The Role of Farmers' Indigenous Knowledge in Integrated Termites Management Strategies: A Case of Nedjo District, West Wellega, Ethiopia




A research project submitted to
Van Hall Larenstein University of Applied Sciences in Partial Fulfillment of the requirements for the degree of Master in Management of Development, specialisation Rural Development and Food Security

By

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September 2017

Acknowledgements

First and foremost, Praise and gratitude to be Allah the most gracious the most merciful.

My special gratitude and heartfelt appreciation goes to my thesis supervisor Dr. Ir. Gerrit-Jan van Uffelen for his critical comments and guidance starting from research proposal writing to final write up. Without his inspirational and professional guidance, the completion of this thesis would not have been realised.

Netherlands Fellowship Programme (NFP) is highly appreciated for supporting me financially in pursuing my master degree at VHL University of applied sciences.

I am grateful to Van Hall Larenstein University for selecting me for the master programme and creating favourable conditions during my stay in the Netherlands. I am grateful to all Van Hall Larenstein University's teachers and staffs for their effort in teaching and guiding us during our study.

Furthermore, I am also grateful to Oromia Agricultural Research Institute for allowing me to leave for my study and supporting me financially and BAERC for assisting me all the necessary facilities and assistance in conducting this research during data collection.

My appreciation goes to all development agents in wegari Buna and Muchucho Gyorgis Peasant Associations for their support during the fieldwork in selecting and contacting respondents. I sincerely recognise farmers' cooperation and patience for sharing me their knowledge and experiences.

Last but not least, I would like to express my thanks to my beloved family especially my father Abdulah Deressa and my mother Yadessa Nagao for their support, encouragement and prayers, my beloved wife Zubeda Jira, my brothers and relatives for their moral support throughout my study.

Dedication

This research work is dedicated to my father Mr. Abdulah Deressa and my mother Mrs. Yadessa Nagao who supported me in my life to reach today's success.

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Abbreviations

BAERC	Bako Agricultural Engineering Research Center
ETB	Ethiopian Birr
FGD	Farmers Group Discussion
FIK	Farmers Indigenous Knowledge
IK	Indigenous Knowledge
IPM	Integrated Pest Management
ITM	Integrated Termite Management
KII	Key Informant Interview
NDBANR	Nedjo District Bureau of Agriculture and Natural Resources
PA	Peasant Association
PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
SLM	Sustainable Land Management

Abstract

This research looks at the role of Farmers' Indigenous Knowledge (FIK) in integrated termite management strategies in Nedjo district, West wellega, Ethiopia. The study aims to document and better understand indigenous farmers' knowledge and experiences on termite infestation and its controlling methods, to assist Bako Agricultural Engineering Research Centre in developing integrated termite management strategies in Nedjo District.

The study employed a research strategy using both desk and case studies for primary data and secondary data. The data was collected through individual interviews, key informant interview, FGD, PRA and observation. The semi-structured interview guide, topic lists and PRA tools were used to collect the primary data. The collected data was grouped, summarised, discussed and interpreted by theme based on the findings from observation, semi-structured interview and focus group discussion qualitatively.

The study found that farmers have a good knowledge and understanding of when termite started in the area and causes of termite infestation. Farmers know the place and time of termite infestation and the reasons for the infestation. They differentiate between different termite species, the damage they do to crops, and types of methods to be applied for the different species.

The main causes of termite infestation were said to be deforestation, overgrazing and inappropriate soil and water conservation practices. Farmers mentioned that the severity of termite infestation became more serious as a result of land degradation and increased soil acidity. Farmers emphasised that poor soil and water conservation practices contribute to land degradation.

The study also found that farmers were able to identify susceptible and resistant crops, trees, herbs and grasses. Most susceptible crops to termite damage are maize, teff, and hot pepper. Sorghum, finger millet, and haricot bean were mentioned to relatively resistant to termites as compared to maize, teff, and hot pepper. Other termite resistant crops, according to farmers are yam, sweet potato, local variety cabbage (*Brassica carinata*), Oromo Potatoes (*Coleus edulis*; its shape is similar to that of a human finger, thin and elongated), Xanthosoma sagittifolium (*Colocasia esculenta (L.)* Schott), and banana. Farmers were found to practice different combinations of traditional, biological and chemical methods for termite control.

The study concludes that Integrated termite management strategies should focus on rehabilitating the degraded land while the strategies should create income for farmers. This will also reduce the effect of termite infestation on household food security situation in the district.

1. INTRODUCTION

1.1 Introduction

This is a research report looking into the role of Farmers' Indigenous Knowledge (FIK) in integrated termite management strategies in Nedjo district, West wellega, Ethiopia. The study aims to document and better understand of indigenous farmers' knowledge and experiences on termite infestation and its controlling methods, to assist Bako Agricultural Engineering Research Centre in developing integrated termite management strategies in Nedjo District.

The structure of the reports is as follows. Chapter one, this chapter, forms the introduction to termite infestation and a background to this study. Chapter two presents the Literature review and chapter three describes the methodology. Chapter four presents the results and discussion. The final chapter, chapter five presents the conclusions and recommendations.

1.2 Back ground

Termite infestation is prevalent worldwide especially in the tropics where the distribution, problems and constraints result in livelihood threats (Fenemore, P.G., 2006), particularly among rural small-scale farmers (Sileshi et al., 2008). The growing interest in sustainable agriculture and food security on the African continent highlights the need for a more integrated approach to termite control (Sileshi et al., 2008) by integrating indigenous knowledge and practices with modern 'scientific' method. This is with the aim of preventing severe ecological damage and loss of ecosystem services provided by termites while using the available resources without exhausting them (Logan et al., 1990)

Termites are abundant throughout the world (Donald and Dweight, 1970). According to Legesse et al. (2013) Termites are severe pests in several parts of Ethiopia, particularly in the Western regions of the country. They cause considerable damage to crops, rangelands, forestry seedlings, and wooden structures such as wooden houses, stores, fences and bridges crossing streams (Assefa, G., 1990). Tadese, A. (1998,) reported 45, 50 and 18 % yield losses of cereal crops due to termites at Bako, Didesa, and Asossa, respectively.

Termite infestation problem can have several effects such as agronomic, economic, or social constraints. The agronomic influence involves the role of termites as pests and ecosystem engineers; whereas, the economic aspect includes the destructive tendencies of termites due to their foraging activities on plants and wood products which cause economic hardship to individual producers (Fenemore and Prakash, 2006). On the other hand, termites are beneficial in that they assist in the conversion of dead trees and other plant products to substances that can be utilised by plants. Moreover, termites are an important part of the food chain for many animals including man. They supply materials for many food chains, soil engineering (translocating and altering soils physically and chemically and maintaining soil fertility (Lee and Wood, 1971).

In the past, several attempts were made in Ethiopia in general and Nedjo District in particular to reduce damage caused by termites, including extensive termites mound poisoning campaigns. Chemical methods of termite control in plantations and farms are expensive, require labour skill Logan et al. (1990), and may not be always effective (Nair, 2007). Such interventions were largely ineffective but were damaging to the environment. The excessive application of insecticides causes environmental pollution and may result in the death of non-target organisms as reported by Dennis (1981), which necessitated the ban of some chemical control measures.

Farmers used several cultural practices to reduce the damage caused by termites. These controls measure include queen removal, flooding and smoking. Traditional methods are simple to follow and conduct and, cost effective. Sileshi et al. (2008), however, argues that the use of traditional methods should be complemented with the conventional methods to achieve great results.

