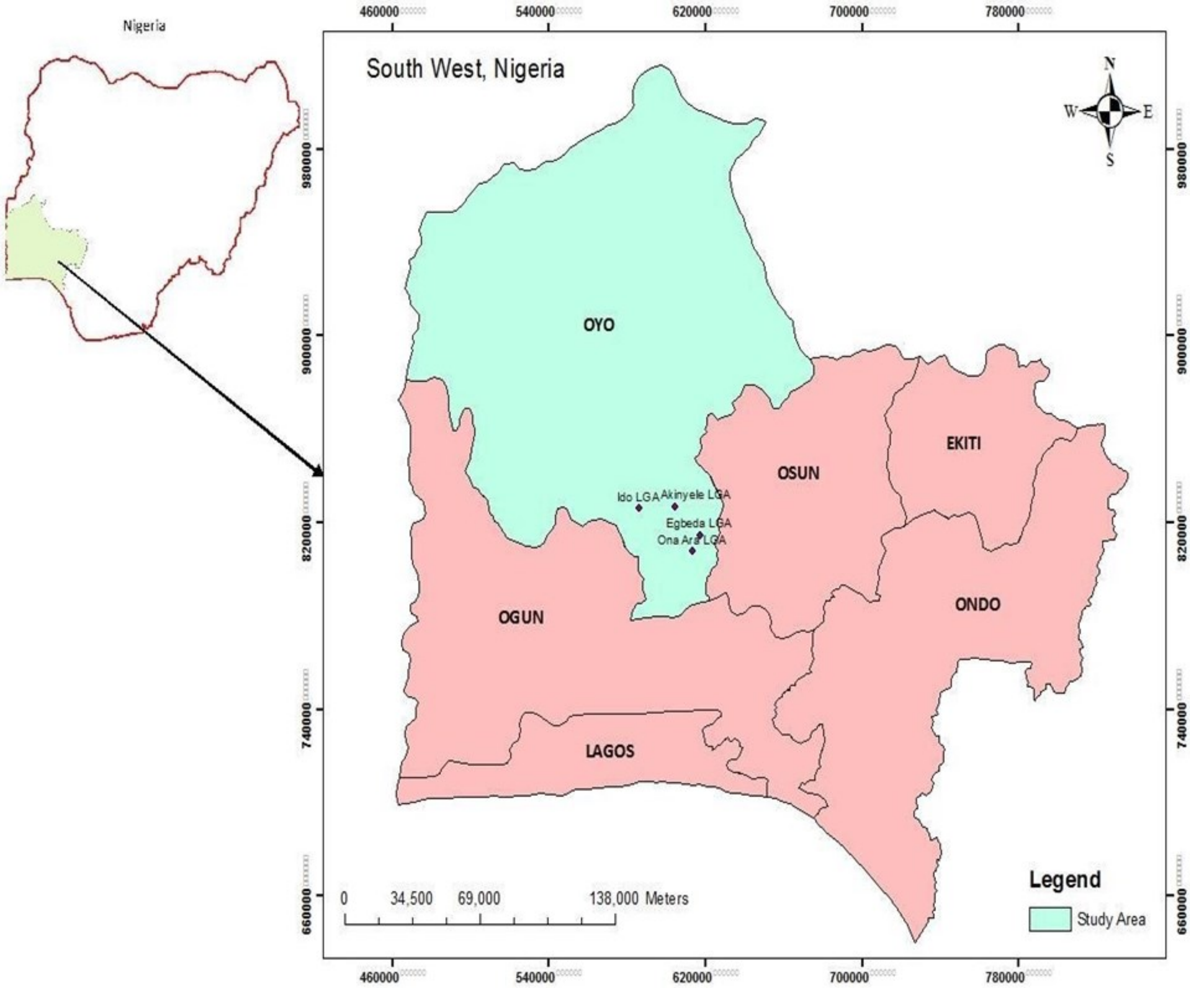


Figure 4.3: Map of Sample area

These Local government areas are Ido, Akinyele, Ibadan-North, Ona-ara and Oluyole. Ido. These farms/farmers sell their produce by wholesale which is mostly pre- ordered by restaurants, canteens, and school kitchens; and also retail to individual consumers on the farm and off-the farm. However, observation on the field showed majority of these farmers sell their produce on the farm and therefore reduce transportation and storage cost for them. Demand for fresh vegetables drive the sale of these produce on the farm and farmers from these areas sell their produce directly on the farm to both middlemen and retail buyers. Eleyele Lake was the primary site for sediment collection while soil samples were also collected from farms in the study vicinity. The following sub- sections describe briefly the local government areas included in the study and Eleyele Lake.

4.3.3.1 Ido Local Government Area

Ido was among the five in Ibadan district before it was cancelled in 1956. Other four Local Governments that were in existence at that time were Mapo, Akinyele, Ona-ara and Olode-Olojumon. Mapo was the headquarters for all the Local Governments by then, which was called Ibadan City Council (ICC). The area was referred to as Akinyele West Local Government (1981-1983) during the second Republic and later merged with Akinyele Local Government by the Buhari/Idiagbon regime in 1984. The present Local Government area was finally restored in May 1989, with its headquarters at Ido, which was carved out of the former Akinyele Local Government. The entire area spans across 986 km^2 with a total population of 103,261 (NPC, 2006).

Ido Local Government covers the area spanning Apata, Ijokodo, Omi-Adio, Akufo and Apete. It shares boundaries with Oluyole, Ibarapa East, Akinyele, Ibadan South-West and Ibadan North-West Local Governments in Oyo State and Odeda Local Government in Ogun State. The council formerly has six wards, which had been increased to ten for ease of administration. The local government now consists of five areas namely, Apata division with eleven (11) communities, Apete with fifteen (15) communities, Ologuneru with eight (8) communities, Ido with thirteen (13) communities, and Omi-Adio with seven (7) communities (Babatunde and Oyekola, 2019).

On the account of extensive fertile soil, which is suitable for agriculture, the basic occupation of the people is farming. There are large hectares of grassland which are suitable for animal rearing, vast forest reserves and rivers. People in the area grow varieties of cash crops such as cocoa, kola nut, palm oil, timber, and food crops such as maize and rice. The area is also suitable for a wide range of edible fruits. In fact, Ido Local Government can serve as the ‘‘food basket of the state” if well utilized. The area has also gained tremendously from industrialization process with the presence of industries such as the Nigerian Wire and Cable Ltd, Nigeria Mining Corporation and the Nigeria National Petroleum Corporation (NNPC) among others. The Local Government has 75 primary schools and 33 secondary schools.

4.3.3.2 Ibadan North Local Government Area

Ibadan North local Government area has the largest land area among the urban local governments’ areas in Nigeria with 145.58km^2 and a population of 306,795 people (NPC, 2006) and a 2016 projected population of 432, 900 (City population 2016). The local government area was created on 27th September 1991 and exists between longitude 30 53’ and 30 56’ East of Greenwich Meridian and latitude 70 23’ and 70 29’ North. It is bounded in the West by Ido and Ibadan North West Local Government, in the East by Lagelu, Egbeda and Ibadan South East Local Government respectively and in the North by Akinyele Local Government.

This area was selected as part of the study because of its close proximity to Eleyele Lake and also because of its cosmopolitan characteristics and location of farming communities (Mokola Barracks). Economic activities undertaken by people in the local government area include trading, public service and agriculture.

4.3.3.3 Akinyele Local Government Area

Akinyele local government area lies in the coordinates between latitude 70 28` and 70 31` and longitude 30 53` and 30 57`. The local government area has its headquarters at Moniya in Ibadan with a total land area of 414,892km2. It is located in the rain forest zone and grassland of South-Western Nigeria. Farming is the primary occupation of the people in the area and the type of crops cultivated includes maize, yam, cassava, and vegetables among others. The local government area is one of the beneficiaries of the Fadama II project because of the preponderance of dry season vegetable production in the area.

4.3.3.4 Ona-Ara Local Government Area

Ona-Ara Local Government Area was created in 1989 with its administrative headquarters located at Akanran, Ibadan. It shares boundaries with Egbeda Local Government to the North, Oluyole to the West, Osun state to the East and Ogun State to the South. The Local Government Area covers a total land area of 425.544 km^2 with a population density of 707 persons per km^2. Using a growth rate of 3.2% from 2006 population census, the 2010 estimated population figure for the Local Government area was projected to be 300,659 (NPC, 2016).

The residents of the Local Government Area are Yoruba's and other tribes from various part of the country. This council was selected as one of the study areas because major areas assume urban status. It has a scattered farming population across its various communities such as Badeku, Jago, Ojoku, Ajia, Foworogun, Idi-Ogun, Elese-Erin, Olosunde, Ojebode, AKanran, Gbada-Efon etc. Among Agricultural activities being practiced by the people are arable and vegetable production, gari processing, oil milling, poultry, piggery, fishing, sericulture to mention a few. The Local Government area is the seat of Ibadan International Airport.

4.3.3.5 Oluyole Local Government Area

Oluyole Local Government is one of the oldest Local Government council in Oyo State with its headquarters situated at Idi-Ayunre Old Lagos/Ibadan road. It shares boundaries with four Local Government Areas within the Ibadan metropolis i.e; Ibadan South-West, Ibadan South-East, Ona-Ara and Ido. It also shares borders with Ogun State through Egbeda-Obafemi, Odeda and Ijebu-North Local Government Areas. The Local Government was established in 1976 and it occupies about 4,000 km^2. Its population according to the 2006 census was declared as 202,725. The urban section of the Local Government comprises areas such as Lagos/Ibadan Express ROAD, Old Lagos road, New Garage, Orita Challenge, Odo-Ona Elewe where many big companies such as British America Tobacco (BATCO), ROM Oil, Agrited, Jubaili Agro-limited (an agro-chemical company) and many others are situated.

4.3.3.6 Eleyele Lake

Eleyele lake is located on latitude 07 21'N and longitude 03 55'E in the city of Ibadan, Oyo state, Nigeria. It is a man-made lake and was constructed in 1942 by damming River Ona within Ibadan Metropolis, by the Oyo state government, purposely for the supply of pipe-borne water to Ibadan city and her environs. The wetland is a modified natural riverine wetland type with area of about 100 km2 including the catchment area.

The elevation is surrounded by quartz-ridge hills towards the downstream section where the Eleyele dam barrage is located. A number of stream channels, among which some are located in three of the local government areas studied, serve as feeding / recharge streams to the Eleyele wetland basin and it has a reservoir storage capacity of 29.5 million litres. The wetland lowland areas are dominated by light forest, riparian wetland forest most of which had been impacted by human activities. The lake has a length of 240m across the Dam and a catchment area of 323.7 km^2 with a maximum water elevation of 9.0m and a total surface area of 162 hectares. The lake is 100 -150m above sea level with an average depth of 6.0m. Eleyele Lake is the only man-made lake in Ibadan metropolis and a very important inland water resource for the city and provides water for the city's consumption and simultaneously used in controlling flood. Due to urbanization and industrialization, a lot of human activities have taken their toll in and around the lake environs. Eleyele Lake is significant to this study as lake sediments are known to be a deposit of contaminant residues including pesticides. Its proximity to agricultural fields and water ways also increases the chances of pesticides reaching the lake from agricultural run-off. There has been reported use of banned organochlorine compounds such as lindane and endosulfan in and around the area. These contaminants, especially pesticide residues could readily cause damage to the lake's water quality and its aquatic population.

The lake is important to the study because sediment analysis can provide physico-chemical and biological information on historical pesticide contamination in the surrounding area due to lakes' dynamic role of integrating environmental effects into a continuous, high- resolution archive of local and regional change. This archival system is achieved through the continuous sedimentation process of the lake right from their formation be it natural or man-made Schnurrenberger *et al*. (2002). This is supported in literature by Sabatier *et al*. (2014) that explained the use of sediment analysis as a reconstruction tool to create a historical timeline of pesticide use in an agricultural ecosystem. Such analysis also provides information on level of pesticide residues present in the environment as it measures the nature and level of any chemical contamination within the environment and its' persistence (Jacob and Resmi, 2014).

The damage from pesticide contamination in and around the lake is also of particular importance because of its central location in the city. The study site is surrounded by Eleyele neighbourhood in the south, Apete in the east and Awotan in the north. Lake Eleyele is a source of recreational water as well as a source of cheap, affordable protein (Ayeloja *et al*., 2014) in the form of catfish (Clarias gariepinus), Africa pike (Hepsetus odoe) and tilapia fish (Oreochromis niloticus). The inhabitants around the lake are also predominantly vegetable crops farmers who use pesticides in their farming activities. This poses repercussion for the people who rely on the lake for their daily use.

4.4 Research methods

This section describes the interdisciplinary methods adopted in this study and the justifications for methods of choice. It also contains a sub-section on ethical decisions and considerations that influenced the research design and methods.

4.4.1 Natural science research

As established in earlier sections, this study adopts an interdisciplinary approach to assessing and understanding pesticide impact on the environment, society, and economy. There are several ranges of benefits attached to pesticide use in agriculture such as increased agricultural productivity and reduced insect-borne disease (Ecobichon, 2001; Ochoa and Maestroni, 2018)), however, it's adverse effects on the environment, humans and livelihoods cannot be overlooked. Some of these damages include both short-term and long-term health effects (Wilson, 2000); elimination of beneficial predators of pests; adverse effects on fauna and flora (Ochoa and Maestroni, 2018).

To answer research question on what impact pesticide use from UA has on the environment and other dimensions of sustainability, one of the objectives of this study was to create a historical and current profile of pesticide contamination in the study area as literature (Nwankwoala and Osibanjo, 1992) recorded the presence of organochlorine pesticides in Ibadan surface waters. As there are many ways in assessing pesticide use and its drivers, the scope of this study is focused on how much pesticide contamination we have in soil and sediments (environment).

This section presents the natural science methods adopted in this study. Even though there are several ways to measure pesticide contamination in the environment, assessment methods in this study are limited to chemical and biological analysis of sediments and soil samples and radioactive dating (Pb-210) to assess both historical and current environmental contamination from pesticide use. These are direct field measurements which are the best way to assess pesticide contamination (Bockstaller *et al* 1997). The rationale for overall methodology and research paradigm has been discussed in the philosophy section. This section therefore describes and justifies the quantitative methods adopted in exploring and explaining the extent of pesticide use in UA. To do this, the following specific objective is the focus of this section:

- an assessment of pesticide residues in the environment to create a historical and current state of pesticide contamination in Ibadan city.

The objective is to use a chronological profile of both historical and current pesticide contamination in assessing how they impact on the environment as a dimension of sustainability. To achieve this specific objective, methods adopted entail in-situ soil and sediment sample collection from the lake and farms, laboratory assays and analysis. This section will therefore describe methods and justify approaches to meeting this research objective of assessing pesticide use, sediment, and soil and diatom analyses. Also, to better understand my choice of methods adopted in this study, this section will discuss different methods of measuring pesticide contamination and justify selected methods. This will display my awareness of other methods and explain reasons for not adopting them in this study.

4.4.1.1 Assessment of pesticide contamination

This section discusses the natural science methods used in answering research questions. These methods include soil pesticide analysis, sediment analysis, diatom analysis and Lead (Pb) 210 dating aimed at assessing pesticide contamination in the environment. As reviewed in Chapter three, pesticide residue can be measured in the environment by chemical analysis, biological analysis, and radioactive dating. This is achieved in the study by carrying out chemical analysis of soils and sediments and biological analysis of diatoms in sediments. Sampling for pesticide residue from direct field measurements and onward use of chemical analysis provides an accurate assessment of pesticide contamination in the environment (Racke *et al*., 1997; Lehotay

&Cook, 2015). The use of chemical analysis through established methodologies such as mass spectrometry discussed in chapter three allows for presenting a true picture of environmental contamination. In like manner, sediment analysis serves a reconstruction tool to create a historical timeline of pesticide use in an agricultural ecosystem (Sabatier *et al*., 2014). In the case of this study, it allows for validation of continuous pesticide use amongst urban farmers in Ibadan, South-Western Nigeria. For example, Sabatier *et al*, (2014) in their studies using sediment analysis to assess pesticide use in a local vineyard, were able to produce results showing how farming practices affect pesticide transfer dynamics. They discovered that introduction of short stay post-emergence herbicide (glyphosate) led to a release of long-term immobilised DDT pesticide. Biological analysis adopts an indicator method to potentially diagnose pesticide contamination (Floch *et al*., 2011).

As discussed in the literature review sections, studies into pesticides assessment in tropical environments especially from urban agriculture is mostly limited to theoretical conditions which do not account for variations that may occur under field conditions. These variations are attributed to high tropical temperatures under which pesticides dissipate quickly than in temperate environment (Racke *et al*. 1997; Moore *et al*., 2007). Pesticide use in Nigeria as a tropical environment is influenced by the environmental conditions suitable for proliferation of insect pests and weeds. The most prominent mechanisms for this acceleration in pesticide dissipation appear to be related to the effect of tropical climates and would include increased volatility and enhanced chemical and microbial degradation rates on an annualized basis.

The soil is the main matrix for pesticide disposition and the bulk of residue are confined to the upper 5cm of the topsoil. They easily move from the surface when they are dissolved in runoff water, or when they percolate down through the soil. It is however unfortunate that these pesticides and their break down compounds remain stable and persist for several decades in soils and sediments such that they can create new reactions that portend danger for the ecosystem and human health (Sabatier *et al*., 2014).

Pesticides reach soil as a deliberate action or through precipitation and air drift from foliar spray. They persist as major deposits in soil and sediments in the environment over a long period of time by moving from treated area through soil, water, air, organisms and consequently affect non-target organisms in the ecosystem (Pimentel and Edwards, 1982; Vryzas, 2018). Their persistence and mobility are determined by the properties of the pesticide which in turn, are influenced by the soil environment, site conditions, weather, and application method (Kerle, Jenkins & Vogue, 2007). In soil, pesticides may persist for days, weeks or years depending on its' chemistry and environmental conditions (Edwards, 1985; Kerle *et al*., 2007). Pesticides' mobility as well as persistence is controlled by their adsorption into soil with organic matter and clay content/composition, soil minerals, soil pH and temperature playing an important role in this process (Pimentel and Edwards, 1982, Racke *et al*. 1997; Asogwa and Dongo, 2009; Moore *et al*., 2007). Pesticide use has been reported in several urban agriculture studies as one of the factors limiting the positive role urban agriculture could play in sustainable development (Stewart *et al*., 2013). It's far reaching effects on the economy, society and environment has been documented in isolated studies, which is why this thesis is important as it studies pesticide impacts on these three sustainability dimension within a single study.

Studies into pesticides in tropical soils under field conditions are limited and the few that exists contain inadequate experimental information for full interpretation. In one of these few studies, Nwankoala and Osibanjo (1992) identified Heptachlor, Endosulfan, Lindane and Dieldrin as priority pollutants in Ibadan waters while other organochlorines such as Aldrin, Endrin and

DDT were not detected. Similarly, study by Olutona *et al*. (2014) in Aiba reservoir in Iwo, a town in a neighbouring state reported low levels of Endosulfan, Dieldrin, Heptachlor and Chlordane in its sediments. This shows that pesticide properties influence persistence in the environment.

As there are a wide range of pesticides used in UA and in limiting the scope of study, organochlorine and organophosphorus pesticides were the only group assessed because of their history of long-term persistence and toxicity (Onianwa, *et al*., 1999; Olufade *et al*., 2014). Organochlorines (OC) are a group of chlorinated compounds widely used as pesticides. They belong to the class of persistent organic pollutants (POPs) and characterised by high persistence in the environment (Jayaraj *et al*, 2016). OC insecticides were successfully used and still being used in control of malaria and typhus, despite being banned in most of the advanced countries (Aktar *et al*., 2009). Statistics on pesticide consumption shows that 40% of all pesticides used in the early 19th century through the early 20th century belongs to the organochlorine class of chemicals (Gupta, 2004; FAO, 2005). Due to their low cost and the need against various pests, organochlorine insecticides such as DDT, hexachlorocyclohexane (HCH), aldrin and dieldrin are among the most widely used pesticides in developing countries of Asia (FAO, 2005; Gupta, 2004; Lallas, 2001).

OCPs have been used in Nigeria agriculture production in the 1980s up to the till the late 1990s', both for agricultural and public health purposes, with their residues been detected in water, sediments, vegetable crops, fish and in humans (Nwankoala and Osibanjo 1992)) Although the production and use of many types of OCPs have been severely limited in many countries including Nigeria, they are nevertheless still being used unofficially in large quantities in many parts of Nigeria and in other developing countries because of their effectiveness as pesticides and their relatively low cost as well as inadequate regulation and management on the production, trade and use of these chemicals. They have been known to cause both health and environmental damages (Asogwa and Dongo, 2009).

Organophosphates, though persists for only a short period time, is known for disruption of nerve function and eventual mortality due to its toxicity as it is readily absorbed through the skin, volatile and enzyme inhibitors (Sandoval-Herera *et al*., 2019). They irreversibly inhibit cholinesterase. This study therefore concentrates on organochlorines and organophosphates pesticide assessments because of their persistence in the environment. Due to the disruption to ecosystem services such as water and soil by pesticide run-off, persistence, and toxicity, one of the many impact of pesticides is its role in altering the structure of some ecosystem population, such as diatoms. This is because pesticides affect their species richness, assemblages, biological density, and diversity in lake sediments (Carvalho and Hance, 1993). Diatoms, which are freshwater algae (Rimet, 2011), are being used as an indicator of past and present ecological conditions of lakes (Hering *et al*., 2006; Stevenson *et al*., 2010; Pandey *et al*., 2017), and by extension can establish pesticide contamination (Morin *et al*. 2012; Stevenson *et al*. 2010; Stevenson 2014; Hirst *et al*., 2002) because they are highly sensitive to toxicants. In aquatic environment, organisms such as diatoms responds to pesticides that has been transported into water from agricultural run-off and falls to the bottom of the aquatic system, becoming part of the bottom sediment. Their sensitivity and responses to pesticides is therefore characterised by change in assemblages' species-specific frustules (MacKay, 2007) which makes them useful as biological indicators in assessing pesticide contamination in sediment samples (Stevenson *et al*., 2010). Their well-preserved siliceous diatom frustules in lake sediments also make them valuable as bio-indicators in pollution assessment.

Studies has been carried out in Nigeria on diatoms as biological indicators of general pollution status which has been discussed in the literature review sections (Akinyemi, Nwankwo and Fasuyi, 2007) and other countries, both for general pollution and pesticide pollution assessment (Sudhakar, Jyothi and Venkateswarlu, 1994; Debenest *et al*., 2009, Namwaya, Raburu and Lubanga, 2013) using diatoms as bio-indicators of pollution status, no studies in Nigeria has adapted this tool to specifically assess pesticide pollution in the aquatic environment. Rimet and Bouchez (2010) described a method of using diatoms life- forms and ecological guilds to assess pesticide contamination in rivers. Lippiat (2005) also described a simple method of isolating and identifying diatoms which could then be used in conjunction with Rimet and Bouchez's methods for assessing pesticide contamination.

Following a review of these chemical and biological methods in the literature review section, with careful consideration of limiting factors which include time, practicality of method, ease of data comparison, safety and financial cost, a pesticide residue analysis in both soil and sediments were adopted for chemical analysis while diatom analysis was used as a possible bio-indicator for pesticide contamination. Figure 4.4 provides a graphical illustration of these methods and how it feeds into the research objectives.

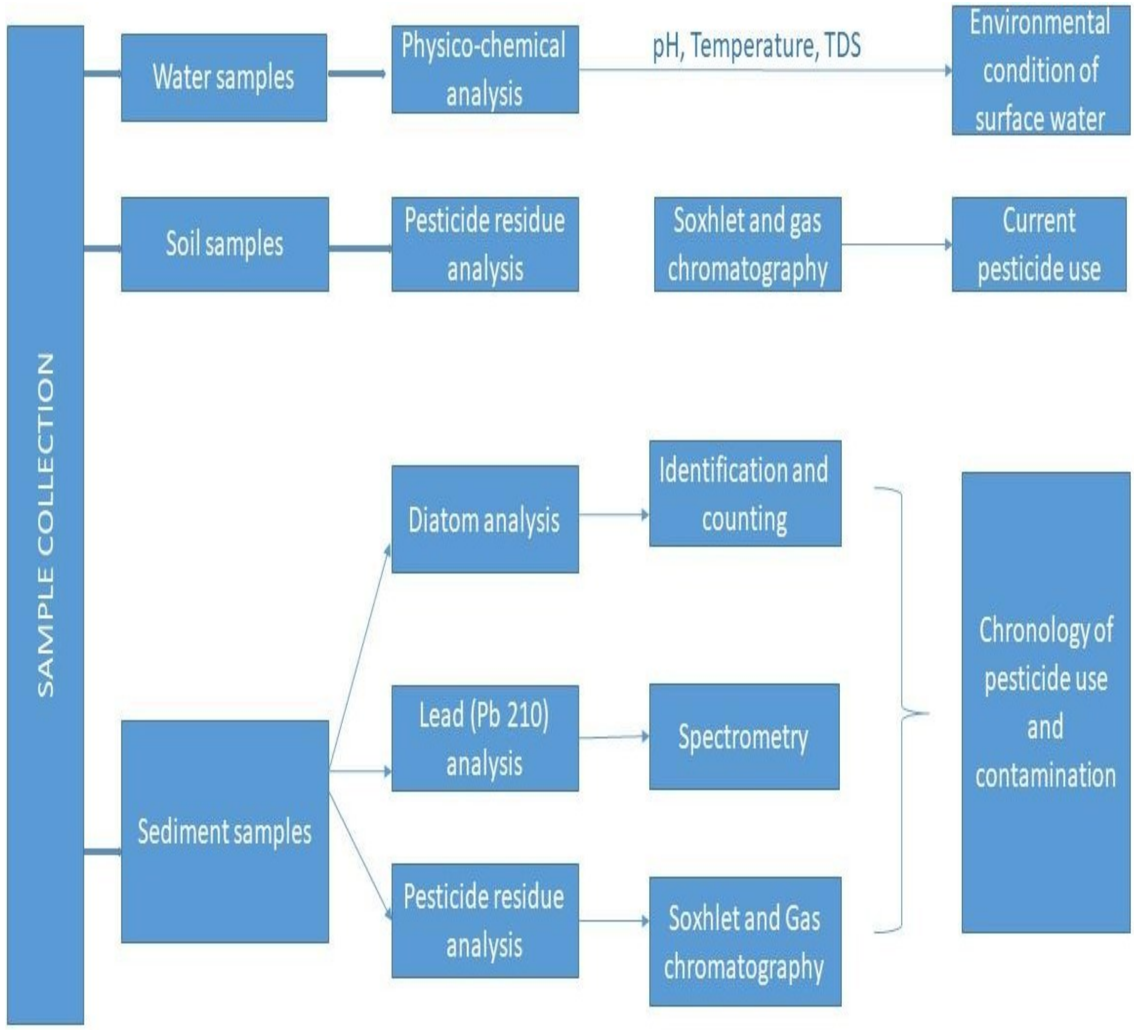


Figure 4.4: Graphical Representation of research activities using natural science methods

4.4.2 Sampling area

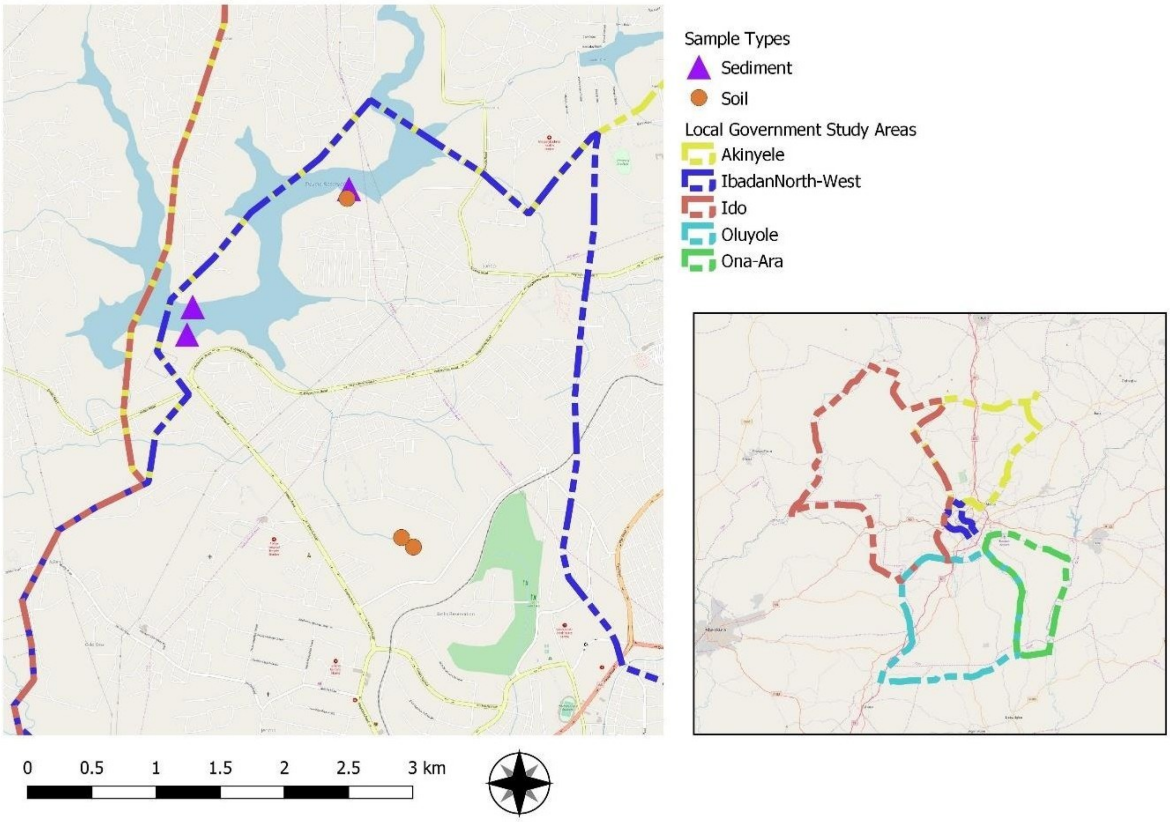
In assessing contamination in the study area, a review of the movement of pesticides from soil to lake and the factors that influence its' mobility and persistence in the environment was done in the literature review chapter. The review revealed the importance of soil type, climate, and geology and what influence it may have on pesticide contamination. Since an assessment of lake sediment will provide historical contamination, Eleyele Lake in Ibadan, Oyo state was purposively selected because it was right in the centre of the study area where urban agriculture is practised, and pesticide use had been recorded.

Historically, Oyo state was an agrarian society, where the residents of the rural areas are mainly into farming. However, with increasing urbanisation, the capital city Ibadan has lost most of its forest reserves to development and industrialisation. Ibadan is one of the many areas in the western, eastern and Northern Nigeria characterised by the presence of Precambrian basement complex composed of quartzite, quartz-schist, biotite-and-biotite- hornblende-gneiss as the main rock (Tijani *et al*., 2004 and Obaje, 2009). Though knowledge on relationship between geological characteristics and pesticide contamination is limited, Gasiorowski (2008) listed geomorphological characteristics as one of the factors that affect the deposition rate of lake sediments. These sediments harbour phytoplanktons which had aggregated, sank and are being preserved (Pandey *et al*., 2017). Topographically, Ibadan city is characterized by undulating terrain with quartzite ridge and Inselbergs of gneisses surrounded by adjoining plains (Tijani et. al, 2004).

Different agricultural and industrial activities take place in this city, ranging from production to processing. However, as this study is concerned with urban agricultural production, with particular focus on small-scale agricultural production, crops grown include vegetables, maize, yam, plantain, okra, pepper, and ornamental plants. As most of these crops are high value crops, some pesticides are extensively used among which include insecticides and herbicides.

Ibadan city is made up of 11 local government areas and for the purpose of this study, five of these areas were purposively selected as the sample area. These are Ibadan North, Ido, Akinyele, Ona-ara and Oluyole local government areas. Urban agriculture is practised in and around these areas as with the whole city. Eleyele Lake, a man-made lake, is surrounded by Ibadan North, Ido and Akinyele local government. The lake was created by clearing a substantial forest reserve area and damming river Ona that runs along the Ona– Ara area with a catchment area of 323.7sqkm and an average depth of 6 metres.

Sediment samples were therefore collected for pesticide residue analysis (to assess



contamination from organochlorine pesticides); Lead 210 dating (for a chrono-static analysis of pesticide contamination) and diatom analysis (diatoms as biological indicators of pesticide contamination). Figure 4.5 shows the sample locations while tables 4.2 and 4.3 presents sampling points at which these samples were collected along the Eleyele Lake axis using a hand-held Garmin e-Trex GPS.

Figure 4.5: Map of sediment and soil sample locations along Eleyele lake

Table 4.2: Sediment sampling locations

Sampling site	Local Area	Site coordinates
ELY1	Eleyele	7°25'21.6"N 3°51'32.4"E
ELY2	Alakuta/Awotan	7°25'28.6"N 3°51'33.8"E
ELY3	Agbaje	7°25'57.3"N 3°52'13.4"E

Source: Field survey, 2017

For soil sampling, two main farm settlements namely Mokola Barracks and Agbaje were also purposively selected because of their proximity to Eleyele lake and also because their streams drain into Eleyele lake. Sampling points were mapped using a hand-held Garmin e-Trex GPS on random farm plots within the farm settlements with two sampling points namely S1 and S2 from Mokola Barracks and one sampling point S3 from Agbaje settlement (see table 4.3).

Table 4.3: Soil sampling points

Sampling site	Local Area	Site coordinates	Elevation
S1	Mokola Barracks upstream	7°24'27.63"N 3°52'29.89"E	212m
S2	Mokola Barracks downstream	7°24'30.04" N 3°52'26.84"E	203m
S3	Agbaje	7°25'56.05"N 3°52'13.05"E	183m

Source: Field survey, 2017

4.4.3 Sediment and surface water samples' collection and preparation

This involved the collection of sediment samples and soil samples for pesticide analysis and Lead 210 dating. The initial sampling plan was to collect sediment cores from the middle, which was described in literature to be the most undisturbed and deepest part of the lake and may be the truest representative of the lake's sediments, due to infrastructural challenges such as lack of equipment to safely navigate the lake, the samples were collected no farther than 1m from the bankside. Previous studies in the area relied on single grab sampling method or collection of surface water only by travelling across the lake in a make-shift canoe. Initial sampling was carried out in June 2016, and subsequent samplings were between July 2017 and August 2018. All these collections time were during the period of less rainfall activity when the lake can be safely reached.

Three different sample areas on the Lake were identified and mapped for sediment collection. Each Lake sediment sampling were mapped as ELY 1, ELY 2, and ELY 3 within a distance of 1 m away from the bank side (see figure below and map of area). Six random replicates of sediment cores (to allow for sufficient sample size for sediment analysis, lead 210 dating and diatom analysis) were collected at each sampling location with a Russian gravity corer to an average depth of 45cm and 5cm diameter, as a discrete vertical sample. The gravity corer was slowly lowered to the substrate and allowed to penetrate the sediment under the samplers' own weight and turned clockwise to seal in the core. The gravity corer was decontaminated between samples and replicates by washing in the water. Replicates were collected at each sample point to determine sample variability. Each core was transferred unto prepared PVC pipes and wrapped tightly with a cling film for a later sectioning. These were stored in iced coolers to preserve the integrity of the samples during transportation to the Laboratory.

In-situ surface water samples were collected in pre-washed 500 ml plastic bottles at each sediment core collection point. These samples were also analysed on site for pH, temperature, total dissolved solids (TDS) and electrical conductivity (EC).

4.4.4 Preparation and extraction

Each sediment core and its replicates were sectioned from the top core into 1cm slices and put inside self-sealing bags, labelled and deep-freeze to preserve the samples for onward transport to the laboratory. After arrival at the laboratory, sediment samples were allowed to thaw under room temperature. After thawing, each section and its replicates were homogenised to form a single sample per section and per sample location. These samples were further divided for use in diatom and Lead 210 analysis. This generated 45 sections for Eleyele axis, 40 for Alakuta/Awotan axis and 43 for Agbaje axis. Each section represents a 1 cm layer of the sediment core. These sections were later aggregated into 5cm layer samples up to the 25cm mark.

4.4.5 Sediment pesticide analysis

Some selected organochlorines and organophosphates were selected for analysis in the sediment samples sent to the laboratory. These compounds are: Aldrin, Dieldrin, DDT, Endosulfan, Endrin, Heptachlor, Heptachlor Epoxide, Dichlorvos, Dimethoate, Diazinon, Malathion and Parathion. They were purposively selected to assess pesticide contamination from banned organochlorines, organophosphates and Triazines.

Some amount of sediment samples was extracted by Soxhlet extraction method for onward pesticide analysis as described by EPA method 3540 (USEPA, 2007). This is a solid phase extraction (SPE) process used for a wide range of analytes and suitable for organochlorine and organophosphate which are of interest in this study. A dried, sieved sediment sample (20 g) was weighed into extraction thimble and placed in a Soxhlet extractor. Extraction was done for about 10 hours using triple-distilled dichloromethane at a temperature of about 40^{0}C. The extract was concentrated by distilling off part of the solvent. The concentrated extract was then cooled to room temperature and then concentrated further to about 2mL under a stream of nitrogen gas of 99.99% purity. The reduced extract was preserved for chromatographic clean-up using a silica gel prior to gas chromatography.

4.4.6 Soil pesticide residue analysis

Samples collected from random farm plots in Mokola and Agbaje farm settlements due to the amount of farming being carried out there. Two sampling areas were identified and selected at Mokola Barracks; and identified as S1 and SO2 at upstream and downstream locations respectively. For each sampling point, five discrete samples with three replicates were collected upstream and downstream to provide a composite for each point.

At Agbaje farm settlement, 5 discrete samples were also taken from 5 different points to produce a composite sample. These two sites were selected because of accessibility and respondents claim to use pesticides frequently. Soil samples and their replicates from the three different sampling locations were collected using a hand trowel at a depth of 0-20cm from the topsoil. These replicates were homogenised by mixing and air dried in aluminium foil papers before sending to the laboratory.

Measurements taken in-situ are: pH, temperature, total dissolved solids (TDS) and electrical conductivity (EC). Water temperature (^{0}C) readings were taken in situ using a mercury thermometer. pH, total dissolved solids (TDS), and EC (electrical conductivity) were measured using a portable Hanna pH/EC/TDS/temperature meter borrowed from the Federal college of forestry soil laboratory.

4.4.7 Diatom Analysis

For diatom sampling, the sediments were bulked into 5cm sections to generate 9 samples. However, because the lake area was fairly new (53 years old), and considering the rate of sedimentation was slow due to geomorphological characteristics of the lake (Obialor, Okeke, Onunkwo & Fagorite, 2019), diatom sampling was limited to the first 25cm depth of the core samples and therefore, samples were prepared for 5cm, 10cm, 15cm, 20cm and 25cm depths respectively.

During preparation of the sample for diatom analysis, organic material and debris were removed through oxidation with Hydrogen peroxide (H2O2). 25 ml (per 2.5 g of sediment) of 30% H2O2 was added to the sediment in the beaker and put inside a water bath mounted on the hot plate at 1000c and gradually brought to boil. After cooling down for few minutes, the supernatant was poured out and the sediment washed thoroughly with distilled water into test tubes to remove all presence of H2O2, agitated to ensure homogeneity and subsequently centrifuged at 1500 rpm. After centrifugation, each test tube was appropriately labelled and stored in the fridge for mounting onto slides for diatom identification. The aliquot (fraction that was centrifuged contained silt that has settled with the supernatant containing diatoms) was collected with a pipette and placed on a slide and allowed to dry on the hot plate. After drying, each slide was mounted on a microscopic slide with Naphrax, a resin with a high refractive index to increase contrast when observing the diatoms. Identification and counting of diatoms was performed by scanning 10 parallels on each slide with a light microscope at a magnification of 1000x using a diatom key presented as figure 2. Species were identified based on the shape and size of the frustule (the shell), the number and orientation of striae (the rows of pores or punctures in the frustule), the structure of the raphe (a slit along the long axis of the valve), and any other specialized structures associated with the particular genus under an electron microscope.

4.4.8 Lead 210 dating

Given the age of the lake, Lead-210, a naturally occurring isotope, is used in this study to provide a sediment chronology for sediments between 0-150 years (Appleby, 2002). This method was chosen as chronology could be used to assess historical pesticide contamination in the study area. ^{210}Pb dating was undertaken using the gamma spectrometry technique as described by Appleby (2002) read radioactive signals for ^{210} Pb and other Uranium isotopes with a typical detection limit of 0.4 Bq/kg. Samples at 1, 2, 3, 4 and 5 cm depths were dried in the oven for 24 hours and the dried samples packed into petri dishes and left to equilibrate for three weeks and then counted on a High Purity Germanium (HP-Ge) gamma spectrometry system. Radionuclides such as ^{210}Pb, ^{226}Ra, ^{137}Cs, ^{7}Be, ^{228}Ra, ^{228}Th, ^{238}U and ^{241}

Am were measured simultaneously.

4.5 Social science research

This section describes social science methods used in meeting research objectives. It entails both social quantitative (farmer survey) and qualitative (interviews, focus group discussions and key informant interviews) research methods. It presents and discusses the social science methods employed in this study. As established in earlier sections, this study adopts a mixed methods research approach which as described by Driscoll *et al*. (2007) are procedures that include collecting and analysing both quantitative and qualitative data in the context of a single study. It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems. The data collection also involves gathering both numeric information such as surveys as well as text information in form of interviews so that the overall data represents both quantitative and qualitative information. This mixed methods approach allowed for triangulation of data between quantitative and qualitative methodologies involving questionnaire surveys, semi- structured interviews, focus group discussions and unstructured observations on pesticide assessment (Thomas, 2014).