1.3 Termite mound situation in Nedjo district

Nedjo District is one of the western wellega Districts located 515 km to the west of Ethiopia's capital city, Addis Ababa. Nedjo District is profoundly affected by termite infestation. One of the bottlenecks of agricultural production in the area is termite infestation. Farmers in the area are using different methods to control termite. Intensive use of insecticides, which is of significant environmental and health concerns, is the most frequently control option.

Termite infestations existed from ancient times but not seen as a threat as it did not affect farmers' food crops. In Nedjo district termite mound are counted from time to time by farmers on their respective farm land and experts estimate the number of mounds on forest land and grazing land. Termites consume grasses from grazing land resulting in a shortage of animal fodder.

Termite removes trees from land and exposes soil for erosion and reduces its fertility, increases soil acidity due to this production and productivity is reduced.

In order to cope with the effects of termite infestation farmers are migrating with their livestock to Benishangul-Gumuz region. According to Nedjo District Bureau of Agriculture and Natural Resources (here after NDBANR) 2016 annual report the number of migrants is about 40 % of the district total population. The other 60% depend on coffee production. Agricultural and livestock are nevertheless important sources of food and income.

The causes for termite infestation are population growth, increased number of livestock, deforestation for expansion of farm land, extinction of termite predators like ants, overgrazing, firing grass and crop residue for land clearing which is feeds for termites. Data from Nedjo District Bureau of Agriculture and Natural Resources shows that the Ministry of Agriculture started queen removal campaign in 1978. The previous termite control methods focus on eradication by chemical but failure to address the root causes.

Termite infestation has an impact on livelihoods of farmers in Nedjo district. Termite infestation is resulting damage to agricultural crop and livestock fodder. It has a wide scale impact on communities in Nedjo district; social impact (seasonal migration and children school dropout, poverty); economic impact (seducing production and productivity of crops and livestock, good shortage, damaging houses, deforestation); and environmental impact (It disturbs climate because of deforestation, Soil erosion-removes grasses and forests from land).

1.4 Problem statement

There is a need to integrate indigenous knowledge about termite management techniques to improve farmers' pest management practices to make termites management more effective and environmentally friendly. Bako Agricultural Engineering Research Centre (hereafter BAERC) wants to develop integrated termite management that will be delivered through water and soil conservation practices and implemented by the Soil and Water Engineering Research Teams. BAERC, however, lacks sufficient information on the indigenous knowledge that farmers are using to control termites in the area. Therefore, this study aims to analyse and document the role of Farmers' indigenous knowledge on termite infestation control in the area. Information generated on the indigenous knowledge of farmers in termite control within the district will be an input and vital for priority setting and development of integrated termite management strategies that are sustainable and meet local needs.

1.5 Objective

To provide information to BAERC on the role of farmers' indigenous knowledge and experiences on causes of termite infestation and control methods to enable BAERC to develop integrated termite management practices combining both indigenous knowledge and modern scientific insights in improved termite control.

1.6 Research Question

What are the indigenous knowledge and experiences of farmers on termite infestation, its causes and control methods; and how can these be integrated with 'scientific' approaches for cost-effective, environment-friendly and sustainable systems of termite control?

Sub research questions

1. What is the level of knowledge and experiences of farmers about termite infestation and its causes in Nedjo district?
2. What are traditional termite control methods and good practices being used/employed by farmers and which ones are most effective?
3. What are the effects of chemical method of termite control in Nedjo district?
4. How can traditional and 'modern' methods of termite management be integrated?
5. What are the effects of termite infestation on Food and nutrition security in Nedjo district?

2 LITERATURE REVIEW

This chapter has six sections focusing on section 2.1 termites, section 2.2 causes of termites' infestation, section 2.3 termite control methods, section 2.4 integrated termite management, and 2.5 indigenous knowledge. The final section, section 2.6, presents a conceptual framework of the study.

2.1 Termites

In tropics, termites are the most damaging pests. They cause damage to agriculture, forestry and housing. There are different families and sub-families. Some live in nests underground, others in wood, hollow trees, and others build mounds (Logan, et al., 1990).

Most of the known genera and those species that damage rangeland, crops, and trees belong to the family Termitidae. This family consists of four subfamilies: Macrotermitinae, Nasutitermitinae, Termitinae, and Apictotermitinae. It is estimated that less than 20% of members of the family Termitidae are serious pests although the exact number of pest species is not known (Pomeroy et al. 1991, Mitchell 2002). Members of the Macrotermitinae is attributed to Over 90% of the termite damage in agriculture, forestry, and urban settings (Pomeroy et al. 1991, Mitchell 2002), which build the large mounds (Glover 1967, Malaisse 1978). The reputation of termites as pests is also associated with the presence of termitaria in crop fields and near trees (Sileshi, G., et al., 2009).

2.2 Causes of Termite Infestation

The causes of termite infestation are declining soil fertility resulting from deforestation, land degradation, overgrazing and other related factors. The aggressive expansion of termites has serious repercussions for local livelihoods, including lack of suitable grass for livestock, nectar for beekeeping, reduced crop yields, and declining productivity of the land. There are reports that termites are even posing a threat to newly built infrastructure (Legesse et al., 2013)

Termites cause direct physical damage often affecting the structural support of crop plants. They also cause indirect damage by interfering with the food crops and water supply, causing the eventual death of part, of all, of the plant (Pearce, 1997). Hickin (1971) indicated that in many areas of the world termite species are serious pests of growing crops including living trees and buildings. Termites by no means confine their attentions to dead plant tissues such as wood. Guachan et al. (1998) described that termites cause widespread damages to a great variety of crops in tropical Africa. The damage from the seedlings to harvest and usually occur every year; termites form almost stable population and foraging by various combinations of several species occur throughout the year. The author reported that termites lowered the yield of maize, sorghum, teff, millet and beans in Manasibu district, West Wollega, Ethiopia.

2.3 Termite Control Methods

2.3.1 Chemical Control Method

The use of organochlorines and queen removal has been in practice as a primary component of termite control in Western Ethiopia (Emana and Gure, 1997). While the reliance on organochlorines stopped following its ban and shortage on the market, the use of queen removal became questionable because of the continued survival of the colony upon the death of primary reproductive.

Mugerwa, S., et al. (2014) indicated that synthetic chemicals were used to destroy the colony. Nyeko and Olubayo (2005) reported that farmers mix chemicals such as Ambush, Dimethoate, Diazole and Thiodan with water, make a hole on top of the mound and pour the mixture into the hole. Mugerwa et al. (2011b) reported this practice as the most common method of termite control Nakasongola in Uganda. Several farmers noted that the method deactivates the colony for a short period and after some time, the colony restores. This probably meant that some termites within the colony especially the queen may not get in contact with the chemicals. There is also a possibility that the amount of the chemicals mixed in water may not be enough to kill the colony or the active ingredients within the chemicals may not be sufficient to destroy the colony (Mugerwa, S., et al., 2014).

Organochlorines, which are regarded as persistent organic pollutants (POPs) have been widely used for termite control until recently, (Logan et al. ,1990, Langewald et al., 2003). The search for alternative insecticides has increased with the banning of POPs.

Termite control method by the chemical has an impact on the environment and human welfare and have also largely ignored or perceived as localised problems. Termites mound is often the primary source of apprehension and targets for application of pesticides and other control measures. As noted by (Sileshi, G., et al., 2009) termite control by pesticides is likely to have adverse effects on human health and the environment in at least three ways. First, direct exposure of farm families to pesticides could occur because people who apply pesticides usually do not take precautions or wear personal protective equipment. Second, people could also be exposed to pesticide residues by consuming termites and mushrooms from a treated termite mound. Thirdly, children and women can be exposed to pesticides through consumption of soil from the treated mound. Also, it may pose risks on non-target organisms that inhabit termite mound or consume the soil (Sileshi, G., et al., 2009).