4.5.1 Quantitative data collection and analysis -questionnaire survey

This section describes the rationale for using questionnaire survey to assess pesticide use, patterns, and behaviours among sample population of urban agriculture practitioners. Questionnaire survey is a quantitative research method that provides empirical evidence on a subject of interest through oral or written questioning (Sarantakos, 2008). In this study, surveys provide evidence of pesticide use, patterns, knowledge, and behaviour amongst small-scale urban farmers through a written survey form (Denscombe, 2010). This survey established the prevalence and intensity of pesticide use and allowed for thematic analysis between pesticide use and farmer characteristics provided information used to generate social qualitative research questions to further explore factors driving the use of pesticides and understand the limitations to good agricultural practice. However, a limitation of this design in quantitative study is its ambiguity in establishing causal influence (Bryman, 2004). The questionnaire schedule used in this study is presented in appendix 1.

4.5.1.1 Participant selection

As stated earlier in the study area section, local government areas were purposively selected because of their urban characteristics and proximity to Eleyele Lake which was the primary site for sediment collection. Within each local government area (Ido, Akinyele, Ibadan North, Oluyole and Ona-Ara), fifty respondents were pre-determined for the questionnaire survey on pesticide use in Ibadan. All efforts to get a register of farmers in the study area proved abortive. Therefore, farm settlements, farmer field schools and farmers' association meetings were visited, and a snow-balling technique was adopted in identifying and selecting participants for the study.

Snowball sampling is defined as a technique for finding research subjects where one subject provides the researcher with the name of another subject, who in turn provides the name of a third, and so on (Atkinson and Flint, 2001). The technique is often used in hidden populations which are difficult for researchers to access; especially where there is a dearth of data or information. In the case of this study, I purposively attended a farmer field school's fortnightly meeting to administer questionnaire survey. Also, areas with high concentration of farm land and farmers were selected in the early hours of the morning to conduct the survey. The advantage of this technique is the increase in credibility of research, as participants are involved in the research process whilst disadvantage include possible researcher bias as it involves deliberate choices. For instance, the study was more interested in small-holder farm practitioners and as such they were mostly approached. Therefore, the participant selection process was not random but a purposive sampling method.

4.5.1.2 Questionnaire design

As there is no reliable existing data on pesticide consumption in Nigeria to use as secondary data, the aim of the survey was to provide a baseline data (primary data) on characteristics of respondents, pesticide use practice, perceptions, and motivations for pesticide use. Data were collected through face-to-face questionnaire survey with 190 urban farmers, from five urban local government area of Ibadan Municipality on their farms and farmers' group meeting. Detailed description of the study area has been provided in the methodology section. The questionnaire was designed in English and administered in English, Yoruba and Pidgin English depending on the language spoken by individual respondents. It included both closed and open-ended questions and pre-tested with 20 farmers. The closed questions were in a multiple-choice format so that respondents had to select only the appropriate answer or answers that best described their opinion or attitude on an issue.

Prior to administering the survey, preliminary activities which included a pilot enquiry; establishing relationships with Oyo state agricultural department, and farmers' associations and key informants such as pesticide dealers were carried out. This allowed me to establish relationship with the extension/liason officers in charge of farmer field school. It also provided me the opportunity to carry out a pilot enquiry of the questionnaire survey with few farmers and few key informant interviews. These activities were important for assessing and improving the suitability of the data collection instruments (survey questionnaires and interviews (Kvale, 1996; Gerson; May, 2001; Horowitz, 2002). They indicated the necessary amendments required and crucial areas to note, especially in relation to the question structure, the type of approach best suited and even cultural norms which influenced the process of data collection.

The questionnaire was structured into five sections derived from the themes of the literature review set out in the research/conceptual framework in chapter two (see table 2.2). The first section was designed to collect background information on characteristics of the farmers including age, educational level, and main occupation, type of farming, years of farming experience and decision-making role. The second and third sections collected information on pesticide use and good agricultural practice aimed at assessing farmers' knowledge of pesticide, farmers' level of awareness of pesticide laws and regulations, storing and disposing of pesticides and empty containers, and use of PPE and other protective practices during and after pesticide application. The fourth and fifth section focused on perceptions, motivations, and economic consideration for pesticide use.

I recruited the help of two research assistants (a colleague at the Federal College of Forestry and a Laboratory staff) and had a one-day training session to introduce them to the background of the study, familiarise them with the questionnaire and ensured that they understand the questionnaire wording, especially when asking the questions in the local dialect.

4.5.2 Qualitative methods

In this study, quantitative and qualitative methods were combined to assess social and demographic characteristics, goals and level of knowledge which may be relevant to understanding farmers' decision to use or not to use pesticides and also to discover patterns and themes to their decision-making process.

In this case, data were collected sequentially as the questionnaire survey is structured to provide empirical evidence of pesticide use and assist in identifying patterns of use, types of pesticides, knowledge of these products and good agricultural practice; and reasons for use/disuse while the interviews and focus group discussions were used to explore and try to explain the patterns and therefore develop key themes pertaining to pesticide use.

4.5.2.1 Interviews and Focus groups

The interviews and focus group discussions were used to explore and try to explain the patterns and therefore develop key themes pertaining to pesticide use. Open-ended questions about pesticide use and practice were identified drawing on the survey results (see Box 1 in results chapter). The survey analysis (details below) identified patterns of pesticide use, and reasons for use/disuse as well as the extent of knowledge and motivation about good agricultural practice, the interviews and focus groups aim to explain these patterns. Investigating the reasons for farmers' overuse necessitated in-depth qualitative- type investigation which was capable of yielding explanatory type data to produce more illuminating results (Punch, 2004).

4.5.2.2 Interviews

Twenty in-depth interviews were conducted across the study areas. Initially, it was planned that five interviews will be conducted in each local government area of the study area to arrive at a total of twenty-five interviews. However, due to timing and availability of interviewees, only 20 were conducted and transcribed. The interviewees were purposively sampled on pesticide use/non-use (3 pesticide user and 1 non-user); gender (2 males and 2 females) and availability (not all farmers approached for interview were available for a sit- down) from the survey pool to increase variability. All participants were interviewed individually using a structured questionnaire in English, Yoruba, and pidgin (local dialects). There was no need for translation when interviewing the respondents as the researcher speaks the languages. The questions were structured in such a way that it provides single answers or multiple answers.

The pesticides used by respondents were classified according to the WHO Recommended

Classification of Pesticides by Hazard, classification used to distinguish the more and less hazardous forms of pesticides from each other based on the acute risk to human health, ranging from extremely hazardous (class Ia), highly hazardous (class Ib), moderately hazardous (class II), slightly hazardous (class III) to unlikely to present acute hazards (class U).

Each interview session took between 30 minutes to 1 hour and were conducted on the farms, during farmers' field school sessions and in offices. All interview sessions were carried out by this researcher and were recorded for later transcription with notes made about the interviewees' non-verbal responses, as well as observations of pesticide practice when this happened. The interview sessions started with a brief background of the respondents to correspond with previous information acquired during the survey. Their ability to produce the same response validated the reliability of the interviewee and hence continued with the interview.

4.5.2.3 Focus group discussions

The same method used to recruit participants for interviews was also adopted in the recruitment of focus group discussion participants. This is because of conflicting time schedule of farmers. Therefore, only three separate focus group sessions were carried as other farmers recruited failed to turn up for the remaining two sessions. Data from questionnaire survey was used to design an interview schedule guide (see in appendix) used in moderating the sessions.

4.5.3 Data handling and analysis

The survey data was entered into an Excel worksheet, revised, and transferred to SPSS version 24. All data were coded, entered into Microsoft Office Excel 2016 worksheet (Microsoft Corporation, Redmond, WA, USA) and transferred to SPSS version 20 (SPSS Inc., Chicago, IL, USA) for analysis. The data was analyzed using statistical methods including simple frequency analysis, descriptive results were expressed as frequencies and percentages, and the Chi-square test ($\chi2$) was used to measure the possible association between nominal variables. All the statistical analyses were performed at the significance level of 0.05.

The interviews and Focus group discussions (FGD) were transcribed from phone records and field notes by myself. Interview and focus group discussion analyses were carried out using transcripts and identifying recurring themes from discussions and interviews with participants' which were structured around the main topics of the interview and analysed. As most farmers could not classify pesticides according to use and toxicity classes, I re-coded their responses by identifying the commercial products to pesticide type and WHO toxicity classes.

4.5.4 Research Ethics

Though an ethical assessment was not formally required at the time of this study, this research was guided by ethical principles of establishing valid scientific methods, minimizing risks in reasonable proportion to potential benefits to the study, protecting the privacy of research participants, maintaining objectivity as a researcher and an awareness of appropriate legislation in study area as highlighted in the Univeristy's Research Ethics Handbook of Principles and Procedures (updated version, 2020).

In ensuring that valid scientific methods are used, it was mandatory to submit a research design form (RD1) to the Faculty Research Degree Committee of the University of Gloucestershire for approval. The RD1, which included a summary of an assessment of my research training, proposed plan of work, significance of research, proposed research methods and a temporal calendar of research was assessed by the committee and approved for field study. This is a vital ethical procedure as the assessment was based on the validity of scientific methods and potential benefits to the research community and participants.

During field research, samples and surveys were conducted in compliance with health and safety protocols to avoid harm to myself, research assistants and participants. For instance, core sediments were designed to be collected from the middle of Eleyele Lake, however, with limited access to safe infrastructure, sediments samples were collected no more than 1 metre away from the bank to ensure safety. I adhered to the rule of informed consent with survey and interview participants by providing them with information on what the research entails (objectives). Whilst most of the respondents use pesticides as it has helped them cut losses to pests and diseases by up to 40% (Oliviera *et al*., 2014), I understood that farmers or pesticide dealers may be reluctant in revealing some practices that are deemed illegal, e.g., use of banned products.

It was therefore important to identify and assess how to handle the ethical issues associated with the use of pesticides and how farmers' position might influence their responses on the field. Most of the consequences of pesticide use pose both ethical and legal dilemma and sometimes difficult to balance the positive and negative impacts, especially with most users (farmers) appreciating the benefits that accrue from pesticide use for their bottomline (profits). During interview sessions, I assured respondents of confidentiality when they spoke about banned products which they use/sell.

Aside the ethics of scientific validity, informed consent and risk minimization, I had to make some situational decisions on the field when interacting with the participants. For instance, some groups of farmers initially refused to participate in the research on the premise of past experiences. The mentioned that they feel marginalized because their expectations from past participation in studies similar to the current one were not met. They implied that I am a representative of the Governement and therefore not interested in taking part. Government hostility was seen amongst several respondents and I had to explain my position as an independent researcher and that this study is academic, and results will be shared publicly. Also, I had transactional dealings with a group of respondents where their participation in the study was in return for a training facilitated by me on pesticide training. To avoid bias and not to compromise their current understanding of the research, I ensured they completed the surveys before I carried out the training during their association meeting. This experience provided me with the opportunity to educate them on pesticide safety and alternatives to pesticide use.

Whilst this research is borne out of my ontological position on the misuse of pesticides, I did not allow this to cloud my line of questioning during fieldwork, especially with respondents who reported their own misuse and continued use or selling of banned products. It was important to have a deep insight of what drives the use and as such, I tailored my line of questioning to answer the research question. Overall, this study was carried out with respect for research rules and participants and ensuring all line of questioning were significant to the research objectives.

Chapter Five

Natural Science Results and Discussions

Natural science, does not simply describe and explain nature; it is part of the interplay between nature and ourselves.

-Werner Heisenberg

5.1 Introduction

This chapter presents the results and discussions of pesticide analysis carried out on soil and sediments samples collected during field studies. The overall aim of this chapter is to meet research objectives two and three which are: to develop and use methods to quantify residual pesticides in soil and sediments; and create a current profile of pesticide use in Ibadan from UA. This profile is used in understanding the possible impacts of pesticide use in UA on dimensions of sustainable development which is the conceptual framework on which this study is based. In order to meet the two objectives highlighted above, chemical analysis, radioactive and biological analyses of soil and sediments were carried out. The determination of OC residues in sediments and soil may give an indication of the extent of aquatic contamination and accumulation characteristics of these compounds in a tropical ecosystem. This will contribute towards understanding the behaviour and fate of these persistent chemicals in tropical environments like Nigeria. The rationale behind these choices has been explained in the methodology section of chapter three with results and discussions of these analyses presented below.

5.2 Physico-chemical characteristics of sampling areas

As persistence and degradation of pesticides in the environment are dependent on its chemistry and environmental conditions, table 5.1 presents the mean values of water and sediment temperature, pH, EC and TDS. An in-situ measurement of the lake's water and sediments' temperature across all sample points range from 30.2 - 30.8 0C and 28.1 – 28.5 0C respectively. Also, pH across all sampling areas confirmed the surface waters and sediments as near neutral to slightly alkaline with a range of 6.9 to 7.1. Electrical conductivity of both water and sediments range between 292- 433 µs/cm whilst total dissolved solids ranged between 198-310 mg/l.

Table 5.1: Physico-chemical parameters of Eleyele lake water and sediments

Parameter (mean values)	Eleyele axis	Awotan axis	Agbaje axis	*Limit for discharge into water/Land
Water				
Temperature (^{0}C)	30.8	30.5	30.2	<40
pH (0-14)	7.1	7.2	7.1	6-9
Electrical conductivity (µs/cm)	320	338	292	na
Total dissolved solids (mg/l)	212	219	198	2000
Sediments				
Temperature (^{0}C)	28.5	28.1	28.3	<40
pH (0-14)	6.9	7.0	6.9	6-9
Electrical conductivity (µs/cm)	433	380	362	na
Total dissolved solids (mg/l)	310	298	302	2000

Source: Field data, 2016, * FEPA, 1991 environmental guidelines

According to the guidelines and standards for environment pollution control in Nigeria produced by Federal environmental protection authority (FEPA, 1991), all physico- chemical properties were all within the range prescribed. Omotoso *et al*. (2011) in their analysis of Eleyele lake water provided average pH, total dissolved solids, and electrical conductivity measurements as 7.655 (0-14), 227.17 mg/l and 327.19 µs/cm respectively. The values obtained in this study are consistent with values reported by Omotoso *et al*. (2011). Also, the measurements in this study are within World health organization's acceptable levels for potable water in this study area (WHO, 2011). Similarly, Olayinka *et al*. (2017) in their assessment of pollution status of Eleyele Lake water reported a pH range of 6.0 - 7.5 and therefore in agreement with the values found in this current study. However, their mean electrical conductivity and total dissolved solid values were reported to be in the range of 205-221 µs/cm and 105-113 mg/l respectively. These values differ from those obtained in this study (table 5.1) but electrical conductivity values are still within the range of 250-344 µs/cm reported by Tijani *et al*. (2012) in their study of impact of urbanisation on Eleyele wetland.

The relationship between changes in pH and the adsorption and degradation of ionisable pesticides has been reported (Kah & Brown, 2007). According to Villaverde *et al*. (2008), pesticide breakdown occurs faster at a high pH for pesticide formulations that are degraded by micro-organisms since microbial activity is often greater in weak alkaline conditions. The near neutral to slightly alkali condition reported for Eleyele Lake in this study indicates a possible effect of pH on soil organic matter preservation and decomposition which lead to slow degradation of organic matter (Idowu *et al*., 2013) such as dead diatoms to which pesticide residues may have been bonded (Seymour *et al*., 2018). This is significant as pesticide residues in this lake may persist longer than if the lake was strongly acidic as degradation is greater under acidic conditions (Zulkefli *et al*., 2019). This persistence in alkali soils due to a longer pesticide degradation process results in toxicity (Villaverde *et al*., 2008). In contrast to the weak alkali soils a found in this study, degradation of pesticide in acidic soil may reduce toxicity but some pesticides have breakdown products that are more toxic than the parent compound (Kah & Brown, 2007).

However, the possible influence of high temperature recorded in this study on degradation cannot be overlooked as Pimentel & Edwards (1982) and Cyon and Piotrowska-Seget (2006) stated that an increase in temperature leads to a faster rate of degradation because of its influence on moisture condition. A moisture condition influenced by high temperature produces a high level of microbial activity, allowing for a low adsorption of pesticides to different soil particles, and therefore, a faster degradation process (Cyon and Piotrowska-Seget, 2006; Arbeli and Fuentes, 2010). The physico-chemical profile of samples in this study suggests condition for rapid rate of degradation exists in the study area.

5.3 Soil and sediment residue

This study assessed only organochlorine and organophosphates pesticide among other types of pesticides. The decision is informed by studies such as this is because, organochlorines though banned, have been reported to be in continued use especially in developing countries like Nigeria (Ecobichon, 2001, Edwards 2003). Also, studies have shown that organophosphates also persist in sediments long after their application on their intended targets (Cembranel *et al.*, 2017). Table 5.2 presents the current residue levels of seven OCPs (Aldrin, Dieldrin, DDT, Endosulfan, Endrin, Heptachlor and Heptachlor epoxide) and five OPs (Dichlorvos, Dimethoate, Diazinon, Malathion and Parathion) in sediment samples from three sample locations (see Fig. 4.5 in chapter 4) along Eleyele Lake in Ibadan, south-western Nigeria. Eleven pesticide analytes of the twelve analytes were detected in the lake sediments with Aldrin found to be below detection limit (BDL).

Table 5.2: Mean levels of pesticide residue in sediments (mg/kg)

Analytes	Eleyele axis	Awotan axis	Agbaje axis
Aldrin	BDL	BDL	BDL
Dieldrin	0.022	0.0191	0.01913
DDT	0.0212	0.0191	0.0193
Endosulfan	0.015	0.01897	0.019
Endrin	0.015	0.013	0.01307
Heptachlor	0.02	0.012	0.012
Heptachlor epoxide	0.0225	0.022	0.022
Dichlorvos	0.016	0.01	0.01
Dimethoate	0.016	0.01007	0.01013
Diazinon	0.016	0.02197	0.022
Malathion	0.016	0.022	0.022
Parathion	0.016	0.02197	0.0219

Source: Fieldwork and laboratory analysis, 2017; BDL: Below detection limit

Current pesticide residue profile of Eleyele lake sediment indicated a below detection limit for Aldrin which is expected because of its' rapid volatilisation into its' stable form, Dieldrin, after application, usually between volatilization from water surfaces is expected to be attenuated by adsorption to suspended solids and sediment in the water column. Residue levels for OCPs in sediments range between 0.01 - 0.022 mg/kg. There are no previously reported studies into sediment analysis for pesticide residue in Ibadan aside from this current study. However, Nwankwoala and Osibanjo (1991) in their baseline study of organochlorine pesticide residues in Ibadan surface waters reported a non-detectable limit for DDT in Eleyele waters but found varying levels (µs/cm) of Aldrin (0.003), Heptachlor (0.135), Heptachlor epoxide (0.009), Endosulfan (0.01) and Dieldrin (0.094). These values are close to those obtained in sediments analysed in this study (table 4.2) with the exception of Aldrin which was below detection limit. This was expected for Aldrin because of its' rapid transformation into Dieldrin, which is more stable in the environment. DDT, though not detectable in Nwankwoala and Osibanjo's (1991) study, this current research recorded its' presence in sediments which confirms the highly persistent nature of this particular organochlorine pesticide in the environment even long after it has been banned or disused (Hodgson, 2012).

Similar studies into pesticide residue in sediments in other Nigerian cities and towns but with locational and topographical differences such as Adeboyejo *et al*. (2011), Williams (2013), Idowu *et al*. (2013), Akan *et al*. (2015), Olafisoye *et al*. (2016) and Adesina *et al*. (2019) all carried out residue analysis of organochlorine pesticides in sediments as part of their studies. Adeboyejo *et al*. (2011) in their studies on pesticide residues across three sampling points in Lagos Lagoon found levels lower to those obtained in this present study for the following analytes: Dieldrin, Endrin, Endosulfan and Heptachlor. The values (mg/kg) for Dieldrin, Endrin, Endosulfan and Heptachlor are in the order of 0.0005<0.02, 0.0156<0.013 and 0.007<0.02. This noted difference could be attributed to additional bio-accumulation of pesticides after a given time period.

Also in Lagos, William (2013) analysed a shallow creek for organochlorine residues during the dry and wet seasons and detected Aldrin, Dieldrin, Endrin, Endosulfan and DDT among other analytes. During the wet season, which is the same season at which samples were collected for this study, the analytes were at levels lower than this study's figures. In the eastern part of the Nigeria, Unyimadu *et al* (2019) found high levels of different organochlorine residues along sampling points on river Niger. Olafisoye *et al* (2016) in their determination of the level of pesticides in sediment and water from the Lagos Lagoon detected high levels of organochlorine pesticides, excluding DDT in both sediments and samples. However, in this study, DDT was present in sediment samples. The presence of DDT in Ibadan sediment, though in small levels, is a possible indication of continued use of the banned product in fishing. According to Ntow (2005), the DDT residues may have come from various pesticide-rich sources such as agriculture and households in the control of vectors. The natural processes of leaching and run-off create an enabling environment for the transfer of this DDT residue into the Lake (Konstantinou *et al*., 2006).

Study on pesticide residues in Volta Lake, Ghana which is man-made like Eleyele Lake, by Ntow (2005), revealed the presence of organochlorine residues that included DDT and endosulfan. According to Ntow (2005), the DDT and endosulfan residues were believed to have originated from various pesticide-rich sources, mainly agricultural and household uses. The natural processes of leaching and run-off create an enabling environment for the transfer of these residues to the lake. Similarly, in studies on persistent organochlorine pesticide residues in sediments from Lake Bosomtwi, Ghana by Darko *et al*. (2008), Lindane, Endosulfan, Aldrin, Dieldrin and DDT were found at ranges between 0.00018 - 0.000055 mg/kg. Canbay *et al* (2014) in their analysis of Golcuk National Park Lake sediments and water in Turkey found no pesticide residues which the author attributed to the organochlorine ban and effective monitoring of these compounds in the area since the seventies. Their result suggests that organochlorine persistence can gradually whittle down to zero level if effective enforcement of ban is pursued through education, training, and monitoring. Dieldrin is a highly persistent organochlorine insecticide, used extensively on different crop types until its' ban that was widely used on a variety of crops for several decades until 1970, and for termite control until 1987 (ATSDR, 2002). In a postmortem study by Fleming *et al*. (1994), dieldrin was detected in 6 of 20 brains from Parkinson disease (PD) patients, but in 0 of 14 controls, and importantly in only 1 of 7 with Alzheimer's disease (AD)—demonstrating a specificity for PD.

Table 5.3 presents the residue levels of five organophosphate (OPs) pesticides in soil samples taken from two farm locations. Due to the topographical characteristics of Barracks farm settlement, a composite sample was each collected upstream and downstream respectively while the third sample was taken from Agbaje farm settlement. Four organophosphate analytes were detected while Parathion was below detection level.

Table 5.3: Mean levels of Organophosphate pesticide residue in soil (mg/kg)

Analytes	Agbaje	Barracks Upstream	Barracks Downstream
DDVP	0.016	0.01	0.01
Dimethoate	0.016	0.01007	0.01013
Diazinon	0.016	0.02197	0.022
Malathion	0.016	0.022	0.022
Parathion	BDL	BDL	BDL

The results are significant for this study since sediments are a source of contamination that release pesticides to the surrounding environment and aquatic organisms (Zhang *et al*., 2013). It also confirms that watershed sediments such as Eleyele Lake will continue to release these contaminants into the next century (Moore *et al*., 2007). In assessing impacts of pesticides in urban agriculture on sustainable development, the levels of organochlorine residues found has the potential to accumulate in aquatic organisms and further transported through bio-accumulation in food chains. For instance, Eleyele Lake is a fishing spot and a source of potable water for Ibadan city. The bio-accumulation of residues could lead to contamination of drinking water. Not only that, it could contaminate aquatic organisms such fish and edible crustaceans (Ozkara *et al*., 2016). As they are very resistant to degradation which is evidenced in the presence of DDT in sediments, they could trigger neurological condition and cancer in human due to their high carcinogenic effects (Zhang *et al*., 2013). All these potential problems would affect the health of the population and negatively impact on social and economic standards.

5.4 Lead 210 analysis

Figure 5.1 presents the result of gamma spectrometry carried out to 5cm depth of sediment samples. Low signals of radiation were detected and therefore, further analysis could not be carried out. This is because chronology of sediments consists of two major parameters; the age of the sediment and burial depth within the sediment (Kosnik *et al*., 2015). In this study, cores were only collected up to 45cm depth. Also, considering that the lake under study is less than a 100 years old, the young sediment age could play a part in the poor signal detected during analysis. The second key parameter, time-averaging, is the amount of time represented in a sedimentary deposit, or stratigraphic unit (Flessa *et al*. 1993; Kowalewski 1996). While the mean age of a sedimentary assemblage is important, it is the age distribution of the constituents within the sedimentary sample, or time-averaging, which fundamentally limits the temporal resolution of a given deposit. Quantifying time- averaging is time- and resource-intensive, so although it is of utmost importance for understanding the processes underlying nearly all paleontological and sedimentological investigations, few studies date a sufficient number of specimens to quantify the age distribution.

The radionuclide 210Pb (half-life 22.26 y) occurs naturally as a member of the 238U decay series (Yang & Appleby, 2016). A fraction of the inert gas 222Rn, a product of 226Ra decay (half-life 1602 y) in soils, escapes to the atmosphere where it decays via a series of short- lived radionuclides to 210Pb. 210Pb atoms in the atmosphere are readily attached to airborne particles which are quickly removed to land surfaces and water bodies by wet and dry deposition. Fallout 210Pb accumulating in soils and sediments is called unsupported 210Pb, to distinguish it from the supported 210Pb that derives from in situ decay of the parent radionuclide 226Ra. The unsupported 210Pb will decay to near-zero concentrations over a period of around six 210Pb half-lives (~130 years). Supported 210Pb, which will usually be in radioactive equilibrium with 226Ra, is determined by measuring the 226Ra activity of the sample. Unsupported 210Pb is determined by subtracting the supported activity from the measured total 210Pb activity.

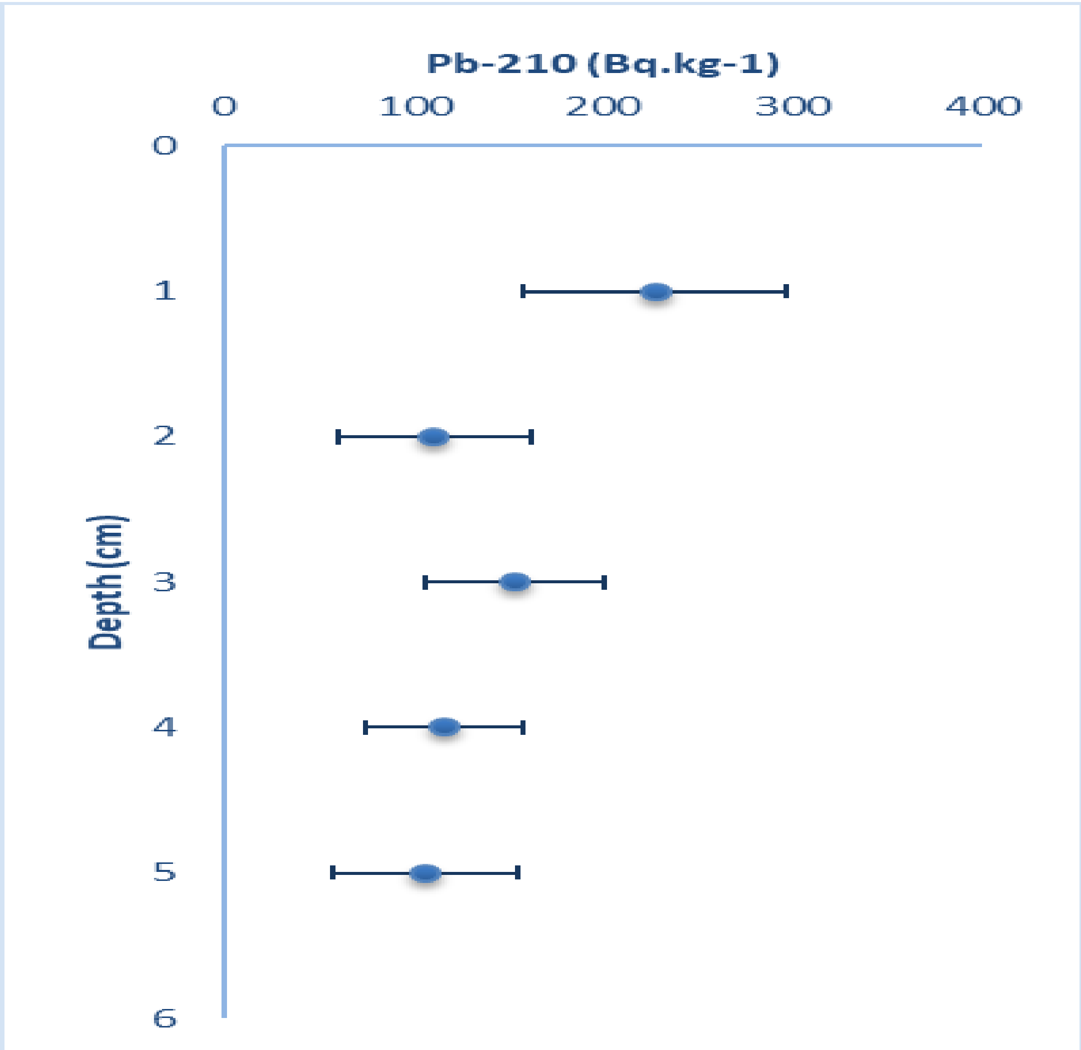


Figure 5.1: Gamma spectrometry of sediment samples at different depths

5.5 Diatom analysis

Table 5.5 presents the diatom taxa identified and counts. A total of 15 taxa groups were identified in the study. To use diatoms as indicator of pollution, a general diatom index of 200 and above is required but none of the diatom species identified in this study had that count. However, the presence of Melosira granulata at every 5cm of the sediment core is interesting. This is because Melosira is a colonial and high profile diatom (Table 5.6) which is tolerant to pollution.

Table 5.5: Diatom identified and count data in Eleyele Lake

	Diatom Taxa	ALA_1	ALA_2	ALA_3	ELY_5	ELY_10	ELY_15
1	*Aulacoseira (Melosira) granulata*		-	-	1	1	6
2	*Gomphonema sp*		-	-	-	-	2
3	*Gyrosigma spenceri*				1		2
4	*Navicula menisculus*						2
5	*Eunotia veneris*						2
6	*Tabellaria sp.*		1				1
7	*Navicula sp.*				2	1	
8	*Navicula cuspidata var. ambigua*				1		1
9	*Navicula holophila*				1		1
10	*Navicula monodi*				2		
11	*Surrirela sp.*				1	1	1
12	*Synedra goulardi*	1			4	2	1
13	*Navicula interrupta var. jocutata*				1		
14	*Cyclotella meneghiana*				5	1	1
15	*Nitzchia sp.*		1		1	2	1
16	*Eunotia exigua*	1	1			1	
15	*Pinnularia debesi*					5	
18	*Eunotia sp.*					1	
19	*Eunotia pectinalis minor*						1
20	*Gomphonema lanceolatum*					1	1
21	*Tabellaria*						2
22	*Synedra ulna*						1
23	*Melosira granulate*	1		10	37	1	24
24	*Gomphonema parvulum*				4		
25	*Achnathes exigma var. constricta*				1		
26	*Pinnularia interrupta*				3		
27	*Gomphonema gracile*		3				
28	*Eunotia lunaris*		1				
29	*Pinnularia acrosphaeria var. dubia*			1			
30	*Cocconeis placentula*						
31	*Gomphonema cuspidate*				3		2
32	*Craticula cuspidate*				8		5

An ecological guild is a group of taxa that live in the same kind of environment but may have had to adapt in different ways in order to survive there (Debenest, 2012). In Debenest (2012), Passy (2007) defined three ecological guilds namely, the high profile guild, low profile guild and Motile guild. Table 5.6 shows the different taxa identified in this study in their ecological guild. The low profile guild is characterised by short stature and very slow-moving while the high profile includes tall and filamentous species. The third guild is the motile one, which are fast moving (Passy, 2007 in Debenest, 2012).

Table 5. 6: Diatoms identified according to Ecological guilds

Ecological guilds	Taxa composition
Low profile	Cyclotella meneghiana, Achnathes exigma var. constricta, Cocconeis placentula
High profile	Aulacoseira (Melosira) granulata, Gomphonema sp, Eunotia veneris, Tabellaria sp.
Motile	Gyrosigma spenceri, Navicula menisculus, Navicula sp.,Surrirela sp.,Craticula cuspidate

Adapted from Debenest, 2012

5.6 Conclusions

This natural science study assessed pesticide contamination in form of residue presence in the Ibadan city. The results showed the presence of residues in soils and sediments sampled but could not tell the extent of historical contamination due to limited results generated from the diatom and Pb-210 analyses. However, this study reveals that residue of organochlorines still persists in the environment despite its' ban.

Chapter Six

Social Science Results

I want to understand the world from your point of view. I want to know what you know in the way you know it. I want to understand the meaning of your experience, to walk in your shoes, to feel things as you feel them, to explain things as you explain them. Will you become my teacher and help me understand?"

— James P. Spradley

6.1. General Introduction

This chapter present results of the social science methods employed in chapter four to assess pesticide use in urban agriculture. This chapter is two-fold: the first part presents all the quantitative results generated from questionnaire surveys while the second part presents qualitative results from focus group discussions, interviews, and key informant interviews. These methods have been explained in detail in chapter 4. The structure of the chapter is as follows: section 6.2 presents results of the survey data on farmer/farm characteristics and pesticide usage respectively while section 6.3 presents the qualitative data from interviews and FGDs on pesticide usage.

Overall, this chapter reports on variables concerning the incidence of pesticide use in the study area, the factors driving its use with particular focus on the dimensions of SD. It presents the statistical results generated from the questionnaire surveys carried out to establish the incidence of pesticide use and also explore farmers' pesticide use pattern from a sample population of 190 producers across Ibadan major urban areas with the intention to discussing these findings within the objectives of this research.

6.2 The questionnaire survey analysis: farmer and farm characteristics

The data is collected from five different local government areas of Ibadan city (Akinyele L.G.A, Ibadan North L.G.A, Ido L.G.A, Ona-Ara L.G.A AND Oluyole L.G.A), with a total sample of 190 (n=190). The results are presented for individual L.G.As' and total sample population. Results are reported for individual L.G.A where variation exists.

6.2.1 Respondents' characteristics

Respondents' socio-economic characteristics which include age, gender, educational status, main occupation, membership of farmers' organisation and decision-making role are important in understanding their actions, behaviours, attitude, knowledge and decision-making in their practices of urban agriculture. This section describes the characteristics of these variables. Table 6.1 presents gender, age, highest educational qualification and main occupation of the respondents while Table 6.2 presents survey results on decision making role and membership of farmers' organisation. Table 6.3 presents the statistical distribution of respondent characteristics of the whole sample population.

Table 6.1: Respondents' demographic characteristics

Characteristics	Variables	Akinyele N=50	%	Ibadan North N=50	%	Ido N=50	%	Ona-Ara N=36	%	Oluyole N=4	%	Total N=190	%
Gender	Male	34	*68.0*	32	*64.0*	38	*76.0*	27	*75.0*	3	*75.0*	135	*70.5*
	Female	16	*32.0*	18	*36.0*	12	*24.0*	9	*25.0*	1	*25.0*	56	*29.5*
Age	15-20	2	*4.0*	3	*6.0*	0	*0.0*	0	*0.0*	0	*0.0*	5	*2.6*
	21-30	6	*12.0*	5	*10.0*	4	*8.0*	2	*5.6*	0	*0.0*	17	*8.9*
	31-40	9	*18.0*	11	*22.0*	7	*14.0*	8	*22.2*	0	*0.0*	35	*18.4*
	41-50	22	*44.0*	23	*46.0*	13	*26.0*	6	*16.7*	2	*50.0*	64	*33.7*
	51-60	9	*18.0*	7	*14.0*	17	*34.0*	14	*38.9*	2	*50.0*	49	*25.8*
	>60	2	*4.0*	1	*2.0*	9	*18.0*	6	*16.7*	0	*0.0*	20	*10.5*
Education	No formal Schooling	5	*10.0*	6	*12.0*	4	*8.0*	2	*5.6*	0	*0*	17	*8.9*
	Primary School Uncompleted	5	*10.0*	6	*12.0*	3	*6.0*	0	*0.0*	0	*0.0*	14	*7.4*
	Primary School completed	12	*24.0*	10	*20.0*	8	*16.0*	10	*27.8*	1	*25.0*	41	*21.6*
	Secondary School	17	*34.0*	17	*34.0*	8	*16.0*	7	*19.4*	1	*25.0*	50	*26.3*
	College/University completed	11	*22.0*	8	*16.0*	24	*48.0*	15	*41.7*	2	*50.0*	60	*31.6*
	Post-graduate	0	*0.0*	3	*6.0*	3	*6.0*	2	*5.6*	0	*0.0*	8	*4.2*
Main Occupation	Farming	31	*62.0*	38	*76.0*	41	*82.0*	24	*66.7*	3	*75.0*	137	*72.1*
	Self-employed	4	*8.0*	9	*18.0*	5	*10.0*	9	*25.0*	1	*25.0*	28	*14.7*
	Public service	15	*30.0*	2	*4.0*	2	*4.0*	3	*8.3*	0	*0.0*	22	*11.6*
	Private service	0	*0.0*	1	*2.0*	2	*4.0*	0	*0.0*	0	*0.0*	3	*1.6*

Local Government areas: Akinyele, Ibadan North, Ido, Ona-Ara, Oluyole

Field survey, 2016

Table 6.2: Farmers' characteristics (Decision maker and membership of farmers' organization)

		Local Government areas											
		Akinyele		**Ibadan North**		**Ido**		**Ona-Ara**		**Oluyole**		**Total**	
Characteristics	**Variables**	N=50	%	N=50	%	N=50	%	N=36	%	N=4	%	N=190	%
Decision maker	Yes	49	***98.0***	47	***94.0***	43	***86.0***	22	***61.1***	4	***100.0***	165	***86.8***
	No	1	***2.0***	3	***6.0***	7	***14.0***	14	***38.9***	0	***0.0***	25	***13.2***
Member of farmers' organization	Yes	26	***52.0***	25	***50.0***	39	***78.0***	26	***72.2***	3	***75.0***	119	***62.6***
	No	24	***48.0***	25	***50.0***	11	***22.0***	10	***27.8***	1	***25.0***	71	***37.4***
Farm organization	[a]Farmers' Ass.	10	***20.0***	15	***30.0***	10	***20.0***	5	***13.8***	2	**50.0**	42	***22.1***
	Market Co-op	16	***32.0***	10	***20.0***	29	***58.0***	21	***58.3***	1	**25.0**	77	***40.5***
	No association	24	***48.0***	25	***50.0***	11	***22.0***	10	***27.8***	1	**25.0**	71	***37.4***
Farmers field school	Yes	19	***38.0***	13	***26.0***	16	***32.0***	2	***5.6***	4	**100.0**	54	***28.4***
	No	31	***62.0***	37	***74.0***	34	***68.0***	34	***94.4***	0	**0.0**	136	***71.6***

Field survey, 2015

a. Farmers association

Table 6.3: Statistical distribution of Respondents' Characteristics

Characteristics	N	Minimum	Maximum	Mean	Std. Dev	Skewness	Std.E
Gender	190	1	2	1.29	.457	.908	.176
Age	190	1	6	4.03	1.210	-.358	.176
Highest educational level	190	1	6	3.77	1.325	-.586	.176
Main occupation	190	1	4	1.43	.758	1.618	.176
Valid N (listwise)	190						

6.2.1.1 Gender

The gender distribution of respondents does not conform to a normal distribution at d.f (190) =0.908, p<0.05. This is the case in each local government, which showed more men participate in urban agriculture within the study area and across all sample populations. Figures 6.1a and 6.1 b. is the bar-chart and pie-chart of gender distribution across the local government areas and the sample population as a whole respectively.

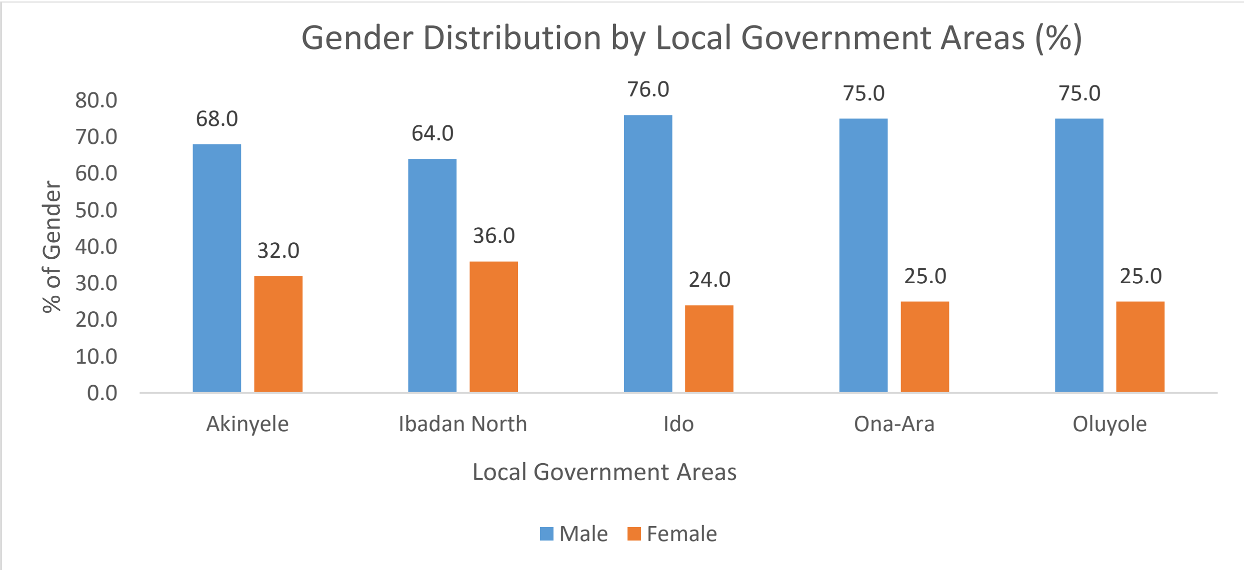


Figure 6.1a. Gender distribution by Local Government Areas
n=50 for Akinyele, Ibadan North and Ido LGAs while n=34 for Ona-Ara and Oluyole LGAs

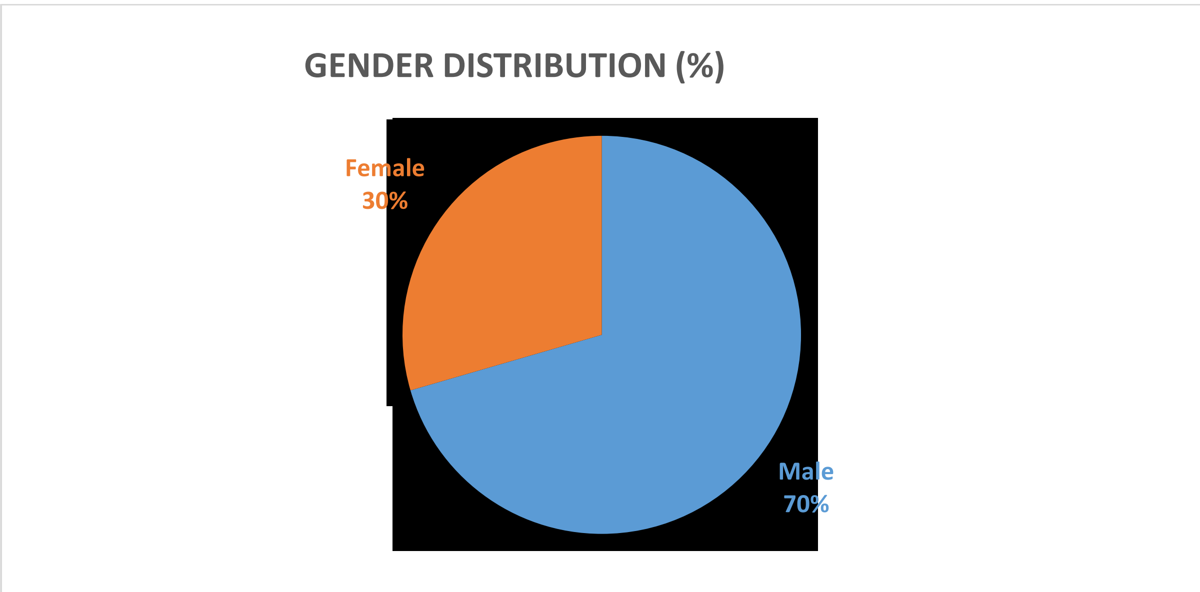


Figure 6.1b: Total gender distribution of sample population (n=190)

6.2.1.2 Age

The age of respondents was captured as a continuous and categorical data. Age groups were in the ordinal format of 15-20; 21-30; 31-40; 41-50; 51-60; and >60 and coded as 1, 2, 3, 4, 5 and 6 respectively, with 1 = 15-20, up to 6 = >60. Descriptive analysis showed the mean code for age as 4.03 and a negative skewness of -0.358 ($p<0.05$) which implies the majority of farmers in the study area are between the ages of 41 and 50 years (33.7%, n= 190) across all local Government areas, while the 15 to 20 years' age group (2.6%) was the least. Figure 6.1c below presents a chart showing the age distribution of the respondents.

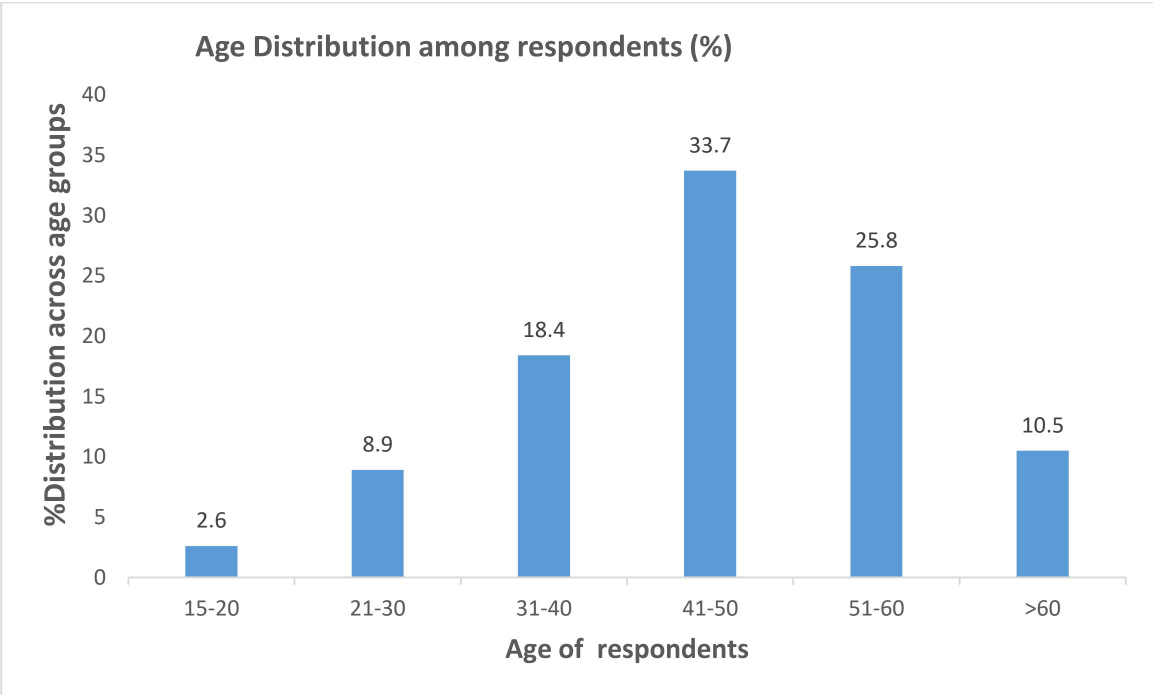


Figure 6.1c. Age distribution of Respondents

6.2.1.3 Main occupation

City living is associated with white collar jobs and therefore it was necessary to ask respondents what their main occupation is. This is categorised in the survey to simplify data collection process as farming, self-employment (any job aside from farming), public service (employed in the public sector) and private service (employed in the private sector). Table 6.1 showed the distribution of respondents' occupation, which shows that 72.1% of total respondents indicated farming as their main occupation, implying that their main source of income is farming. 14.7% of sample population identified themselves as self-employed in other business other than agriculture with 11.6% and 1.6% of sample population working within the public and private sector respectively. Figure 6.2 shows a graphical representation of respondents by occupation.

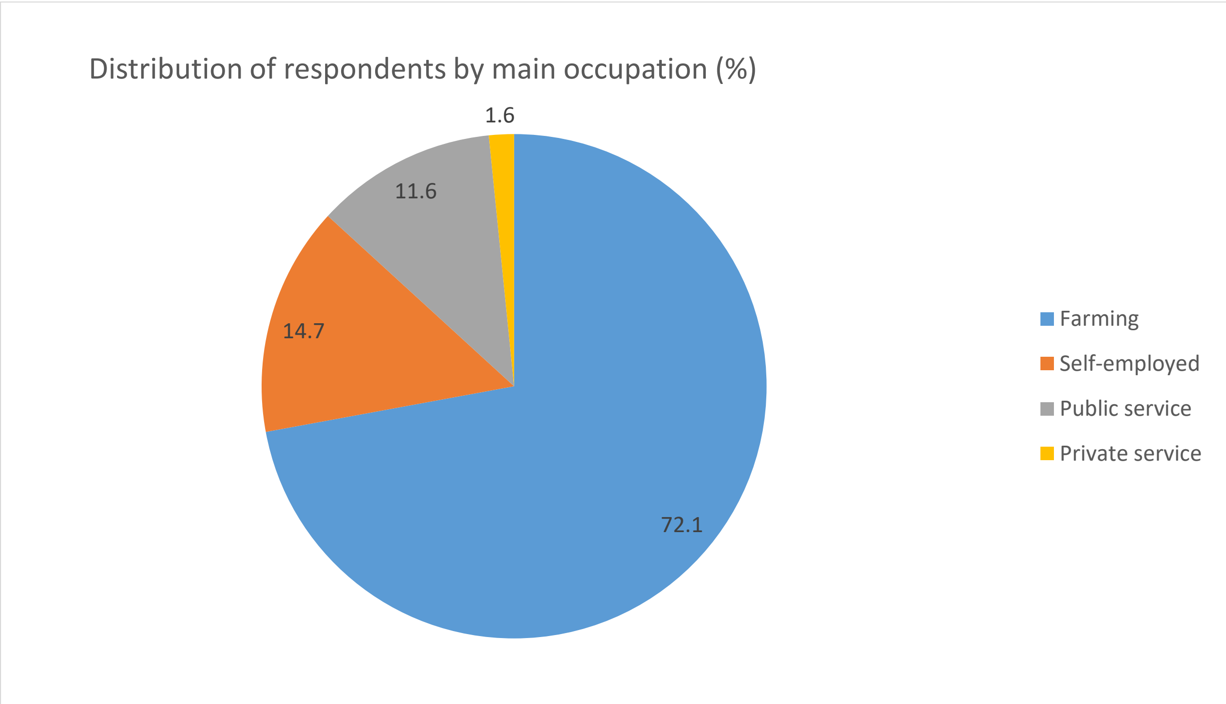


Figure 6.2a: Distribution of respondents by main occupation, n=190

6.2.1.4 Educational status

The educational status of all respondents was assessed by categorising data according to the highest level of education attained and presented in Figure 6.2b. The categories are no formal schooling (8.9%), primary school uncompleted (7.4%), primary school completed (21.6%), secondary school completed (26.3%), college/university completed (31.6%) and postgraduate completed (4.2%). Statistics also revealed that of all respondents, men were more educated than their female counterparts.

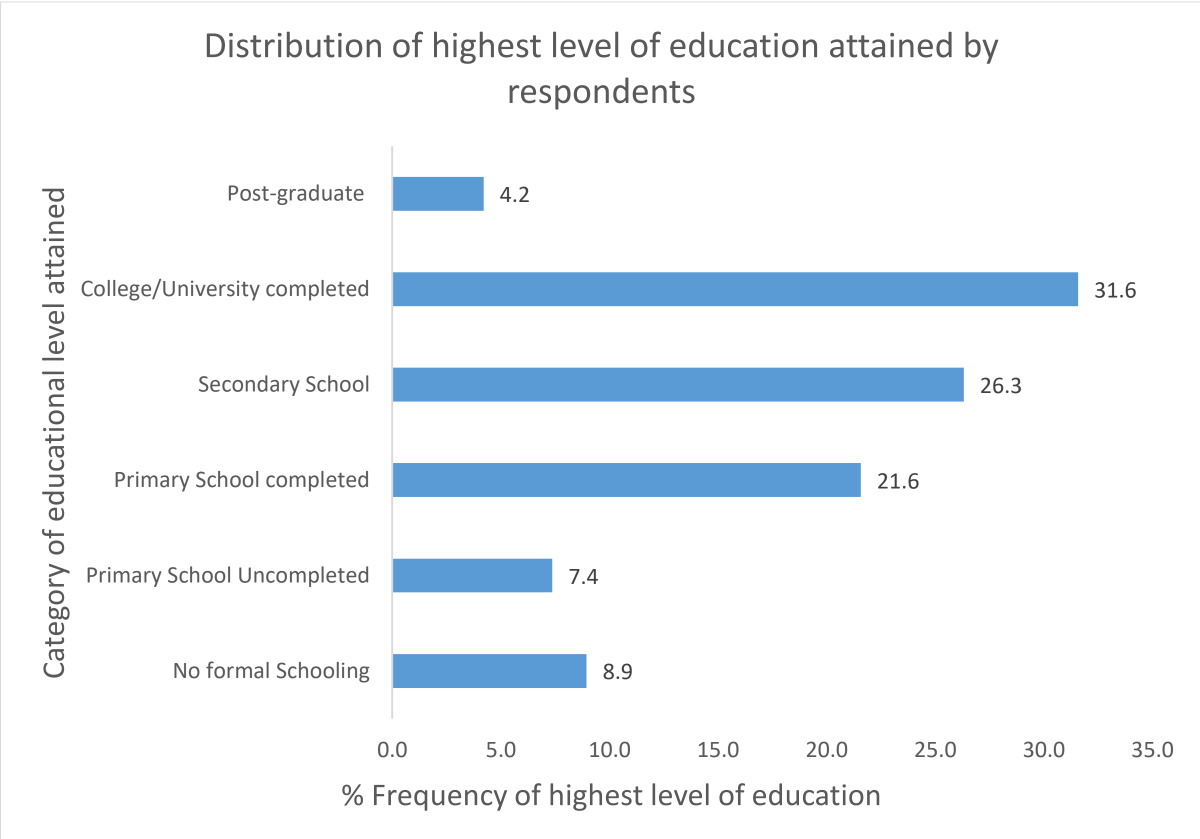


Figure 6.2b: Distribution of Highest educational qualification attained by respondents

6.2.1.5 Decision maker and membership of farmers' organisation

Table 6.3 showed the survey results on other farmer characteristics such as decision making role and membership of a farming group. 86. 8% of all respondents are responsible for making decisions on their farms, especially on pesticide use. Also, 62.6% of the sample population belong to a farmer organization which was categorised as farmers' association and market cooperative societies while 37.4% do not belong to any organization. 28.4% of respondents indicated their regular attendance at a farmers' field school. Also, across L.G.As, there is a variation in membership of organisations. Ido, Ona-Ara and Oluyole has high statistics in membership of organisation. This variation could be because these areas recently became highly urbanized. This variation will be discussed in the discussion section.

6.2.2 Farm Characteristics

Data on farm characteristics which include farm size, farming purpose, type of farming, and land tenure status are presented in tables 6.4 and 6.5. These characteristics are important as they potentially shape farm decisions and exert influence on pesticide choices.

6.2.2.1 Farming purpose, experience, and farm size

Urban agriculture can be practiced solely as a household venture, commercial venture, or a mix of both. These different scales of practice showed the contribution of UA to social and economic needs. While some practice it solely for sustenance, another group practice it as a source of livelihood and the third group, practice both sustenance and for additional income. Consequently, respondents were asked to indicate the purpose for which they farm, and these were categorised in the survey as: household consumption, commercial venture or consumption and commercial mix. Farming experience and farm size were also considered for subsequent assessment of its relationship to pesticide use. Farming experience was categorised in the survey as 1-2 years, 3-5 years, 6-10 years, 11-15 years, 16-20 years and above 20 years, while farm size was categorised as <1, 1-2, 3-5, 6-10 and >10 plots. The results are presented in table 6.4 and provide an overview of these characteristics by L.G.A and as a percentage of the total sample population.

Table 6.4: Farm Characteristics (Farming purpose, experienceand farm size)

		Local Government areas											
		Akinyele		**Ibadan North**		**Ido**		**Ona-Ara**		**Oluyole**		**Total**	
Characteristics	**Variables**	N=50	*%*	N=50	*%*	N=50	*%*	N=36	*%*	N=4	*%*	N=190	**%**
Farming Purpose	HOUSEHOLD CONSUMPTION	5	***10.0***	3	***6.0***	9	***18.0***	6	***17.0***	4	***100.0***	27	***14.0***
	COMMERCIAL	16	***32.0***	25	***50.0***	24	***48.0***	12	***33.0***	0	***0.0***	77	***41.0***
	HOUSEHOLD AND COMMERCIAL	29	***58.0***	22	***44.0***	17	***34.0***	18	***50.0***	0	***0.0***	86	***45.0***
Farm size	<1 PLOT	0	***0.0***	2	***4.0***	0	***0.0***	4	***11.1***	0	***0***	6	***3.2***
	1-2 PLOTS	9	***18.0***	11	***22.0***	9	***18.0***	10	***27.8***	2	***50.0***	41	***21.6***
	3-5 PLOTS	9	***18.0***	13	***26.0***	16	***32.0***	11	***30.6***	2	***50.0***	51	***26.8***
	6-10 PLOTS	6	***12.0***	14	***28.0***	14	***28.0***	8	***22.2***	0	***0.0***	42	***22.1***
	>10 PLOTS	26	***52.0***	10	***20.0***	11	***22.0***	3	***8.3***	4	***100.0***	50	***26.3***
Farming experience	1-2 YRS	8	***16.0***	9	***18.0***	7	***14.0***	8	***22.2***	1	***25.0***	33	***17.4***
	3-5 YRS	7	***14.0***	5	***10.0***	12	***24.0***	10	***27.8***	1	***25.0***	35	***18.4***
	6-10 YRS	4	***8.0***	7	***14.0***	7	***14.0***	4	***11.1***	1	***25.0***	23	***12.1***
	11-15 YRS	11	***22.0***	18	***36.0***	7	***14.0***	2	***5.6***	1	***25.0***	38	***20.0***
	16-20 YRS	10	***20.0***	8	**16**	4	**8.0**	6	**16.7**	0	***0***	29	***15.3***
	>20 YRS	10	***20.0***	3	**6**	13	**26.0**	6	**16.7**	0	***0***	32	**16.8**

Field data, 2016

The survey results in table 6.4 reveals 45.8% of sample population practice urban agriculture solely as a commercial venture while 44.2% do it for combined commercial and consumption purposes; and 10.0% for consumption purpose only. This signifies farmers practice UA both for social and economic needs as only 10% of the sample practice it solely for sustenance. The purpose for which UA is practiced could influence their pesticide use, especially where almost all practitioners produce for economic gain.

Farm sizes ranged from a single plot to more than 10 plots (a plot=50 feet by 100 feet) with 24.8% of total respondents having a plot size of ≤2 plots. 48.9% of the respondents had farm sizes between 3-10 plots while 26.3% had more than 10 plots each. This variation in farm size could also influence pest management. Respondents' farming experience assessed in years are presented as 17.4% (1-2 years), 18.4% (2-5 years), 12.1% (6-10 years), 20.0% (11-15 years), 15.3% (16-20 years) and 16.8% above 20 years. With over 50% of the sample having over 10 years' experience, the significance of this degree of experience would be discussed in the discussion section.

6.2.2.2 Type of farming and land tenure status

Table 6.5 presents the results of questions about respondents' land tenure status and type of farming practised. Data shows a mixed range of farming types are practised by respondents which could be dependent on the scale or need type. However, 72.3% of total sample population are involved in vegetable farming, with the remaining proportion in livestock, agroforestry, ornamental horticulture and aquaculture at 16.6%, 7.5%, 2.8% and 0.8% respectively (Figure 6.3). Land tenure status is defined by direct ownership, rented, farmers' association, Government-owned, streambanks and undeveloped land and distributed as 30.1%, 19.1%, 3%, 34.6%, 1.8% and 11.4% respectively.

Table 6.5: Farm Characteristics (Type of farming and Land Tenure Status)

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	No.	%	No.	%	No.	%	No	%	No	%	No	%
Type of farming	VEGETABLE/ARABLE	44	**62.0**	49	**79.0**	50	**79.4**	36	**73.5**	4	**50.0**	183	***72.3***
	LIVESTOCK[c]	9	**12.7**	8	**12.9**	10	**15.9**	11	**22.4**	4	**50.0**	42	***16.6***
	AQUACULTURE	1	**1.4**	0	**0.0**	0	**0.0**	1	**2.0**	0	**0.0**	2	***0.8***
	HORTICULTURE[b]	7	**9.9**	0	**0.0**	0	**0.0**	0	**0.0**	0	**0.0**	7	***2.8***
	AGROFORESTRY	10	**14.1**	5	***8.1***	3	***4.8***	1	**2.0**	0	**0.0**	19	***7.5***
	TOTAL	71	**100.0**	62	***100.0***	63	***100.0***	49	**100.0**	8	**100.0**	253	***100.0***
Land tenure status	OWNED	0	***0.0***	1	***1.2***	38	***34.5***	36	***63.2***	3	***42.9***	100	***30.1***
	RENTED	16	***22.0***	1	***1.2***	23	***20.9***	20	***35.1***	3	***42.9***	63	***19.1***
	FARMERS' ASSOC.	9	***12.5***	0	**0.0**	0	**0.0**	1	***1.8***	0	**0.0**	10	***3.0***
	GOVERNMENT	16	***22.2***	50	***58.1***	49	***44.5***	0	**0.0**	0	**0.0**	115	***34.6***
	STREAMBANK	2	***2.8***	4	***4.7***	0	***0.0***	0	***0.0***	0	***0.0***	6	***1.8***
	UNDEVELOPED LAND	7	***9.7***	30	***34.9***	0	***0.0***	0	***0.0***	1	***0.1***	38	***11.4***
	TOTAL	72	***100.0***	86	***100.0***	110	***100.0***	57	***100.0***	7	***100.0***	332	***100.0***

[a]*Responses are analysed as a dichotomous group tabulated at the value of 1*

[b] *Ornamental Horticulture*, [c] Livestock include poultry and small ruminants.

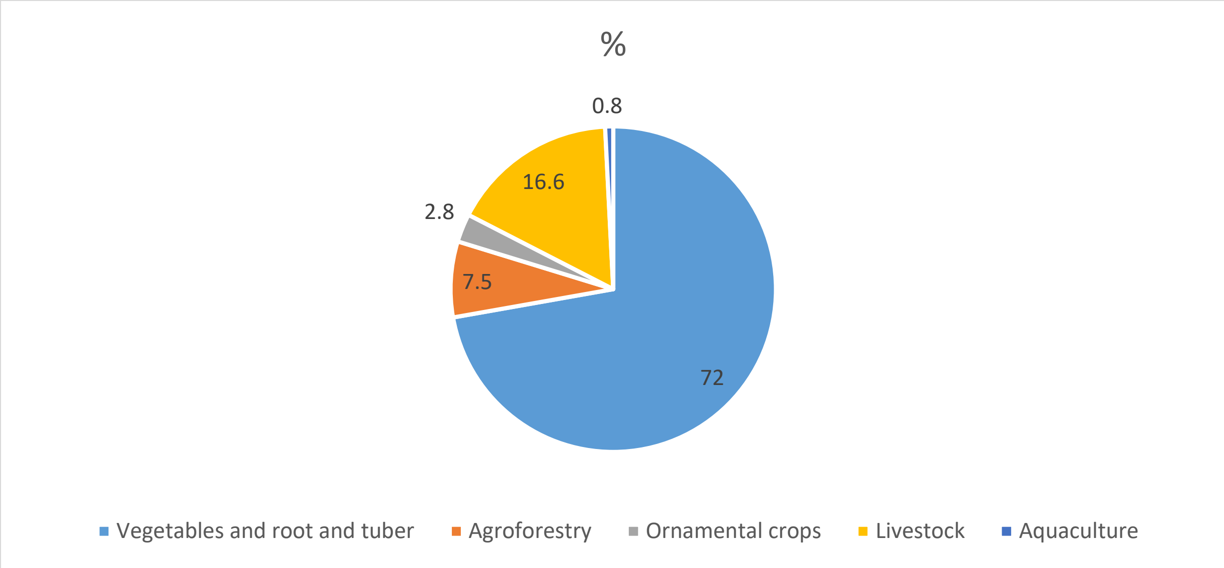


Figure 6.3: Proportion of farming types in UA amongst sample population

6.2.3 Pesticide use: Respondents' characteristics and behaviour

One of the research objectives is to explore factors that determine farmers' pesticide use/non-use and therefore, respondents were asked to indicate the nature and extent of pesticide use. This section presents survey results on these behaviours which include pesticide use/non-use, reason for use, time of pesticide application and how long they have been applying pesticides on their farms. Tables 6.6 and 6.7 presents an overview of pesticide use where 88% of respondents indicated pesticide use.

Table 6.6: Types of pesticides used by farmers

	Local Government areas											
	Akinyele		**Ibadan North**		**Ido**		**Ona-Ara**		**Oluyole**		**Total**	
[a]**Type of pesticide**	N=50	*%*	N=50	*%*	N=50	*%*	N=36	*%*	N=4	*%*	N=190	**%**
Insecticides	47	***25.4***	44	***31.0***	43	***34.9***	29	***20.1***	4	***16.6***	167	***27.0***
Herbicides	30	***16.2***	22	***15.5***	20	***16.3***	29	***20.1***	4	***16.6***	105	***17.0***
Fungicides	45	***24.3***	30	***21.1***	20	***16.3***	29	***20.1***	4	***16.6***	128	***20.7***
Nematicides	30	***16.2***	20	***14.1***	18	***14.6***	20	***13.9***	4	***16.6***	92	***14.9***
Acaricides	15	***8.1***	10	***7.0***	10	***8.1***	20	***13.9***	4	***16.6***	59	***9.5***
Rodenticides	15	***8.1***	10	***7.0***	5	***4.1***	10	***6.9***	4	***16.6***	44	***7.1***
Not applicable	3	***1.6***	6	***4.2***	7	***5.7***	7	***4.9***	0	***0.0***	23	***3.7***

[a] Multiple response provided by respondents.

Table 6.7: Pesticide use and behaviour

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	No.[a]	%	No.[a]	%	No.[a]	%	No.[a]	%	No.[a]	%	No.[a]	%
Do you use pesticides	Yes	47	***94.0***	44	***88.0***	43	***86.0***	29	***80.6***	4	***100.0***	167	***87.9.***
	No	3	***6.0***	6	***12.0***	7	***14.0***	7	***19.4***	0	***0.0***	23	***12.1***
[a]What purpose do you use it for	Pest control	36	***25.0%***	41	***27.9%***	45	***32.4%***	24	***30.8%***	3	***37.5%***	149	***29.4***
	Increase yield	28	***19.4%***	25	***17.0%***	25	***18.0%***	9	***11.5%***	1	***12.5%***	88	***17.0***
	Improved storage	27	***18.8%***	31	***21.1%***	22	***15.8%***	14	***17.9%***	1	***12.5%***	95	***18.4***
	Improve quality of produce	16	***11.1%***	18	***12.2%***	10	***7.2%***	7	***9.0%***	2	***25.0%***	53	***10.3***
	Precautionary use	34	***23.6%***	26	***17.7%***	30	***21.6%***	18	***23.1%***	1	***12.5%***	109	***36.8***
	Not applicable	3	***2.1%***	6	***4.1%***	7	***5.0%***	7	***7.7%***	0	***100.0%***	23	***4.4***
[a]When do you apply pesticide	Pre-planting	11	***10.9***	30	***24.8***	5	***6.3***	18	***29.0***	4	***50.0***	68	***18.3***
	Growing stage	47	***46.5***	44	***36.4***	43	***54.4***	29	***46.8***	4	***50.0***	167	***45.0***
	Just before harvesting	35	***34.6***	40	***33.0***	25	***31.6***	7	***11.3***	0	***0.0***	107	***28.8***
	Storage and transportation	4	***3.9***	2	***1.6***	0	***0.0***	0	***0.0***	0	***0.0***	6	***1.6***
	Not applicable	4	***3.9***	5	***4.1***	6	***7.6***	8	***12.9***	0	***0.0***	23	***6.2***
How long have you been using it	<2 Years	7	***14.0***	7	***14.0***	6	***12.0***	4	***11.1***	1	***25.0***	25	***13.1***
	>5 Years	14	***28.0***	12	***24.0***	15	***30.0***	7	***19.4***	2	***50.0***	50	***26.3***
	>10 Years	11	***22.0***	16	***32.0***	11	***22.0***	6	***16.7***	0	***0.0***	44	***23.1***
	>15 Years	14	***28.0***	10	***20.0***	12	***24.0***	11	***30.5***	1	***25.0***	48	***25.3***
	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***22.2***	0	***0.0***	23	***12.1***

[a]Responses are analysed as a dichotomous group tabulated at the value of 1

6.2.3.1 Type of pesticides, application timing and purpose of use

Figure 6.4a shows the percentages of each pesticide type being used by respondents. Insecticides is the most common choice of pesticide with respondents.

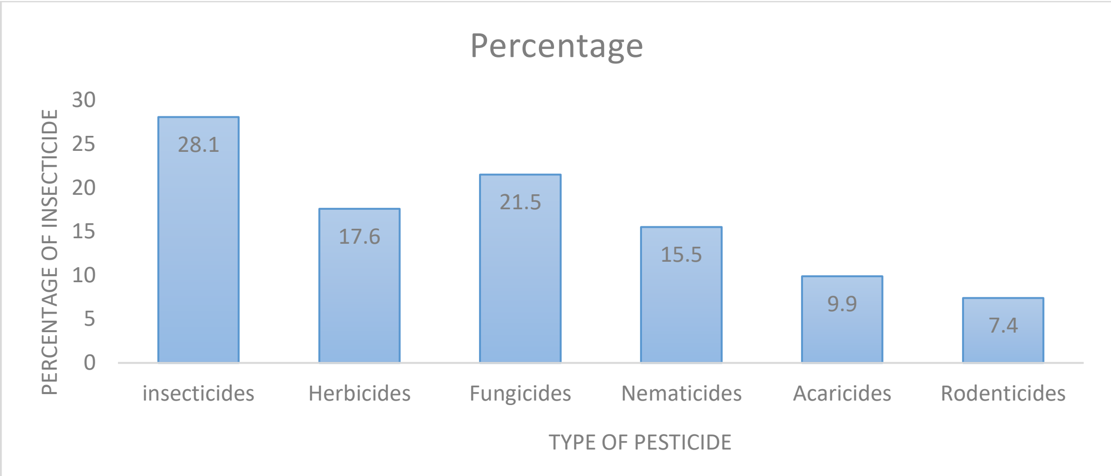


Figure 6.4a: Pesticides used by farmers

Figure 6.4b presents a graphical representation on what respondents indicated they use pesticides for, which is mainly for pest control. Some also indicated increased yield, improved storage, improved quality of produce and precautionary use as other reasons for use.

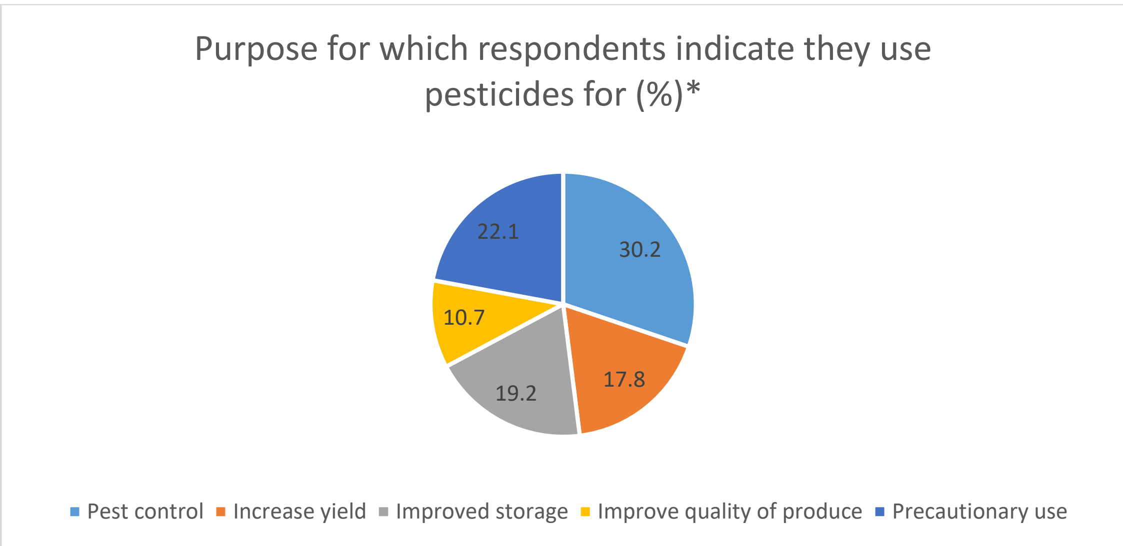


Figure 6.4b: Purposes for which pesticides are used

** Responses are analysed as a dichotomous variable (n=167)*

Figure 6.4c presents a pie-chart on time of pesticide application, which shows 50% of pesticide users apply pesticides mainly during the growing season and 30.7% right before harvesting.

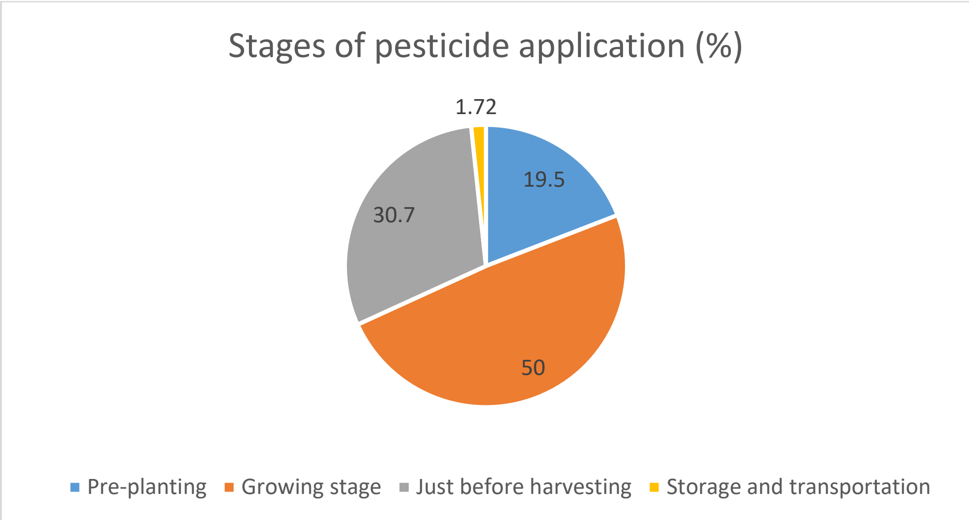


Figure 6.4c: Stages of pesticide application

Figure 6.4d presents data on how long respondents have been using pesticides on their farm indicating that 85% of pesticide users have been using pesticides at more than five years.

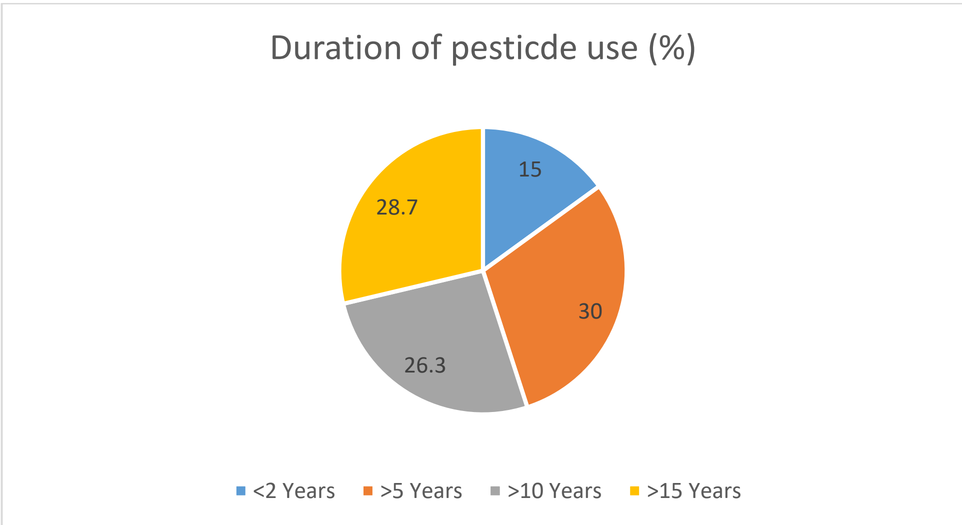


Figure 6.4d: **Duration of pesticide use**

6.2.3.2 Respondents' characteristics and use

In relation to pesticide use, the gender distribution of respondents, presented in Figures 6.5a and b suggests there are more male pesticide users (69.5%, n=167) as compared to non-pesticide users (78%. n=23). This conforms to the male-female distribution of the sample population.

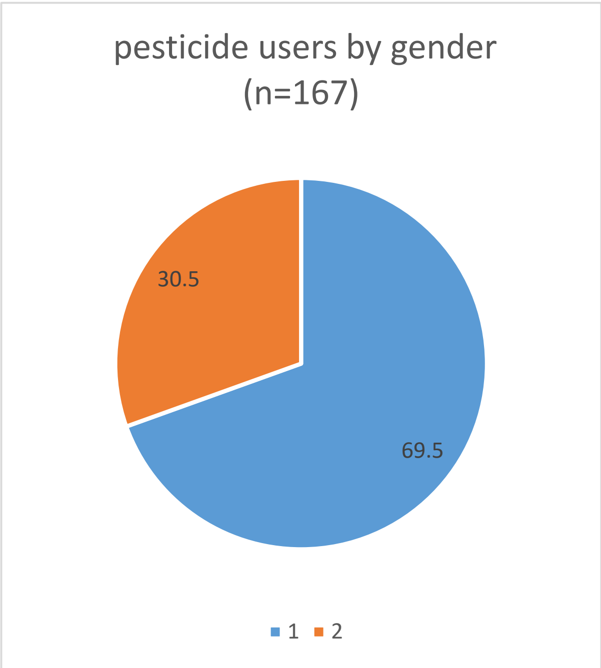


Figure 6.5a: Pesticide user by gender

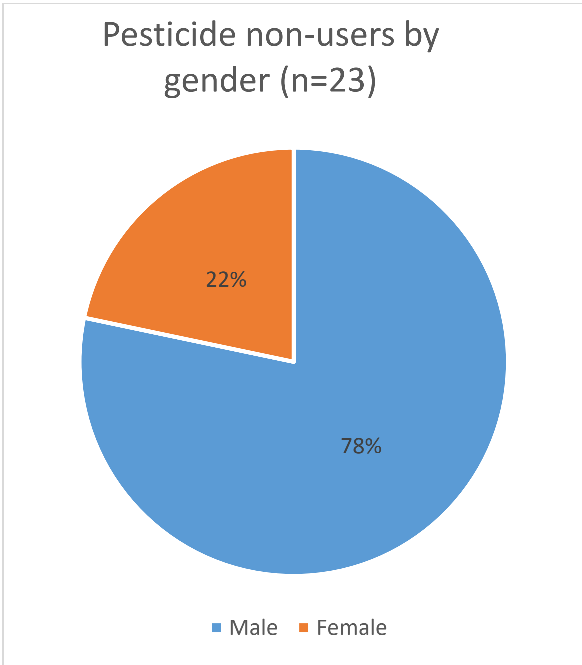


Figure 6.5b: Pesticide non-user by gender

Figure 6.5c shows the distribution of pesticide users by age where n=167 i.e., the total number of pesticide users. It shows highest pesticide user by age group are those between the age 41 and 50 years.

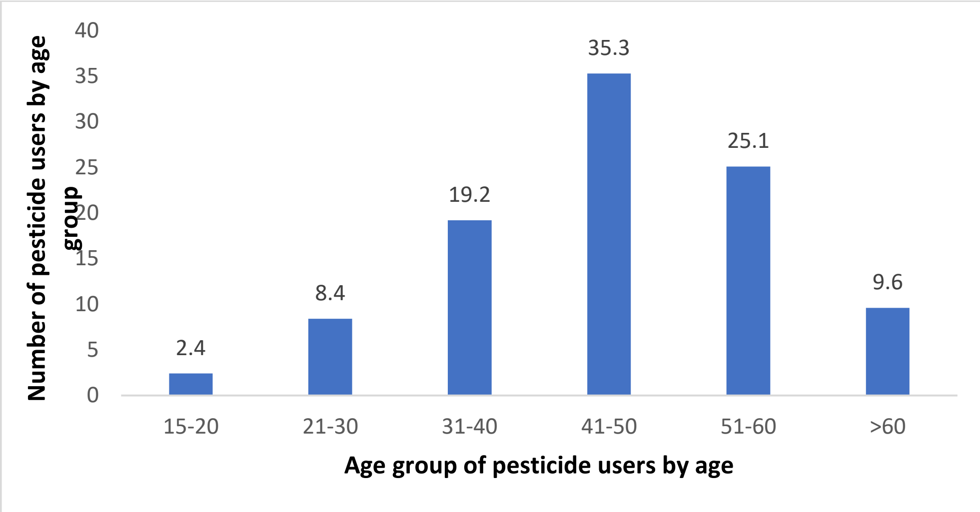


Figure 6.5c: Pesticide use by age

Figure 6.5d shows pesticide use/non-use (n=190) according to farming experience where farmers with more than 10 years of experience use pesticides more than other groups. However, the majority of farmers with less experience are pesticide non-users.