2.3.1 Cultural Control Methods

Destruction of termites' mound and removal of queen

Guachan et al. (1998) described that digging mound and queen removal expose termites to the sun, birds and other predators and prevent their access to crops.

Farmers employ different termite control methods aimed at destroying the colony that mitigate termite damage on vegetation and in an attempt to reduce termite densities by dig out the entire mound (Mugerwa, S., et al., 2014).

Mound destruction on land such as grazing lands is costly and labour intensive. Termite mound driller technology other than physically digging out the queen directing the chemicals to the queen chambers may be developed (Mugerwa, S., et al., 2014).

Flooding

It is possible to reduce termite population by facilitating flooding to enter in the mounds of termites. This may lead to the disturbance of members of the colony by suffocation (Pearce, 1997). Excavating the top parts of the mounds and burning straw can suffocate and kill the colony (Guachan et al., 1998).

Plant materials

Farmers used many plant species across Sub-Saharan Africa to control termites (Logan et al. 1990, Nkunika 1998). Among the plant species frequently mentioned Euphorbia tirucalli in the literature and particular study sites rank first. Farmers in Zambia and Malawi believe that planting of E. tirucalli in crop fields or applying its branches in planting holes prevents termites (Orr and Ritchie 2004, Sileshi et al. 2008b).

Farmers in Zambia apply Bobgunnia (Swartzia) madagascareinsis crushed pods in planting holes (Nkunika 1998, Sileshi et al., 2008). In Tanzania, the leaves and roots of E. tirucalli are soaked in water, and the solution is sprayed to protect seedlings from termites (Logan et al. 1990).

Extracts from Tephrosia vogelii leaves are also used to protect tree seedlings in Zambia and Malawi (Nkunika 1998, Sileshi et al. 2008b). The drawback of plant materials is that farmers' procedures vary widely. The mechanism which these mixtures reduce termite damage is as yet unclear.

The breakdown of most plant materials rapidly in the soil and may not give sustained control to termite (Logan et al. 1990). In addition, the threat they cause to humans, as well as the environment, is often unknown. Therefore, better care is required in their use. Rigorous toxicological, safety and environmental evaluation are also needed for their extensive application.

Application of wood ash

Wood ash has been widely mentioned as one of the control practices in eastern and southern Zambia (Nkunika 1998, Sileshi et al. 2008b) and Nigeria (Banjo et al. 2003). Logan et al. (1990) summarise reports about the use of wood ash for termite control. However, the mechanism by which ash protects against termites is unclear. Variations also exist on the effectiveness of ash (Nkunika, 1998).

Cow dung

Farmers control termite by applying cow dung and urine in different parts of Africa (Malaret and Ngoru 1989, Nkunika 1998). In an experiment conducted in Uganda, a decrease in termite damage to rangeland by using cow dung has been demonstrated (Tenywa, 2008). In Zambia, farmers used fresh cow dung to reduce termite damage to maize (Nkunika 1998). Likewise, in southwestern Nigeria farmers believe that goat and cow dung reduce termite damage (Banjo et al. 2003). (Sileshi, G., et al., 2009).

Weed and tillage practices

Farmers in Malawi and eastern Zambia avoided ridging the soil when weeding or reduced the weeding to a minimum to reduce termite damage on maize crops (Sileshi et al. 2008b). Tillage and weeding may have adverse effects on termite activity because of the physical disruption of their feeding, exposure to predators and, alteration of soil environment and food resources (Logan et al. 1990, Black and Okwakol 1997). However, there are contradictory reports on the effects of weeding on termite populations (Sileshi, G., et al., 2009.

2.3.2 Biological Control Method

In this method, natural enemies such as parasites, pathogens and predators are used. Termites can be preyed by a wide range of predators like birds, lizards, frogs, spiders, bats, mammals and ants. These natural enemies can destroy many swarming males and females when they leave the nests or during the flight. Ants are also the predators of termites, which have the great potential as biological control agents (Su and Scheffran, 1998). Biological control of termites has mainly focused on the use of fungi (e.g. Metarhizium) and nematodes though some viruses and bacteria are also used for their control (Abdurahman, 1991).

Many natural enemies (predators, parasites and pathogens) attack termites in nature. Biological control is the use of these natural enemies in termite management. It constitutes a more environmentally acceptable alternative to traditional chemical control measures.

2.4 Integrated Termite Management

Some species of termites can cause significant damage to crops, rangeland, trees, and structural timber. Simultaneously, they can also play a beneficial role in the promotion of essential ecological processes. The ongoing attention in sustainable agriculture and food security in Africa indicates the need for a more balanced approach to termite control and maintenance of their ecosystem services. A holistic consideration of the termite problem and opportunities for their sustainable management is needed

Sustainable termite management is here defined as one that ensures (1) control of the termites without causing ecological damage as well as loss of the ecosystem services provided by termites, (2) conservation of termite species that are not-pest, and (3) The appropriate use of termites and other resources. in sustainability, risk management and ensuring resilience are key concepts and these needs for a strategy that combines the skills and indigenous technical knowledge of farmers with modern scientific knowledge (Sileshi et al. 2008a). Integrated termite management (here after ITM) requires approaches that lead to the rehabilitation of degraded lands. Achieving this will raise environmental health and human prosperity through increased land and water productivity (Mugerwa, S., et al., 2014).

Some conditions need to be satisfied for termite management strategy to be effective in African production systems. Firstly, provision of adequate food resources to termites to deter them from attacking crops. Secondly, enhancing multiplication and proliferation of both micro (such as entomopathogenic fungi) and macro (such as predatory ants) enemies of termites. Thirdly reduce the vulnerability of crops through improved agricultural water and soil nutrient management for vigorous growth, and Fourthly integration of repellent organisms (such as vetiver grass) in African cropping and pasture systems (Mugerwa, S., et al., 2014).

Review of the different termite control practices revealed that no single management practice met all these four conditions. Ineffectiveness of these termite management strategies calls for an integrated termite control (ITM) approach addressing all the above aspects of termite control mechanisms (Mugerwa, S., et al., 2014).

Environmental rehabilitation, chemical treatment, use of lodging resistant crops, queen removal aided by flooding and chemical poisoning and use of some botanical plants are some of the components to be integrated for effective control of termites (Emana and Gure, 1997).

Termite control practices can have adverse effects on human welfare and the environment in some ways. Consequently, more balanced termite management practices are needed to ensure maintenance of the ecosystem services provided by termites and human well-being.

2.5 Indigenous Knowledge

In the control of termites and efforts to reduce crop and fodder losses farmers and local communities are likely to have developed indigenous knowledge as relevant to local contexts. Indigenous knowledge may play an important role in improved and integrated termite management.

Berkers (2008) defined IK as ‘’a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generation by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment”. Therefore, IK is a cumulative knowledge that can develop over time.

According to (UNEP, 2008; 22) there is general the terms “indigenous (local) knowledge”, “traditional (community) knowledge”, “rural peoples’ knowledge” , “traditional ecological(environmental) knowledge (TEK)” “indigenous traditional knowledge”, and are used for knowledge belonging to local people while there are distinctions that can be made between these terms. Indigenous knowledge is the exceptional knowledge that individuals in a given community developed from time to time (Samal *et al.,* 2010, 140). It is recognized that IK plays a major role in sustainable management of ecosystem; however, IK has its limitations.