Figure 6.5d: Pesticide use by farming experience

Table 6.8 presents pesticide use grouped by highest education level and it can be seen that of the 167 respondents who report pesticide use, 86.7% (n=167) of them had completed college and university. It is evident that more farmers who were highly educated used pesticides as compared to those with low formal qualifications. However, statistically there was no significant correlation between educational status and pesticide use (table 6.9).

Table 6.8: Distribution of pesticide use grouped by highest educational qualification

		Pesticide use			
		Yes		No	
Characteristics	**Variables**	Frequency	**Percentage**	Frequency	**Percentage**
Education	**No formal Schooling**	14	**82.4**	3	**18**
	Primary School Uncompleted	14	**100**	0	**0**
	Primary School completed	35	**85.4**	6	**15**
	Secondary school completed	45	**90**	5	**10**
	College/University completed	52	**86.7**	8	**13**
	Post-graduate	7	**87.5**	1	**13**
	Total	**167**		23	

Figures 6.6a and b presents farmers' awareness of other pest control methods aside from chemical control methods. 57.6% of respondents declared an awareness of other pest control methods. A small proportion of respondents are aware of integrated pest control method.

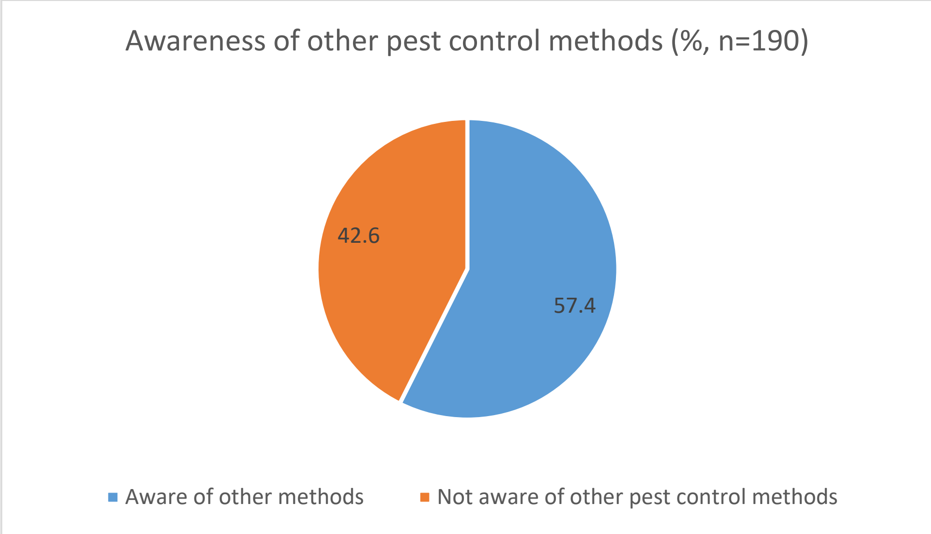


Figure 6.6a: Awareness of other pest control methods

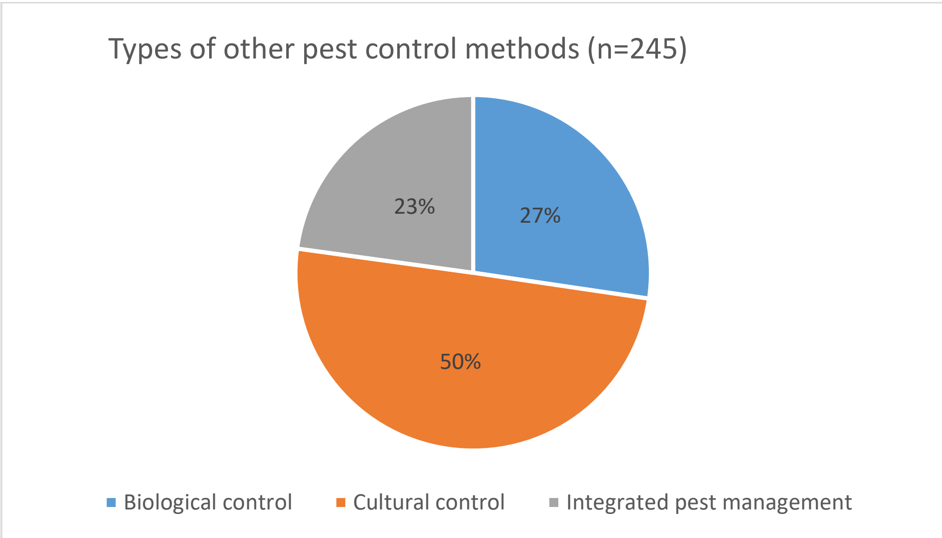


Figure 6.6b: Types of pest control methods aside from chemical control

6.2.3.3 Relationships between pesticide use and respondents' characteristics

Table 9 presents the correlation coefficients between pesticide use and respondents' characteristics at $p<0.01$. It can be seen that there is no statistically significant relationship between respondents' characteristics and pesticide use.

Table 6.9: Correlations between pesticide use and respondents' characteristics

		Pesticide use
Gender	Pearson Correlation	**.063**
	Sig. (2-tailed)	.388
	N	190
Age	Pearson Correlation	**-.032**
	Sig. (2-tailed)	.661
	N	190
Highest educational level	Pearson Correlation	**-.004**
	Sig. (2-tailed)	.956
	N	190
Main occupation	Pearson Correlation	**.103**
	Sig. (2-tailed)	.159
	N	190

6.2.4 Good agricultural practice and farmers' knowledge

Respondents' good agricultural practice regarding pesticide use was assessed by asking them questions on purchase of pesticides, record keeping, training or information received on pesticide handling and safety. Other questions concerned pest control advice, equipment used in applying pesticides, personal protective equipment, disposal of pesticide residue and packaging, storage of pesticide products.

Table 6.10 presents responses on how pesticides are applied, use of personal protective equipment, disposal of pesticide residues and packaging, and storage of products. 70.6% of pesticide users indicated they use backpack sprayer machines while 12.6% and 16.8% of the remaining pesticide users indicated watering cans and buckets respectively (see Figure 14). The results also show that 87% of respondents had no access to or an idea of what a personal protective equipment is. However, 54.5% of total respondents indicated that they cover their body and face with cloth while 39% and 5.9% cover face with cloth and no protection respectively. This level of protection suggests an awareness of the impact of pesticides to them during application.

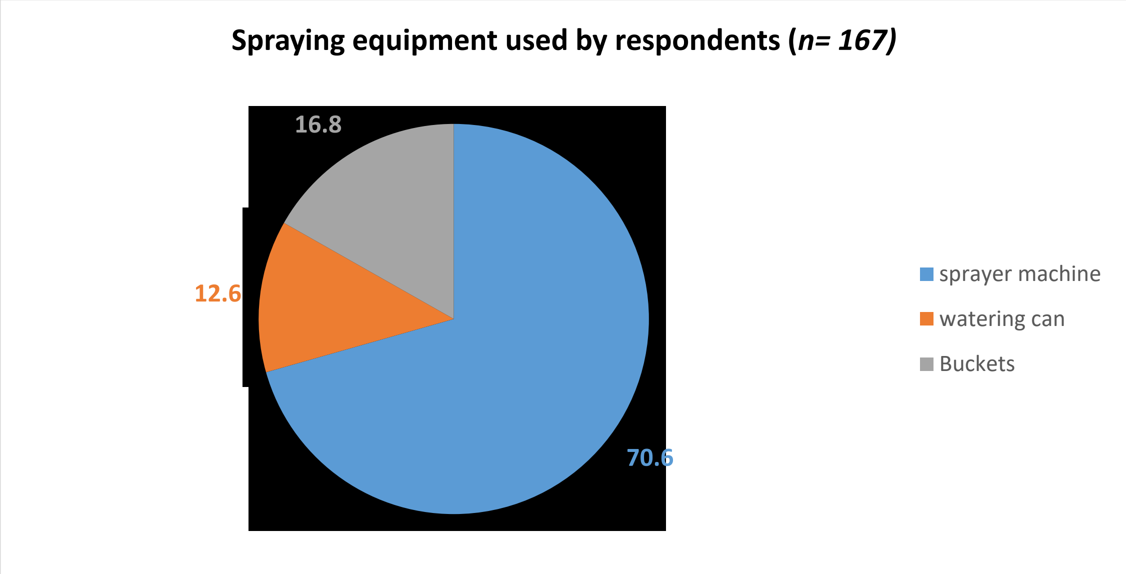


Figure 6.7a: Types of equipment used by respondents to apply pesticide

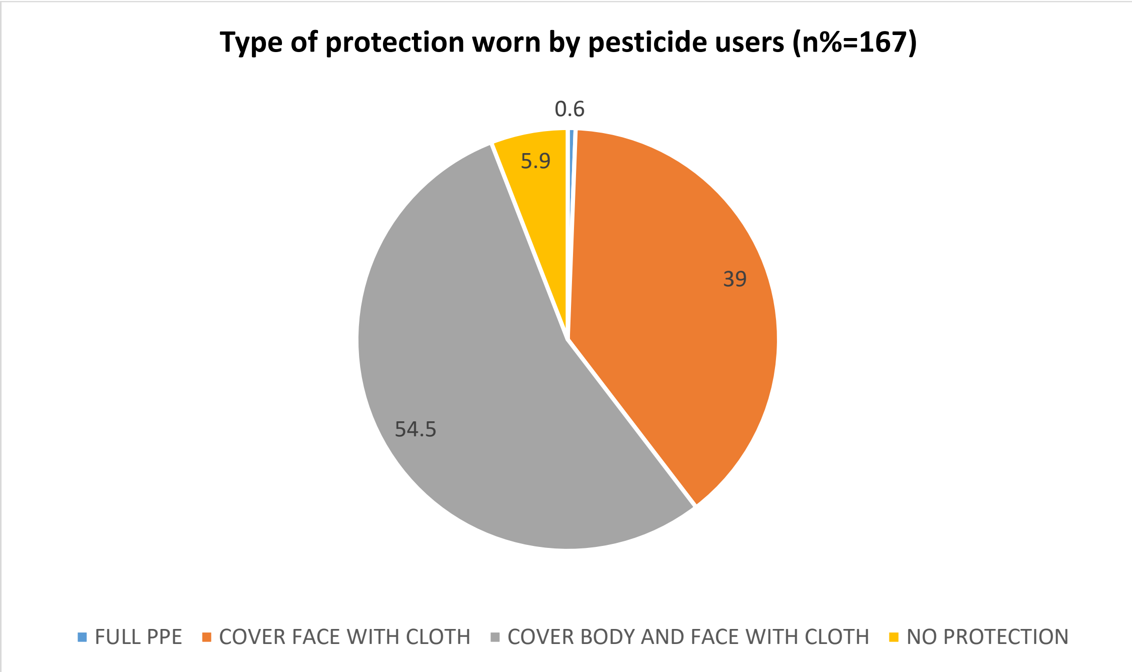


Figure 6.7b: Protective clothing worn by pesticide users

Table 6.10: Respondents' good agricultural pesticide practice

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	RESPONSES	**%**	RESPONSES	**%**	RESPONSES	**%**	RESPONSES	**%**	RESPONSES	**%**	RESPONSES	**%**
	Sprayer machine	34	***68.0***	30	***60.0***	30	***60.0***	20	***55.6***	4	***100.0***	118	***62.1***
	Watering can	7	***14.0***	6	***12.0***	4	***8.0***	4	***11.1***	0	***0.0***	21	***11.1***
	Bucket and bowl	5	***10.0***	9	***18.0***	10	***20.0***	4	***11.1***	0	***0.0***	28	***14.7***
How do you apply pesticides	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***22.2***	0	***0.0***	23	***12.1***
	Yes	0	***0.0***	1	***2.0***	0	***0.0***	0	***0.0***	0	***0.0***	1	***0.5***
	No	46	***92.0***	44	***88.0***	44	***88.0***	28	***77.8***	4	***100.0***	166	***87.4***
Do you use full personal protective equipment?	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***22.2***	0	***0.0***	23	***12.1***
	On site	35	***49.9***	23	***37.1***	19	***26.0***	21	***51.2***	2	***11.3***	65	***35.3***
	Dump	12	***16.4***	16	***25.8***	25	***34.2***	7	***17.1***	4	***75.0***	52	***28.3***
	Burning	22	***30.1***	18	***29.0***	23	***31.5***	5	***12.2***	2	***11.3***	48	***26.1***
[a]How do you discard residues and containers	Not applicable	4	***3.6***	5	***8.1***	6	***8.2***	8	***19.5***	0	***0.0***	19	***10.3***
	On site	13	***38.5***	15	***30.0***	10	***20.0***	11	***30.5***	4	***100.0***	53	***27.9***
	In storage boxes	18	***36.0***	12	***24.0***	9	***18.0***	3	***0.0***	0	***0.0***	42	***22.1***
	Shed	15	***30.0***	18	***36.0***	25	***50.0***	14	***0.0***	0	***0.0***	72	***37.9***
How do store your products?	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***0.0***	0	***0.0***	23	***12.1***

[a]Responses are analysed as a dichotomous group tabulated at the value of 1

Farmers' storage and disposal behaviour were also assessed. 31.7% of farmers store their products in unsecured places on site, 25.2% in storage boxes while 43.1% store theirs in a shed (Figure 6.7c). Respondents also discard residue and containers using a combination of on-site disposal, dump, and burning at 39.4%, 31.55 and 29.1% respectively (Figure 6.7d).

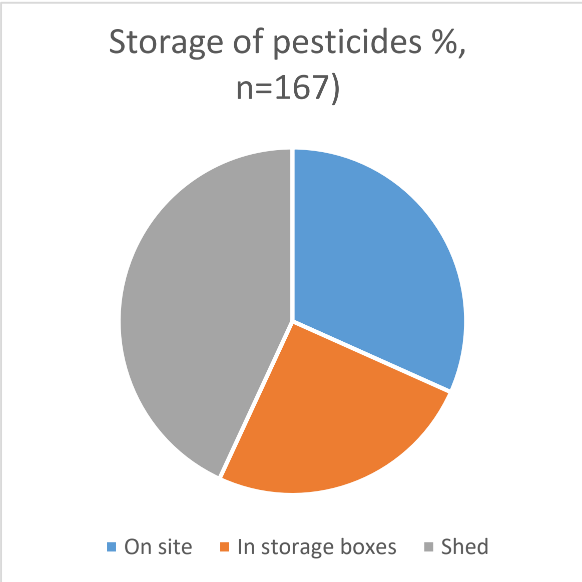


Figure 6.7c: Storage of pesticides

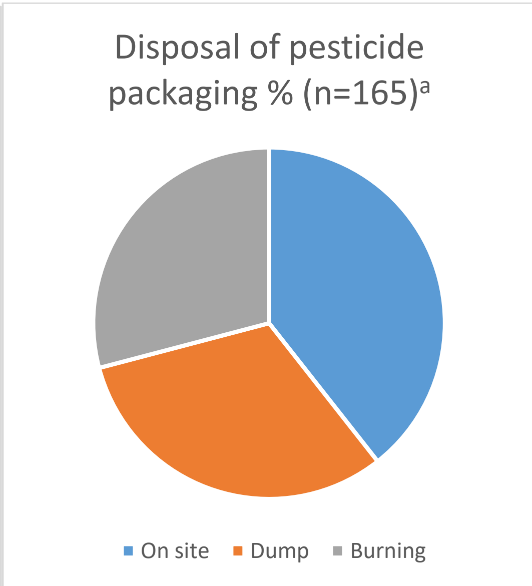


Figure 6.7d: Disposal of pesticides

With respect to accessing knowledge and advice, Table 6.11 shows where respondents purchase their products, what training, information, or pest control advice they might have received, whether they read label instructions and if their neighbours behave the same way they do.

Most respondents purchase their products from multiple sources which include agro-dealers (42.6%) and retailers (50.3%). Analysis shows that 58.9% of all respondents had never received training or information on pesticide handling and safety while the 41% had received training at one point or the other during occasional workshops or farmer field schools. Also, 50.5% of pesticide users indicate they do not read or follow label instructions while the remaining pesticide users do not. Pest control advice is not limited to one source for all respondents, but the majority (57.2%) rely on pesticide dealers to give them pest control advice. 76.8% of respondents also indicated that their friends and neighbours who practice UA also handle pesticides in the same manner that they do.

Table 6.11: FARMERS' KNOWLEDGE ON PESTICIDES' GOOD AGRICULTURAL PRACTICE

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	RESPONSES	%	RESPONSES	%	RESPONSES	%	RESPONSES	%	RESPONSES	%	RESPONSES	%
[a]Who provides you with pest control advice	Extension agents	2	3.4	3	3.5	5	8.1	2	3.9	0	0.0	12	4.5
	Pesticide dealer	42	72.4	47	55.3	30	48.4	28	54.9	4	50.0	151	57.2
	Neighbours	10	17.2	30	35.3	23	37.1	15	29.4	4	40.0	82.0	31.1
	Media	4	6.9	5	5.9	4	6.5	6	11.8	0	0.0	19.0	7.2
Have you received training or information on pesticide handling and safety	Yes	11	22.0	15	30.0	25	50.0	26	72.2	1	25.0	78	41.1
	No	39	78.0	35	70.0	25	50.0	10	27.8	3	75.0	112	58.9
Where did you receive training	Farmers' field school	4	36.4	5	41.7	15	46.9	10	35.7	1	100.0	35	41.7
	Workshops	6	54.5	7	58.3	10	31.3	18	64.3	0	0	41	48.8
	Extension workers	0	0.0	0	0.0	7	21.9	0	0.0	0	0	7	8.3
	Media	1	9.1	0	0.0	0	0.0	0	0.0	0	0	1	1.2
[a]Where do you purchase your products?	Agro-dealers	42	48.3	42	44.7	20	26.7	25	35.2	4	50.0	133	39.7
	Retailers	36	41.4	47	50.0	40	53.3	30	42.3	4	50.0	157	46.8
	Extension Outlets	2	2.3	0	0.0	5	6.7	4	5.6	0	0.0	11	3.3
	Street vendors	3	3.3	0	0.0	4	5.3	4	5.6	0	0.0	11	3.3
	Not applicable	4	4.6	5	5.3	6	8.0	8	11.3	0	0.0	23	6.9
Do you read label instructions	Yes	20	40.0	15	30.0	18	36.0	14	38.8	4	100.0	71	37.4
	No	26	52.0	30	60.0	26	52.0	14	38.8	0	0.0	96	50.5
	Not applicable	4	8.0	5	10.0	6	12.0	8	22.3	0	0.0	23	12.1
Do your friends and neighbour behave the same way about pesticides	Yes	40	80.0	42	84.0	38	76.0	22	61.1	4	100.0	146	76.8
	No	10	20.0	8	16.0	12	24.0	14	38.9	0	0.0	44	23.2

[a]Responses are analysed as a dichotomous group tabulated at the value of 1

6.2.5 Perceptions of respondents on pesticide use

Respondents were asked to give their opinions on benefits and deleterious effects of pesticide which were classified into: pest control, increased profit, improved storage, promotes good farm management and no opinion for benefits of pesticides. For deleterious effects, responses were grouped into: natural enemies' mortality, water pollution, air pollution, harmful to labour, harmful to people and animals, pesticide poisoning, reduced profit, and resistance to chemical control.

Table 6.12 presents multiple responses of respondents on their perception of pesticide. 33.2% of all responses show the primary benefit of pesticides that farmers' value is as pest control. 32.3% of responses indicated that respondents believe it also helps in increasing profits while 33% stated it promotes good farm management.

Table 12: Perceptions on pesticide

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	RESPONSES[a]	%	RESPONSES[a]	%	RESPONSES[a]	%	RESPONSES[a]	%	RESPONSES[a]	%	RESPONSE[a]	%
Opinion on benefits of pesticides	Pest control	49	32.5	50	33.6	50	33.6	36	33.3	4	33.3	189	33.2
	Increased profit	46	30.5	49	32.9	49	32.9	36	33.3	4	33.3	184	32.3
	Improved storage	7	4.6	0	0.0	0	0.0	0	0.0	0	0.0	7	1.2
	Promotes good farm management	48	31.8	50	33.6	50	33.6	36	33.3	4	33.3	188	33.0
	No opinion	1	0.7	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
Opinion on deleterious effects of pesticides	Natural enemies mortality	33	9.7	42	11.3	34	9.4	25	9.4	4	12.5	138	10.1
	Water pollution	34	10.0	37	9.9	42	11.7	25	9.4	4	12.5	142	10.3
	Air pollution	40	11.7	50	13.4	50	13.9	36	13.5	4	12.5	180	13.1
	Harmful to farm labour	50	14.7	50	13.4	50	13.9	36	13.5	4	12.5	190	13.8
	Harmful to people and animal	50	14.7	50	13.4	44	12.2	36	13.5	4	12.5	184	13.4
	Pesticide poisoning	41	12.0	50	13.4	44	12.2	36	13.5	4	12.5	175	12.8
	Reduce profit	49	14.4	50	13.4	50	13.9	36	13.5	4	12.5	189	13.8
	Resistance to control	44	12.9	44	11.8	46	12.8	36	13.5	4	12.5	174	12.7
Why use pesticides if harmful	Affordable	48	17.8	41	16.0	36	14.3	25	14.7	4	16.7	154	15.8
	Reduce crop loss to pests	47	17.4	43	16.7	44	17.5	28	16.5	4	16.7	166	17.0
	Protect investment	43	15.9	37	14.4	44	17.5	28	16.5	4	16.7	156	16.0
	Effective	40	14.8	45	17.5	41	16.3	28	16.5	4	16.7	158	16.3
	Convenient	43	15.9	44	17.1	39	15.5	28	16.5	4	16.7	158	16.3
	Crop protection	45	16.7	42	16.3	41	16.3	25	14.7	4	16.7	157	16.2
	Not applicable	4	1.5	5	1.9	6	2.4	8	4.7	0	0.0	23	2.4

[a]*Responses are analysed as a dichotomous group tabulated at the value of 1*

Figure 6.8a presents the variables on the respondents' perceived deleterious effects of pesticides. All respondents showed an awareness of the deleterious effects of pesticide use with 10.1% of responses in agreement that pesticides are harmful to natural enemies of pests, 23.4% thought they cause water and air pollution, 27.2% stated pesticides are harmful to farm labour, people and animal, 12.85% stated risk of pesticide poisoning and 12.7% agreed that overtime, pests may grow resistance.

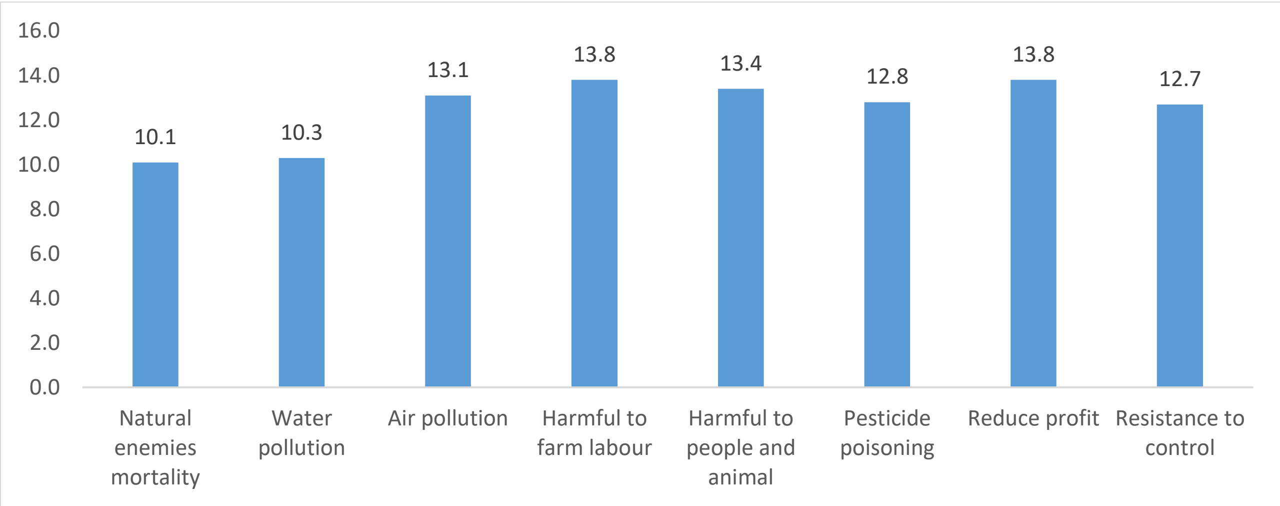


Figure 6.8a: Opinion on deleterious effect of pesticides

Figure 6.8b presents perceived benefits of pesticide use by respondents where 32.3% of farmers' responses on benefits of pesticides was the perceived notion that it helps to increase profit. This may be argued because aesthetically-maintained produce such as vegetables command better price as compared to damaged produce from pest infestation. Other responses include pest control (the main function of pesticides), good farm management and improved storage.

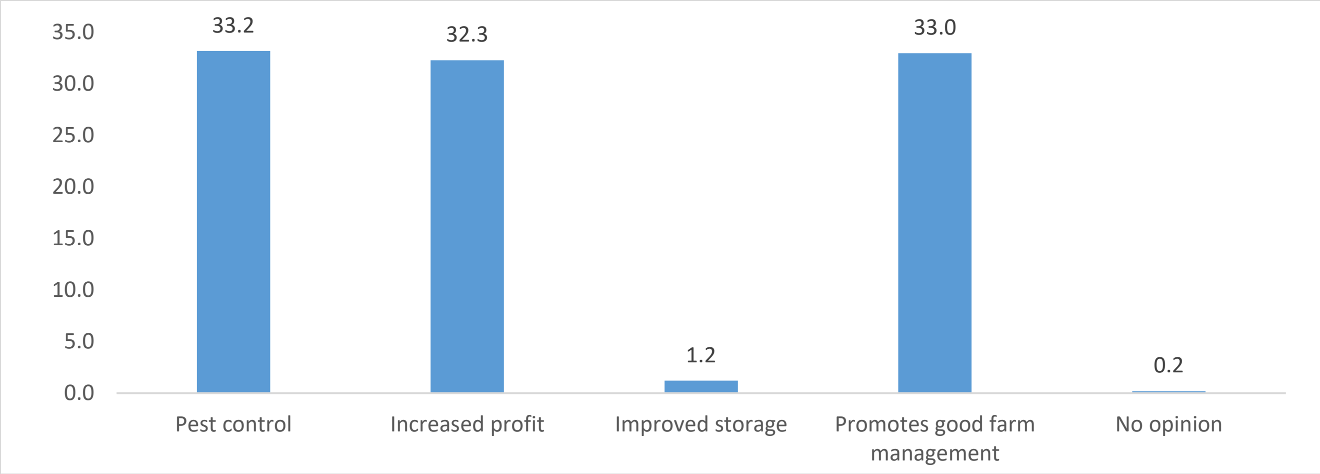


Figure 6.8b: Benefits of Pesticides

Farmers' indicated continued pesticide use whilst being aware of its harm because of the benefits they enjoy (Fig. 6.8c). These responses suggest respondents are motivated to use pesticide to secure profit and prevent debt.

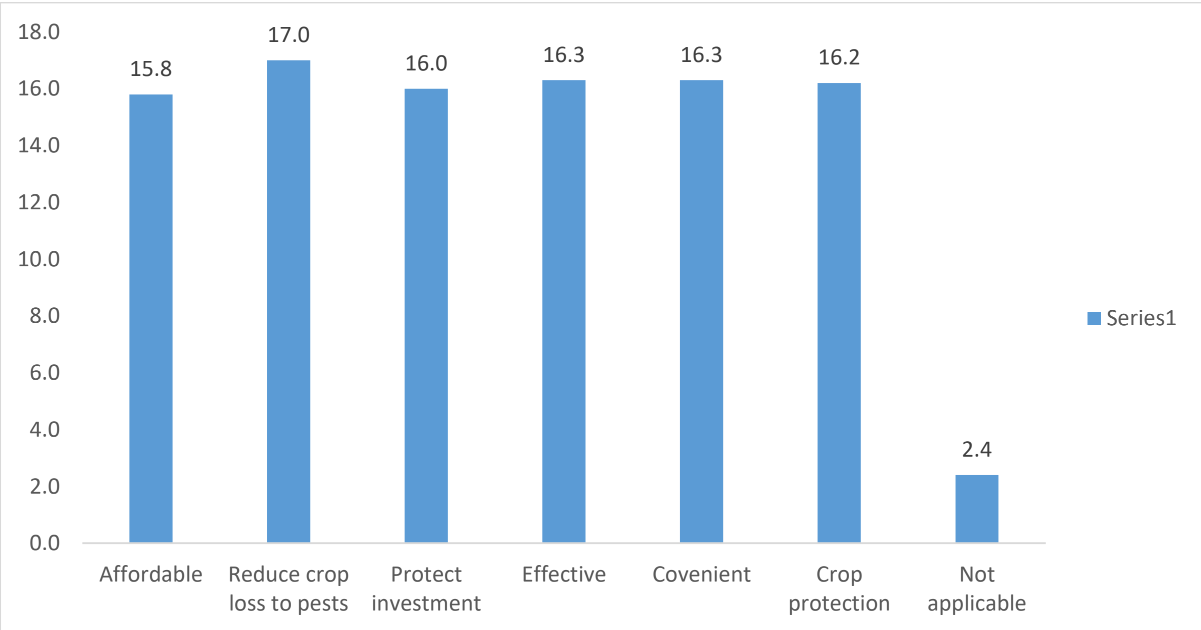


Figure 6.8c: Reasons respondents continue to use pesticide despite being aware of its harm

6.2.6 Economic consideration on pesticide use

Tables 6.13a and b presents variables on economic considerations on pesticide use. Since respondents were involved in different types of urban farming, they were asked to indicate the proportion of income generated from the types of farming they are engaged in. More than 50% of respondents' population earn a substantial fraction (more than 50%) of their income from vegetable farming. This indicates vegetable production is significant with respect to farmers' livelihoods and is likely to influence farmers' decisions about pesticide use especially since vegetable production is prone to insect infestation if not adequately managed. Furthermore, majority of the farmers indicated a decline in yield without using pesticide which translates to a loss in potential earning. Also, 88% of farmers claim the risk of crop failure is very high if they do not use pesticides. To prevent this loss and the risk of crop failure, 84% of study farmers commit between 10-20% of their production costs towards purchasing pesticides This is significant as it could explain their precautionary use (table 6.6) and will be discussed in later sections.

Table 6.13a: Economic consideration on pesticide use

		Local Government areas											
		Akinyele		**Ibadan North**		**Ido**		**Ona-Ara**		**Oluyole**		**Total**	
Characteristics	**Variables**	Responsew[a]	***%***	Response[a]	***%***	Response[a]	***%***	Response[a]	***%***	Response[a]	***%***	Response[a]	***%***
Percentage of annual income from vegetable	<20%	13	***26.0***	16	***32.0***	3	***6.0***	2	***5.6***	0	***0.0***	34	***17.9***
	20-50%	12	***24.0***	6	***12.0***	7	***14.0***	12	***33.3***	1	***25.0***	38	***20.0***
	<50%	25	***50.0***	28	***56.0***	40	***80.0***	22	***61.1***	3	***75.0***	118	***62.1***
Percentage of annual income from Livestock	<20%	2	***28.6***	7	***87.5***	10	***100.0***	5	***45.5***	1	***25.0***	25	***62.5***
	20-50%	5	***71.4***	1	***12.5***	0	***0.0***	6	***54.5***	3	***75.0***	15	***37.5***
	<50%	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***
Percentage of annual income from Aquaculture	<20%	0	***0.0***	0	***0.0***	0	***0.0***	1	***0.0***	0	***0.0***	1	***50.0***
	20-50%	1	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	1	***50.0***
	<50%	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***
Percentage of annual income from Horticulture	<20%	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***
	20-50%	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	0	***0.0***	o	***0.0***
	<50%	7	***100.0***	7	***100.0***	0	***0.0***	0	***0.0***	0	***0.0***	14	***100.0***
Percentage of annual income from Agro-forestry	<20%	0	***0.0***	0	***0.0***	0	***0.0***	1	***100.0***	0	***0.0***	1	***5.3***
	20-50%	6	***60.0***	5	***100.0***	3	***100.0***	0	***0.0***	0	***0.0***	14	***73.7***
	<50%	4	***40.0***	0	***0.0***	0	*0.0*	0	***0.0***	0	***0.0***	4	***21.0***

Table 6.13b: Economic consideration on pesticide use

		Local Government areas											
		Akinyele		Ibadan North		Ido		Ona-Ara		Oluyole		Total	
Characteristics	**Variables**	RESPONSES[a]	*%*	RESPONSES[a]	*%*	RESPONSES[a]	*%*	RESPONSES[a]	*%*	RESPONSES[a]	*%*	RESPONSE[a]	*%*
Decline in yield without pesticide	0-10%	15	***31.9***	32	***62.7***	10	***19.6***	10	**27.8**	3	***75.0***	70	***37.0***
	10-20%	13	***27.7***	13	***25.5***	28	***54.9***	16	***44.4***	1	***25.0***	71	***37.6***
	20-30%	15	***31.9***	1	***2.0***	7	***13.7***	2	***5.6***	0	***0.0***	25	***13.2***
	Not applicable	4	***8.5***	5	***9.8***	6	***11.8***	8	***22.2***	0	***0.0***	23	***12.2***
Percentage of production cost spent on pesticide	5%	0	***0.0***	7	***14.0***	0	***0.0***	3	***8.3***	0	***0.0***	10	***4.9***
	10%	35	***70.0***	18	***36.0***	21	***42.0***	4	***11.1***	4	***100.0***	82	***40.6***
	15%	0	***0.0***	19	***38.0***	21	***42.0***	21	***58.3***	0	***0.0***	61	***30.2***
	20%	4	***22.0***	1	***2.0***	21	***4.0***	0	***0.0***	0	***0.0***	26	***12.9***
	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***22.2***	0	***0.0***	23	***11.4***
Risk of crop failure without pesticide	Low	0	0	0	0	0	0	0	0	0	0	0	0
	Medium	0	0	0	0	0	0	0	0	0	0	0	0
	High	46	***92.0***	45	***90.0***	44	***88.0***	28	***77.8***	4	***100.0***	169	***88.0***
	Not applicable	4	***8.0***	5	***10.0***	6	***12.0***	8	***22.2***	0	***0.0***	23	***12.0***
Economic benefits of pesticide you enjoy	Improved yield	46	***32.4***	45	***31.7***	44	***29.3***	28	***25.9***	4	***33.3***	169	***26.7***
	Increased saleability	46	***32.4***	46	***32.4***	50	***33.3***	36	***33.3***	4	***33.3***	182	***28.8***
	Increased income	46	***32.4***	46	***32.4***	50	***33.3***	36	***33.3***	4	***33.3***	182	***28.8***
	Not applicable	4	***2.8***	5	***3.5***	6	***4.0***	88	***7.4***	0	***0.0***	100	***15.7***

[a]*Responses are analysed as a dichotomous group tabulated at the value of 1*

6.3 Qualitative results

This section's focus is to present the results from the qualitative analysis of data collected about farmers' pesticide use/non-use. The data collection methods include focus group discussions, interviews with farmers and key informant discussions. These were carried out to explore in detail, patterns identified from the survey data analysis, and examine what drives pesticide use in relation to farmers' knowledge, awareness of impacts of pesticide use and motivations.

One of the aims of this study was to integrate qualitative and quantitative data, therefore, this section shall present findings from focus group discussions, interviews and key informant interviews in a thematic format supported with statistics from the questionnaire survey. Themes identified from the analysis of all qualitative methods are therefore presented. All responses are presented under pseudonyms to preserve their privacy as explained in chapter four.

6.3.1 Incidence and nature of pesticide use

Themes that emerged from FGDs and interviews on pesticide use include extent and type of pesticide usage, frequency of use and time of application. Results from survey showed 87.9% of respondents use pesticides in their farm practice. This level of usage is reflected in responses in focus group discussions, interviews, and key informant interviews.

During focus group discussion, majority of the participants stated pesticide use for them is a norm and has adopted it as standard farm practice. They confirmed they have been using pesticides, especially with their vegetable crops which are in high demand. This is briefly put together by Farmer S. during an interview:

> *'Right from land preparation, seed preparation, planting, weeding and harvesting, use of pesticide is very crucial because these insects are very stubborn and need to be dealt with at every stage that they might arise'*- Farmer S.

Also, another participant voiced his opinion during interview:

'I always use pesticides when I start planting preparation; that is a constant practice. I then use it when we experience outbreak of pests or when there is news of outbreak experienced by other farmers' - Farmer As, Army Barracks.

The above statements resonate with the survey finding that 36.8% of respondents indicated they use pesticides as a form of precautionary control of pests. They do not have to see pests before they use pesticides, but pesticide use is an anticipatory behaviour.

Farmers during FGD says it is better to use the chemicals than be sorry when your crops are under attack. This behaviour is also capitalised on by pesticide dealers who market products to consumers by informing them to use these products as a precaution on the promise it will save them time and money and reduce the possible risk should there be an outbreak. The FGD participants pointed out that the timing and frequency of pesticide application is determined by how severe an infestation is or anticipated to be. They use pesticides throughout the growing period and increase the dose according to the severity. Participants are not so particular about the type of pest and can only describe it when they go to the market to purchase pesticides from the retailers. During an interview session with Farmer S., he admitted to using pesticides at a higher frequency to increase its' efficacy. These responses show that farmers in the study area do not have a timing and frequency pattern in their pesticide application practice and are therefore likely to overuse products and apply at higher dosage than prescribed, causing over-dosage and leading to possible insect resistance.

Farmers, during focus group discussions, identify pesticide dealers as the source of information on possible pest outbreak when they go to purchase products and are encouraged into panic purchase of new products or combination of products as prophylactic treatment. It is however interesting to note from discussions during FGD that the knowledge and information being passed by these dealers and retailers to farmers are from wholesale marketers who tell these dealers what their product can do and its superiority to other products in an attempt to increase their market share. These marketers often incentivise dealers with increased commission based on their sale volume to encourage them to refer their products to farmers. A pesticide dealer during key informant interview justified this action by saying:

> *Our customers who buy pesticides and use on a regular basis, experience less yield loss during periods of outbreak as compared to those that buy when it occurs. Therefore, overtime, our customers have come to understand it is better to be prepared than be caught unawares and risk huge loss.* Mr OG.

However, for Baba FA., he believes the anticipatory approach to pesticide use is wrong, as he argues that it increases pest resistance development. He does not use chemical pesticides (part of a group that consists of 12.1% of sample population) and says one of the reasons is because of the risk of becoming dependent on them.

> *'I believe others just see use of pesticide as a norm; because there has always been pests in times past when there was no chemical formulation to combat them. These chemicals become 'addictive' when you use them and you end believing that without pesticides, your yield loss to pests will be high'.* Baba FA.

6.3.2 Awareness of pest control methods

57.4% of respondents indicated an awareness of other pest control methods aside from chemical control in the survey. The methods mentioned during the survey are biological control, cultural control and integrated pest management.

However, during focus group discussions and interviews, it was evident that the majority of participants claimed an awareness of these other methods but lacked the knowledge to support such claims. This is illustrated by a question asked by a farmer during one interview:

'Is integrated pest control not the one where you don't use any chemical?' Mr SO.

This response was echoed among FGD participants which indicated poor understanding of what IPM entails. Some participants in interviews and FGDs also indicated that IPM is sole substitution of synthetic pesticides with biopesticides such as Neem extract (Azadiracta indica).

On biological control, respondents in FGD said they are aware of neem extract but believe the process of producing it is arduous and time-consuming. they did not fully adopt this innovation because not only was it very time consuming to extract the active ingredients from seeds and leaves of the neem plant, the efficacy of the extract to control pest in the dry season was very limited. The extra time burden required for the extraction of the biopesticide by time-constrained farmers together with the farmers „perception of the ineffectiveness of the bio-pesticide especially in the dry season led to the initial low adoption rate and its abandonment by the few who adopted shortly afterwards.

When probed on why they cannot purchase it, most respondents say it is not available on a wide scale and very expensive compared to insecticides. This is supported by information from a major online marketing site in Nigeria, 50ml of neem oil extract cost (#1800=£4) as compared to 1 litre of DD force^{tm} which is being sold for #4500 (£10). Pesticide dealers during interviews say they do not stock these alternatives to chemical control because they are not in demand.

It was also clear during interviews and discussions that participants who favoured chemical control do so because of its affordability, effectiveness in controlling pests, quick intervention, and its ability to secure potential yield. These reasons resonate with the result of the survey on why respondents continue to use pesticides even when they consider there are deleterious effects (see table 9 in chapter 5). It could be concluded that participants have an awareness of other pest control methods, but clearly lacked an understanding of how they work. They are also limited in their access to alternative products and choice because of their perceptions on the efficacy of chemical control compared to other methods.

6.3.3 Knowledge of pesticide impacts on crops, animals, personal and environmental health

The survey analysis in table 9 (chapter 5) showed the respondents' opinion on the benefits and deleterious effects of pesticide use. All respondents (both interviews and FGDs) indicated some degree of knowledge about deleterious effects of pesticides on environment, income, and biota. The majority of participants during FGD agreed that pesticides are harmful in one way or another, but they will still continue their use as it provides them with secured yield. FGD participants said that the effect on the environment is secondary to crop protection because in the words of one of them, *'the earth takes care of itself'*. An interview participant (Jagaban) said it is important to use pesticides on the crops the use of pesticide is a "relatively easy" way of farming as compared to IPM. With many of the farmers at the district having other jobs apart from growing vegetables, spraying with pesticide to control pest saves them time for their other jobs. Most participants said they have never worried about pesticide residue on the products they sell because they believe that cooking will remove any residue left on the product.

The majority of FGD participants who were pesticide users said they had not experienced significant effects of pesticides on their health. On prioritising crop protection over personal safety, participants say they are careful in using pesticides and take precautions such as covering their nose with handkerchief. One participant said he takes milk when he has finished applying the pesticide and that way, he experiences no symptoms.

However, one of the participants who is a pesticide non- user commented that:

> *When I used pesticide in the past both in the house and on the farm, I had headaches and my eyes became swollen. I stopped using it because I cannot risk my health and that of my family because of this and also several mysterious deaths of families after eating food has been tied to pesticide poisoning - Mr S.M, household consumption only.*

An interview with a respondent who farms near a water stream was asked if she is aware of impacts of these chemicals in the soil and water around her. She said:

> *'Look around, this is the water we have been using to wash our bodies and clothes in this area, especially during water scarcity, no one has complained of any sickness that may be attributed to these chemicals'. Mama AL.*

Respondents believe there is little they can do about what happens when pesticides remain in the soil or water because they have no control over them. The only thing they can propose is to use pesticide in moderation and store their products carelessly. They also said that the use of knapsack sprayer has reduced accidental spillage of mixture as compared to when they relied mainly on buckets.

On the risk of pesticide poisoning, all participants agree it is very high because of the potency of the compounds. Some participants recalled the issue of beans poisoning that affected a lot of people and was attributed to pesticide poisoning. They stated that they buy pesticides on a needs basis and do not keep much in storage.

Respondents' perception of pesticide toxicity may influence the quantity of pesticide used by them. This perception may also be influenced by several factors which include, age, gender education, training, potential health implications which will be explored in the discussion chapter. During a particular interview, the interviewee was asked about how poisonous different pesticides which she uses are and how she can identify this. Her response was that they are poison which suggests that she does not know how to interpret symbols on the label. Further discussions and interviews indicate participants do not really distinguish between toxicity and effectiveness of pesticides.

Some participants described pest resistance to chemical control but rather attributed this resistance to quality of the product. These participants were of the opinion that the manufacturers may have reduced the potency of the product to increase profits. One of the participants who disagreed that resistance control is due to quality of product said:

> *'You know how anti-malaria was no longer working because people keep using it over and over again (abuse), I think it is the same that has happened with pesticides which is why we end up mixing different products to combat resistance'* – Mr STH

Participants confirm they do mix products to increase the potency of the products and ensure quick action, for example one said:

> *'I occasionally mix the brand especially during the dry season when insects and worms destroy over 60% of our vegetables. When I bought the usual brand, there was no change but when I mixed two/three different products together, I got some favourable results'* **Farmer V, Mokola Barracks**.

These 'cocktail' methods were practised by majority of FGD and interview participants. A key informant also confirmed that he sometimes advises his customers to mix products when they do not get desired results. It can be concluded that farmers are very aware of the possible dangers of pesticide use and the risk it poses to their health and the environment but wilfully ignore this knowledge in favour of their expected output.

Despite this knowledge claims, they do not appear to understand the relationship between their pesticide uses and its possible impacts on the environment. These impacts could affect their health and income indirectly through sickness from acute pesticide poisoning, leading to poor health that limits them from working, and a subsequent impact on their income.

6.3.4 Farmers' behaviour and decision-making on pesticide use

This theme arose from discussions in FDG centred on why respondents use pesticide despite being aware of the risk it poses to them and their environment. The theme is sub-divided into economic considerations, marketing decision and environmental decision

6.3.4.1 Economic considerations

As urban agriculture has become a viable source of income when substantial amount of money is invested in it, quantitative data shows 72.1% of farmers rely on their urban agriculture practice as a main source of income. According to Focus group discussions with farmers, the majority of the farmers say the primary consideration that drives their pesticide use is the prospect of servicing their debts. This is because most of them borrow money from cooperative societies which attracts interest, and they must do all they can to ensure profitability. Also, their livelihood depends on a good profit as loss to pests range from between 10 – 65% (survey data?) if pesticides are not deployed and therefore *'bad business if you do not apply pesticides as you will not break even'* (Baba JAK.).

In the words of a farmer:

> *'If it is only to eat, you may not need pesticides as you still get sufficient yield to eat. But when you grow for sale, you need to ensure your output is consistent which can only be by using pesticides'- Baba JAK*

6.3.4.2 Aesthetic considerations

All farmers agree that pests are a bane to production and therefore, it is economical to use pesticides to prevent or control them. Pest affect quality as well as quantity of crops. Most customers are city people and want appealing produce. Most of the farmers interviewed produce vegetables and ornamental crops. For them, it is more rewarding to have a better looking crop as it commands better price.

> *'Some of our customers patronise us because the products look healthy and they repackage the vegetables to sell in supermarkets'……* Baba JAK

6.3.4.3 Environmental considerations

Farmers agreed during interviews and focus group discussions that the environment must be taken into consideration but argue that there have not really been any immediate effects of pesticide use on their farm environment. They believe that the extra profit secured as a result of pesticide use outweighs the impact on the environment as long as they mitigate (not their choice of word- it is mine) it. However, when I asked how Farmer MOS mitigates the effect on the environment, he only shrugged suggesting that the environment knows how to take of itself.

6.3.4.4 Role of training and information on pesticide handling and safety

Farmers agreed that having access to regular training on pest management could inform their pesticide handling and safety measures. Majority of farmers have no access to training and handling manual and therefore rely on product labelling instruction and directions from pesticide marketers. Only few farmers in the study had attended a session on pesticide management and they could not recall the date. When asked if the training has had any influence on their practice, Farmer S (Mile 10) said his only takeaway was the protective equipment he received which he doesn't use because of the discomfort. They agreed that understanding the labelling formats and meaning of symbols such as precautionary statements about human health hazards. They also said regular information in leaflets or media broadcasts on safe handling, transporting, storing, and disposing of pesticides will be welcome.

6.3.4.5 Role of pesticide advisers on use

Pesticide dealers and marketers provide advice and information on effectiveness of products. Farmers said they are the only accessible and consistent source of information they can go to as company representatives regularly organise workshops to introduce products to them.

Farmer J, Agbaaje:

'When we go to the dealers and tell them the kinds of insects and worms we find on our crops, they give us different brands and tell us how to mix it. When I asked the farmer if he reads the instruction label, he has this interesting opinion:

Once they have told me how to mix it, I do not bother to read the label as I believe the chemical will not work as instructed because these things (products) are imported and therefore have to adjust it to our own farm'.

The main reason given for mixing was to counter the different resistant strains affecting farm produce. In all the farms, there was a majority (all farms) response compared to whether they changed the dosage of pesticides applied as against the instructions on the labels or from advisers. Most farmers maintained the same dosage while some increased because the early dose did not work for them.

6.4 Conclusion

This chapter has presented results of data generated from quantitative and qualitative research methods. Summary of findings indicate UA as a main source of income for most farmers motivates farmers' decisions to use pesticides to secure their livelihood as over 62% of respondents earn more than 50% of their income from UA. With high demand for high quality crops, especially the aesthetic consideration in vegetables, farmers use pesticides to ensure returns on their investment and therefore guarantee economic returns.

Also, despite an awareness of alternatives to synthetic pesticides high incidence of pesticide use and poor agricultural practices such as continuous use of pesticides as a precaution and taking advice from non-experts such as dealers and retailers, farmers' pesticide use, and behaviour raises significant concerns. This is because significant percentage of farmers in this study are educated with many belonging to farmers' organisation, their knowledge and awareness of pesticide impacts lacks depth. These findings will be discussed in chapter seven.

Chapter Seven

Discussion

7.1 Introduction

This chapter is a discussion of results from chapters six, an integration of both quantitative and qualitative social research findings with reference to relevant literature. It addresses the research objective aimed at assessing and understanding farmers' knowledge, behaviour, motivations and perception on pesticide use. The findings have been grouped into themes from results presented in chapter five such as livelihoods, knowledge and awareness of pesticide safe handling, economic considerations, pesticide use and behaviour.

Therefore, section 7.2 discusses the study area and its urban agriculture characteristics while 7.3 describes the farmer and farmer characteristics with respect to other urban agriculture studies. This characterises the respondents and provide the context of the analysis, which helps with any comparison with other studies. Sections 7.4 -7.6 discuss the findings in a thematic format with respect to the research objective. These findings are used in discussing the inter-relationships that exist between social and economic development from both historical and current pesticide use in urban agriculture and how it affects the environment.

7.2 Study area

This section is a brief discussion on urban agriculture in the study area and how it relates with UA in other parts of the country and the continent. This provides a locational context to the study's findings.

Ibadan is the country's largest city in terms of geographical definition; and the third most populous city (over 3 million) in Nigeria after Lagos and Kano (NPC, 2015, WPR, 2019). It is the major point of trade in the south-west region of Nigeria because of its proximity to Lagos state, the economic capital of Nigeria (Fourchard, 2003). The study was carried out in five local government areas out of the eleven local government areas that make up Ibadan urban area

(Wahab and Popoola, 2017) because of their proximity to Eleyele Lake in some of these LGAs such as Ona Ara feeds into the lake. These areas are built up environments with active urban farming activities. These include vegetable production, arable crop production, agro-forestry production, aquaculture, livestock production and other processing activities. In this study, there was 72.3% of vegetable production with the remaining proportion shared amongst livestock, aquaculture, horticulture, and agroforestry farming.

Vegetable production is a major part of urban agriculture in West African cities such as Lagos, Port-Harcourt and Kano (Ezedinma and Chukuezi, 1999, Binns *et al.,* 2003), Accra in Ghana (Amoah *et al.*, 2006), Bobo-Dioulasso in Burkina-Faso (Centres, 1996), Cotonou in Benin (Brock and Foeken, 2006), Yaounde in Cameroon and Dar-es Salaam in Tanzania (Dongus, 2001; Lee-Smith and Lamba, 2015). This is supported by evidence reported in this study area where 72.3% of urban agriculture practice involves vegetable production and agrees with the baseline report on urban agriculture in Oyo state, which reported that 1521 farms out of 3688 agricultural farms were devoted to vegetable production (RUAF, 2015).

One of the constraints in vegetable production in the tropics is pests and diseases (Ugwu *et al.*, 2015) and as a consequence they receive considerable high amount of pesticide, especially being a high value crop (Jeyanthi and Kombairaju, 2005). This high dependence on pesticides is supported by evidence found in this study where 87.9% of farmers surveyed use these chemicals. This is consistent with the report by WAAPP (2013) on pesticide use in Nigeria where 92.3% of farmers use pesticides. Pesticide misuse (RUAF, 2015) was highlighted in literature as one of the constraints to urban agriculture in Ibadan and evidence supporting this has been presented in this study. It can therefore be said that the value of crop is one of the factors that drives pesticide use in urban agriculture.

7.3 Farmer and farm characteristics

This section discusses findings about respondents' characteristics which include gender, age, educational status, and main occupation, and about their farm characteristics such as- farm size and tenure and type.

7.3.1. Gender

Literature suggests the role of female gender in urban agriculture is pertinent to survival strategies for most low-income urban households (Hovorka *et al.*, 2009) because of their socio-economic status and their traditional role of providing food for the family (Maxwell, 1993). It is within this context that urban agriculture is portrayed as a survival strategy for women to secure food (IDRC, 1993), and subsequently females are seen as the predominant gender in urban agriculture (Wilbers, 2004). More women were reported to participate in urban agriculture in Cameroon (Asongwe *et al*, 2014), especially vegetable production (Gockowski *et al*, 2003).

However, in this study, the gender of participants is favourably skewed (0.908) towards the male group, with 71% of overall sample population as compared to their female counterparts. This is consistent with studies on gender participation in urban agriculture in Nigeria where more male UA farmers were reported. Earlier studies conducted in selected areas within urban and rural areas of Oyo and Lagos states validate this research's findings of more male participation in agricultural production (Anosike, 2004, Adeyemo *et al*., 2017 (*85%*), Ogunniyi *et al*., 2017 (*78.3*%), Babarinsa *et al*., 2018 (74%), Ugwu *et al*., 2015). Also, according to the WAAPP-Nigeria report (2013) on pesticide use in Nigeria, 82.8% of participants in the nationwide study were male (*n=360*).

It was important to explore if gender influence pesticide use in urban agriculture within Ibadan city, South-west Nigeria as men and women approach decision making with different motives, perspectives, rationales and considerations. Gender analysis of pesticide use in this study showed 69.5% of pesticide users (n=167) were male. This statistic indicated that a large proportion of pesticide users were men which agrees with the results of the study conducted into pesticide use by Ugwu *et al.*, 2015, Ogunniyi *et al.,* 2017). Furthermore, among the 56 female participants in this study, 91.1% of them use pesticide.

Correlation analysis showed a weak relationship between gender and pesticide. However, Atreya (2007) in her study into gender differences in pesticide use knowledge and practices found that pesticide use can be influenced by gender. The absence of relationship or association between pesticide use and gender in this study may be attributed to high male participation recorded in this study, such that variation is too low to be statistically significant. Another possible reason may be that 99% of participants are solely responsible for decision making and therefore, both genders do not have to defer to anyone on pesticide use.

This high male participation seen in urban agriculture is an extension of patterns seen in overall agriculture practice in Oyo state (WAAPP-Nigeria, 2013). Similarly, this same pattern has been reported in neighbouring countries like Ghana (Danso *et al*., 2003; Obuobie *et al*, 2004) and Cameroon (Ngome & Foeken, 2012). High male gender representation in urban agriculture within the study area shows low participation of female in the production aspect of UA even though it was seen as a way of encouraging female empowerment through income generation (Hovorka *et al*., 2009).

7.3.2 Age

One would expect age to have an influence over pesticide use as most of the participants above 50 years of age had more farming experience than those below 30 years. However, age showed no statistical significance to pesticide use even though majority of pesticide users belonged to the 41-50 age group (33.7%). This is similar to studies into fertilizer and pesticide use in Cameroon where there was no relationship between pesticide use and age of farmers (Nkamleu and Adesina, 2000); and studies by Salameh *et al.* (2004) and Sharafi *et al.* (2018) also reported no relationship between pesticide use and age of farmers. However, Atreya (2007) reported a relationship between age and pesticide use with older females (<40) using pesticides but males are not influenced by age in pesticide use.

Whilst the majority of farmers, especially vegetable farmers, reported by Ugwu *et al*., 2015) were within the 31-40 years' age group (84.6%), age characteristics of farmers in this present study recorded a high number of participants belonging to the 41-50 age group. This difference in statistics may be attributed to locational factors where Ugwu *et al*.'s (2015), study was a random study across the state. However, results in this study agree with those presented by Obuobie and Lesley (2014) on Accra urban practitioners where the above 40 age group had the highest representation. The 15-30 age group had the lowest participation in urban agriculture in the current study which is similar to that presented by Ogunniyi *et al.* (2017) in their study of the contribution of UA to household food insecurity in three local government areas (n=110). Other age groups were represented as 31-40 (18.4%) and 51-60% (25.5%), which is an indication of wide representation of the older adult population.

Although age is considered an unreliable indicator of farmers' behaviour, it has been used to examine farmers' behaviour on environmental issues with mixed results (Burton, 2014). Some studies in mainstream agriculture concluded with suggestions that younger farmers in dairy production tend to be proactive in adopting good behaviour (e.g., Rahelizatovo and Gillespie, 2004); whereas no significance was found between age and adoption of improved soil conservation (Tiwari *et al*., 2008). In this study, the correlation analysis between age and good agricultural practice showed no significant relationship, and therefore it can be concluded in this study that age does not have a possible influence on pesticide use among UA practitioners in Ibadan.

7.3.3 Educational status

The belief that the higher the level of education, the more likely farmers are willing participants in good agricultural behaviour (Burton, 2014). Also, Rios-Gonzalez *et al.* (2013) opined that literate farmers are likely to have a better understanding of the effects of pesticide on health and environment; however, this study's finding was contrary to this. This was why education as a characteristic was explored in this study in assessing farmers' pesticide use behaviour. Respondents in this study are more educated than farmers in studies conducted by Ugwu *et al*, 2015, Ogunniyi *et al*, 2017, Yassin *et al*, and Oztas *et al*, 2018, as the analysis shows that the majority were educated up to college/university level. This significantly indicate a possible high level of awareness and that their high level of education should grant them access to media publications and online materials that could help them in minimizing pesticide use. This is however not the case in this study. Statistically, there was no significant association between pesticide use and highest educational level attained by respondents in this study. This is because pesticide use was found to be high among the highly educated participants (31%, n=167) as compared to less educated participants (8.4%, n=167). Despite the higher levels of education, there are also high levels of pesticide use. Follow-up findings from interviews and discussions showed that these farmers are aware of pesticide issues but do not reflect this knowledge in their practice.

The results of this study on educational status and pesticide knowledge suggests urban farmers in Ibadan use pesticides despite their high educational status, which was expected to have an influence on their choice of pesticide use. Even though focus group participants argued that being educated increase their awareness of pesticide risk and therefore, inform them on better handling practices, Atreya (2007) explained that high educational status is not synonymous to an awareness of pesticide good agricultural practices. Their use of pesticides may also be linked to lack of training activities and programmes designed to support their pest management practices.

7.3.4 Main occupation

Even though the majority of respondent identified as fulltime farmers (72.1%), other categories of occupation identified suggest that there are other part time farmers conducting urban agriculture to improve their food intake and concurrently provide food for the urban market. This is evident in the proportion of respondents (44.2%) who indicated in the survey that they farm for dual purposes to feed their family and earn income. This finding is reflected among the variants of UA definition where food security, job creation and income generation has been described as some of its' endearing characteristics (Altieri *et al*., 1999; Mougeot, 2000; Hubbard and Onumah, 2001; Zezza and Tasciotti, 2010; de Bon *et al*., 2010; Lynch *et al*., 2001; Pasquini 2006; Zezza and Tasciotti, 2010; Smart *et al*., 2015).

A huge advantage of urban agriculture is the ready provision of reliable and regular access to wholesome food in an urban setting where these items can account for a high proportion of income. Food coming from rural areas are increasingly subjected to challenges in market flow because of limited infrastructure in terms of good road and adequate storage facilities. This has increased demand for food grown in the city and many residents see it as an opportunity to earn additional income and improve their household income. A survey of percentage income from urban agriculture showed farmers attributing a huge portion of their income to urban agriculture. This income generation may drive farmers' pesticide use in order to secure a steady source of income. Furthermore, the increase in demand for urban grown food may also encourage pesticide use with 87.9% of sample population using pesticide to control pests and weeds on their farms.

7.3.5 Land tenure

Urban agriculture is often considered as a transitory land-use activity with Maxwell (1995) and Lynch *et al*. (2001) pointing out the land insecurity threats faced by practitioners, with a subsequent impact on livelihoods. According to Stewart *et al*. (2013), land status in urban agriculture is characterised by cession, lease, sharing, authorised or illegal but reports according to RUAF (2010) on characteristics of urban agriculture have also identified inheritance, lease or purchased as land tenure. Though this study showed the majority of land used by farmers are self-owned (30.1%), providing them with some secured land holdings, land tenure for others is not as secure, which agrees with Lynch *et al*., 2001. Other land tenure status includes 34.6% Government-owned, 19.1% rented and 11.4% undeveloped land; none of the farmers attributed their land ownership to inheritance. The bulk of the Government-owned land is allocated to military families living within the barracks and right to land ceases when they are either transferred or reach the end of service; while the remaining land is leased, for which farmers pay a small amount to use over a long period of time. For rented land, farmers have an informal understanding with the legal owner to pay some amount to use the property until the owner is ready to develop it, with little or notice. The undeveloped land is mostly occupied by farmers illegally and therefore pose a risk to the security of their farm production. This distribution provides an opportunity for Government to incentivise pesticide use on their land by encouraging farmers using their land to minimize pesticide.

7.3.6 Farm size and type

The Majority of farmers in this study (26.8%) has between 3-5 plots of land (a plot= 50 feet by 100 feet). This is quite a sizeable amount of land compared to Lagos where UA is characterised by wetlands that are typical of the landscape (Adedeji & Ademiluyi, 2009). In this study, there was 72.3% of vegetable production with the remaining proportion shared amongst livestock, aquaculture, horticulture, and agroforestry farming. This is consistent with UA as vegetables are highly valued crops and are in demand.

7.4 Key themes identified from results

In exploring and assessing pesticide use in urban agriculture, three major themes emerged from results obtained from both quantitative and qualitative methods used in this study in assessing pesticide use in UA. The themes are pesticide use incidence behaviour; livelihoods and economic motivation and how they influence pesticide usage; farmers' knowledge and awareness in relation to farmer characteristics, quality of training and advice received and the sources of information (Figure 7.1).

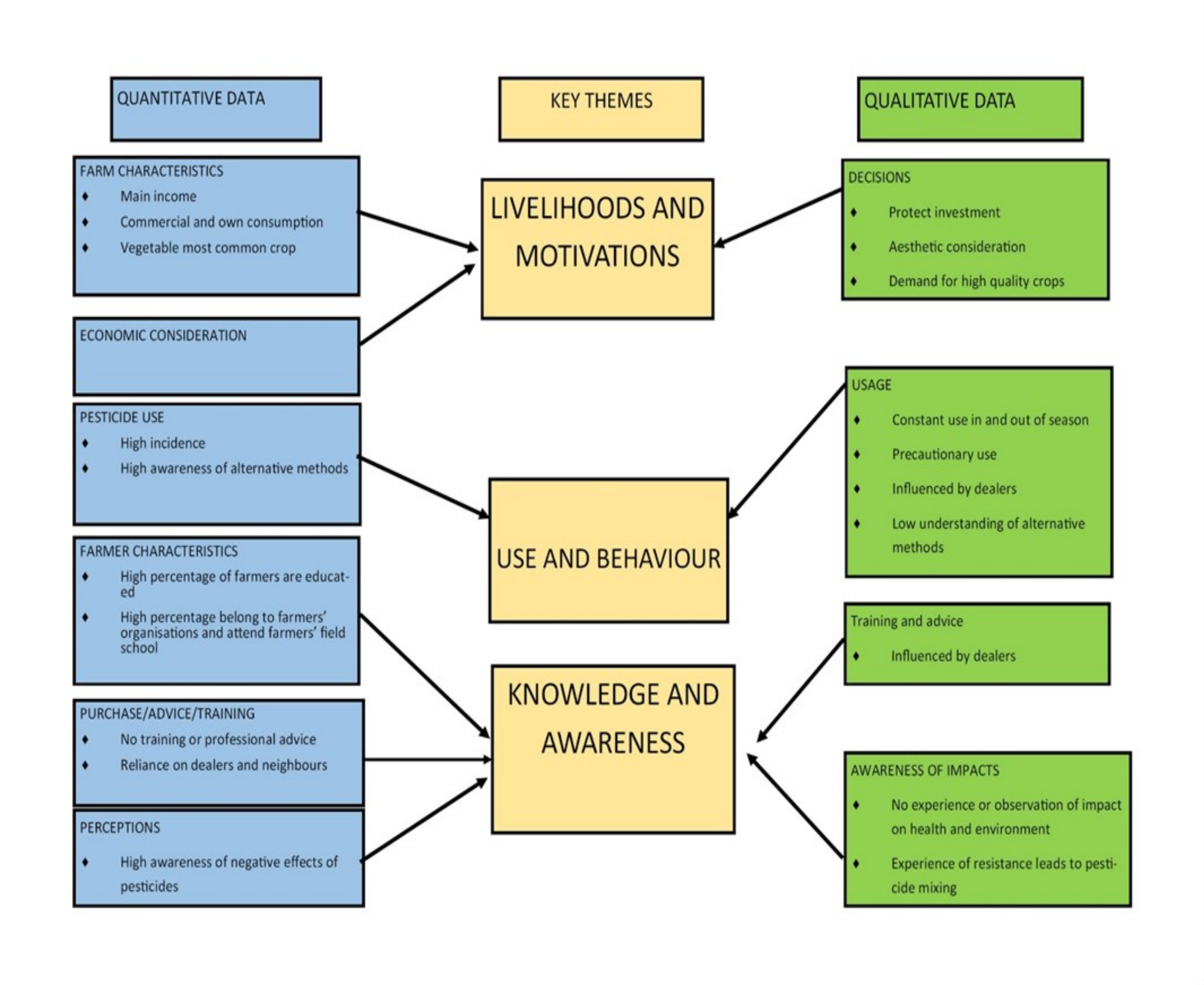


Figure 7.1: Graphical summary of relationship between themes and data

7.4.1 Pesticide use and behaviour

This section discusses the results of this study on pesticide use and behaviour in urban agriculture. Results presented in chapter six showed high incidence of pesticide (87.9%) use despite a high awareness of alternative pest control methods (42.6%). Their behaviour is also defined by abuse of pesticide by using it as precautionary method of pest control (36.8%) and constantly as farm practice (45%). This was revealed to be influenced by pesticide dealers and marketers as a way to maintain their own sales target as 57.2% of respondents rely on them for pest control advice.

One of the aims of this study was to establish incidence of pesticide use in urban agriculture because of the dearth of information pertaining to such in Nigeria and there are limited statistics on pesticide use in the study area. The incidence of pesticide use among urban farmers is very high in this study (87.9%). Though there are no literature that directly assessed pesticicde use in UA in Nigeria, the findings on pesticide use in this study are similar to incidence reported in the WAAPP baseline study on pesticide use in Nigeria where 92.3% of farmers interviewed across nine states used pesticides. This is also similar to Babarinsa *et al*'s (2017) results into pesticide use in selected local government areas of Oyo state where 94% of farmers use pesticides. Also, Tijani (2006) in his study on pesticide use and practice by cocoa farmers in UA in Nigeria recorded 96% of farmers using pesticides. Other studies on pesticide use in agriculture, with no direct reference to urban agriculture also reported high pesticide use amongst Farmers e.g Mbagwu and Ita, 1994; Ibitayo, 2006; Ugwu *et al*, 2015; Oluwole *et al*., 2015).

In Ghana, Mattah *et al* (2015) reported 70% of urban cultivators use pesticide in their study of health implication of pesticide application among farmers in the city of Ashaiman. This result is consistent with the findings of this study in Ibadan City. Corriols *et al* (2009) linked high incidence of pesticide use in agriculture to acute pesticide poisoning in Nicaragua. Farmers in our study area do not report cases of poisoning or pesticide-related health problems as they opined in FGDs that they use milk whenever they have headache symptoms after pesticide application.

These reports support the findings in this study and suggests that pesticide use pattern in urban agriculture is similar to that of rural agriculture. Furthermore, this high incidence of pesticide use in urban agriculture has been attributed to the intensive management of vegetable pests (Dinham, 2003); perceived ease of use and effectiveness in control of pests and weeds in agriculture (Okonya and Kroschel, 2015, Jallow *et al.*, 2017 and Bhandari *et al.*, 2018). This high level of usage is a concern since studies report the serious risk posed by pesticides to the environment and the society as a whole from agricultural production (Ajayi, 2000; Jansch *et al.*, 2006; Odewunmi, 2013).

7.4.1.1 Pesticide behaviour

As attitudes and intention of decision makers are influenced by beliefs, norms, and the expectation of significant others are central drivers of behaviour rather than profit alone. Pesticides in developing countries like Nigeria coupled with the absence of adequate farmers' education and effective regulatory measures has led to concern about the impacts of these pesticides on public health and in particular the exposure and poisoning of farmers and farm workers. For these farmers and farm workers, the consequences of the pesticide treadmill are high indeed as many respondents (50.5%) do not read labels, pesticide warnings and instructions (Damalas, 2009). Farmers' behaviour in pesticide use may also be explained using the theory of reasoned behaviour and planned behaviour.

Data on farmers' pesticide application patterns, quantity per surface area and spray concentrations were limited in this study mostly due to lack of record keeping by farmers. Farmers in this study have limited knowledge on the importance of record keeping in helping them maintain good agricultural behaviours which may reduce the risk of overdose to crops and human poisoning, and environmental contamination. Data results on timing, frequency of use, appropriate equipment and pesticide mixing behaviour are discussed in full in the following sections

7.4.1.2 Timing

Participants in discussions were probed on their timing of pesticide application. Contrary to findings by Ntow *et al*. (2006), Tijani (2006) and Okoffo *et al*. (2016) that farmers do not consider weather conditions before pesticide application, participants in this study displayed an awareness of weather conditions in pesticide application. They claim to take into consideration the temperature, humidity, and wind pattern before applying pesticides. This awareness of influence of weather condition on spray drifts is a positive finding, especially given the tropical nature of the study area, where temperatures can be more than 30^0c. This is good agricultural practice in pesticide application as there is less chance of drift which could have potentially led to volatilisation or evaporation of droplets, and a subsequent dispersal at a distance from initial area of application, thus leading to non-point pollution or poisoning (Ntow *et al*., 2006, Tepper, 2017). It also reduces farmers' exposure to risk of pesticide inhalation and skin contact (Okoffo *et al.* 2016). Given that participants in this research report minimal levels of use of protection when spraying, any awareness of weather can only be a good thing for the health of farmers and farm labourers who spray. The evidence of the use of personal protective equipment (or PPE) will be discussed in the next section.

Timing of application becomes very important in urban farming due to the nature of cities. It is also particularly important that farmers in urban farmers' limit risk of exposure during application because of the condensed built environment; the risk of impact to the local population is increased if application timing is not on point. However, farmers from this study did not show an awareness of the risk of exposure timing.

7.4.1.3 Frequency of use

Farmers admitted they use pesticides throughout the growing season as a precautionary procedure. This agrees with the findings of Lekei *et al* (2014) in their studies of farmers' pesticide behaviour in Tanzania. As well as precautionary use, farmers increase frequency of pesticide application if there are signs of an impending attack. The survey, interview and discussion data suggest that, despite high level of education of most participants, farmers mostly ignore the recommended frequency of application provided on formulation labels. Pesticide dealers also influence their pesticide use especially during outbreaks or massive infestations by encouraging farmers to increase the dose and frequency of use. This behaviour could be explained by the concept of pesticide treadmill theory. The pesticide treadmill theory has been used by entomologists, environmental campaign groups such as pesticide action network and friends of the earth to describe farmers' dependence on pesticide in their practice (Bosch 1978).

7.4.1.4 Use of appropriate equipment for application

Exposure to pesticides is a major occupational hazard in developing countries due to inadequate access to protective equipment (Okoffo *et al.*, 2016). Respondents in the survey appear to be aware of these hazards although a great proportion of them indicated the non-use of full personal protective equipment in pesticide application (87.4%). This is similar to findings reported by Tijani (2006), Panuwet *et al.* (2012) Mengistie *et al.* (2015) in developing countries where the majority of farmers do not wear full PPE. Although 54.5% of respondents reported that they cover their body and face with cloth during application and another 39% only cover their face, it would appear from focus group discussions that they mostly use their hands when mixing pesticides in the knapsacks or buckets. They also do not adequately protect their feet as most farmers reported that they wear slippers during application. This is an unsafe behaviour with potential risks to pesticide exposure, and a subsequent impact on their health. An explanation for non-use of PPE was given by farmers during interviews and focus group discussion as high cost of procurement and the discomfort that comes with it in a hot climate. The only farmer in the study who indicated a possession of PPE described the discomfort that comes with it discouraged him from wearing it. This agrees with Ecobichon (2001) when he mentioned that farmers fail to wear PPE due to heat-related discomfort.

The use of a knapsack sprayer was very high among survey respondents (62.1%) even though most of them rent it. This can improve efficiency of spray applications if good agricultural practice is adhered to. Participants in focus group discussions agreed that use of knapsack sprayers has reduced their cost on pesticides because they have less waste and can direct the nozzle to the spray area. This efficiency arising from knapsack sprayer was also highlighted by Sikkema *et al.* (2008).

7.4.1.5 Mixing

The issue of pesticide cocktails was raised during focus group discussions particular with respect to infestation of high value leafy vegetables. This practice has been reported in several studies carried out in developing countries (Mariyono, Mengestie *et al*, 2013). This practice was referred to as 'booster' by one of the pesticide dealers as they claim to occasionally advice customers to mix products when they complain about ineffectiveness of a product. This finding is consistent with that reported by Xu *et al.*, (2008) where pesticide dealers are motivated by profit to advise farmers to mix pesticides to obtain higher pesticide efficacy.

Dealers and farmers alike do not appear to give consideration to the adverse effects that could arise from antagonistic reactions between two different pesticides when mixed together. It was clear from the discussions that they do not realize the significant impact pesticide cocktail practice can have on the crop and the environment. Ngowi *et al* (2007) explained that interactions between insecticides, fungicides, and water mineral content can influence the efficacy of pesticides against fungal pathogens and insect mortality, some mixtures may lead to phytotoxicity in tomato, onion, and cabbage (Mengistie *et al.*, 2015).

7.4.1.6 Storage of pesticides

Storage of pesticides was indicated by farmers as on site, in storage boxes, and sheds. About 27.9% of respondents indicated they kept pesticides on site, which may pose the risk of accidental use and spillage, leading to contamination of the soil environment. This is common in developing countries according to Ngowi *et al.* (2001) and Murphy *et al.* (2002). 22.1% of farmers in the present study stored their products in secured storage boxes which is similar to what Tijani (2006) reported.

Respondents in this study had no record of their farming practice and could not provide documented information on their pesticide use. This is poor practice and may be responsible for aggravating farmers' perception on benefits of pesticide use.

There was no indication of respondents reusing pesticide containers or packaging in this study as reported by Tijani (2006). This however does not guarantee that respondents do not reuse these containers as there was no system in place for disposal or recycling of this waste. Furthermore, knowledge and behaviour of respondents on disposal of containers and packaging is very low as these are being disposed on site, burning and on the dump.

7.4.2 Knowledge and awareness

Farmers' knowledge and awareness of pesticide risks are crucial for improving safety of human health and environment (Damalas and Koutroubas, 2018). The level of knowledge can influence behaviour of individuals; the higher the knowledge level, the more likely the individual is expected to show safe behaviours with respect to pesticides (Rezaei *et al.*, 2017). Knowledge and awareness have been related to education, experience, training, extension, farming, membership of farmers' organisation and attendance at farmers' field school and other sources of information (Oztas, 2018; Damalas *et al.*, 2018) Farm characteristics such as type of farm are also known from previous research to influence knowledge about pesticide use and some of these characteristics.

7.4.2.1 Education

Education arguably should indicate a high level of awareness and possible good agricultural practice because a high level of education which would grant farmers access to media publications and online materials that could help them in using pesticides more effectively and safely or inform them about alternative methods. In the study by Oztas *et al*. (2018), highly educated farmers were found to have high level of awareness and knowledge because of their educational status. This is however not the case in, the survey data supported by findings from interviews and discussions showed that these farmers are aware of pesticide issues but do not reflect this knowledge in their practice. Reasons proffered by participants for this include affordability and preference for the perceived cheap chemical control products compared to alternatives.

7.4.2.2 Purchase, advice, and training

Farmers' dependence on pesticide dealers and neighbours may be attributed to limited access to extension services and zero training provided to farmers within the city. This is confirmed in this study when an agricultural extension agent at the Fadama field office said, '*are there real farmers in the city'*. This suggests that the priority on agricultural training and information is given to farmers in the rural areas and this lack of extension services is one of the challenges of urban agriculture in Ibadan city. Also, Chukwudebe *et al* (1997) argued that agricultural extension agents are possibly distracted by commercial incentives from dealers and subsequently spend more time on commercial activities than on extension activities such as information on safe handling of pesticides. This may be case for few extension activities that happen in the cities such as farmers' field school where substantial amount of time is spent marketing products to attendees (Researcher's observation, 2016).

7.4.2.3 Awareness of impacts, pests, and alternative methods

Farmers in this study are aware that pesticides can pose hazards to human health, especially the risk of pesticide poisonings. This danger may be determined by the pesticide's chemical makeup and formulation, its path into the body, the amount that enters the body and the length of exposure. Farmers agree that wearing PPE can greatly reduce the potential for dermal, inhalation, eye, and oral exposure, and thereby significantly reduce the chances of a pesticide poisoning. This finding indicates a correct knowledge of pesticide routes of absorption which is consistent with other studies regarding awareness of pesticide risk and handling of pesticide by farmers (Burleigh *et al*, Berg, 2001; Matthews *et al*, 2003, Isin and Yildrim 2007).

Awareness of pesticides has been linked to educational status (Atreya, 2007; Rios-Gonzalez *et al.*, 2013 and Oztas *et al*, 2018), however as reported in this study's results, the majority of farmers demonstrate some poor pesticides practice despite their education and knowledge of risks associated with it. Similarly, farmers with more than 10 years of farming experience use pesticides more than other groups even though there is an expectation that more years of experience in farming can lead to increased production, effective input use, increased output quality and increased amount of output, and reduced costs (Oztas *et al*., 2018). It is expected that experience will have a positive influence on the management ability of a farmer.

Most farmers during discussions indicated limited awareness of pest types and they could only identify few pests and cannot differentiate from beneficial natural enemies. They perceived all insects and growth as a threat to their production and therefore use pesticides to control them. This is substantiated from the responses on their opinion of deleterious effects of pesticides to which only 10.1% respondents showed an awareness of natural enemies' mortality. Some farmers could however identify pests and pest types based on experience.

Awareness of pest and pesticide information is limited to what farmers learn from pesticide dealers and other farmers (referred to as neighbours in this study), with results showing that

57.2% and 31.1% of respondents rely on pesticide dealers and their neighbours respectively for pesticide advice. Few farmers in this study had contact with extension agents, which they claimed was through farmers' field school. Pesticide dealers and fellow farmers play a significant role in farmers' pesticide knowledge as more than half of the respondents had never received training on pests and pesticides. This is similar to Yilmaz's (2015) findings who reported a significant amount of information on pesticide use is received from pesticide dealers. Also the results align with those of Mubushar *et al.* (2019) who found that 69% of farmers rely on neighbours for pesticide information. Despite the awareness displayed on the deleterious effects of, farmers continue to use pesticides because they claimed the effectiveness, convenience, and affordability of products in pest control.

7.4.2.4 Perception of benefits and risk

Farmer behaviour is often influenced by their perception of benefits and risk. Farmers' perception of the benefits pesticides suggests their dependence on these products are likely to continue unless there is an aggressive and consistent intervention program (education and training) to provide alternatives to chemical pest control. This is because evidence from focus group discussions indicates farmers perceive pesticides increase their yield. This is a category error as pesticides are only intended to protect crop against loss or damage from pests. They also perceived pesticides' affordability, availability, and convenience as benefits. This was not the case in the earlier years when pesticides were first introduced as reported by Banjo *et al.* (2003) who found cost and availability were constraints to pesticide use decades ago.

Alternatives to chemical control may appear costly or difficult to adopt, the high environmental and social cost of over-dependence on pesticides still need to be considered. This is so because farmers during interviews and focus group discussions clearly displayed a nonchalance to risk of pesticides and see symptoms of poisoning/exposure as a mild occurrence which they ignore or in one case handle by taking milk. They also lack the full understanding of IPM as an alternative to reducing pesticide use and increasing long-term productivity of their farm practice.

Respondents in focus group discussions indicated that the benefits of pesticides include the reduction in pest levels with immediate results. This perception may inform farmers' rationalization on the effectiveness of pesticide to reduce pesticide severity and hence prevent loss of yield due to pest. This can be explained using the theory of reasoned behaviour/action. TRA (as developed by Fishbein and Ajzen 1975, Ajzen and Fishbein, 1980) assumes human beings usually behave in a sensible manner, by taking into account every available piece of information and implicitly or explicitly consider the implications of their actions. Reasoned action predicts that behavioural intent is created or caused by two factors: attitudes and subjective norms. This infers that farmers' use pesticides based on their reasons/motives such as profit, insurance, income.

7.4.3 Livelihoods and Motivations

A great advantage of urban agriculture is the ready provision of reliable and regular access to wholesome food. Food coming from rural areas is increasingly subjected to challenges in market flow because of limited infrastructure in terms of good road and adequate storage facilities. This has increased demand for food grown in the city and many residents see it as an opportunity to earn additional income and improve their household income. The survey found that farmers attributed a large percentage of their income to urban agriculture. For instance, survey presented in table 6.13 indicated 62% of respondents earn over 50% of their annual income from UA. As a result of this reliance, farmers agree that it motivates pesticide use as a form of insurance for their expected income. Furthermore, the increase in demand for urban grown food, mainly vegetables, is also a motivating factor for pesticide use with 87.9% of sample population using pesticide to control pests and weeds on their farms. As farmers' livelihood rely on product yield and quality, farmers protect their crops against all forms of pesticide attack.

Consumers demand for high quality crop influenced farmers in this study. As discussed in earlier sections, vegetable production forms a big part of urban agriculture production. Vegetable production is a major part of urban agriculture in West African cities such as Lagos, Port-Harcourt and Kano (Ezedinma and Chukuezi, 1999, Binns *et al.,* 2003), Accra in Ghana (Amoah *et al.*, 2006), Bobo Dioulasso in Burkina-Faso (Centres, 1996), Cotonou in Benin (Brock and Foeken, 2006), Yaounde in Cameroon and Dar-es Salaam in Tanzania (Dongus, 2001; Smith and Lamba, 2015). This trend is supported by evidence reported in this study where 72.3% of urban agriculture practice is geared towards vegetable production.

Vegetables have been reported to receive considerable high amount of pesticide being a high value crop (Jeyanthi and Kombairaju, 2005). This high dependence on pesticides is supported by evidence found in this study where 87.9% of farmers use these chemicals. It can therefore be said that the value of crop is one of the factors that drives pesticide use in urban agriculture.