The attention to Indigenous Knowledge (IK) is increasing a, and its’ importance in sustainable development is well acknowledged (Samal *et al.,* 2010, 140). Scientists and indigenous people are collaborating In various places in the world to build bridges between modern science and indigenous knowledge (Shiferaw, A., et al.,2011). The need to understand indigenous knowledge systems are beginning to recognised by policy makers and agricultural development planners and renewed interest in this type of knowledge has been shown (Warren and Rajasekaran, 1993, 8). The importance of indigenous knowledge has been recognized in ecosystem management and its’ contribution to the advancement of knowledge in modern science.

Indigenous peoples have high social and cultural values, ordered social control and cohesive social systems rooted in their indigenous knowledge of the universe and their locals. There are limitations in studies about the indigenous knowledge in the academic arena, and there is a limited attention on the importance of understanding the ecological knowledge of the indigenous people in minimising environmental and social problems (Melaku Getahun, J., 2016).

Local communities use different indigenous knowledge in selection of land for different crops, weed control, improving soil fertility, a method of storing and preservation of seeds (Mosissa, R., Jimma, W. and Bekele, R., 2017). This indigenous knowledge can be more effective when we integrate them with scientific knowledge. Indigenous communities have an enormous understanding of these insects and have improvised ways of identifying and controlling them (Melaku Getahun, J., 2016).

Farmers’ indigenous knowledge in termite control may help in improving the existing practices or adopting environmentally friendly and socially acceptable management approaches. Farmers’ indigenous practices depend on an understanding of the local situation. Unfortunately, without adequate research, indigenous practices have been dismissed by some researchers as unsatisfactory. This is due to the performance of indigenous practices is often compared to chemical control, which often gives an immediate result. Their advantages and limitations need to be identified to generate contextual and site-specific knowledge instead of dismissing such practices as ineffective. In this way, drawbacks of indigenous practices can be solved, and solutions may be found with local relevance. This emphasises the point that ethno ecological knowledge is best a substitute for scientific knowledge rather than employed as a complement. The participatory research approach that targets farmers to build coherent principles for termite management in Africa is recommendable (Sileshi, G., et al., 2009).

2.6 Conceptual Framework

In this research there is a strong focus on indigenous knowledge (any traditional/cultural methods that farmers practise to control termites) as well as modern knowledge and practice on the management of termites.

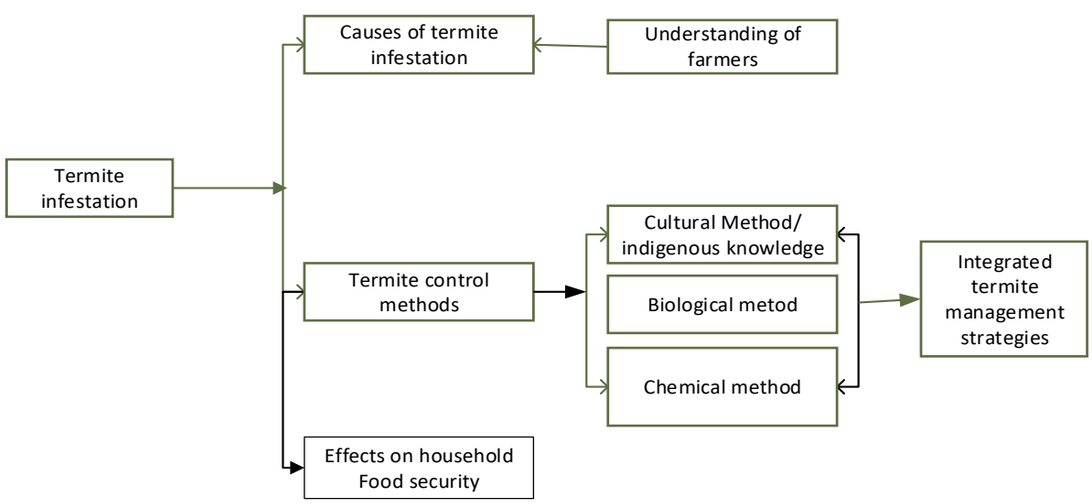
The farmers' indigenous knowledge systems resulted from the frequent observation of crops, pasture and trees during the cropping, grazing and production cycles over many years, and it comprehends continuities within the landscape and vegetation. Understanding the capacities and weaknesses of farmers' indigenous knowledge of pest management may form the basis for the constructive generation of appropriate termite management strategies.

Nevertheless, there may still need to demonstrate the verity of farmers' knowledge through science based research. Traditional approaches to termite control commonly involve interventions such as manual removal of queens and nests, application of chemical termicides, baiting and use of repellent plant, urine and animal excreta (UNEP, 2003; Abdulahi et al., 2010; Mugerwa, 2013). Furthermore, chemicals potentially harm non-pest species and interfere with the positive roles termites play in healthy ecosystems. In general, these approaches are costly. Complete prevention and eradication of termites is not a possible management objective; instead, the focus should be on integrated management, and on reducing the costs to people and the environment.

This study adopts the following conceptual framework. It starts by looking at termite infestation from three different angles: causes of termite infestation, termite control methods and its effects on HH food security.

In looking at the causes of termite infestation it is important to look at the scientific explanation as well as farmers understanding and perceptions (as this presents 'their reality'). With regard to termite control methods the study looks at cultural, chemical and biological termite control methods. Because these are relevant as elements of integrated termite management. The study also looks at effects on household food security as this may form a major driver for coping mechanisms in terms of management of termites, and if not successful, coping mechanisms employed by farmers to meet basic food security (see fig. 1).

Figure 1: conceptual framework



Source: own work, 2017

3 METHODOLOGY

This chapter presents the methodology of the research. The sections present the description the study area, the research strategy, access to the study area, sampling technique and method of data collection. Further, this chapter also describes data analysis, limitation of the study and informed consent. Finally, it presents the reflection.