7.5 Legislation and pesticide monitoring

The laws on pesticide management in Nigeria can be blurry because of the multiple agencies involved. As discussed in Chapter 2, regulation of the distribution and use of pesticides are regulated under several policies which include the Nigerian Agricultural Policy (1988), the National Policy on Environment (1989), amended Federal Environmental Protection Agency Act 58 (1992), National Environmental Standards and Regulations Enforcement Agency Act (2007) and National Agency for Food and Drug Administration and Control, amidst other many others. However, research findings showed that respondents are not aware of the legislations behind pesticide management and therefore lack understanding. This shows there is no awareness in the premise behind it. Farmers will only adopt safety measures if they believe the benefits outweigh its non –use which as a participant said:

When you go to the market and can't find the product you have been using, you are told it is no longer available and marketers provide you with an alternative. I have been offered some of these banned products at a higher cost because it works better. (Farmer S)

Aside for lack of awareness on the part of the farmers, the country's pesticide legislative bill is yet to be passed into law which explains the zero awareness exhibited by farmers.

Chapter Eight

Pesticide Use in Urban Agriculture and Sustainable Development

8.1 Introduction

This chapter is a synthesis of the interdisciplinary study, using a combined methodology from natural and social sciences. Results from each method used has been discussed in chapters five and seven. This chapter discusses the subject of concern within the context of sustainable development i.e., the impacts of pesticide use on SD. This chapter begins with a recap of the research aims and activities carried out in finding answers to these questions. It is followed by discussion of research findings relevant to the study of exploring/assessing pesticide use in urban agriculture in Ibadan, south-west region of Nigeria. The chapter concludes with a section on my reflections on research positionality which might have influenced research findings, summary of findings and recommendations for future research directions.

8.2 Recap of research objectives, questions, and activities

As highlighted in Chapter 2, Urban Agriculture has been endorsed internationally by several organizations, agencies, and studies as a strategy to promote food security, poverty reduction, sustainable use and environmental management, social integration and participatory governance (Binns and Lynch, 1998, FAO, 1999, Lynch *et al.*, 2001, Pasquini, 2006, Zezza and Tasciotti, 2010, Dubbeling and Merzthal, 2014). However, one of the factors limiting it from fulfilling its potential is impact of pesticide use on the environment, society, and long-term economic sustainability (RUAF, WAAPP-Nigeria, 2013). Similarly, few of the studies that acknowledge the benefits that comes with UA also suggest exercising caution on its wider implication for the environment (Binns and Lynch, 1998).

Pesticides are frequently used to protect crops in the midst of the global challenge of securing food production despite its many negative impacts arising from misuse of the compounds (Ajayi, 2000 and Jansch *et al.*, 2006). It is regularly used by farmers to protect their crops and livestock, and subsequently reduce the loss of yield to pests (Carvalho, 2007). However, as important as it is to promote food security and reduce poverty by reducing losses to pests, the need for promoting sustainable agricultural practices is paramount. Since UA has the potential to promote a sustainable environment, with sustainable environment being synonymous with mitigating climate change effects, a premise on which this study was based on, an assessment of pesticide uses amongst urban farmers in Ibadan, southwest Nigeria, was carried out. This study recognised the significance of multi-dimensional research enquiry to proffer an effective snapshot of the problems being investigated.

8.2.1 Research objectives and activities

The overall research aim of this thesis was to combine an investigation of pesticides contamination in the study area with an exploration/assessment of pesticide use in urban agriculture in Ibadan, South-West Nigeria.

The specific objectives were:

- to develop a research framework for an integration of natural and social science investigation into pesticide use
- to assess pesticide contamination through chemical and biological analysis
- an attempt to create a possible historical and current profile of pesticide use in the study area
- an assessment of farmers' knowledge, behaviour, motivations, and perception on pesticide use.

The research activities included:

- literature review to develop a research framework
- sample collections and pesticide analysis
- questionnaire survey, coupled with focus group discussions, interviews and key informant discussions.

8.3 Research framework for an integration of natural and social science investigation into pesticide use

As highlighted above, the need to assess the impacts of pesticide use among urban agriculture practitioners in Ibadan is important because of the strategic contribution of this form of agriculture to sustainable development goals. Table 2.1 in chapter 2 summarises the relevance of this research study to sustainable development goals 1, 2, 3, 8, 11, 14 and 15 in line with Africa's Agenda for growth in Agenda 2063 (AU, 2015).

Given this background, after conceptualising the subject of concern within the context of sustainable development, this study presented a research framework in chapter four and graphically illustrated in Figure 4.1 that encompasses the research paradigms that allow for the integration of approaches from both the field of natural and social sciences. With the methods defined in the framework, the other objectives of this study were attempted.

8.4 Pesticide use and the environment

Despite studies reporting the serious risk posed by pesticides to the environment and the society (Ajayi, 2000; Jansch *et al.*, 2006; Odewunmi, 2013; Damalas *et al.*, 2018), the incidence of pesticide use among urban farmers is very high in this study (87.9%) and comparable to studies carried out by other researchers on pesticide incidence in Nigeria. In the baseline study on pesticide use across the whole of Nigeria, WAAPP (2013) reported 92.3% of farmers interviewed across nine states used pesticides. Tijani (2006) in his study on pesticide use and practice by cocoa farmers in Ondo state recorded 96% of farmers using pesticides. Also, 94% of farmers were reported to use pesticides in the study carried out by Babarinsa *et al.*, (2017) in five local government areas of Oyo state. Similar studies that reported high pesticide use include Mbagwu and Ita, 1994; Ibitayo, 2006; Ugwu *et al.,* 2015; Oluwole *et al.*, 2015). This high incidence of pesticide use could be attributed to the intensive management of vegetable pests (Dinham, 2003) as the majority of participants in this study practice vegetable production, which is a high value crop and has high demand. The high incidence of pesticide use may also be a result of the perceived ease of use and effectiveness in control of pests and weeds in agriculture (Okonya and Kroschel, 2015; Jallow *et al.,* 2017; Bhandari *et al.*, 2018).

Furthermore, soil and sediment analysis indicate the presence of organochlorine and organophosphate residues in the study area. These organochlorine residues are possibly from historical pesticide use before it's ban. However, this study confirms previous report of organochlorine use amongst farmers long after it's ban. The findings from this study suggest 72.1% of sample population rely on urban farming as a sole source of income; with 62.1% of them earning more than 50% of their income from vegetable production alone. Vegetables being a high value crop for most of these farmers may influence their decision to use pesticides, possibly due to pressure to protect their income and a reluctance to risk economic losses as a result of poor economic conditions (Atreya, 2007) in developing countries such as Nigeria. The evidence from this study agrees with previous studies that indicated a relationship between farmers' income and pesticide use (Robinson *et al.*, 2007; Xu *et al.,* 2008; Lagerkvist *et al.*, 2012; Rahman and Chima, 2018).

8.5 Pesticide use and the society

One of the endearing characteristics of urban agriculture is the opportunity it proffers to provide food for household, food for income or a mixture of both (Mougeot, 2000; Gockowski *et al.,* 2003; Zezza and Tasciotti, 2010; Zeeuw and Drechsel, 2015). This way, UA had the potential of providing wholesome (Amar-Klemesu, 2000) and pesticide-free food as compared to conventional agriculture, where there has been reports of high pesticide use, with associated risks to health from consumption.

Findings in this study showed 44.2% of respondents practice urban agriculture for the dual purpose of generating income and providing subsistence food. Coupled with the high of incidence of pesticide use reported in this study (87.9%), it is clear that to protect their crops and animals, sustain their yield and secure their food, most farmers, even those that grow for household consumption only, relied on chemical control to achieve this. Given that a combined 27.9% of respondents work in private and public sectors, with 1.6% being self-employed, the use of pesticides may be motivated by the need to cut their food costs because of low wages, as urban residents are likely to spend 60-80% of their income on food (Maxwell *et al.* 1999 and Amar-Klemesu 2000). For those who practice urban agriculture as a sole source of income are more motivated to use pesticides to protect their investments and would not want to risk crop failure.

Farming experience of respondents in years varied from 12.1% to 20.0%. This study had an aggregate of 52.1% of farmers who had 11 years and above farming experience. This experience could mean more knowledge for these farmers and therefore, help to reduce reliance on pesticides (Zhang *et al.,* 2018). This is however not the case in this study as there was no statistically significant relationship between farming experience and pesticide use. On the contrary, farmers who had 11 year's experience and above use more pesticides while most farmers with 1-2 years farming experience do not use pesticides. This is a deviation from expected behaviour by experience but can be explained with new farmers' probable pest management strategy to adopt other forms of pesticide control aside from chemical control.

As a majority of participants in this study are into vegetable production, there could be relationship between crop type grown and pesticide use because of the high susceptibility of some crops to pests. Leafy vegetables such as Celosia and Amaranth are in high demand and are very susceptible to insects' attacks. Farmers may be motivated to use pesticides on a heavy rotation to protect their investment. This was the case at the start of this research survey where farmers in Mokola barrack complained of pest outbreak and why they needed to change products to control the pestilence.

This brought about the issue of pesticide cocktails during focus group discussions. This practice has been reported in several studies carried out in developing countries (Mariyono, Mengestie *et al*, 2013). Participants in the discussions and interviewees mentioned that they do practice pesticide cocktail because they see better results when they so apply it. They also said during multiple pestilence outbreaks, mixed pesticides are very effective in combatting the pests and reduce the application time. For example, one farmer who participated in this research said he has had instances of repeating the same product twice to control a single pest with no result and that when he mixed it with other products, he saw results.

This practice was referred to as '*booster*' by one of the pesticide dealers as they claim to occasionally advise customers to mix products when they complain about ineffectiveness of a product. This finding is consistent with that reported by Xu *et al.*, (2008) where pesticide dealers are motivated by profit to advise farmers to mix pesticides to obtain higher pesticide efficacy.

Dealers and farmers alike do not give consideration to the adverse effects that could arise from synergistic reactions between two different pesticides when mixed together. It was clear from these discussions that they do not realize the huge impact pesticide cocktail practice may have on the environment. For example, Ngowi *et al.* (2007) explained that interactions between insecticides, fungicides, and water mineral content can influence the efficacy of pesticides against fungal pathogens and insect mortality, some mixtures may lead to phytotoxicity in tomato, onion, and cabbage (Mengistie *et al.*,2015). This practice, revealed by this research to be widespread amongst urban cultivators and advocated by input dealers, needs to be tackled in order to avoid risk of chemical pollution.

Urban agriculture was often considered as a transitory land-use activity, with Lynch *et al.* (2001) pointing out the land insecurity threats faced by practitioners in their research on urban farming in the context of Kano, and a subsequent impact on livelihoods. However, this study showed a majority of land used by farming plots are self-owned (30.1%), with 34.6% Government-owned, 19.1% rented and 11.4% undeveloped land. This distribution provides an opportunity for Government, as landlord of a substantial proportion of the respondents to this survey. It could be possible to use their influence as land owner to incentivise pesticide use on their land by encouraging farmers using their land to minimize pesticides or allocating access to land with conditions on pesticide use.

8.6 Pesticide use and farmers' pesticide application patterns/behaviours

The data acquired from farmers in this study were not sufficient to define pesticide application patterns, such as total number of applications per season, quantity per surface area and spray concentrations. This is because all respondents' (including pesticide users and non-users) did not keep records. Record keeping in farm management is essential to a successful farm operation of application. It is helps in maintaining good agricultural practice which may reduce risk of overdose and poisoning. The lack of records made this an area of practice that was beyond the scope of this research, as an additional method of evidence gathering would have been required. This is therefore an area that could be explored in future research, which should include both the generation of a method of data capture on application practice as well as the data on the practice itself. However, information on time of application**.**

Inadequate access to protective equipment during pesticide application has been cited as a major occupational hazard in developing countries (Okoffo *et al.*, 2016). Respondents in this research appear to be aware of this hazard though a great proportion of them indicated that they did not use full PPE in pesticide application (87.4%). This is similar to findings reported by Tijani (2006), Panuwet *et al.* (2012) Mengistie *et al.* (2015) in developing countries where majority of farmers do not wear full PPE. Although full PPE is rarely used, 54.5% of respondents reported that they cover their body and face with cloth during application and another 39% only cover their face. From follow-up discussions during the interviews and FGD respondents reported that they mostly use their hands when mixing pesticides in the knapsacks or buckets, exposing them to the risk of chemical effects through dermal contamination. They also do not adequately protect their feet as most farmers' wear slippers during application.

This is an unsafe behaviour with potential risks to pesticide exposure, and a subsequent impact on their health. An explanation for non-use of PPE was given by farmers during interviews and focus group discussions as high cost of procurement and the discomfort that comes with it in a hot climate. The only farmer in the study who indicated they were in possession of PPE, described the discomfort that comes with it discouraged him from wearing it. The evidence from this research therefore is in agreement with Ecobichon (2001) when he mentioned that farmers fail to wear PPE due to heat-related discomfort. The implications of the results of this research therefore are that there is a significant challenge in ensuring that PPE equipment I both accessible and used by farmers in pesticide application, particularly where dermal contamination is a high risk.

The use of knapsack sprayer was found to be very high among respondents (62.1%) even though most of them rent it. This may improve efficiency of spray applications if good agricultural practice is adhered to. Participants in discussions agreed that use of knapsack sprayers has reduce their cost on pesticides because they have less waste and can adequately direct the nozzle to the spray area. This efficiency arising from knapsack sprayer was also highlighted by Sikkema *et al.* (2008).

However, respondents were able to provide stages of growth that they apply pesticides. In the case of herbicides, farmers mostly use pre-emergence herbicides after land clearing, during land preparation for a new cycle of planting. During growth, they resort to hand-weeding or use of hoes (simple farm tools) to clear emerging weeds. However, for some of the horticultural farmers interviewed, they use both pre-and post- emergence herbicides as a routine. Some interviewees indicate that the frequency of application is influenced by factors such as availability of pesticides, field conditions (pest, disease and weed), and farm area. This agrees with the findings of Lekei *et al.* (2014) in their studies of farmers' knowledge in Tanzania. Others apply pesticides on a precautionary basis monthly, and then they increased the frequency of application if they detect signs of an impending attack. It can be inferred from surveys, interviews, and discussions that despite a relatively high level of education amongst the participants of this research, farmers mostly ignore the recommended frequency of application provided on formulation labels or by advisers. This behaviour could be explained by the concept of 'pesticide treadmill theory'. The pesticide treadmill theory has been used by entomologists, environmental campaign groups such as Pesticide Action Network and Friends of the Earth to describe farmers' dependence on pesticide in their practice (Bosch 1978). This theory argues that farmers will continue to depend on pesticides as more pests grow resiitant to the formulation. The evidence from this research is that farmers are on the pesticide treadmill as they use these products as part of their farm practice, regardless of whether there is an outbreak or not.

8.6.1 Farmers behaviour and good agricultural practice

Knowledge has been defined as a fluid mix of framed experiences. The level of knowledge can influence behaviour of individuals; the higher the knowledge level, the more likely the individual is expected to show safe behaviours (Rezaei *et al.*, 2017). However, as has been demonstrated by the evidence collected for this study, there appears to be a mismatch between the levels of knowledge, experience, and education on the one hand and expected safe behaviours on the other. Storage of pesticides was indicated by farmers as on site, in storage boxes, and sheds. About 27.9% of respondents indicated they kept pesticides on site which may pose the risk of accidental use and spillage, leading to contamination of soil environment. This is common in developing countries according to Ngowi *et al.*, 2001 and Murphy *et al.*, 2002. 22.1% stored their products in secured storage boxes which is similar to what Tijani (2006)

Respondents in this study had no record of their farming practice and could not provide documented information on their pesticide use. This is alarming and may be responsible for aggravating farmers' perception on benefits of pesticide use. There was no report of respondents reusing pesticide containers or packaging for storage of other items in this study as reported by Tijani (2006). This however does not suggest that respondents do not reuse this container as there was no system in place for disposal or recycling of this waste. However, knowledge and behaviour of respondents on disposal of containers and packaging is very low as these are being disposed on site, burning and on the dump. Pesticides in developing countries like Nigeria coupled with the absence of adequate farmer education and effective regulatory measures has led to concern about the impacts of these pesticides on public health and in particular the exposure and poisoning of farmers and farm workers. This is particularly acute in an urban agricultural setting, as in addition to these direct exposures from agrochemical effects, in an urban setting, there are more people in proximity to the sites of pesticide application that can be affected than might be found in a rural setting.

8.6.2 Farmers' pesticide awareness, knowledge, and behaviour

Farmers' awareness and knowledge of pesticide risks are crucial for improving safety (Damalas, Spyridon and Koutroubas, 2018). For example, in Öztaş *et al*. (2018) study into 'knowledge level, attitude, and behaviors of farmers in Cukurova region regarding the use of pesticides', farmers' awareness of pesticides was found to be related to their educational status as educated farmers can read publications and access information through the Internet. Other studies reinforce this position in similar contexts (Atreya, 2007 and Rios-Gonzalez *et al.*, 2013). The majority of farmers in this study were educated beyond secondary education, though they reported high levels of pesticide use and low levels of risk management in the handling and applications processes. However, with this high degree of educational knowledge, a majority of farmers use pesticides despite the risks associated with it. Also, most farmers during discussions indicated limited awareness of pest types and they could only identify few pests and cannot differentiate from beneficial natural enemies. They perceived all insects and growth as a threat to their production and therefore use pesticides to control it. This is substantiated from the response rate on their opinion of deleterious effects of pesticides to which only 10.1% response portraying an awareness of natural enemies' mortality. Some farmers could however identify pests and pest types based on experience.

Farmers in this study are aware that pesticides can pose hazards to humans, especially the risk of pesticide poisonings. As discussed in chapter 3, this danger may be determined by the pesticide's chemical makeup and formulation, its path into body, the amount that enters the body and the length of exposure. Farmers agree that wearing PPE can greatly reduce the potential for dermal, inhalation, eye, and oral exposure, and thereby significantly reduce the chances of a pesticide poisoning. However, they complained about the possible discomfort from wearing it during application. This finding indicates a correct knowledge of pesticide routes of absorption which is consistent with other studies regarding awareness of pesticide risk and handling of pesticide by farmers (Burleigh *et al.*, Berg, 2001; Matthews *et al.*, 2003, Isin and Yildrim 2007). However, there appears to be a mismatch between he perceived seriousness longer term pesticide poisoning and short term discomfort of wearing PPE equipment.

The evidence gathered in this research indicates that urban farmer awareness of pest and pesticide information is limited to what they learn from pesticide dealers and other farmers (referred to as neighbours in this study), with results showing 57.2% and 31.1% of respondents rely on pesticide dealers and their neighbours respectively for pesticide advice. Few farmers in this study had contact with extension agents during farmers' field school.

Pesticide dealers and fellow farmers play a huge role in farmers' pesticide knowledge as more than half of the respondents had never received training on pests and pesticides. This is similar to Mubushar *et al.*, (2019) findings in a study on 'assessment of farmers' knowledge on pesticides and trainings on pesticide waste management in central Punjab – Pakistan' in which 69% of farmers rely on neighbours in. Yilmaz (2015) also reported a significant amount of information on pesticide use is received from pesticide dealers in their study in analysis of environmental awareness of farmers' decisions and attitudes in pesticide use in Turkey. This research is indicating a pattern of knowledge acquisition that replicates what has been found elsewhere. Farmers' dependence on pesticide dealers and neighbours may be attributed to the complete lack of training provided to farmers within the city. As stated by an agricultural extension agent in the Fadama field office, '*Are there real farmers in the city?* This suggests priority is given to farmers in the rural areas when it comes to agricultural training and information. Providing training and support is rural farmers is important, however, considering the synergistic contribution of UA to food production with the most reliable data recorded nearly 800 million people involved in UA in 1996 (Smit *et al*., 1996), it is important that urban farmers are valued as part of the Agricultural production system. Another possible explanation for the poor information dissemination to urban farmers may be due to limited incentives as described by Chukwudebe *et al.* (1997) who opined that agricultural extension agents are possibly distracted by commercial incentives from dealers and subsequently spend more time on commercial activities in areas with more farmers (which are rural areas) than on extension activities such as information on safe handling of pesticides. This may be the case for few extension activities that happen in the cities such as farmers' field school where substantial amount of time is spent marketing products to attendees (Researcher's observation, 2016). The significance of this is that crucial training of farmers is neglected.

Environmental impacts from pesticide use are determined by the type of chemical used, quantity applied and weather conditions. Results from surveys and interviews revealed that respondents use many types of pesticides, which include insecticides, herbicides, fungicides, rodenticides, acaricides and nematicides. These pesticides are classified according to the new globally-harmonized system, which replaced the 1975 WHO hazard classification system based on physical, health and environmental hazards (WHO, 2009). They are also classified according to their oral and dermal toxicity; and chemical groups (WHO, 2009). It is designed as a general and simple approach to defining and classifying hazards; communicating information on labels and safety data sheets for all chemicals; and provides the underlying infrastructure for establishment of national, comprehensive chemical safety programs. The pesticides used by respondents in this study belong to Organophosphates, Pyrethroids, Triazines, Carbamates and Glyphosates chemical classes. Organophosphate and carbamate pesticides are inhibitors of cholinesterase (an enzyme responsible for the breakdown of acetylcholine which could cause problems in the nervous system). However, evidence gathered in this research has demonstrates that some farmers still use some products which have been banned but can still be found on the black-market.

8.6.3 Farmers' motivation for pesticide use

One of the motivations for pesticide use according to farmer participants in this research is the perceived opportunity to ensure high sensory quality attributes of vegetables to meet the demand for aesthetic quality by consumers (Lagerkvist *et al.*, 2012). Insect pests and plant diseases are major yield reducing factors that threaten food security and farmers' income. In this study, 74.6% of respondents indicated they expected that they would suffer up to 20% decline in yield without using pesticides.

The application of pesticides can be seen as a way to manage this potential loss. When compared the potential 20% loss in yield, the comparative outlay of chemicals and renting a knapsack sprayer can be offset against this loss from discounted net present value of stream of returns from doing so is positive. This can support the use of unsustainable pest control strategies and is more likely to do so, the higher the real discount rate. This is usually considered to be higher in less developed countries (LDCs) than in more developed countries (MDCs). Hence, to use less sustainable techniques is more likely in LDCs. It is also possible that farmers in LDCs are less informed about pesticides than those in MDCs.

8.7 Pesticide use in urban agriculture within the sustainability framework

One of the theoretical concepts of this research is how pesticide use in urban agriculture impacts sustainability. Sustainability has three main dimensions namely, society, economy and environment (Brundtland Commission, 2000). This principle transcends a single industry but cuts across all sectors or industries whose activity in one or the other may impact sustainability. One of such industry/sector is agriculture and achieving sustainable agriculture is one of the most important goals for attaining sustainable development (UNCED, 1992; Conway and Barbier, 2013; FAO, 2002). Sustainable agriculture's definition, fashioned after the Brundtland Commission's definition of sustainable development, is agriculture that meets society's need for food without compromising the ability of future generations to meet their own needs (Pretty, 2008; Velten *et al.*, 2015).

The sustainability of African agriculture is important to the continent's food security and for maintaining agriculture's contribution to her rural communities and national economies, especially with Agenda 2030 project. Agriculture, in all its forms, impacts on society, economy and environment in its practice. Its impact on society stems from food provision which is necessary for human sustenance and survival; this could be said to be agriculture's greatest impact (Robertson *et al.*, 2014). Also, it drives economy on all levels through the generation of income, being a significant sector in Nigeria's economy with 20.8% contribution to its' gross domestic product (World Bank, 2017) and an economic mainstay of its many households

(Udoh, 2000). However, agriculture's impact on the environment is characterised by land degradation from intensive land use, deforestation, biodiversity loss, pesticide contamination, pest resistance to pesticides, among other environmental problems (Ruttan, 1999; Jirtle & Skinner, 2007; Aktar *et al.*, 2009; Rohila *et al.*, 2017). It is now very clear that routine use of pesticides as part of agricultural practice has adverse effects on the health of ecosystems and humans as many of these substances are highly toxic and have been progressively banned as their toxicity has been proven. What is even more frightening is that the new products that are categorised as safe are far more toxic than those that stay long in the soil.

Organophosphates are considered ecological alternatives to organochlorines and include malathion, parathion, and dimethoate and glyphosate. Some of them however are known for being potential endocrine disruptors. The possible synergistic effects of pesticide cocktails need to be highlighted to stop the practice because the combination of substances with possible carcinogenic or endocrine-disrupting effects may produce unknown adverse health effects. Therefore, the determination of safe levels of exposure to single pesticides may underestimate the real health effects, ignoring also the chronic exposure to multiple chemical substance. Considering the several possible effects of health and environmental effects of chemical pesticides, especially with its potential impact on non-farming residents, urban agriculture can be redirected to protect the environment.

Urban agriculture was promoted as an alternative to modern rural agriculture to enrich and transform cities on its pathway to sustainability whilst still providing food and income (Mougeot, 1994). Several studies have however mentioned the unsustainable urban agricultural practices such as pesticide misuse and overdependence are causing pest resistance to pesticides, loss of biodiversity and, among other environmental problems (Ruttan, 1999). This research indicates that UA, which may be a survival strategy for practitioners, practised by different categories of people for different reasons, is being threatened by an over-dependence on pesticides. Findings in this study have shown that pesticides are being used by majority of farmers in their urban farming practice which resonates with other studies (Mbagwu and Ita, 1994, Ibitayo, 2006; Ngowi *et al.*, 2007; Ugwu *et al.*, 2015; Okonya and Kroschel, 2015; Oluwole *et al.*, 2015). Though farmers in this study claim pesticide is used for pest control, increased yield, improved storage, and improved quality of produce, it is concerning that a majority of farmers use pesticide as a precautionary management practice. Continued dependence of farmers on pesticides may hamper their future livelihoods through pest resistance to chemical control, and thereby, affect their earnings. It also has a potential to reduce crop yields and the nutritional quality of the produce. It also affects their health (Oluwole and Cheke 2009; Damalas and Eleftherohorinos, 2011) even though farmers in this study did not report any significant health impacts from pesticide use. In order to raise the potential of urban agriculture as a form sustainable agricultural practice, an appropriate Government response to pesticide use is important. In this study, some farms are situated near water bodies and therefore present a huge risk of pesticide contamination of the water bodies and subsequent onward transmission of the chemicals into the urban system and potentially into human consumption. Pesticides enter waterbodies in farming systems through spray drift, rinsing of pesticide containers and packaging, and leaching into water courses (Damalas *et al.*, 2008). The influence of several physical, chemical, and biological processes acting on pesticides that are exposed to high temperatures may change their composition and effect on non-target organisms.

8.8 Reflections

This section is a brief reflection of my research journey, highlighting both personal and academic curiosities that formed and shaped this study. The ontology of studying the incidence of pesticide use stemmed from it's widespread use amongst residents in Ibadan after a first-hand experience of how much people rely on it from household pest control to weed control and in small-scale farming. Given me my professional and academic background in Agriculture, I decided to focus on pesticide use in farming.

With the report by RUAF highlighting pesticide use as a possible impediment to UA' s potential for promoting sustainability, it became important to explore both the natural and social dimensions of uses and impact and therefore laying a foundation for a mixed method research. I had to attend workshops and one-to-one trainings on using social methods research to develop my research skills. I also had to learn new methods of natural science inquiries such diatom analysis to support my research methodology.

In retrospect, carrying out a mixed method research was daunting, but it was the most logical research method that could help me understand the dimensions of sustainability that were the bedrock of this study. I realised that not only assessing contamination in the environment but understanding the motivation driving the primary consumers (farmers), I was able to highlight issues and possible measures to mitigate them. I had to learn and relearn research skills that I might require, and I must say it has been a learning curve for me, especially in my interactions with the farmers.

8.9 Research recommendations

An understanding of the factors that drive pesticide use by farmers may be informative in developing effective policies on sustainable pest management in Nigeria, which will also improve UA's chances in promoting sustainability. Urban agriculture can promote urban food security and therefore, supporting farmers to reduce their reliance on chemicals will help in ensuring sustainability. According to Pimentel *et al*., (1997), promoting natural pest regulation may reduce farmers' dependence on pesticides and subsequently, improve their long-term productivity and profit. This will in turn feed into the sustainable development goals of achieving sustainable agriculture whilst still promoting food security.

Participants in this study are mainly small-scale urban farmers who are important in the global drive to adopt urban agriculture as tool to promote food security, reduce the length of food chains and bring producers closer to consumers. They however lack the technical know-how on pesticide handling which has increased the risk of pesticide impact in the environment. With the continued high incidence of pesticide use, it became necessary to reassess the role of urban agriculture in promoting sustainability and mitigate the limitations presented by this. To fully realise its potential for agricultural sustainability, its impact on the environment, most especially from pesticide use driven by limited knowledge of pesticide risks, poor agricultural practices, and financial and aesthetic motivations; must be acknowledged.

Farmers, according to Wilson and Tisdell (2001), will continue to use pesticides as long as they enjoy its' perceived benefits. Benefits in terms of high profit from aesthetically acceptable products, low labour cost on labour, ease of acquisition and application will continue to drive pesticide use only if alternatives to these chemicals are made accessible. Farmers in this study says the use of Neem extract is expensive for their business and to prepare a homemade version is challenging. Incentives in form of discounts to farmers who adopt bio-pesticides will redirect farmers' perceived opinion on pesticides. Furthermore, educating the public on the danger of possible pesticide residue may influence their demand for quality and sensory attributes in agricultural products.

The results of this study on educational status and pesticide knowledge suggests urban farmers in Ibadan use pesticides despite their high educational status, which was expected to have an influence on their choice of pesticide use. Even though focus group participants argued that being educated increase their awareness of pesticide risk and therefore, inform them on better handling practices, Atreya (2007) explained that high educational status is not synonymous to an awareness of pesticide good agricultural practices. Their use of pesticides may also be linked to lack of training activities and programmes designed to support their pest management practices. By acknowledging it, capacity building, knowledge drive and ecological responsibility need to be adopted. If farmers can become convinced on benefits of sustainable farming, their reliance on pesticide will be minimized. Stakeholders and policy developers need to create an awareness on ecological responsibility through a participatory approach by engaging farmers on impacts of pesticide dependence in our urban environment. Sustained efforts at training farmers through the strengthening of extension agents as source of correct information would minimize the influence of the suppliers and dealers on farmers' decisions to use pesticides. According to findings of this study, suppliers are found to be biased in their advice even though some evidence also pointed to extension agents being influenced by marketers in the information they provide.

Urban agriculture can promote urban food security and therefore, supporting farmers to reduce their reliance on chemicals will help in ensuring sustainability. According to Pimentel *et al.*, (1997), promoting natural pest regulation may reduce farmers' dependence on pesticides and subsequently, improve their long-term productivity and profit. This will in turn feed into the sustainable development goals of achieving sustainable agriculture whilst still promoting food security. Achieving this will require a sustained effort in farmer education, strengthening agricultural extension services and moving away from the suppliers of pesticides providing (not always unbiased) advice.

The sustainability of African agriculture is critical to the continent's food security and for maintaining agriculture's contribution to Africa's rural communities and national economies. Support for local and regional farming, climate prediction methods, financial aid for development and infrastructure, and a more united aid initiative would lead Sub Saharan Africa towards sustainable and reliable food sources and a more secure future. But more importantly, these solutions would lead to less dependency on foreign food aid and greater reliance on solutions from within Sub Saharan Africa. The establishment of properly functioning economic and political structures would help to lead countries to food security, as well as help to improve the overall wellbeing of the people.

References

Abang AF, Kouame CM, Abang M, Hannah R, Fotso AK (2013). Vegetable growers' perception of pesticide use practices, cost, and health effects in the tropical region of Cameroon. International Journal of Agronomy and Plant Production 4: 873-883

Abrahams, P.W. (2002). Soils: Their Implications to Human Health in the Journal of Science of the Total Environment 291(1-3):1-32 DOI: 10.1016/S0048-9697(01)01102-0 Source: PubMed.

Abtew, A., Niassy, S., Affognon, H., Subramanian, S., Kreiter, S., Garzia, G.T. and Martin, T. (2016). Farmers' knowledge and perception of grain legume pests and their management in the Eastern province of Kenya. Crop Protection, 87, pp.90-97.

Ackerman, Kubi & Culligan, Patricia & Plunz, Richard & Sutto, Maria-Paola & Whittinghill, Leigh. (2014). Sustainable Food Systems for Future Cities: The Potential of Urban Agriculture. The Economic and social review. 45. 189-206.

Adedeji, O.H. and Ademiluyi, I. A (2009). Urban agriculture and urban land use planning: Need for a synthesis in metropolitan Lagos, Nigeria. 2(3), pp. 043- 050, Available online at http://www.academicjournals.org/JGRP ISSN 2070-1845

Adekunle, C.P., Akinbode, S.O., Akerele, D., Oyekale, T.O. and Koyi, O.V. (2017). Effects of agricultural pesticide utilization on farmer's health in Egbeda Local Government Area, Oyo State, Nigeria. Nigerian Journal of Agricultural Economics, 7(2066-2018-1339).

Adelekan, I., Olajide-Taiwo, L., Ayorinde, A., Ajayi, D. and Babajide, S. (2014). Building Urban resilience: Assessing Urban and Peri-urban Agriculture in Ibadan, Nigeria. [Padgham, J. and J. Jabbour (eds.)]. United Nations Environment Programme (UNEP), Nairobi, Kenya.

Adewunmi, A. & Fapohunda, S. (2018). Pesticides and food safety in Africa. European Journal of Biological Research, 8(2), 70-83. Retrieved from http://www.journals.tmkarpinski.com/index.php/ejbr/article/view/44

Adewuyi S, & B, Folorunso & Okojie, Luke & Akerele, D. (2015). Effect of climate change on food crop production and vulnerability assessment in Oyo State. Journal of Economics and International Finance. 7. 18-24. 10.5897/JEIF2013.0516.

Adeyemo, R., Ogunleye, A.S., Kehinde, A.D., and Ayodele, O.A. (2017). Urban Agriculture (UA) and Its Effects on Poverty Alleviation: A Case Study of Vegetable Farming in Ibadan Metropolis, Nigeria. American Journal of Environmental Science and Engineering, 1(3), pp.68-73.

Adeyolanu, O.D., Are, K.S., Adelana, A.O., Oluwatosin, G.A., Denton, O.A., Ande, O.T., Egbetokun, O., Ogunsumi, L. and Adediran, J.A. (2018). Assessing soil quality issues for crop production function based on farmers' perception: An experience from Itapaji Watershed in Southwestern Nigeria. Eurasian Journal of Soil Science, 7(4), pp.337-345.

Agber, T., Iortima, P.I., Imbur, E.N. (2013). Lessons from implementation of Nigeria's past national agricultural programs for the transformation agenda. American Journal of Research Communication, 2013, 1(10): 238-253} www.usa-journals.com, ISSN: 2325-4076.

Aina O. Adeogun, Oju R. Ibor, Sherifat D. Adeduntan, Augustine Arukwe (2016). Intersex and alterations in reproductive development of a cichlid, Tilapia guineensis, from a municipal domestic water supply lake (Eleyele) in Southwestern Nigeria, Science of The Total Environment, Volume 541, 2016, Pages 372-382, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2015.09.061.

Aina, T. A., Etta, F. E., & Obi, C. I. (1994). The Search for Sustainable Urban Development in Metropolitan Lagos, Nigeria: Prospects and Problems. Third World Planning Review, 16(2), 201. doi:10.3828/twpr.16.2.8427914726231775

Ajayeoba, T.A., Atanda, O.O., Obadina, A.O., Bankole, M.O. and Adelowo, O.O. (2016). Food science & nutrition, 4(1), pp.59-66.

Ajayi, O.C. (2000). Pesticide use practices, productivity and farmers' health: the case of cotton–rice systems in Coˆ te d'Ivoire, West Africa. Pesticide Policy Project, No. 3. Hannover.

Akinyemi S.A., Nwankwo S.A. and Fasuyi A.O. (2007). Diatoms as Indicator of Pollution in Awon Reservior, Oyo Town, Nigeria. Research Journal of Microbiology, 2: 228-238.

Aktar, M. W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary toxicology, 2(1), 1–12. doi:10.2478/v10102-009-0001-7

Alam, M.Z., Haque, M., Islam, M., Hossain, E., Hasan, S.B., Hasan, S.B. and Hossain, M., (2016). International Journal of Zoology, 2016.

Aliyu AA, Amadu L. Urbanization, cities, and health (2017). The challenges to Nigeria – A review. Ann Afr Med [serial online] 2017;16:149-58. Available from: http://www.annalsafrmed.org/text.asp?2017/16/4/149/216708

Ameh, M. and Andrew, C., (2017). Socio-Economic Factors Influencing Agricultural Loan Acquisition among Small-Scale Rice Farmers in Benue State, Nigeria.

Angner Erik & Loewenstein George (2012) Behavioral Economics, Editor(s): Uskali Mäki, In Handbook of the Philosophy of Science, Philosophy of Economics, North-Holland, 2012, Pages 641-689, ISBN 9780444516763, https://doi.org/10.1016/B978-0-444-51676-3.50022-1.

(http://www.sciencedirect.com/science/article/pii/B978044451676350 0221).

Ann Chih Lin (1998). Bridging positivist and interpretivist approaches to qualitative methods. Policy Studies Journal, Vol. 26, No. I, 1998, 162-180.

Appeaning-Addo, Kwasi. (2010). Urban and Peri-Urban Agriculture in Developing Countries Studied using Remote Sensing and In Situ Methods. Remote Sensing. 2. 10.3390/rs2020497.

Appleby, P., Shotyk, W. & Fankhauser, A. (1997). Lead-210 Age Dating of Three Peat Cores in the Jura Mountains, Switzerland. Water, Air, & Soil Pollution 100, 223–231. https://doi.org/10.1023/A:1018380922280

Araújo F. G, Morado C. N, Parente T.T.E, Paumgartten F.J.R & Gomes I. D (2018). Biomarkers and bioindicators of the environmental condition using a fish species (Pimelodus maculatus Lacepède, 1803) in a tropical reservoir in Southeastern Brazil. Braz J Biol. 2018; 78(2):351-359 (ISSN: 1678-4375)

Arbeli, Z., & Fuentes, C. L. (2010). Microbial Degradation of Pesticides in Tropical Soils. Soil Biology and Agriculture in the Tropics, 251–274. doi:10.1007/978-3-642-05076-3_12

Archibald M. M. Radil A. I. Zhang X. Hanson W. E. (2015). Current mixed methods practices in qualitative research: A content analysis of leading journals. International Journal of Qualitative Methods, 14(2), 6–33. 10.1177/160940691501400205

Asogwa, E. U., & Dongo, L. N. (2009). Problems associated with pesticide usage and application in Nigerian cocoa production: A review. African Journal of Agricultural Research, 4(8), 675–683.

Atkinson Rowland & Flint John (2001). Accessing Hidden and Hard-to-Reach Populations: Snowball Research Strategies. Issue 33, Social research update (ISSN: 1360-7898), published by Department of Sociology University of Surrey Guildford GU2 5XH United Kingdom. Accessed online at http://sru.soc.surrey.ac.uk/SRU33.PDF

Attah, Nkechinyere V. (2010). "Environmental Sustainability and Sustainable Growth: A Global Outlook" Master of Science in Organizational Dynamics Theses. 34. http://repository.upenn.edu/od_theses_msod/34

Atungwu, J.J., Agbonlahor, M.U., and Aiyelaagbe, I.O., 2018. A community-based farming scheme in Nigeria: enhancing sustainable agriculture. Innovative markets for sustainable agriculture: How innovations in market institutions encourage sustainable agriculture in developing countries, p.57.

AU (2015). Agenda 2063, the Africa we want. African Union, Final edition published in 2015 © African Union Commission ISBN: 978-92-95104-23-5. Last accessed online on 26-04-2021 Agenda 2063: The Africa we want (Popular version) | African Union (au.int)

Ayeloja A.A., George F.O.A., Shorinmade A.Y., Jimoh Adeyemi, Opasola Afolabi, Olaniyi & K.D., Olawepo (2014). Heavy metal concentration in selected fish species from Eleyele reservoir Ibadan Oyo State South-western Nigeria. African Journal of Environmental Science and Technology. 8. 422-427. 10.5897/AJEST2014.1700.

Babatunde Akeem Adesola and Oyekola Martins Adewale (2019). Assessment of Crime and Security in Ido Local Government Area, Oyo State, Southwest Nigeria." IOSR Journal of Humanities and Social Science (IOSRJHSS). vol. 24 no. 03, 2019, pp. 47-69.

Baer E. Tamara, Emily A. Scherer, Eric W. Fleegler & Areej Hassan (2015). Food Insecurity and the Burden of Health-Related Social Problems in an Urban Youth Population, Journal of Adolescent Health, Vol. 57, Issue 6, 2015, Pp 601- 607.

Baharoglu, Deniz and Christine Kessides. (2002). Poverty Reduction Strategies (Vol. 2): Macroeconomic and sectoral approaches [PDF file: Chapter 16]. Retrieved from siteresources.worldbank.org/INTPRS1/Resources/383606 1205334112622/4418_chap16.pdf

Baiphethi M N & Jacobs P T (2009) The contribution of subsistence farming to food security in South Africa, Agrekon, 48:4, 459-482, DOI: 10.1080/03031853.2009.9523836

Balaram, P. (2003). Pesticides in the environment. Current Science 85, 561 –562.

Barrett C.B. (2010). Measuring food insecurity. Science 327:825–28 DOI: 10.1126/science.1182768

Basiago A. D. (1999). Economic, social and environmental sustainability in development theory and urban planning practice The Environmentalist, 19 (1999), pp. 145-161

Basu, N., Ayelo, P.A., Djogbénou, L.S., Kedoté, M., Lawin, H., Tohon, H., Oloruntoba, E.O., Adebisi, N.A., Cazabon, D., Fobil, J. and Robins, T., (2016). Occupational and environmental health risks associated with informal sector activities—Selected case studies from West Africa. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, 26(2), pp.253-270.

Bayleyegn, Andnet, Niassy Saliou, Affognon Hippolyte, Subramanian Sevgan, Kreiter Serge, Tropea Garzia Giovanna & Martin Thibaud. (2016). Farmers' knowledge and perception of grain legume pests and their management in the Eastern province of Kenya. Crop Protection. 87. 90 - 97. 10.1016/j.cropro.2016.04.024.

Beketov, M.A., Foit, K., Biggs, J.P., Sacchi, A., Schäfer, R.B., Schriever, C.A., Liess, M. (2008). Environment Agency, Rio House, Waterside Drive, www.environment-agency.gov.uk

Ben-Eli, M. (2012). The cybernetics of sustainability: definition and underlying principles in J. Murray, G. Cawthorne, C. Dey, C. Andrew (Eds.), Enough for All

Forever: A Handbook for Learning About Sustainability, Common Ground Publishing: University Of Illinois, Champaign, IL (2012) Available at: http://www.sustainabilitylabs.org/files/The_Cybernetics_of_Sustainability%20FF.pd f

Benin, Samuel. (2016). Impacts of CAADP on Africa's agricultural-led development. IFPRI Discussion Paper 1553. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130647

Ben-Iwo, J., Manovic, V. and Longhurst, P., (2016). Biomass resources and biofuels potential for the production of transportation fuels in Nigeria. Renewable and Sustainable Energy Reviews, 63, pp.172-192.

Binns, T. and K Lynch (1998). Feeding Africa's growing cities into the 21st century: the potential of urban agriculture- Journal of international development DOI: 10.1002/(SICI)1099-1328(1998090)10:6<777:AID-JID532>3.0.CO;2-Z

Blake, William H., Ficken, Katherine J., Taylor, Philip, Russell Mark A. & Walling, Desmond E. (2012). Tracing crop-specific sediment sources in agricultural catchments, Geomorphology,Volumes 139–140, 2012, Pages 322-329, ISSN 0169-555X, https://doi.org/10.1016/j.geomorph.2011.10.036.

Bockstaller C., Girardin P., van der Werf H.M.G. (1997). Use of agro-ecological indicators for the evaluation of farming systems, European Journal of Agronomy, Volume 7, Issues 1–3, 1997, Pages 261-270, ISSN 1161-0301, https://doi.org/10.1016/S1161-0301(97)000415.(http://www.sciencedirect.com/science/article/pii/S1161030197000415)

Boyd James and Banzhaf Spencer (2007). What are ecosystem services? The need for standardized environmental accounting units, Ecological Economics, Volume 63, Issues 2–3, 2007, Pages 616-626, https://doi.org/10.1016/j.ecolecon.2007.01.002. (http://www.sciencedirect.com/science/article/pii/S0921800907000341)

Branchet, P., Cadot, E., Fenet, H., Sebag, D., Ngatcha, B.N., Borrell-Estupina, V., Ngoupayou, J.R.N., Kengne, I., Braun, J.J. and Gonzalez, C. (2018). Polar pesticide contamination of an urban and peri-urban tropical watershed affected by agricultural activities (Yaoundé, Center Region, Cameroon). Environmental Science and Pollution Research, 25(18), pp.17690-17715.

Briggs David (2003). Environmental pollution and the global burden of disease. British Medical Bulletin, Volume 68, Issue 1, December 2003, Pages 1–24, https://doi.org/10.1093/bmb/ldg019

Brodt, S., Six, J., Feenstra, G., Ingels, C. & Campbell, D. (2011) Sustainable Agriculture. Nature Education Knowledge 3(10):1

Brooks J. (2016). Food security and Sustainable development goals in OECD Insights accessed online at http://oecdinsights.org/2016/04/06/food-security-and-the-sustainable-development-

Brown, E. (2004). UK Pesticides Residue Committee Report (available online http://www.pesticides.gov.uk/uploadedfiles/Web_Assets/PRC/PRCannualreport2004. pdf

Brown C., Sabine B., Jeremy B., Chris H., Lorraine M., Wendy B., Ryan W. and Marian Y. (2006). Assessing the impact of agricultural pesticides in the environment, Environment Agency, Waterside Drive, England.

Brown, K., Bailkey, M., Meares-Cohen, A., Nasr, J., Smit, J., & Buchanan, T. (2002). Urban agriculture and community food security in the United States: Farming from city center to the urban fringe. Venice: Urban Agriculture Committee of the Community Food Security Coalition.

Brundtland Report. (1987). "Towards Sustainable Development" in Our Common Future, pp 43 - 66. Oxford University Press, Oxford.

Bryld, E. (2003). Agriculture and Human Values 20: 79. https://doi.org/10.1023/A:1022464607153

Burrows L.A. and Edwards C.A. (2002). The use of integrated soil microcosms to predict effects of pesticides on soil Eur. J. Soil Biol., 38, pp. 245-249

Cabannes, Y. (2012). Financing urban agriculture. Environment and Urbanization, 24(2), 665–683. https://doi.org/10.1177/0956247812456126

Caldwell, B. (1994). Beyond Positivism: Economic Methodology in the 20th Century, rev edn London: Routledge.

Floch Carine, Chevremont Anne-Céline, Joanico Karine, Capowiez Yvan & Criquet Stéven, (2011). Indicators of pesticide contamination: Soil enzyme compared to functional diversity of bacterial communities via Biolog® Ecoplates, European Journal of Soil Biology.

Carter, A.D. (2000). How pesticides get into water – and proposed reduction measures. Pesticide Outlook 11(4): 149-157.

Carvalho, F.P., (2017). Pesticides, environment, and food safety. Food and Energy Security, 6(2), pp.48-60.

Cembranel, Adir S., Frigo, Elisandro P., Sampaio, Silvio C., Mercante, Erivelto, Reis, Ralpho R. Dos, & Remor, Marcelo B. (2017). Residue analysis of Organochlorine and Organophosphorus pesticides in urban Lake sediments. Engenharia Agrícola, 37(6), 1254-1267. https://doi.org/10.1590/1809-4430-eng.agric.v37n6p1254-1267/2017

Cerda R, Avelino J, Gary C, Tixier P, Lechevallier E, *et al*. (2017) Primary and Secondary Yield Losses Caused by Pests and Diseases: Assessment and Modeling in Coffee. https://doi.org/10.1371/journal.pone.0169133

Chaplain Véronique, Mamy Laure, Vieublé-Gonod Laure, Mougin Christian, Benoit Pierre, Enrique Barriuso and Sylvie Nélieu (2011). Fate of Pesticides in Soils: Toward a

Integrated Approach of Influential Factors, Pesticides in the Modern World - Risks and Benefits, Dr. Margarita Stoytcheva (Ed.), ISBN: 978-953-307-4580, InTech, Available from: http://www.intechopen.com/books/pesticides-in-the-modern-world-risks- and benefits/fate-of-pesticides-in-soils-toward-an-integrated-approach-of-influential- factors

Chepchirchir, R.T., Macharia, I., Murage, A.W., Midega, C.A. and Khan, Z.R. (2017). Impact assessment of push-pull pest management on incomes, productivity and poverty among smallholder households in Eastern Uganda. Food Security, 9(6), pp.1359-1372.

Citypopulation(2016).https://www.citypopulation.de/php/nigeriaadmin.php?adm2id=NGA031008

Clark Allen L. (2009). Environmental Challenges to Urban Planning: Fringe areas, Ecological Footprints and Climate Change Presented at Key Challenges in the Process of Urbanization in Ho Chi Minh City: Governance, Socio-Economic, and Environmental Issues Workshop 16-18 September 2009 Ho Chi Minh City, Vietnam Accessed https://www.eastwestcenter.org/fileadmin/resources/seminars/Urbanization_Seminar/HCMC_Workshop/Papers_and_Presentations/Allen_Clark___HCMC_Workshop_Final_Paper_formatted_version_.pdf

Clark, M. and Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. Environmental Research Letters, 12(6), p.064016.

Clayton Susan (2007). Domesticated nature: Motivations for gardening and perceptions of environmental impact Journal of Environmental Psychology 27 (2007) 215–224 Department of Psychology, The College of Wooster, 930 College Mall, Wooster, OH 44691, USA Available online 29 June 2007

Clinton, N., Stuhlmacher, M., Miles, A., Uludere, N., Wagner, M., Georgescu, M., Herwig, C., & Gong, P. (2018). A Global Geospatial Ecosystem Services Estimate of Urban Agriculture, Earth's Future, 6, 40–60, https://doi.org/10.1002/ 2017EF000536

Coelho, Fábio Cunha, Coelho, Enilce Maria, & Egerer, Monika. (2018). Local food: benefits and failings due to modern agriculture. Scientia Agricola, 75(1), 84-94. https://doi.org/10.1590/1678-992x-2015-0439

Cohen B. (2006). Urbanisation in developing countries: current trends, future projections, and key challenges for sustainability. Technlogy in society, 28(1-2), 63-80. Doi. 10.1016/j.techsoc.2005.10.005

Cohen, L., & Manion, L. (1994). Research Methods in Education (4th ed.). London: Routledge

Cohen, L., Manion, L., & Morrison, K. (2007). Research methods in education (6th Edition). London: Routledge.

Cohen, M. J., & Garrett, J. L. (2010). The food price crisis and urban food (in) security. Environment and Urbanization, 22(2), 467–482. https://doi.org/10.1177/0956247810380375

Colosio C, Laan GVD, Mandic-Rajicevic S. (2018). Use, misuse, abuse of pesticide in agriculture. Which interventions are needed to promote safety and health of workers? Occupational and Environmental Medicine 2018;75: A473.

Corriols, M., Marin, J., Berroteran, J., Lozano, L. M., & Lundberg, I. (2009). Incidence of acute pesticide poisonings in Nicaragua: a public health concern. Occupational and Environmental Medicine, 66(3), 205–210. doi:10.1136/oem.2008.040840

Costanza, R., d'Arge, R., de Groot, R. *et al*. The value of the world's ecosystem services and natural capital. Nature 387, 253–260 (1997) doi: 10.1038/387253a0

Cousins Ian T., Ng Carla A., Wang Zhanyun and Scheringer Martin (2019). Why is high persistence alone a major cause of concern? Environmental Science: processes and impacts Issue 5, 2019 accessesd online at https://pubs.rsc.org/en/journals/journal/em

Cozens, P. M (2002). Sustainable Urban Development and Crime Prevention Through Environmental Design for the British City. Towards an Effective Urban Environmentalism for the 21st Century, Cities, Volume 19, Issue 2, 2002, Pages 129-137, ISSN 0264-2751, https://doi.org/10.1016/S0264-2751(02)00008-2.

Crossan, F. (2003). Research philosophy: Towards an understanding. Nurse Researcher, 11(1), 46-55. Accessed online at http://journals.rcni.com/doi/pdfplus/10.7748/nr2003.10.11.1.45.c5914

Crotty, M. (1998). The foundations of social research, London: Sage, Introduction pp.1-17

Cumming, G., Buerkert, A., Hoffmann, E. et al. (2014). Implications of agricultural transitions and urbanization for ecosystem services. Nature 515, 50-57 (2014) doi:10.1038/nature13945

Damalas Christos A., Telidis Georgios K. & Thanos Stavros D. (2007). Assessing farmers' practices on disposal of pesticide waste after use, Science of The Total Environment, Volume 390, Issues 2–3, 2008, Pages 341-345, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2007.10.028.

Damalas, Christos. (2009). Understanding benefits and risks of pesticide use. Scientific research and essays. 4. 945-949.

Damalas C. A & Eleftherohorinos I.G. (2011). Pesticide exposure, safety issues, and risk assessment indicators Int J Environ Res Public Health, 8 (2011), pp. 1402-1419

Damalas Christos A & Koutroubas Spyridon D. (2018). Farmers' behaviour in pesticide use: A key concept for improving environmental safety, Current Opinion in Environmental

Science & Health, Volume 4 2018, Pages 27-30, ISSN 2468-5844, https://doi.org/10.1016/j.coesh.2018.07.001.

Daniel F., Simon S., Ondo J. A., Mfopou M. Y. C., Nguefack J., Njomgang R., Ngueguim M. and Feujio T. P. (2013). Impacts of land use on soil microbial biomass and soil organic status in Western Cameroon Journal of Biology, Agriculture and Healthcare Vol.3, No.1

Danso, George & Cofie, Olufunke & Annang, L. & Obuobie, Emmanuel & Keraita, Bernard. (2003). Gender and urban agriculture: the case of Accra, Ghana.

Darkoh, Michael.B. & Rwomire Apollo (2018). Human impact on the environment and sustainable development in Africa. Routledge.

de Bon Hubert, Huat Joël, Parrot Laurent, Sinzogan Antonio, Thibaud Martin, Malézieux Eric, Vayssières Jean-François (2014). A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2014, 34 (4), pp.723-736. ff10.1007/s13593-014- 0216-7ff. ffhal-01234836

de Bon Hubert, Huat Joël, Parrot Laurent, Sinzogan Antonio, Thibaud Martin, Malézieux Eric, Vayssières Jean-François (2014) Pesticide risks from fruit and vegetable pest management by small farmers in sub-Saharan Africa. A review. ff10.1007/s13593-014-0216-7ff. ffhal- 01234836

De Bon, H., Parrot, L. & Moustier, P. (2010)/Sustainable urban agriculture in developing countries. Agron. Sustain. Dev. 30, 21–32 (2010) doi:10.1051/agro:2008062

de Groot, R. S. (1987). Environmental functions as a unifying concept for ecology and economics. Environmentalist 7, 105-109 (1987).

De Zeeuw, H. (2004). The development of Urban Agriculture. Some lessons learnt. Urban Agriculture, Agro-Tourism and City Region Development, 20.

Deelstra, T.; Girardet, H. (2000). Urban agriculture and sustainable cities. In Growing Cities, Growing Food: Urban Agriculture on the Policy Agenda; Bakker, N., Dubbeling, M., Gundel, S., Sabel-Koschela, U., de Zeeuw, H., Eds.; Deutsche Stiftung fur Internationale Entwicklung (DSE): Feldafing, Germany, 2000; pp. 43– 65.

Della Porta, D. and Keating, M. (2008). in Donatella della Porta and Michael Keating (eds), Approaches and Methodologies in the Social Sciences. A Pluralist Perspective, Cambridge: Cambridge University Press, 2008. ISBN-13: 9780521709668 e-book 384 pp.

Dick, R. P. (1994). Soil enzyme activities as indicators of soil quality in Defining Soil Quality for a Sustainable Environment in Doran et al., 1994 (Eds.), Soil Science Society of America, Madison (1994), pp. 107-124

Diesendorf, Mark. (2001). Models of sustainability and sustainable development. International Journal of Agricultural Resources, Governance and Ecology. 1. 109-123. 10.1504/IJARGE.2001.000007.

Dixit, S. S., Smol, J. P., Kingston, J. C., & Charles, D. F. (1992). ES&T Diatoms: Powerful Indicators of Environmental Change. Environmental Science and Technology, 26(1), 22–33. https://doi.org/10.1021/es00025a002

Djouaka, R.J., Atoyebi, S.M., Tchigossou, G.M., Riveron, J.M., Irving, H., Akoton, R., Kusimo, M.O., Bakare, A.A. and Wondji, C.S., 2016. Evidence of a multiple insecticide resistance in the malaria vector Anopheles funestus in South West Nigeria. Malaria journal, 15(1), p.565. DOI: 10.3923/jm.2007.228.238

Djurfeldt, A. A. (2015). Urbanization and linkages to smallholder farming in sub-Saharan Africa: Implications for food security. Global Food Security, 4, 1-7. https://doi.org/10.1016/j.gfs.2014.08.002

do Paço, A. and Raposo, M. (2009), "“Green” segmentation: an application to the Portuguese consumer market", Marketing Intelligence & Planning, Vol. 27 No. 3, pp. 364-379. https://doi.org/10.1108/02634500910955245

Edwards, Clive A. (2002). Assessing the effects of environmental pollutants on soil organisms, communities, processes and ecosystems, European Journal of Soil Biology, Volume 38, Issues 3–4, 2002, Pages 225-231, ISSN 1164-5563, https://doi.org/10.1016/S1164-5563(02)01150-0.

Edwards Clive A. and Wali, Mohan K. (1993). The global need for sustainability in agriculture and natural resources, in C.A. Edwards, M.K. Wali, D.J. Horn, F. Miller, 1993 Agriculture and the Environment, Elsevier, 1993, Page iii, ISBN 9780444898005, https://doi.org/10.1016/B978-0-444-89800- 5.50001-4

Enete Anselm A and Achike Anthonia I. (2008). Urban Agriculture and Urban Food Insecurity/Poverty in Nigeria: The Case of Ohafia, South-East Nigeria Outlook on Agriculture, Volume: 37 issue: 2, page(s): 131-134 https://doi.org/10.5367/000000008784648915

McGranahan Gordon and Satterthwaite David. (2014). Urbanisation concepts and trends. IIED Working Paper. Retrieved from https://pubs.iied.org/pdfs/10709IIED.pdf

Doran et al. (Eds.), Defining Soil Quality for a Sustainable Environment, Soil Science Society of America, Madison (1994), pp. 107-124

Drogui, P., & Lafrance, P. (2012). Pesticides and Sustainable Agriculture. Farming for Food and Water Security, 23–55. doi:10.1007/978-94-007-4500-1_2

Dunleavy, P. (2003). Authoring a PhD, Basingstoke: Palgrave MacMillan, Chapter 3: Planning an integrated thesis: the macro-structure pp.43-75

Ecobichon, D.J. (2001) Pesticide Use in Developing Countries. Toxicology, 160, 27-33.

ECHA(2012).https://eurlex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:02012R0649-20200901

EEA,2015:https://www.eea.europa.eu/downloads/4b43f90302684e02a0ca70f7c920aa3a/1479205839/natural-capital-and-ecosystem-services.pdf accessed on 09/12/2019 at http://markdiesendorf.com/wp-content/uploads/2015/09/CorpSust2000.pdf

Egendorf, S.P., Cheng, Z., Deeb, M., Flores, V., Paltseva, A., Walsh, D., Groffman, P. and Mielke, H.W. (2018). Constructed soils for mitigating lead (Pb) exposure and promoting urban community gardening: The New York City Clean Soil Bank pilot study. Landscape and Urban Planning, 175, pp.184-194.

Ekeleme, I.Y. Dugje, F. Ekeleme, A.Y. Kamara, L.O. Omoigui, A. Tegbaru, I.A. Teli, and J.E. Onyibe. (2008). Guide to safe and effective use of pesticides for crop production in Borno State, Nigeria. 23pp.

Engstrom, R., Ofiesh, C., Rain, D., Jewell, H., & Weeks, J. (2013). Defining Neighborhood Boundaries for Urban Health Research in Developing Countries: A Case Study of Accra, Ghana. Journal of maps, 9(1), 36–42. doi:10.1080/17445647.2013.765366

Fall, S. and H. de Zeeuw (2001). Appropriate Methods for Technology Development. UA Magazine. Dec. No. 5 p.33-35. RUAF. Leusden.

FAO (1999). Urban and Peri-Urban Agriculture. Report to the FAO Comm. Agric. (Coag) Meet. from Jan. 25–26. FAO, Rome.

FAO (2007). Report by Van Veenhuizen Profitability and sustainability of urban and peri-urban agriculture in agricultural management, marketing and finance occasional paper 19 accessed http://www.fao.org/3/a-a1471e.pdf

Fahy, Frances & Rau, Henrike. (2013). Methods of Sustainability Research in the Social Sciences. SAGE, London (2013), pp. 193-208

Fenoll, J., Ruiz, E., Flores, P., Hellín, P., & Navarro, S. (2011). Reduction of the movement and persistence of pesticides in soil through common agronomic practices. Chemosphere, 85(8), 1375–1382. doi: 10.1016/j.chemosphere.2011.07.063

Fenner Kathrin, Canonica Silvio, Wackett Lawrence P., & Martin Elsner (2013). Evaluating pesticide degradation in the environment: blind spots and emerging opportunities. Science 2013 Aug 16; 341(6147):752-758. doi: 10.1126/science.1236281.

FEPA (1991). Guidelines and Standards for Environment Pollution Control in Nigeria. Federal environmental protection agency, Federal Republic of Nigeria.

FMARD (Federal Ministry of Agriculture and Rural Development) (2016). The Agriculture Promotion Policy (2016–2020): the building on the successes of the ATA, closing key gaps policy, and strategy document. Abuja FCT, Nigeria. pp 26–47. Retrieved May 2018, from http://fscluster.org/sites/default/files/documents/2016-nigeria-agric-sector-policy- roadmap_june-15-2016_final1.pdf Food Policy, Volume 28, Issue 3, 2003, Pages 221-235, ISSN 0306-9192,

Fox, S., Bloch, R., & Monroy, J. (2018). Understanding the dynamics of Nigeria's urban transition: A refutation of the 'stalled urbanisation' hypothesis. Urban Studies, 55(5), 947-964. https://doi.org/10.1177/0042098017712688

Foy, G. Environmental Management (1990). 14: 771. https://doi.org/10.1007/BF02394171

Francis Robert A, Chadwick Michael A. (2013). Understanding the Human Environment in Urban Ecosystems https://doi.org/10.4324/9780203133644

Gaber, S., Abdel-Latif, S.H. Effect of education and health locus of control on safe use of pesticides: a cross sectional random study. J Occup Med Toxicol 7, 3 (2012). https://doi.org/10.1186/1745-6673-7-3

Gavrilescu, M. (2005). Fate of Pesticides in the Environment and its Bioremediation. Engineering in Life Sciences, 5(6), 497–526.

Gbeddy G, Glover E, Doyi I, Frimpong S, Doamekpor L (2015). Assessment of Organochlorine Pesticides in Water, Sediment, African Cat fish and Nile tilapia, Consumer Exposure and Human Health Implications, Volta Lake, Ghana. J Environ Anal Toxicol 5: 297. doi:10.4172/2161-0525.1000297

Geiger Flavia, Jan Bengtsson, Frank Berendse, Wolfgang W. Weisser, Mark Emmerson, Manuel B. Morales, Piotr Ceryngier, Jaan Liira, Teja Tscharntke, Camilla Winqvist, Sönke Eggers, Riccardo Bommarco, Tomas Pärt, Vincent Bretagnolle, Manuel Plantegenest, Lars W. Clement, Christopher Dennis, Catherine Palmer, Juan J. Oñate, Irene Guerrero, Violetta Hawro, Tsipe Aavik, Carsten Thies, Andreas Flohre, Sebastian Hänke, Christina Fischer, Paul W. Goedhart, Pablo Inchausti (2010). Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland, Basic and Applied Ecology, Volume 11, Issue 2, 2010, Pages 97-105, ISSN 1439-1791, https://doi.org/10.1016/j.baae.2009.12.001.

Gill Harsimran Kaur and Garg Harsh (2014). Pesticides: Environmental Impacts and Management Strategies, Pesticides - Toxic Aspects, Marcelo L. Larramendy and Sonia Soloneski, IntechOpen, DOI: 10.5772/57399. Available from: https://www.intechopen.com/books/pesticides-toxic-aspects/pesticides-environmental-impacts-and-management-strategies

Golay Christophe, (2010). The Food Crisis and Food Security: Towards a New World Food Order? International Development Policy | Revue internationale de politique de développement [Online], 1 | 2010, Online since 11 March 2010, accessed on 07 January 2020. URL: http://journals.openedition.org/poldev/145; DOI: 10.4000/poldev.145

Golding RM and Giles LGF. The Globe and the Human Being, The International Journal of Environmental, Cultural, Economic and Social Sustainability 2009; 5(1): 301-311

Goldsmith Peter D., Gunjal Kisan & Ndarishikanye Barnabé (2004) Rural–urban migration and agricultural productivity: the case of Senegal, Agricultural Economics, Volume 31, Issue 1, Pp 33-45, ISSN 0169-5150, https://doi.org/10.1016/j.agecon.2003.01.002.(http://www.sciencedirect.com/science/article/pii/S016951500400043X)

Goyol, S., Pathirage, C. and Kulatunga, U. (2017). September. Climate change risk on infrastructure and policy implications of appropriate mitigation measures in the Nigerian agricultural sector. In 13th International Postgraduate Research Conference (IPGRC): conference proceedings (pp. 786-797). University of Salford.

Gockowski James, Mbazo'o Julie, Mbah Glory & Moulende Fouda Terese (2003). African traditional leafy vegetables and the urban and peri-urban poor, Food Policy, Volume 28, Issue 3, 2003, Pages 221-235, ISSN 0306-9192, https://doi.org/10.1016/S0306-9192(03)00029-0.

Graziosi, I., Dung, N.T., Buamas, C., Wongtiem, P. and Wyckhuys, K.A. (2017). 21 Integrated Pest Management of Cassava Crops in South-east Asia.

Grix, J. (2004). The foundations of research. Basingstoke: Palgrave Macmillan. [eBook] File Growth projection 2018 accessed at https://data.worldbank.org/indicator/SP.POP.GROW

Güendel, S. (2002). Peri-Urban and Urban Livestock Keeping in East Africa – A Coping Strategy for the Poor? Aylesford, UK: NR International.

Hallett Steve, Hoagland Lori, & Toner, Emily. (2016). Urban Agriculture: Environmental, Economic, and Social Perspectives. 10.1002/9781119281269.ch2.

Hammersley, M. & Atkinson, P. (2007). Ethnography: principles in practice, 3rd ed. London:

Hammersley, M. (2012). Methodological Paradigms in Educational Research. Retrieved from http://www.bera.ac.uk/resources/methodological-paradigms-educational-research

Hari, Sharma and Prabhakar, (2014). https://doi.org/10.1016/B978-0-12-398529-3.00003-8

Harrington, A. (2005). Modern social theory, Oxford: Oxford University Press, Introduction,

Hart, C. (2001). Doing a literature search, London: Sage, Chapter 1: The purpose of searching the literature, pp. 2-21

Henderson J. Vernon (2003) Urbanization and economic development Annals of Economics and finance 4, 275-341

Hladik, Michelle & Main, Anson & Goulson, Dave. (2018). Environmental Risks and Challenges Associated with Neonicotinoid Insecticides. Environmental Science & Technology. 52. 10.1021/acs.est.7b06388.

Hou, J, Johnson, J M, Lawson, LJ (2009). Greening Cities, Growing Communities: Learning from Seattle's Urban Community Gardens. Seattle, WA: University of Washington Press.

Houbraken, M., Bauweraerts, I., Fevery, D., Van Labeke, M.-C., & Spanoghe, P. (2016). Pesticide knowledge and practice among horticultural workers in the Lâm Đồng region, Vietnam: a case study of chrysanthemum and strawberries. Science of The Total Environment, 550, 1001–1109.https://doi.org/10.1016/j.scitotenv.2016.01.183.

Hsin, R. (1996). Guidelines and Principles of Sustainable Community Design. A study of sustainable design and planning strategies in North America from and urban design perspective. Masters' thesis submitted to the Faculty of the School of Architecture at Florida Agricultural and Mechanical University. http:///\sustanable.state.fl.us/fdi/edesign/news/9607/thesis.htm

Ibeawuchi II, Okoli NA, Alagba RA, Ofor MO, Emma-Okafor LC, Peter-Onoh CA, Obiefuna JC (2015). Fruit and vegetable crop production in Nigeria: the gains, challenges and the way forward. J Biol Agric & Healthcare 5:194–208

Ibitayo, O. O. (2006). Egyptian Farmers' Attitudes and Behaviors Regarding Agricultural Pesticides: Implications for Pesticide Risk Communication. Risk Analysis, 26(4), 989–995. doi:10.1111/j.1539-6924.2006. 00794.x

Ifeanyichukwu, U.S., Ike, E.C., Eluwa Akubuike, N. and Felix, E., (2018). Analysis of Technical Inefficiency in Rice Production among Farmers in Ezza South LGA of Ebonyi State of Nigeria (Application of Stochastic Frontier Production).

IIED, 2013 https://pubs.iied.org/pdfs/17149IIED.pdf

ILOSTAT (2019).https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=ZG&name_desc=f alse

Implementation of the SDGs: A National Voluntary Review June (2017). Retrieved from https://sustainabledevelopment.un.org/content/documents/16029Nigeria.pdf June 2017 on 18th Dec., 2019

Issaka, S., Jean, O., Urbain, S.D., Bismarck, N.H. and Antoine, S.N. (2018). Characteristics and typologies of production units in urban agriculture in area of Bobo-Dioulasso (Burkina Faso), Int. J. Pure App. Biosci.6(1): 16-24 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6202

IWMI Report (2007). Urban and Peri-urban Agriculture in Ibadan: Characteristics, challenges Jacob Susan and Resmi. G. (2014). Analysis of Persistent Pesticide Residue in the Water Samples of Idukki District, the Indian Cardamom Hills, International journal of engineering research & technology (IJERT) Volume 03, Issue 07 (July 2014)

Jallow, M. F., Awadh, D. G., Albaho, M. S., Devi, V. Y., & Thomas, B. M. (2017). Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey. International journal of environmental research and public health, 14(4), 340. https://doi.org/10.3390/ijerph14040340

Jansch, S., Frampton, G.K., Ro¨ mbke, J., Van den Brink, P.J. and Scott-Fordsmand, J.J. (2006). Effects of pesticides on soil invertebrates in model ecosystem and field studies: a review and comparison with laboratory toxicity data. Environmental Toxicology and Chemistry 25: 2490–2501.

Jayaraj, R., Megha, P., & Sreedev, P. (2016). Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment. Interdisciplinary toxicology, 9(3-4), 90–100. doi:10.1515/intox-2016-0012

Jepson, P. C., Guzy, M., Blaustein, K., Sow, M., Sarr, M., Mineau, P., & Kegley, S. (2014). Measuring pesticide ecological and health risks in West African agriculture to establish an enabling environment for sustainable intensification. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 369(1639), 20130491. doi:10.1098/rstb.2013.0491

Jibir, A., Abdu, M. and Isah, A., (2016). Environmental and Sustainable Agricultural Development in Nigeria: Matters Arising and the Way Forward. Indian Journal of Sustainable Development, 2(2).

Jim, C.Y. (2013). Sustainable urban greening strategies for compact cities in developing and developed economies in Urban Ecosystem Journal 2013 16: 741. https://doi.org/10.1007/s11252-012-0268-x

Jirtle, R. & Skinner, M. (2007). Environmental epigenomics and disease susceptibility. Nat Rev Genet 8, 253–262 (2007). https://doi.org/10.1038/nrg2045

Johnson, R. B. (2014). Mixed methods research design and analysis with validity: A primer. Department of Professional Studies, University of South Alabama, USA.

Johnson, R. B., & Onwuegbuzie, A. J. (2012). Mixed Methods Research: A Research Paradigm Whose Time Has Come. JSTOR, 33(7), 14-26

Joko Mariyono, Apri Kuntariningsih &Tom Kompas, (2018). "Pesticide use in Indonesian vegetable farming and its determinants", Management of Environmental Quality: An International Journal, Vol. 29 Issue: 2, pp.305-323, https://doi.org/10.1108/MEQ-12-2016-0088

Kah Mélanie & Brown Colin D. (2007). Behaviour of ionisable pesticides in soils. Earth Sciences. The University of York. HAL Id: tel-00185485 https://tel.archives-ouvertes.fr/tel-00185485

Karunamoorthi, K., Mohammed, M., & Wassie, F. (2012). Knowledge and Practices of Farmers with Reference to Pesticide Management: Implications on Human Health. Archives of Environmental & Occupational Health, 67(2), 109–116. doi:10.1080/19338244.2011.598891

Kassam, A., Derpsch, R., and Friedrich, T. (2017). Overview of the global spread of conservation agriculture. In Sustainable Development of Organic Agriculture (pp. 75-90). Apple Academic Press.

Kerle E.A., Jenkins J.J., and Vogue P.A. (2007) Understanding pesticide persistence and mobility for groundwater and surface water protection http://croptechnology.unl.edu/Image/Robles%20VazquezWilfredo1129928587/EFATE_general.pdf

Kim Jong-Hun & Smith Alistair. (2001). Distribution of organochlorine pesticides in soils from South Korea, Chemosphere, Volume 43, Issue 2, Pages 137-140, ISSN 0045-6535, https://doi.org/10.1016/S0045-6535(00)00281-2.

King, N. & Horrocks, C. (2010). Interviews in qualitative research, London: Sage

Konstantinou S. K., Hela Dimitra G. & Albanis A. Triantafyllos (2006). The status of pesticide pollution in surface waters (rivers and lakes) of Greece. Part I. Review on occurrence and levels, Environmental Pollution, Volume 141, Issue 3, 2006, Pages 555-570, ISSN

0269-7491, https://doi.org/10.1016/j.envpol.2005.07.024.

Kosnik, M.A., Hua, Q., Kaufman, D.S., Darrell S. Kaufman & Atun Zawadzki (2015). Sediment accumulation, stratigraphic order, and the extent of time-averaging in lagoonal sediments: a comparison of 210Pb and 14C/amino acid racemization chronologies. Coral Reefs 34, 215–229 (2015). https://doi.org/10.1007/s00338-014-1234-2

Kutiwa, S., Boon, E., & Devuyst, D. (2010). Urban Agriculture in Low Income Households of Harare: An Adaptive Response to Economic Crisis. doi:10.1080/09709274.2010.11906325

LaCroix, C. (2014). Urban Agriculture and the Environment. The Urban Lawyer, 46(2), 227-248. Retrieved from www.jstor.org/stable/24392805

Lagerkvist Carl Johan (2012). Measuring farmers' preferences for risk: a domain-specific risk preference scale, Journal of Risk Research, 15:7, 737-753, DOI: 10.1080/13669877.2012.657217

Lagerkvist Carl Johan, Sebastian Hess, Julius Okello & Nancy Karanja (2012): Consumer Willingness to Pay for Safer Vegetables in Urban Markets of a Developing Country: The Case of Kale in Nairobi, Kenya, The Journal of Development Studies, DOI:10.1080/00220388.2012.724165

Lal, R., (2015). A system approach to conservation agriculture. Journal of Soil and Water Conservation, 70(4), pp.82A-88A.

Layder, D. (1998). Sociological practice, London: Sage.

Lechenet M, Bretagnolle V, Bockstaller C, Boissinot F, Petit M-S, Petit S, et al. (2014). Reconciling Pesticide Reduction with Economic and Environmental Sustainability in Arable Farming. PLoS ONE 9(6):e97922. https://doi.org/10.1371/journal.pone.0097922

Lechenet, M., Dessaint, F., Py, G., Makowski, D. and Munier-Jolain, N. (2017). Reducing pesticide use while preserving crop productivity and profitability on arable farms. Nature Plants, 3(3), p.17008.

Lee-Smith, D., & Lamba, D. (2015). Nutrition and Urban Agriculture in Sub-Saharan African Cities. Watch Article 7. Available at https://www.righttofoodandnutrition.org/files/Watch_2015_Article_7_eng_Nutrition%20and%20Urban%20Agriculture%20in%20Sub-Saharan%20African%20Cities.pdf. Accessed 1 July 2019.

Lehman, H., Clark, E.A. & Weise, S.F. (1993). Clarifying the definition of Sustainable agriculture. J. of Agric. Environ Ethics 6, 127–143 https://doi.org/10.1007/BF01965480

Lehotay, S. J., & Cook, J. M. (2015). Sampling and Sample Processing in Pesticide Residue Analysis. Journal of Agricultural and Food Chemistry, 63(18), 4395–4404. doi:10.1021/jf5056985

Lekei, E.E., Ngowi, A.V. & London, L. (2014). Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. BMC Public Health 14, 389 (2014) doi:10.1186/1471-2458-14-389

Leon A David (2008). Cities, urbanization and health, International Journal of Epidemiology, Volume 37, Issue 1, February 2008, Pages 4–8, https://doi.org/10.1093/ije/dym271

Lester, D. (1990). Maslow's hierarchy of needs and personality. Personality and Individual Differences, 11, 1187–1188.

Liew, Anthony. (2007). Understanding Data, Information, Knowledge and Their Inter-Relationships. Journal of Knowledge Management Practice. Vol. 7.

Liu, F., & Zhang, H. (2013). Novel methods to assess environmental, economic, and social sustainability of main agricultural regions in China. Agronomy for Sustainable Development, 33(3), 621–633. doi:10.1007/s13593-012-0131-8

Liu, P, Koroma, S., Arias, P., Hallam, D. (2013). Trends and impacts of foreign investment in developing country agriculture: evidence from case studies pp xxxv+342pp Local government profiles https://oyostate.gov.ng/oluyole-local-government/#1503060887939-20bea9f5-1dd28198-3909

Lovell, S.T. (2010). Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States. Sustainability 2010, 2, 2499-2522.

Lynch, K., Binns, T., & Olofin, E. (2001). Urban agriculture under threat. Cities, 18(3), 159–171. http://doi.org/10.1016/S0264-2751(01)00008-7 Malden: Blackwell. p. 624. ISBN 0-631-21305-8.

MacRae, R.J.; Hill, S.B.; Henning, J.; Mehuys, G.R. Agricultural Science and Sustainable Agriculture: A Review of the Existing Scientific Barriers to Sustainable Food Production and Potential Solutions. Biol. Agric. Hortic. 1989, 6, 173–219.

Mahmood I., Imadi S.R., Shazadi K., Gul A., Hakeem K.R. (2016). Effects of Pesticides on Environment. In: Hakeem K., Akhtar M., Abdullah S. (eds) Plant, Soil and Microbes. Springer, Cham10.1007/978-3-319-27455-3_13.

Manyong, V.M.; Maeda, C.; Kanju, E.; Legg, J.P. (2012). Economic damages of cassava brown streak disease in sub-Saharan Africa: a framework. In 11th Triennial Symposium of the ISTRC-AB; International Society for Tropical Root Crops-Africa Branch: Kinshasa, DR Congo, 2012; pp. 78–82.

Marcel, R., Berthon, V., Castets, V., Rimet, F., Thiers, A., Labat, F., & Fontan, B. (2017). Modelling diatom life forms and ecological guilds for river biomonitoring. Knowledge

& Management of Aquatic Ecosystems, (418), 1. https://doi.org/10.1051/kmae/2016033

Martellozzo, F, Landry, J-S, Plouffe, D, Seufert, V, Rowhani, P and Ramankutty, N (2014). Urban agriculture: a global analysis of the space constraint to meet urban vegetable demand. Environmental Research Letters, 9 (6). ISSN 1748-9326

Mattah, M. M., Mattah, P. A. D., & Futagbi, G. (2015). Pesticide Application among Farmers in the Catchment of Ashaiman Irrigation Scheme of Ghana: Health Implications. Journal of Environmental and Public Health, 2015, 1–7. doi:10.1155/2015/547272

Mbagwu, I., & Ita, E. (1994). Pesticide Use in the Sub-Humid Zones of Nigeria: Implications for Conservation of Aquatic Resources. Environmental Conservation, 21(3), 214-219. doi:10.1017/S0376892900033178

McKenzie, S. (2004). Social Sustainability: towards Some Definitions, Hawke Research Institute, Working Paper Series No. 27 University of South Australia

McNamee M. (2005). Positivism Popper and Paradigms: an introductory essay in the philosophy of science. In McNamee M. (Ed.) Philosophy and the Sciences of Exercise Health and Sport (pp. 1-19). London: Routledge.

Mengistie, B.T., Mol, A.P.J. & Oosterveer, P. (2017). Pesticide use practices among smallholder vegetable farmers in Ethiopian Central Rift Valley. Environ Dev Sustain 19, 301–324 https://doi.org/10.1007/s10668-015-9728-9

Millennium Ecosystem Assessment (2005). Millennium Ecosystem Assessment Ecosystems and Human Well-Being: Synthesis Island Press, Washington, DC (2005) Google Scholar

Mok, Hoi-Fei, Williamson Virginia, Grove James, Burry Kristal, Barker Sarah & Hamilton, Andrew. (2013). Strawberry Fields Forever? Urban Agriculture in Developed

Countries: A Review. Agronomy for Sustainable Development. 34. 10.1007/s13593-013-0156-7.

Morelli, John (2011). "Environmental Sustainability: A Definition for Environmental Professionals,"Journal of Environmental Sustainability: Vol. 1: Iss. 1, Article 2. DOI: 10.14448/jes.01.0002 Available at:http://scholarworks.rit.edu/jes/vol1/iss1/2

Mougeot, L.J.A. Growing Better Cities: Urban Agriculture for Sustainable Development; International Development Research Centre: Ottawa, ON, Canada, 2006; p. 97

Mougeot, L.J.A., "The Hidden Significance of Urban Agriculture" (brief 6) in: Garrett, J.L. and Ruel, M.T., Achieving Urban Food and Nutrition Security in the Developing World, Focus 3, IFPRI, Washington, August 2000.

Mullins, D.E., Johnsen, R.E., Starr, R.I. (1971). Pesticide Monitoring Journal 5: 268-275. Munda, Giuseppe & Saisana, Michaela. (2011). Methodological Considerations on Regional Sustainability Assessment Based on Multicriteria and Sensitivity Analysis. Regional seghezzStudies. 45. 261-276. 10.1080/00343401003713316.