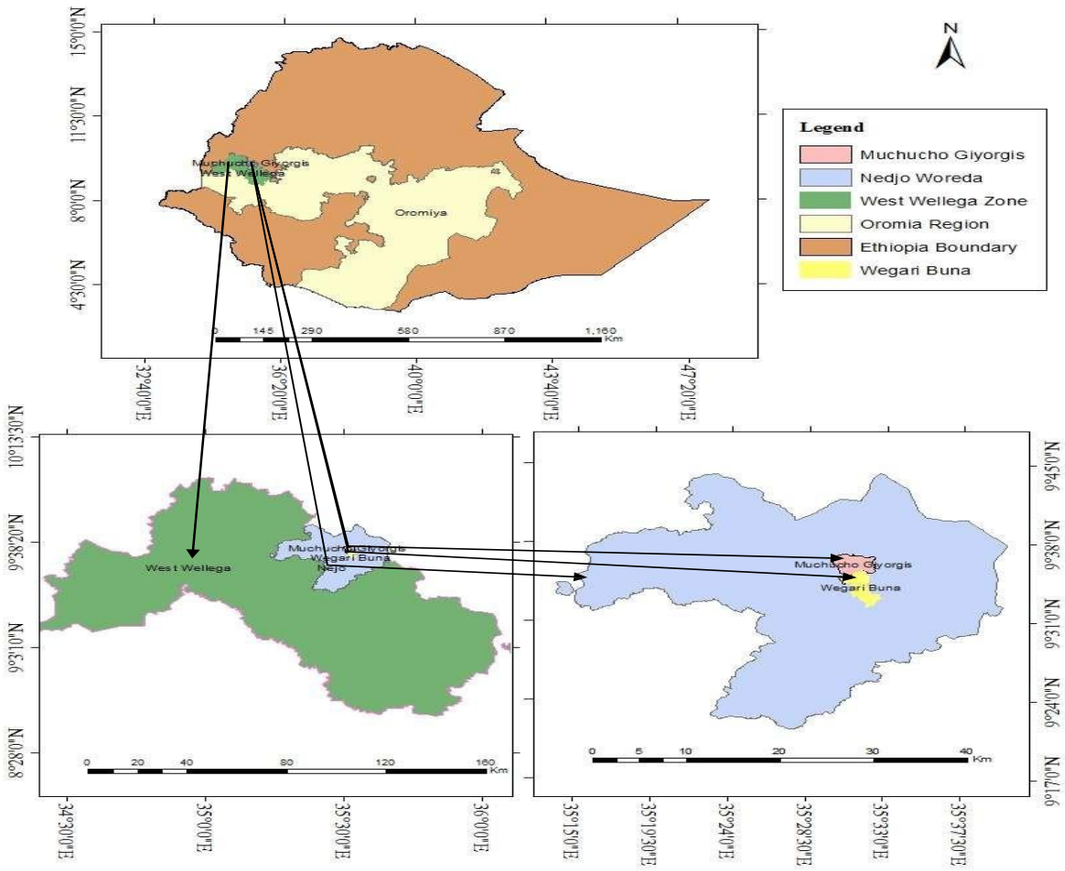
3.1 The Study Area

The study was conducted in Wegari Buna and Muchucho Gyorgis Peasant Associations of Nedjo district, West wellega Zone of Oromia Region, Ethiopia. Nedjo district is located 515 km to west direction from the capital city Addis Ababa. It is located at 75 km from Gimbi to west direction, which is the capital city of western welllega zone. Nedjo district is one of 180 districts of Oromia region. It is bordered by Benishangul-Gumuz in the North, Jarso District in the South, Bojji Dirmagi district in the East and Kiltu Karra district from the west.

The district has 39 peasant associations with four administrative towns. Nedjo district has an estimated total population of 144,302, of whom 70726 are men and 73576 women; 6725 of its population were urban dwellers and 137,577 residents were rural dwellers. Based on Nedjo district agricultural department in 2016 the total area coverage of this district is estimated to 72,601.777 hectares (NDBANR, 2016).

The altitude of the district ranges from 1600 to 2200 meters above sea level. The temperature of the district range from 18 degrees centigrade with 800-1300 millimetres annual average rain fall. Majority of the district is under the agroclimatic zone of woina dega. Agricultural production is the main means of livelihoods for the district (NDBANR, 2016).

Figure 2: Administrative Map of the study areas (including the map of Ethiopia, wellega zone and Nedjo district of the study area)



Source: Adapted from GIS map data, 2017

3.2 Research Strategy

Desk study and qualitative case study approach were used for this study. According to Laws, et al. (2013) case study is research method focused on an in-depth investigation of a single issue, individual, group or event. Therefore, a case study was conducted to gain an in-depth insight of indigenous knowledge and experiences of farmers on termite control and its causes in Nedjo District.

3.3 Access to study area

To get access to the study area, the researcher first introduced his research proposal with the Center Manager of Bako Agricultural Engineering Research Center in order to obtain a support letter.

Having the required support letters, the researcher travelled to Nedjo district where he presented both letters including the support letter from Van Hall Larenstein University and his organisation and explained the purpose of the research to the head of Nedjo District Bureau of Agriculture and Natural Resources to get permission access to the field. They approved his request and assigned experts for him to select two peasant association based on the criteria.

Accordingly, Wegari Buna and Muchucho Gyorgis PA were selected based on their severity in terms of termite infestation and current government intervention areas. Another support letter was written to the selected PA's and copied for respective development agents and supervisors. After that, the researcher enters to the PA and introduces himself to PA administrators and DAs. Then the researcher again explained the purpose of his research and mentioned the criteria to select respondents and setting the dates and times for farmers to conduct focus group discussion with the support of the Development Agent in the PA.

In undertaking his research, the researcher was supported by the development agents to appoint and contact farmers in their home as well as at their farms.

3.4 Sampling Method

Two Peasant Associations (hereafter PA) namely Wegari Buna and Muchucho Gyorgis were selected from Nedjo district purposively based on the severity of termite infestation where the farmers practice different termite control methods.

The PAs were selected with the cooperation of Nedjo District Bureau of Agriculture Experts. From each of the selected PAs, 15 respondents were selected and interviewed (using a semi-structured interview format) purposively based on their awareness and experience on termite infestation in order to get in-depth information on their local knowledge on termite infestation and control methods.

Three key informants were selected and interviewed based on their experiences on termite infestation from government and NGO working in the district.

3.5 Method of Data Collection

Primary and secondary sources were used for this study. Primary sources were collected through a case study with farmers and experts in Nedjo district while secondary information was collected through desk study. Primary data was collected through focus group discussion, semi-structured interview, key informant Interview, Participatory Rural Appraisal(PRA) and observation.

Key Informant Interview(KII): Key informant interview were conducted with Nedjo district bureau of agriculture expert (crop production and protection team coordinator), Nedjo Green Livelihood and Natural Resources Development Project Facilitator, and World Vision Ethiopia Nedjo Area Programme Supervisor. This was done before entering/visiting the PAs to get a general overview about termite infestation in the district and to know what has been done by these organisations in termite management strategies. A topic guide (see appendix 1c) was prepared and used separately for the key informant.

Participatory Rural Appraisal (PRA): PRA was conducted in both PAs before conducting semi-structured interview and FGD. This to know and understand the general overview of the PA and the history of termite infestation by using community mapping and history timeline. PRA tools used were community mapping and history timeline. They were used to get general and basic information about termite infestation and their distribution in the PA.

Semi-structured interview: next to PRA, semi-structured interview was conducted with 15 respondents in each PA. In total 30 respondents were interviewed on the basis of this semi-structured interview format, 15 respondents in each PA. Through these interviews in-depth information, individual knowledge, good practices and experiences of farmers on causes of termite infestation and traditional termite control method by using semi-structured interview guide (see Appendix 1a) were obtained. A semi structured interview guide was used to get in-depth information on knowledge and experiences of farmers on termite infestation and its controlling methods and how it can be integrated to termite management methods in the district.

Focus group discussion: In total two Focus Group Discussions (FGDs) were conducted with farmers to get in-depth information and opinions about termite infestation and its controlling methods and how can local knowledge be integrated into termite management from farmers in the PA. One focus group discussion in each PA was conducted with farmers composed of 7-8 members by using the topic list (see appendix 1b). These FGDs proved instrumental in understanding farmers' knowledge of termite infestation, its causes and local control methods. In both PA the FGD was conducted after the semi-structured interview in order to also discuss important issues coming out of the semi-structured interviews.

Observation: systematic observation was conducted to understand the area which is affected by termite infestation and the method local farmers are practising to control termite, their traditional knowledge on their farm field by using a topic guide (see appendix 1 d) prepared for this. The observation was used as triangulation for information collected through focus group discussion and a semi-structured interview. The observation was conducted in both PAs. Pictures were also taken during observation. Application of these instruments yielded good insights into practices of integrated termite management practices both on individual farmers' fields and on communal land.

Before the actual case study, pilot- testing of the guideline was undertaken. On the basis of the pilot-test, some modifications were made on the check list. Finally, the data was collected by using semi-structured guide lines, FGD and KII topic lists.