Murgante, B., & Danese, M. (2011). Urban Versus Rural: The Decrease of Agricultural Areas and the Development of Urban Zones Analyzed with Spatial Statistics. International Journal of Agricultural and Environmental Information Systems (IJAEIS), 2(2), 16-28. doi:10.4018/jaeis.2011070102

Mwanja, M., Jacobs, C., Mbewe, A.R. and Nosiku Sipilanyambe Munyinda (2017). Food Contamination 4: 11(2017). https://doi.org/10.1186/s40550-017-0056-8

Ndimele, P. E., Akanni, A., Shittu, J. A., Ewenla, L. O., & Ige, O. E. (2018). Trade-off Analyses of Ecosystem Services in Nigerian Waters. The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem, 229–256. doi:10.1016/b978-0-12-809399-3.00016-1

Nickols, F. W. (2000). The knowledge in knowledge management. In Cortada, J.W. & Woods, J.A. (Eds) The knowledge management yearbook 2000-2001 (pp. 12-21). Boston, MA: Butterworth-Heinemann.

Ngome, I. & Foeken, D. (2012). “My garden is a great help”: gender and urban gardening in Buea, Cameroon. GeoJournal 77, 103–118 (2012). https://doi.org/10.1007/s10708-010-9389-z

Nguyen Cao Thanh & Tran Thi Le Thanh (2015). The Interconnection Between Interpretivist Paradigm and Qualitative Methods in Education. American Journal of Educational Science Vol. 1, No. 2, 2015, pp. 24-27 http://www.aiscience.org/journal/ajes

Nkamleu and Adesina (2000). Determinants of chemical input use in peri-urban lowland systems: bivariate probit analysis in Cameroon https://doi.org/10.1016/S0308-521X(99)00074-8

NRC (1999). Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials. National Research Council (US) Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials. Washington (DC): National Academies Press (US); 1999. 2, Natural Radioactivity and Radiation. Available from https://www.ncbi.nlm.nih.gov/books/NBK230654/

Ntow, W. J. (2005). Pesticide residues in Volta Lake, Ghana. Lakes and Reservoirs: Research and Management, 10(4), 243–248. doi:10.1111/j.1440-1770.2005. 00278.x

Ntow William J., Gijzen Huub J., Kelderman Peter and Drechsel Pay (2006). Farmer perceptions and pesticide use practices in vegetable production in Ghana First published: 10 March 2006 https://doi.org/10.1002/ps.1178

Nur Ahmed, Jan-Eric Englund, Inger Åhman, Mats Lieberg, Eva Johansson (2011). Perception of pesticide use by farmers and neighbors in two periurban areas, Science of The Total Environment, Volumes 412–413, 2011, Pages 77-86, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2011.10.022.(http://www.sciencedirect.com/science/article/pii/S0048969711012149)

Obayelu, O.A., Obayelu, A.E. and Usman, Z.A. (2016). Irrigation Technology and Technical and Resource-Use Efficiencies in Smallholder Urban Vegetable Farming. International journal of vegetable science, 22(1), pp.91-100.

Oberndorfer, E., Lundholm, J., & Bass, B. (2007). Green roofs as urban ecosystems: Ecological structures, functions, and services. BioScience, 57, 823–833. https://doi.org/10.1641/B571005

Obialor, C & Okeke, O & Onunkwo, A & Fagorite, Victor. (2019). Reservoir Sedimentation: Causes, Effects and Mitigation. 2488-9849. Accessed from https://www.researchgate.net/publication/337254018_RESERVOIR_SEDIMENTATION_CAUSES_EFFECTS_AND_MITIGATION/citation/download

Ochoa, V. and Maestroni, B. (2018). Pesticides in water, soil and sediments. In: Integrated Analytical Approaches for Pesticide Management, Maestroni, B and Cannavan, A. (Eds.). Academic Press, London, UK, pp 133-145.

Odewumi, S.G., Awoyemi, O.K., Iwara, A.I. and Ogundele, F.O. (2013). Farmer's perception on the effect of climate change and variation on urban agriculture in Ibadan Metropolis, South-western Nigeria. Journal of Geography and Regional Planning, 6(6), p.209.

Odoemelam, L.E. and Ajuka, P.N. (2015). Indigenous farm management practices among rural farmers: Implications for a sustainable environment in South-East agro-ecological zone, Nigeria. Discourse Journal of Agriculture and Food Sciences, 3(1), pp.7-14.

Oerke, E. (2006). Crop losses to pests. The Journal of Agricultural Science, 144(1), 31-43. doi:10.1017/S0021859605005708 Pesticides as water pollutants: Fao.org/3/w2598e/w2598e07.htm

Oesterlund, A. H., Thomsen, J. F., Sekimpi, D. K., Maziina, J., Racheal, A., & Jørs, E. (2014). Pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda: a cross-sectional study. African health sciences, 14(2), 420–433. doi:10.4314/ahs. v14i2.19

Ofem Beulah I. (2012). A Review of the Criteria for Defining Urban Areas in Nigeria, Journal of Human Ecology, 37:3, 167-171, DOI: 10.1080/09709274.2012.11906461

Ojo Joshua (2016). Pesticide use and health in Nigeria https://www.ajol.info/index.php/ijs/article/viewFile/156080/145706

Ojo, T.F., Koledoye, G.F. and Olaniran, F.I. (2016). Assessment of precautionary measures in agrochemicals usage among urban arable crop farmers in Oyo state, Nigeria. Ethiopian Journal of Environmental Studies and Management, 9(1), pp.804-814.

Okonya, J.S.; Kroschel, J. (2015). A cross-sectional study of pesticide use and knowledge of smallholder potato farmers in Uganda. BioMed Research International. (USA). ISSN 2314-6133. 2015(ID 759049):9 p.

Okrikata, E. and Ogunwolu, E.O. (2017). Farmers' Perceptions on Arthropod Pests of Watermelon and their Management Practices in the Nigerian Southern Guinea Savanna. International Journal of Agricultural Research, 12, pp.146-155.

Oliveira, C.M., Auad, A.M., Mendes, S.M., and Frizzas, M.R. (2014). Crop losses and the economic impact of insect pests on Brazilian agriculture. Crop Prot 56: 50– 54.

Olowogbon, T., Fakayode, S.B., Jolaiya, A.J., Oke, A.O., & Omolara, A. (2013). Nigeria's Small Scale Farmers' Agrochemical Use and the Health and Safety Implications.

Accessed [PDF] NIGERIA'S SMALL SCALE FARMERS' AGROCHEMICAL USE THE HEALTH AND SAFETY IMPLICATIONS | Semantic Scholar

Olsen, Wendy. (2004). Triangulation in social research: Qualitative and quantitative methods can really be mixed. Developments in sociology. 20. 103–118.

Olsen, W. K., Haralambos, M. (Ed.), & Holborn, M. (Ed.) (2004). Triangulation in Social Research: Qualitative and Quantitative Methods Can Really Be Mixed. In Developments in Sociology Causeway Press Ltd.

Olsen, W. (2019). Bridging to Action Requires Mixed Methods, Not Only Randomised Control Trials. European Journal of Development Research. https://doi.org/10.1057/s41287-019-00201-x

Oluwole, O. and Cheke, R.A. (2009). Health and environmental impacts of pesticide use practices: a case study of farmers in Ekiti State, Nigeria. International journal of agricultural sustainability, 7(3), pp.153-163.

Omojokun Jane (2013). Regulation and Enforcement of Legislation on Food Safety in Nigeria, Mycotoxin and Food Safety in Developing Countries, Hussaini Anthony Makun, IntechOpen, DOI: 10.5772/54423. Available from: https://www.intechopen.com/books/mycotoxin-and-food-safety-in-developing-countries/regulation-and-enforcement-of-legislation-on-food-safety-in-nigeria

Onianwa, P.C.; Adetola, I.G.; Iwegbue, C.M.A.; Ojo, M.F. and Tella, O.O. (1999). Trace heavy metals composition of some Nigerian beverages and food drinks. Food Chemistry, 66: 275-279.

Onibokun, Adepoju & Faniran, Adetoye (1995). Urbanization and urban problems in Nigeria In: Urban Research in Nigeria [online]. Ibadan: IFRA-Nigeria, (generated 06 août 2019). Available on the Internet:<http://books.openedition.org/ifra/544>. ISBN: 9791092312188. DOI: 10.4000/books.ifra.544.

Onyeneke, R.U., Igberi, C.O., Uwadoka, C.O. and Aligbe, J.O. (2018). Status of climate-smart agriculture in southeast Nigeria. GeoJournal, pp.1-14.

Oxford dictionary https://www.oxfordlearnersdictionaries.com/definition/american_english/environment

Özkara A., Akyıl D., Konuk M. (2016). Pesticides, environmental pollution, and health Environmental Health Risk. (2016), 10.5772/63094

Padgham, J., Jabbour, J., and Dietrich, K. (2015). Managing change and building resilience: A multi-stressor analysis of urban and peri-urban agriculture in Africa and Asia. Urban Climate, 12, pp.183-204.

Pandey, L. K., Bergey, E. A., Lyu, J., Park, J., Choi, S., Lee, H. & Han, T. (2017). The use of diatoms in ecotoxicology and bioassessment: Insights, advances and challenges. Water Research. https://doi.org/10.1016/j.watres.2017.01.062

Pasquini W.M (2006). The use of town refuse ash in urban agriculture around Jos, Nigeria: health and environmental risks. Sci. Total Environ. 354: 43– 59.

Pawłowski, A. (2008). How Many Dimensions Does Sustainable Development Have? Sustainable Development, 81–90. doi: DOI: 10.1002/sd.339

Peare David, Barbier Edward and Anil Markilndya (1990). Sustainable development: economics and environment in the Third World 5.6. P43 I990 338.9'009172'44~20 89-23587 CP ISBN 978-1-13415-906-2 (ebk)

Pendleton, W., Crush, J. & Nickanor, N. (2014) Migrant Windhoek: Rural–Urban Migration and Food Security in Namibia in Urban Forum 25: 191. https://doi.org/10.1007/s12132-014-9220-x

Phillips, D. C. (1987). Philosophy, science and social inquiry: Contemporary methodological Phophi, Mutondwa and Mafongoya, Paramu. (2017). Constraints to Vegetable

Production Resulting from Pest and Diseases Induced by Climate Change and Globalization: A Review. Journal of Agricultural Science. 9. 11. 10.5539/jas.v9n10p11. Journal of Agricultural Science, 9, 11. doi:10.5539/jas.v9n10p11.

Pimentel, D. (2005). Environmental and Economic Costs of the Application of Pesticides Primarily in the United States'. Environ Dev Sustain 7, 229–252 (2005). https://doi.org/10.1007/s10668-005-7314-2

Pimentel, D. (2007). Environmental and economic costs of vertebrate species invasions into the United States. Managing Vertebrate Invasive Species 38. https://digitalcommons.unl.edu/nwrcinvasive/38

Pimentel D., Hart K. (2001) Pesticide Use: Ethical, Environmental, and Public Health Implications. In: Galston A.W., Shurr E.G. (eds) New Dimensions in Bioethics. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-1591-3_6

Pizam, A. and Mansfield Y. (2009). Consumer Behaviour in Travel and Tourism. New York: Howarth Hospitality Press.

Popp J., K Pető K, Nagy J. (2013). Pesticide productivity and food security. A review Agronomy for sustainable development 33 (1), 243-255

Poyearleng, C., Kai, Z., Shahriar, S. and Reakine, O.P.S. (2019). Factors Influencing Consumers' Purchasing Behavior on Organic Vegetables: A Case Study in Vientiane, Lao PDR. Open Journal of Social Sciences, 7,199-215. https://doi.org/10.4236/jss.2019.72017

Pretty, J.N. (1997). Sustainable agriculture, people and the resource base: Impacts on food production. Forum Dev. Stud. 1997, 1, 7–32.

Pretty Jules (2007). Agricultural sustainability: concepts, principles and evidence Phil. Trans. R. Soc. B http://doi.org/10.1098/rstb.2007.2163

Putnam, H. (1999). The threefold cord: Mind, body, and world. New York: Columbia University Press.

Qiu Guo-yu, Li Hong-yong, Zhang Qing-tao, Chen Wan, Liang Xiao-jian, Li Xiang-ze (2013). Effects of Evapotranspiration on Mitigation of Urban Temperature by Vegetation and Urban Agriculture, Journal of Integrative Agriculture, Volume 12, Issue 8, 2013, Pages 1307-1315, ISSN 2095-3119, https://doi.org/10.1016/S2095-3119(13)60543-2. (http://www.sciencedirect.com/science/article/pii/S2095311913605432)

Quinn, Laura & Vos, J. & Fernandes-Whaley, Maria & Roos, Claudine & Bouwman, Hindrik & Kylin, Henrik & Pieters, Rialet & Van den Berg, Johnnie (2011). Pesticide Use in South Africa: One of the Largest Importers of Pesticides in Africa. 10.5772/16995.

Rahelizatovo, Noro C. and Gillespie, Jeffrey (2004). The Adoption of Best-Management Practices by Louisiana Dairy Producers, Journal of Agricultural and Applied Economics, 36, issue 1, p. 229-240, https://EconPapers.repec.org/RePEc:cup:jagaec:v:36:y:2004:i:01:p:229-240_02.

Randolph, Justus (2009). A Guide to Writing the Dissertation Literature Review. Practical Assessment, Research & Evaluation, 14(13). Available online: http://pareonline.net/getvn.asp?v=14&n=13.

Rao, N., & Rogers, P. (2006). Assessment of agricultural sustainability. Current Science, 91(4), 439-448. Retrieved January 10, 2020, from www.jstor.org/stable/24093944

Redwood, M. (2008). Urban agriculture and changing food markets in The Global Food Crisis: Governance Challenges and Opportunities edited by Clapp Jennifer and Cohen Marc J. https://www.researchgate.net/profile/Jennifer_Clapp/publication/293157288_The_global_food_crisis_Governance_challenges_and_opportunities/links/56c5bc1508ae7fd4625c54f3.pdf#page=223 edited by Jennifer Clapp, Marc J. Cohen

Reganold, J.P.; Papendick, R.I.; Parr, J.F. (1990). Sustainable Agriculture. Sci. Am. 1990, 262, 112– 120. 24.

Reid, W. V., Mooney, H. A., Cropper, A., Capistrano, D., Carpenter, S. R., Chopra, K., Zurek, M. B. (2005). Ecosystems and human well-being - Synthesis: A Report of the Millennium Ecosystem Assessment. Washington D.C.: Island Press.

Report, S. (2014). Urban and Peri-urban Agriculture for Food Security in Low-income Countries – Challenges and Knowledge Gaps.

Rimet, F., & Bouchez, A. (2011). Use of diatom life-forms and ecological guilds to assess pesticide contamination in rivers: Lotic mesocosm approaches. Ecological Indicators, 11(2), 489–499. https://doi.org/10.1016/j.ecolind.2010.07.004

Robinson, Elizabeth & Das, Sumona & Chancellor, Tim. (2007). Motivations behind farmers' pesticide use in Bangladesh rice farming. Agriculture and Human Values. 24. 323-332. 10.1007/s10460-007-9071-3.

Robson, Colin (2002). Real World Research. A Resource for Social Scientists and Practitioner-Researchers (Second Edition).

Rohila Anil, Duhan Ansul, Maan Devashri, Kumar Amit & Kumar Krishan (2017). Impact of agricultural practices on environment. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 19. 381-384.

Roncarolo, F., & Potvin, L. (2016). Food insecurity as a symptom of a social disease: Analyzing a social problem from a medical perspective. Canadian family physician Medecin de famille canadien, 62(4), 291–e163.

Ronner, E., Franke, A.C., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., Bala, A., Van Heerwaarden, J. and Giller, K.E. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. Field Crops Research, 186, pp.133-145.

Roser Max (2020). "Employment in Agriculture". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/employment-in-agriculture' [Online Resource]

Ruaf.org. (2015). The RUAF Foundation | The RUAF Foundation. [online] Available at: http://www.ruaf.org/ [Accessed 20 Feb. 2015].

Ruberson, John & Roberts, Phillip. (2005). Pesticide effects on insect natural enemies of cotton pests. 2004 Georgia Cotton Research-Extension Report. 124-132.

Ruttan Vernon W. (1999). The transition to agricultural sustainability. Proceedings of the National Academy of Sciences May 1999, 96 (11) 5960-5967; DOI: 10.1073/pnas.96.11.5960

Ruxandra Malina, Petrescu-Mag, Ioan Banatean-Dunea, Stefan Cristian Vesa, Sofia Copacinschi and Dacinia Crina Petrescu (2019). What Do Romanian Farmers Think about the Effects of Pesticides? Perceptions and Willingness to Pay for Bio-Pesticides 4. sustainability Received: 5 May 2019; Accepted: 28 June 2019; Published: 2 July 2019

Saba, A., & Messina, F. (2003). Attitudes towards organic foods and risk/benefit perception associated with pesticides. Food Quality and Preference, 14(8), 637–645. doi:10.1016/s0950-3293(02)00188-x

Sabiiti E.N., Katongole C.B. (2014). Urban Agriculture: A Response to the Food Supply Crisis in Kampala City, Uganda. In: Maheshwari B., Purohit R., Malano H., Singh V., Amerasinghe P. (eds) The Security of Water, Food, Energy and Liveability of Cities. Water Science and Technology Library, vol 71. Springer, Dordrecht

Salameh, Pascale & Baldi, Isabelle & Brochard, Patrick & Saleh, Bernadette. (2004). Pesticides in Lebanon: A knowledge, attitude, and practice study. Environmental research. 94. 1-6. 10.1016/S0013-9351(03)00092-6.

Sanchez, P.A. (2019). Properties and Management of Soils in the Tropics. Cambridge University Press.

Sánchez-Medina, Agustín & Romero-Quintero, Leonardo & Cabrera, Silvia. (2014). Environmental Management in Small and Medium-Sized Companies: An Analysis from the Perspective of the Theory of Planned Behavior. PloS one. 9. e88504. 10.1371/journal.pone.0088504.

Sandoval-Herrera, N., Mena, F., Espinoza, M. & Adarli Romero (2019). Neurotoxicity of organophosphate pesticides could reduce the ability of fish to escape predation under low doses of exposure. Sci Rep 9, 10530 (2019). https://doi.org/10.1038/s41598-019-46804-6

Satterthwaite, D., McGranahan, G., & Tacoli, C. (2010). Urbanization and its implications for food and farming. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 365(1554), 2809–2820. doi:10.1098/rstb.2010.0136

Schäfer R.B., Liess M. (2013). Species at Risk (SPEAR) Biomonitoring Indicators. In: Férard JF., Blaise C. (eds) Encyclopedia of Aquatic Ecotoxicology. Springer, Dordrecht

Schiesari, L., Waichman, A., Brock, T., Adams, C., & Grillitsch, B. (2013). Pesticide use and biodiversity conservation in the Amazonian agricultural frontier. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 368(1619), 20120378. doi:10.1098/rstb.2012.0378

Schloter M., Dilly O. and Munch J.C. (2003). Indicators for evaluating soil quality Agriculture, Ecosystems and Environment 98 (2003) 255–262

Schoolman ED, Guest JS, Bush KF, Bell AR (2012). How interdisciplinary is sustainability research? Analyzing the structure of an emerging scientific field. Sustain Sci 7(2):67–80. DOI 10.1007/s11625-011-0139-z

Schreinemachers P., Simmons E. B., Wopereis Marco C.S. (2018). Tapping the economic and nutritional power of vegetables. Global Food Security, 16, 36-45.

Scotland, J. (2012). Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. English Language Teaching, 5(9). doi:10.5539/elt.v5n9p9

Sethunathan N., Adhya T.K., Raghu K. (1982). Microbial Degradation of Pesticides in Tropical Soils. In: Matsumura F., Murti C.R.K. (eds) Biodegradation of Pesticides. Springer, Boston, MA

Sequeira, A. H. (2014). Conceptualization in Research (August 30, 2014). Available at SSRN: https://ssrn.com/abstract=2489284 or http://dx.doi.org/10.2139/ssrn.2489284

Serrat, O. (2010). The sustainable livelihoods approach. Washington, DC: Asian Development Bank.

Seymour Mathew, Durance Isabelle, Cosby Bernard J., Ransom-Jones Emma, Deiner Kristy, Ormerod Steve J., Colbourne John K., Wilgar Gregory, Carvalho Gary R., de Bruyn Mark, Edwards François, Emmett Bridget A., Bik Holly M. & Creer Simon (2018). Acidity promotes degradation of multi-species environmental DNA in lotic mesocosms. Communication Bioliogy 1, 4 (2018) doi:10.1038/s42003-017-0005-3 Communications Biology volume 1, Article number: 4 (2018)

Shabani F, Kumar L, Hamdan Saif al Shidi R. (2018). Impacts of climate change on infestations of Dubas bug (Ommatissus lybicus Bergevin) on date palms in Oman. PeerJ 6: e5545 https://doi.org/10.7717/peerj.5545

Shahbazi-Gahrouei, D., Gholami, M., & Setayandeh, S. (2013). A review on natural background radiation. Advanced biomedical research, 2, 65. https://doi.org/10.4103/2277-9175.115821

Sharifzadeh Mohammad Sharif, Abdollahzadeh Gholamhossein, Damalas Christos A., and Rezaei Rohollah (2018). Farmers' Criteria for Pesticide Selection and Use in the Pest Control Process 1 Department of Agricultural Extension and Education, Gorgan University of Agricultural Sciences and Natural Resources, 4913815739 Gorgan, Iran; Received: 30 December 2017; Accepted: 7 February 2018; Published: 12 February 2018

Sharma S., Kooner R., Arora R. (2017). Insect Pests and Crop Losses. In: Arora R., Sandhu S. (eds.) Breeding Insect Resistant Crops for Sustainable Agriculture. Springer, Singapore

Sharafi Kiomars, Pirsaheb Meghdad, Maleki Sara, Arfaeinia Hossein, Karimyan Kamaladdin, Moradi Masoud & Safari Yahya (2018). Knowledge, attitude and practices of farmers about pesticide use, risks, and wastes; a cross-sectional study (Kermanshah, Iran), Science of The Total Environment, Volume 645, 2018, Pages 509-517, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2018.07.132.

Shiva, V. (2016). The violence of the green revolution: Third world agriculture, ecology, and politics. University Press of Kentucky.

Shiu W.Y., Ma K.C., Mackay D., Seiber J.N., Wauchope R.D. (1990). Solubilities of Pesticide Chemicals in Water Part I: Environmental Physical Chemistry. In: Ware G.W., Niggs H.N., Bevenue A. (eds) Reviews of Environmental Contamination and Toxicology. Reviews of Environmental Contamination and Toxicology (Continuation of Residue Reviews), vol 116. Springer, New York, NY DOI: https://doi.org/10.1007/978-1-4612-3434-0_1

Shreck, A., Getz, C. & Feenstra, G. (2006). Social sustainability, farm labor, and organic agriculture: Findings from an exploratory analysis in Agricultural Human Values (2006) 23: 439. https://doi.org/10.1007/s10460-006-9016-2

Smit Jac, Nasr Joe, and Ratta Annu (2001). Urban Agriculture: Food Jobs and Sustainable Cities (2001 edition, published The Urban Agriculture Network, Inc. A Non-Profit, 501 (c)(3) Organization With the financial support and permission of the United Nations Development Programme (UNDP) 2001 Edition

Smol, J.P., Battarbee, R.W., Davis, R.B., & Merilaeinen, J. (1986). Diatoms and lake acidity: reconstructing pH from siliceous algal remains in lake sediments. [Melosira; Fragilaria; Tabellaria binalis]. United States.

Snapp, S. and Pound, B. eds. (2017). Agricultural systems: agroecology and rural innovation for development: agroecology and rural innovation for development. Academic Press.

Somparn, A., Iwai C. B. & Noller, B. N (2017). Assessment of pesticide contaminated sediment using biological response of tropical chironomid, Chironomus javanus Kiffer as biomarker, Asian Pacific Journal of Tropical Biomedicine, Volume 7, Issue 8, Pages 719-724, ISSN 2221-1691, https://doi.org/10.1016/j.apjtb.2017.07.014.

Songsore, Jacob (2003). Towards a Better Understanding of Urban Change: Urbanization, National Development and Inequality in Ghana, (Accra: Ghana Universities Press).

Spangenberg, Joachim. (2005). Economic sustainability of the economy: Concepts and indicators. International Journal of Sustainable Development. 8. 10.1504/IJSD.2005.007374.

Srinidhi, B. (2013). An essay on conceptualization of issues in empirical accounting research. China Journal of Accounting Research, 6(3), 149-166. doi:doi.org/10.1016/j.cjar.2013.05.001.

Stamoulis K. & Zezza A. (2003). A conceptual framework for national agricutural, rural development and food security strategies and policies. ESA Working Papers. FAO, Agricultural and Development Economics Division, Rome, Italy.

Stephen E. Lewis, D. Mark Silburn, Rai S. Kookana, and Melanie Shaw (2016). Pesticide Behavior, Fate, and Effects in the Tropics: An Overview of the Current State of Knowledge Journal of Agricultural and Food Chemistry 2016 64 (20), 3917-3924 DOI: 10.1021/acs.jafc.6b01320

Stewart, R., Korth, M., Langer, L., Rafferty, S., Da Silva, N., & Rooyen, C. Van. (2013). What are the impacts of urban agriculture programs on food security in low and middle-income countries? Environmental Evidence, 2(1), 7. http://doi.org/10.1186/2047-2382-2-7

Sustainable development goals (2015) retrievedfrom https://sustainabledevelopment.un.org/?menu=1300

Sweet L (1999). Room to live—healthy cities for the urban century. IDRC briefing. Ottawa, Can. 7 IDRC.

Tabibian, M. & Movahed, Sepideh. (2016). Towards Resilient and Sustainable Cities: A Conceptual Framework. Scientia Iranica. 23. 2081-2093. 10.24200/sci.2016.2273.

Tait J. (2001). Pesticide regulation, product innovation and public attitudes J Environ Monitor, 3/4 (2001), pp. 64N-69N

Taiwo, L.B., Adesokun, K.T., Olatoberu, F.T., Oyedele, A.O., Ojo, A.O. and Olayinka, A.A., (2018). Effect of plant growth promoting rhizobacteria (pgpr) and biochar on soil properties and performance of cowpea (Vigna unguiculata (L.) Walp). Ife Journal of Agriculture, 30(3), pp.56-71.

Thiollet-Scholtus Marie and Bockstaller Christian (2015). Using indicators to assess the environmental impacts of wine growing activity: The INDIGO® method, European Journal of Agronomy, Volume 62, Pages13-25,ISSN1161-0301, https://doi.org/10.1016/j.eja.2014.09.001.(http://www.sciencedirect.com/science/article/pii/S116103011400104X)

Thompson, Helen (2014). Popular Pesticides Linked to Drops in Bird Populations in Smithsonian Magazine, accessed online at https://www.smithsonianmag.com/science-nature/popular-pesticides-linked-drops-bird-population-180951971/

Thornton, P. K. (2010). Livestock production: recent trends. Phil. Trans. R. Soc., 365, 2853–2867.

Tijani M.N, Olaleye A. O Olubanjo, O. O (2012). Impact of urbanization on wetland degradation: A case study of Eleyele Wetland, Ibadan, South West, Nigeria COLERM Proceedings 2, 434-456

Trace Gale (2005). Exploring Differences between Positivistic and Post-positivistic Philosophy: An Interpretivistic Case Study of Tourist expectations and satisfactions. Proceedings of the 2005 Northeastern Recreation Research Symposium GTR-NE-341

Transforming our World SDGs (2015). Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld

Tricase, C., Lamonaca, E., Ingrao, C., Bacenetti, J. and Giudice, A.L. (2018). A comparative Life Cycle Assessment between organic and conventional barley cultivation for sustainable agriculture pathways. Journal of cleaner production, 172, pp.3747-3759.

Turner, R. K. (1988). Economics, Economics, Growth and Sustainable Environments (eds Collard, D. et al.) (Macmillan, London, 1988).

Udoh, A.J. and Umoh, C.E. (2016). Utilization pattern of pesticides by Nigerian farm households. Indian Research Journal of Extension Education, 11(2), pp.6-14.

Ugwu, J.A., Omoloye, A.A., Asogwa, E.U. and Aduloju, A.R., 2015. Pesticide-handling practices among smallholder Vegetable farmers in Oyo state, Nigeria. Age, 20(30), p.2.

Uwagboe, E.O., Meludu, N.T. and Famuyiwa, B.S. (2017). Influence of psychological disposition on IPM adoption behavior among cocoa farmers in Osun state, Nigeria

Vaage, Andrea (2015). "Understanding competing motivations for urban agriculture: an analysis of U.S. municipal ordinance adoption" Graduate Theses and Dissertations. 14859. https://lib.dr.iastate.edu/etd/14859

Vardoulakis, S., Dear, K. & Wilkinson, P. (2016). Challenges and Opportunities for Urban Environmental Health and Sustainability: the HEALTHY-POLIS initiative. Environ Health 15, S30 (2016) doi:10.1186/s12940-016-0096-1

Veerle G, Griensven A. V., Holvoet K., Seuntjens P.and Vanrolleghem P. A. (2008). SWAT developments and recommendations for modelling agricultural pesticide mitigation measures in river basins, Hydrological Sciences Journal, 53:5, 1075-1089, DOI: 10.1623/hysj.53.5.1075

Velten, Sarah & Leventon, Julia & Jager, Nicolas & Newig, Jens. (2015). What Is Sustainable Agriculture? A Systematic Review: Supplementary Information.

Villaverde, J., Kah, M., & Brown, C. D. (2008). Adsorption and degradation of four acidic herbicides in soils from southern Spain, 64(7), 703–710. Retrieved from https://doi.org/10.1002/ps.1545

Vryzas Zisis (2018). Pesticide fate in soil-sediment-water environment in relation to contamination preventing actions, Current Opinion in Environmental Science & Health, Volume 4, 2018, Pages 5-9, ISSN 2468-5844,https://doi.org/10.1016/j.coesh.2018.03.001.

Waichman Andrea Viriana, Nailson celso Da Siva Nina (2007). Do farmers understand the information displayed on pesticide product labels? A key question to reduce pesticides exposure and risk of poisoning in the Brazilian Amazon

Wahab, B. and Abiodun, O. (2018). Strengthening Food Security through Peri-Urban Agriculture in Ibadan, Nigeria. Ghana Journal of Geography, 10(2), pp.50-66.

Wahab, Bolanle and Popoola, Ayobami. (2018). Climate-induced problems and adaptation strategies of urban farmers in Ibadan. Ethiopian Journal of Environmental Studies & Management, 11(1), pp.31-42.

Wahba Mahmoud A. & Bridwell, Lawrence G. (1976) Maslow reconsidered: A review of research on the need hierarchy theory, Organizational Behavior and Human Performance,

Walsh, P. R. (2011). Creating a "values" chain for sustainable development in developing nations: where Maslow meets Porter. Environment, Development and Sustainability, 13(4), 789–805. doi:10.1007/s10668-011-9291-y

Wandaat, Emmanual Yennumi and Kugbe, Joseph Xorse (2015). Pesticide misuse in rural-urban agriculture: a case study of vegetable production in Tano south of Ghana http://hdl.handle.net/123456789/2068

Wang F, Jiang X, Bian Y R, Yao F X, Gao H J, Yu G F, MunchJ C, Schroll R. (2007). Organochlorine pesticides in soils un-der different land usage in the Taihu Lake region, China.J. Environ Sci.19: 584–590

Warburton H., Palis F.G. and Pingali P.L. (1995). Farmer perceptions, knowledge, and pesticide use practices In: P. L. Pingali et al. (eds.), Impact of Pesticides on Farmer Health and the Rice Environment © Kluwer Academic Publishers 1995

Wilson Clevo and Tisdell Clem (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs, Ecological Economics, Volume 39, Issue 3,2001, Pages 449-462, ISSN 0921-8009, https://doi.org/10.1016/S0921-8009(01)00238-5.

World Urbanization Prospects: (2018). The 2018 Revision, Online Edition. POP/DB/WUP/Rev.2018/1/F21

Wossen, T., Alene, A., Abdoulaye, T., Feleke, S., Rabbi, I.Y. and Manyong, V. (2018). Poverty Reduction Effects of Agricultural Technology Adoption: The Case of Improved Cassava Varieties in Nigeria. Journal of Agricultural Economics.

Yang, H., & Appleby, P. G. (2016). Use of lead-210 as a novel tracer for lead (Pb) sources in plants. Scientific reports, 6, 21707. https://doi.org/10.1038/srep21707

Yeadon, M. (2005). 'What are the limitations of experimental and theoretical approaches in

Yeboah, I. (2013). Urban agriculture and pesticide overdose: a case study of vegetable production at dzorwulu-accra

Yehouenou A. Pazou, E., Aléodjrodo, P. E., Azehoun, J. P., van Straalen, N. M., van Hattum, B., Swart, K., & van Gestel, C. A. M. (2013). Pesticide residues in sediments and aquatic species in Lake Nokoué and Cotonou Lagoon in the Republic of Bénin. Environmental Monitoring and Assessment, 186(1), 77–86. doi:10.1007/s10661-013-3357-2

Yekinni, Taofeeq & Oguntade, Mariam. (2015). Training needs of women vegetable farmers in Akinyele local government area of Oyo state, Nigeria. Tropical Agricultural Research and Extension. 17. 38. 10.4038/tare. v17i1.5296.

Yilmaz, H. (2015). Analysis in terms of environmental awareness of farmers' decisions and attitudes in pesticide use: the case of Turkey. Bulgarian Chemical Communications, Volume 47, Number 3 (pp. 771 – 775) 2015

Zakari S., Ying L., Song B. (2014). Factors influencing household food security in West Africa: the case of southern Niger. Sustainability, 6 (2014), pp. 1191-1202

Zezza, A. and L. Tasciotti (2010). Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries, in: Food Policy Vol.35(4), pp. 265-273.

Zhang Wei, Kato Edward, Bianchi Felix, Bhandary Prapti, Gort Gerrit, van der Werf Wopke (2018). Farmers' perceptions of crop pest severity in Nigeria are associated with landscape, agronomic and socio-economic factors, Agriculture, Ecosystems & Environment,

Zougmoré, R., Partey, S., Ouédraogo, M., Omitoyin, B., Thomas, T., Ayantunde, A., Ericksen, P., Said, M. and Jalloh, A., (2016). Toward climate-smart agriculture in West Africa: a review of climate change impacts, adaptation strategies and policy developments for the livestock, fishery, and crop production sectors. Agriculture & Food Security, 5(1), p.26.

Zulkefli, N. S., Kim, K. H., & Hwang, S. J. (2019). Effects of Microbial Activity and Environmental Parameters on the Degradation of Extracellular Environmental DNA from a Eutrophic Lake. International journal of environmental research and public health, 16(18), 3339. doi:10.3390/ijerph16183339

Appendix 1

QUESTIONNAIRE SURVEY

Research Title: An Assessment of the Impact of Pesticide Use by Urban Cultivators in Oyo State, South-Western Nigeria.

Dear Respondent,

Thank you for taking time to complete this survey which is looking at the incidence and understanding of pesticide use amongst urban agriculture farmers in Ibadan. The responses will be use in compliance to strictest confidentiality.

Date of interview ………………………….. LGA ………………………………..

Respondent name/ ID No. ………………… Contact No: ………………………...

Section A: Respondent information (circle all that applies)

1. Gender: Male Female

2. Age: 15-20 21- 30 31-40 41- 50 51-60 >60

3. Highest educational level: (a) No formal schooling (b) Primary school uncompleted (c) Primary school completed (d)Secondary school completed (e) College/University completed (f) Postgraduate degree

4. Main Occupation: (a) Farming (b) Self-employed (c) Public service (d) Private Service

5. Farming experience: (a) 1- 2 yrs (b) 3 - 5yrs (c) 6 -10yrs (d) 11 - 15yrs (e) 16 – 20yrs (f) >20yrs

6. Type of farming: (a) Vegetable/Arable (b) Agro-forestry (c) Aquaculture (d) Animal Husbandry (e) Ornamental horticulture

7. Farm Size: (a) < 1 plot (b) 1-2 plots (c) 3 -5 plots (d) 6 – 10 plots (e) >10 plots

8. Land tenure status: (a) Own (b) Rented (c) Farmers association (d) Other

9. Are you a member of any farmers' organization? Yes No

If yes, which farmers' organizations are you a member of?

(a) Farmers' association (b) Marketing co-operative society (c) Youth club (d) Other

10. What percentage of your annual income comes from urban agriculture? *Tick all that applies*

	<20	20 – 50%	> 50%
Vegetable:			
Arable Crops:			
Ornamental crops:			
Animal Husbandry			
Aquaculture			
Agro-forestry (fruits)			

11. 11. Are you the sole grower/decision maker or do other family members/people work on the plot/apply pesticides? Yes No

Section B: Pesticides use/practice

12. Do you use pesticides? Yes No ; If No, go to question 19

13. What type of pesticides do you use? *Tick all that applies*

Herbicides	**Insecticides**	**Fungicides**	**Acaricides**	**Rodenticides**	**Nematicides**

14. How long (years) have you been using it/them? *Tick all that applies*

Duration	**Herbicides**	**Insecticides**	**Fungicides**	**Acaricides**	**Rodenticides**	**Nematicides**
<2 yrs						
>5 yrs						
>10yrs						
>15 yrs						
Others (specify)						

15a. For what purpose do you use it for? *Tick all that applies*

Routine farm management	**Increase Yields**	**Higher quality produce**	**Improved Storage**	**Precautionary use**	**Others**

15b. Please list others from 15a. ……………………………………………………………

16a. When do you apply it? *Tick all that applies*

Seed treatment	Pre-planting	During planting & growing	Harvesting stage	Storage and Transportation

16b. Total number of applications per season? *Tick all that applies*

	Herbicides	Insecticides	Fungicides	Acaricides	Rodenticides	Nematicides
Frequency						

17a. Are you aware of other pest control methods? Yes (go to 17b) No (please go to 17c&d)

17b. If yes, what methods? Specify

………………………………………………………………………………………..

………………………………………………………………………………………..

17c.Why do you not apply pesticides?

…………………………………………………………………………………………

…………………………………………………………………………………………

17d. How do you then control or manage pests?

………………………………………………………………………………………..

………………………………………………………………………………………..

Section C: Good Agricultural Practice

18.Where do you buy your pesticides? *Tick all that applies*

Agro-Dealers	Extension Outlets	Street Vendors

19. How do you decide what to buy/use? ………………………………………..............

…………………………………………………………………………………...

…………………………………………………………………………………...

20. How do you apply pesticide(s)? *Tick all that applies*

Spraying equipment	Watering Can	Other means (please specify)	Not applicable

21. How do you discard any residues or clean machines/sprayer after use?

……………………………………………………………………………………………..

22. Have you changed your products or practices over the years? Yes No

If Yes, why? ……………………………………………………………………………..

23. Are you aware of any legislation? Yes No

24. Have you received any training or information about using pesticides safely? Yes No

24b. If Yes, provide date of most recent training

25. Who gives you pest control advice? *Tick all that applies*

Neighbour	Extension agents	Farmer groups	Relatives	Pesticide dealers	Media	Others (please specify)

26. Do your neighbours, friends behave in the same way as you? Yes No

27. Can you rank your level of understanding of GAP for pesticide usage? (Rank 1-5 low- high)

1	2	3	4	5

Section D: Perceptions and Motivations

28. What are your opinions on the benefits of pesticides? …………………………………

……………………………………………………………………………………………

29. What are your opinions about the deleterious effects of pesticides? …………………

……………………………………………………………………………………………

30. If you think pesticides are harmful in anyway, why do you use them? ……………………

……………………………………………………………………………………………...

31. What is the greatest production risk to your produce? *Rank each one 1-5 low-high*

Pests	weather	soil fertility	other

32. What percentage risk of crop failure do is there if you do not apply pesticides?

0 - 10%	11 – 20%	21 – 30%	31 – 40%	41% and above

Section E: Economic Consideration

33. What economic benefits of pesticides do you enjoy? …………………………………

………………………………………………………………………………………

34. What % decline in yield would you would suffer if you did not use pesticides?

……………………………………………………………………………………..

35. What % of your production costs (seeds, fuel, labour, agrochemicals, equipment) do you spend on pesticides? ……………………………………………………………………….

Thank you for taking the time to participate in this survey!

Appendix 2

Field Photographs

Plate a: Farmer wearing his rarely used PPE as a demonstration of how uncomfortable it is
Photo credit: A. Bodede

Plate b: Meeting with horticultural farmers' group
Photo credit: A. Bodede

Plate c: Open markets like Ogunpa are common where pesticides are being sold
Photo credit: A. Bodede

Plate d: A pesticide retailer providing advice on which products to choose which is common service as many farmers rely on their advice
Photo credit: A. Bodede

Plate e: Female farmer working on her vegetable farm; this is her sole source of income
Photo Credit: A. Bodede fieldwork

Plate f: Farmer working on his mixed farm (agroforestry, vegetables and annual crops)
Photo Credit: A. Bodede fieldwork

Plate g: Farmer applying herbicide mixed with insecticide at the lakeside
Photo credit: A. Bodede

Plate i: Collecting lake sediments by one of the field asistants
Photo credit: A. Bodede

Plate g: Sediment sample collected from one of the study sites
Photo credit: A. Bodede

Plate h: Diatom extraction
Photo credit: A. Bodede