3.6 Data Analysis

Data was analysed qualitatively. All data collected through individual interviews, Focus Group Discussion, Key Informant Interviews and observations were organised by theme and entered into Microsoft Excel programme daily from the beginning day of the data collection. The organised data was grouped, summarised, discussed and interpreted by theme based on the findings from

observation, semi-structured interview and focus group discussion qualitatively. The data collected by PRA tools was analyzed with the community on the field.

3.7 Limitation of the study

During semi- structured interview not all audio was recorded. Only four individual interviews were recorded out of 30 interviews. The researcher observed that although farmers and other stakeholders gave their informed consent orally and agreed to be recorded, some of them felt uneasy and not relaxed while others started talking like to a journalist only sharing official government policies. This diverted their attention and resulted in a poor focus on the topics to be discussed. To overcome this problem, the researcher decided to note down key words and expanded his notes immediately after each interview.

3.8 Informed consent

All interviewees were asked their willingness to participate in the research process. They were told as the study is a confidential and their name will not be disclosed anywhere, as this information will only be used in the report to be submitted to Van Hall Larenstein University and as they are free to discontinue/withdraw participation at any time without prejudice.

3.9 Reflection

The researcher proposed to use audio as data recording methods in methodology. However, after interviewing four individuals, the researcher realised that this audio recording is not suitable for interviewing. They want to talk either about positive or negative of what we were discussed. They prefer to speak of a solution from the government like resettlement or supplying of chemical for termite control by the government although the researcher has told them the purpose of the research. Therefore, The researcher has decided to stop recording audio, and took note of key words, and after finishing the interview, the researcher immediately sat down at the place and expanded his notes. However, all FGDs were recorded.

The researcher realised that respondents should clearly inform the purpose of the research and expectation of the research outcome. Sometimes the respondents may expect direct benefits by participating in in the research. The researcher realised this during community mapping at Wegari Buna. Farmers were discussing and drawing the map in a group. The researcher asked them to indicate on the map the villages with the most severe termite infestation problem of the PA because this will help him to contact respondents from the affected area. One of the participants disagrees with the group when the other indicate the villages on the map. They asked him why he did not agree with their idea because it is the most severe area. He said it is true there is termite infestation problem in the area. However, the area got chemical supports from the government so it should be in other villages. The researcher realised the expectation of that participant and he explained the purpose and the expected outcome of the research. The researcher learned from this for his next interviews since this was his beginning for data collection with farmers.

The researcher understands there are unique cultures that a certain community have. It is important to know these cultures and respect it to create smooth relationship during the interview. The researcher understands that, in Nedjo District, one should show respect while greet and communicate to elders. To make the ease of communication for the interview, the researcher greeted the farmers with two hands to show respect for the elders as it is done culturally. Knowing the culture of the area helped the researcher to communicate easily with the respondents to get the idea and insight from the elders on termite infestation. This makes mutual understanding and trusts strong.

The researcher was born into a farming family in west wollega zone where termites infestation is a big problem. He knows some of the traditional termite control methods. He used to apply some of the methods with his father until he joined high school. Some of the cultural termite control methods that he knows are queen removal and flooding. When he was in grade five, he sowed eucalyptus seeds and transplant on his father's land. His eucalyptus seedlings were totally damaged by termites. Due to this personal experiences mentioned above, he perceived termites as the enemy. He thought termites have no benefits before reading some literature about benefits of termites. For this reason, during the interview, the researcher might be biased due to his personal experience when probing an interview or summarise and interpret the respondents' idea.

4 FINDINGS

This chapter presents the research findings. The chapter follows the sub-research question as a logical structure to report on study findings.

Section 4.1 presents the findings on the level of knowledge and experiences of farmers about termite infestation and its causes in Nedjo district. Section 4.2 describes traditional termite control methods and good practices being used/employed by farmers and which ones are most effective. Section 4.3 presents the findings on the effects of 'modern' chemical method of termite control in Nedjo district. Section 4.4 describes how traditional and other methods of termite management can be integrated. The final section, 4.5 presents the findings on the effects of termite infestation on Food and nutrition security in Nedjo district.

4.1 Level of knowledge and experiences of farmers on termites' infestation.

This section answers the first sub-research question 'What is the level of knowledge and experiences of farmers about termite infestation and its causes in Nedjo district? '. The research found that farmers have understanding about the causes of termite infestation (section 4.1.1); Susceptible crops to termites (section 4.1.2); Termite tolerant crops (section 4.1.3); Termite resistant trees, shrubs and grasses (section 4.1.4); and they are able to identify termite species based on termite's body size (section 4.1.5).

4.1.1 Understanding of farmers on history and causes of termite infestation in the district

Interview findings showed that farmers have an understanding about the causes of termite infestation. According to key informants the causes of termite infestation are overgrazing, intensive cropping for long periods, inadequate alternative food sources for termite, increased number of livestock, soil erosion, declined soil fertility. Farmers believe that termites are natural and exist naturally since a long time in their area. The problem has become serious because of a lack of food sources, in particular the disappearance of forests and particular kinds of grasses, with termites turning to crops and fodder stocks.

All of the FGD participants stated that the main causes of termite infestation are overgrazing, deforestation and poor soil and water conservation practices. They mentioned that deforestation is started for expansion of agricultural land due to population growth. Farmers also stated that previously there were many indigenous trees in the area. They estimated that around 13 species of trees and grasses are extinct from the area some of them are *Lippie javanica (*'kusaayee' in Afan Oromo*)*, *Salix subserrata* ('*alaltuu*' in Afan Oromo), and *Cynodon dactylon* ('*coqorsaa*' in Afan Oromo). During FGD it is was also mentioned that there were ants at the time lived in the forests, particular ants that were feeding on the termites. With the disappearance of the forests these ants disappeared as well.

Farmers explained that deforestation is the main causes of termite infestation. This is the reason why termite infestation has now become endemic. Older farmers mentioned that they were told by their parents to collect branches and other organic materials from the forests for the termites to decompose it on farm land to increase soil fertility. The termites at that time are tiny and white. During the Derg regime a new termite variety appeared; one with big and very a hard heads feeding on agricultural crops.

Box 1 : Deforestation as the main cause of termite infestation

Interview excerpts from a respondent in Muchucho Gyorgis who shared his experience of the termite infestation and its impact on people's livelihoods.

'*Termite infestation increased from time to time. It was started in Mana Sibu district in the area called Bafannoo Korreechee during Derg regime. When it came to our area, from the direction of Danno Michael at that time, we started to remove the queens by means of regular community campaigns.*

…. Due to the problems of termites our mind has no rest … we are exposed to hunger. Not because of other factors but because of termites.…when we order our children farm activities they asked us why we are work farm activities looking this damage by termites? We have no answer for them. As you see, this crop being cut by termites at this stage. We lose a moral to do farm activities. We are trying to control by firing. …. Termites is everywhere. Even there are termites in Benishangul-Gumuz region where we migrate to seasonally for farming. In Benishangul-Gumuz farmers compete to cultivate sorghum on termites' mound. They said it is used as fertiliser. Termite does not eat sorghum although they sowed on termite mound because there is a forest. It has something to eat. It has alternative food sources. I am telling you this from what I have seen with my eyes there. However, here it is opposite. It eats sorghum. It eats every crop. What aggravates termite infestation here is a lack of forest due to deforestation. Previously there are different indigenous trees over here. These termites become severe due to inadequate food sources. We are being punished for what our ancestors put for us. I mean deforestation. We are living by consuming Yam.'

Source: own field work, 2017

According to most of the farmers and key informants, it is more than 20 years since termite infestation become severe in the area. Farmers said that termite had started infestation during Haile Selassie regime and it became serious during the Derg regime. The FGD participants said that landlords owned land during Haile Selassie regime and during that time large parts of the area were covered by forest. After that Derg took over power the land was distributed amongst the peasants. Then the expansion of land for agriculture started, forests disappeared, soils were exploited, overgrazing started and termite infestation grew rapidly. The farmers mentioned that termite exists from ancient time and it exists in their neighbour district also. However, the reason why termites became severe in the area is in the end the lack of alternative food sources for termites.

Box 2: Farmers description of termite infestation and its causes in Wegari Buna

One of the respondents in Wegari Buna described the termite infestation situation and its causes as follows.

'*Termite infestation is started in Mana Sibu district, neighbour district to Nedjo, at a place called Bafanno korrachee. However, in this area, it is about 20 years since it is started. It devastates the grazing land, farmland, removing grass from land. No grasses that cattle are feeds on due to termite. The cause of our poverty is this termite. What hit us by hunger, the stick of hunger that hit us is termites. We are migrating seasonally to Benishangul-Gumuz region, with our cattle due to these termites. We are paying 25 birrs per season per cow, and we also pay 50 birrs for one quintal of every product. This is a tax. We also divide equally, what we produce with the owner of the land. The place is 9 hours from here on foot. During Derg regime, there are herbs like alaltuu (Salix subserrata) around the river, so it protects soil and good for our wetland. This area was a forest. Population growth is the causes for deforestation. Look on this side (Showing the direction by pointing with hand). During Derg regime, there are about five households on this land but now at least 20 households on the same area land. Look the land is the same. It is not changed*'.

Source: own field work, 2017

Another 60 years old man in Muchucho Gyorgis described the history of termite infestation and its causes as follows. He indicated that deforestation and soil acidity is the primary cause of termite infestation.

> *'I am 60 years old now. When I was a teenager, I used to keep cattle over this land, where we are sitting now, during that time there are different types of trees. This area is full of forest. We fear wildlife to keep cattle alone. For this reason, we keep cattle together with our neighbouring children. Now look this area, as you can see, it is a bare land even without any grass. After the Derg took over power, the ownership of land is given to farmers. Then deforestation started. Termites exist from the ancient. During that time, it has something to eat. Now it has nothing to eat. Therefore, it is started to damage our crops.'*

Farmers mentioned that the severity of termite infestation became high with land degradation and soil acidity. They emphasized poor soil, and water conservation practices lead to land degradation. The way of drainage leads to soil erosion.

4.1.2 Susceptible crops to termites

Key informants and farmers reported that termites attack almost all cereal crops. However, the degree of susceptibility of these crops is different. Farmers mentioned that most susceptible crops to termites are maize, teff, and hot pepper. However, sorghum, finger millet, and haricot bean are relatively resistant cereal crop as compared to maize, teff and hot pepper. Farmers also revealed that improved crop varieties are more susceptible than the local ones. It is also observed that maize and sorghum are highly attacked at their early stage by termites in Muchucho Gyorgis and Wegari Buna peasant associations.

Figure 3: Shows maize and sorghum attacked by termites at early stage in Muchucho Gyorgis and Wegari Buna PA

Source: observation data from own field work July 2017

4.1.3 Termite tolerant crops

Farmers said that tubers and vegetables have a higher tolerance to termite attack. They some of the vegetables and tuber crops which are resistant to termites.

The termite resistant crops that are resistant to termites according to farmers are yam, Sweet potato, *Brassica carinata* (local variety cabbage), *Coleus edulis* (Oromo Potatoes in local name), its shape is similar to that of a human finger, thin and elongated, Xanthosoma sagittifolium (*Colocasia esculenta (L.)* Schott) ('*Goodarree'* in Afan Oromo), and banana. All FGD on the two study area also agreed that

these crops are resistant to termites. However, this year termite started to attack yam now a day it began to cut its root/stem. They said that they are stopping farming cereal crops switching to these tolerant crops. All of the respondent's farm these crops as a coping mechanism to avoid food shortages due to crop loss as a result of the termites.

Some of this crops are also observed in farmers' field (see figure 4) below.

*Figure 4: The following picture showed three types of crops (Yam, Sweet potato, local variety cabbage (Brassica carinata) and Oromo potato (*Coleus edulis*) planted in the same field of farmers as termite coping strategies*

a) Yam, sweet potato and coleus edulis

b) coleus edulis with Brassica carinata

Source: Observation data from own field work 2017

4.1.4 Termite resistant trees, shrubs and grasses

Farmers said that there are trees and grasses that are resistant to termites. They used some of this trees to control termites by planting as fences, as shading for coffee and also they plant on terraces.

Termite resistant trees are *Croton macroStachyus* ('*Bakkanniisaa*' in Afan Oromo), *Vernonia amygdalina* ('*eebichaa' in Afan Oromo*), *Acacia abyssinica* ('*laaftoo*' in Afan Oromo), *Cassia petersiana* ('*Raamsoo' in* Afan Oromo) and the other shrub local name called ababo (red colour with white water in its body, it is planted in seedling of eucalyptus tree and coffee to control termites,) and commo grasses.

The FGD participants stated that Bakkanniisaa (*Croton macrostachyus*) is multi-purpose trees used for termite control, and it is planted for shading of coffee as well. Its leaf also resists termites; they put its leaf under harvested crops like sorghum and teff before threshing. The leaf of *Croton macrostachyus* also used as an additive to local alcohol. Some of this trees are observed on communal land and farmers' field. As shown in the following figure, these trees are planted and grown on termite mounds.

Figure 5: Shows Croton macrostachyus and Vernonia amygdalina termite resistant trees that are planted and grown on termite mound

Source: Observation data from own field work, 2017

4.1.5 Types of termites and benefits of termites

Farmers can identify termites based on their body size, colour and activities. According to them, there are three different types of termites. These are big with a red head that forms a mound, the smaller with white colour and termite that have wings. Farmers said that the bigger ones are the one, which damage the crop. The small ones, feed on dry wood, decompose it and enriches the soil.

Most of the respondents percieved that termite does not have benefit. Only a few of the farmers reported that the smaller white termites have benefits. Those who said termite has benefit reported that termite improves soil fertility by decomposing straws, maize stalks and grasses. One of the farmers mentioned that he had heard that termites are eaten as food in some African countries like in Uganda.

4.2 Traditional termite control methods and its effectiveness

This section answers the second sub-research question 'What are traditional termite control methods and good practices being used/employed by farmers and which ones are most effective? '. The research found that the main traditional control methods practices by the farmers are: digging the mound and removal of the queen (section 4.2.1); flooding the termite nest (section 4.2.2); Smoking with crop residues, hot pepper and cow dung (section 4.3.3); Applying wood ash, hot local alcohol residues (*called 'Atala Araqe' in Afaan Oromo*), gas or salts (section 4.2.4); Planting termite tolerant trees, herbs and grasses (section 4.2.5).

4.2.1 Digging mound and queen removal

All of the respondents said that they practice queen removal as termite control strategies. They break mound by using traditional implements like hoe and shovel. They know where the queen sits on the mound. They said that the queen always lies to the east of the mound. They said they start breaking termite mound from the east direction. In both Wegari Buna and Muchucho Gyorgis, they dig 50-200 centimetres deep to get the queen. The depth differs from the mound to the other, and it also depends on the season. During the rainy season, it is not too deep. Farmers can also estimate the year of the mound and the age of the queen by counting the line on the back of the queen. The age of the queen is equal to the line on its back.

They said that queen removal is not sufficient by itself for termite control. They indicated that it worsens the situation if it is not supplemented by chemical or other traditional methods. They said that it has either reserved queen or replace another since 2-3 queen might exist in a single mound. They suggested the integration of this method with other traditional methods or chemical method. Farmers said that the mound would reappear if it is not supplemented by other methods. So after digging the mound and removing the queen(s), they either apply chemicals, hot peppers or flooding.

During FGD discussion farmers stated that termites in the area stopped forming mound above ground. They said that termites also developed a method as they continue to develop control methods. Termite started to form mound underground. It is also difficult to control non mound-building termite by chemical method. For this reason, some of them said they started to spray chemicals on the land prepared for sowing teff, one day before sowing. It is observed that on farmers' field break the mound and the termite are disappeared from the mound (see figure 6) below.

Figure 6: shows termite mound dug and queen removed from mound



a) Recently removed mound b) disappeared termite mound

Source: own field work 2017

4.2.2 Flooding

All of the farmers both in Wegari Buna and Muchucho Gyorgis are using flooding as traditional termite control method. They said that it is effective method than chemical method. However, it is used only for mound forming termites. They said that Flooding depends on rainy season and the slope of the land. They apply flooding after breaking mound and removing queen. Sometimes they also flood the mound without removing the queen by drilling termite mound. They said that this might not be effective as the queen sits in the hard nest. It might not be killed and removed by the floods. It is observed on farmers' field how farmers dig, remove and flood termites' mounds as shown in the following figures.

Figure 7: Shows termite mound prepared for flooding by farmers in Muchucho Gyorgis PA



Source: own field work 2017

4.2.3 Smoking with crop residues, hot pepper and cow dung

Farmers both in Wegari Buna and Muchucho Gyorgis said that they control termites traditionally by smoking termite mound, especially during summer season after digging and removing queen. Most of them fire with crop residues like teff straws, hot pepper and cow dung. They said that this method is useful, but it is not as flooding. They said that it is also laborious since it is done during summer when the soil is hard to break mound.

4.2.4 Applying wood ash, hot local alcohol residues (*called 'Atala Araqe' in Afaan Oromo*), gas or salts

Some of the farmers apply either wood ash, hot local alcohol residues *(called 'Atala Araqe' in Afaan Oromo)*, gas or sometimes salts to a termite mound. They said that this method is effective however

gas and salts are expensive so that they didn't frequently use this method. The FGD participant agreed that they used these methods and they said it is effective.

4.2.5 Planting termite tolerant trees, herbs and grasses

Farmers in the study area able to differentiate termite resistant trees, herbs and grasses. They mentioned that this is the most effective method for termites that are not forming a mound. They plant these trees as shading for another plant or fencing. For example, all of them plant *Croton macrostachyus*, *Vernonia amygdalina* and acacia abyssinica as shading for coffee and termite control in the area.

Farmers said that recently they found another herb locally called *abaaboo*, which is red, they plant this herb between rows of maize and around their home to control termites.

Commo grass is also widely sown on farmers' field in both PA. Farmers said that commo grass is tolerant to termites. They stated that commo grass continues to grow after cut by termite. It covers many areas of land in a short period and avoids soil erosion. It becomes alternative food sources for termites. Another advantage of commo grass raised by FGD participant is its uses to control termites that does not form a mound. Farmers said that planting commo grass is an effective method as it has a multi-purpose for soil fertility.

Farmers said that Vetiver grass is also tolerant to termites. They said it also continues to grow after termites cut it.

Figure 8: Shows ababoo, commmo grass and vetiver grass that are resistant to termites

a) *Abaaboo (local name)*

b) Commo grass

C) vetiver grass

Source: own field work 2017

4.3 Effects of chemical methods of termite control

This section answers the third sub-research question 'What are the effects of chemical method of termite control in Nedjo district? '. The research found that chemical method of termite control has both positive effects (4.3.1) and negative effects (section 4.3.2)

All of the farmers in both districts use the chemical for poisoning termite mound. They said that they began to work on a campaign to control termites by breaking mound/ queen removal and poisoning a mound with the chemical at that time. They were started applying chemicals during Derg regime. Farmers said that the chemical at that time is called Alderline. They said that it was effective but hazardous for human being and animals. It needs high caution.

One of the key informants said that they apply chemicals to poison mounds. The Chemicals are Diaznon, endosulfan (thiosulfate), Dursban 45%. According to the key informant, these chemicals are

costly. For example, 1 Litre of Dursban is about 400 ETB (16 EUR) that is used only to poison 30 termite mounds. However, there are more than 30 pounds per hectare. They said that these chemicals are not available on the market for farmers. It is supplied by government or supported by projects. It is a problem to get these chemicals after the phase out of the project. The Unions sometimes supply this chemical. According to FGD and key informants, they apply these chemicals as last options for termite control.

4.3.1 Positive effects of chemical methods of termite control

Farmers said that chemical method has positive effects for immediate action and it is also the best option where cultural methods are not effective. Farmers prefer chemicals due to the severity of termites in the area for immediate action.

They said that Chemical method is effective methods for those forming mound, but now termites stopped forming mound above ground. They said termites started to form mound underground.

4.3.2 Negative effects of chemical methods of termite control

According to key informants and FGD participants, the adverse effects of the chemical method are due to lack of PPE (Personal Protective Equipment). It has side effects on farmers during application.

Farmers mentioned that using chemical have a side effect on the soil. They said they soil becomes hard and difficult for seed germination. They also said that it kills Aardvark and ants that feed on termites.

They said that the problem with the chemical application is related to the way the mound is dug. when termite mound is dug traditionally it is not easy to cover immediately after application of the chemical. They also indicated that the effectiveness depends on the amount of chemical applied, the types of chemical and the size of the mound.

FGD participant in Muchucho Gyorgis stated that Chemical method of termite control worsens termite infestation, they said that when they poison one mound, it forms another two to three mounds around the poisoned mound. They said that chemical is not that much effective as previous.

Farmers said that it becomes hard to control termites by chemical methods. Because termites are hiding by forming mound underground. Therefore, people started spraying a chemical on the ground for sowing crop which can aggravate the negative effects of termites.

4.4 Integrated termite management practised by farmers

This section answers the fourth sub-research question 'How can traditional and 'modern' scientific methods of termite management be integrated? '. The research found that farmers practice a combination of traditional methods and chemical methods to control termites. Farmers integrated these methods by considering termite resistant trees, grasses and shrubs and applying chemicals where termite infestation is severe. Farmers said that no single control method is effective by itself. They said for this reason they practice a combination of different methods.

All respondents in both Wegari Buna and Muchucho Gyorgis said that they apply a combination of different termite control methods. They said that they practice a combination of traditional, chemical and biological control methods. Farmers said that they integrate all methods they think useful to control termites. For instance, they said that when they dig mound and remove the queen, they

immediately either apply chemical, floods or smoking. They make terracing if it is farming land and plant commo grass if the land is grazing land.

All FGD participant stated that combining these all methods are the most effective methods for termite control for a long-term solution for termite problem. However, they said that combining this all methods needs labour, energy and time.

Key informants said that IPM (Integrated Pest Management) is the best option for termite control. According to key informants different integrated termite management strategies are being practised in the district by a combination of cultivating termite resistant crops such as finger millet and improved sweet potato with soil and water conservation structures like soil bund and terracing at the same time they also practice queen removal. They said that chemical method is used when the severity of termite is high, especially on nursery site as the last option.

FGD participants in Muchucho Gyorgis stated that integrated termite strategies are the best option to control termites. They shared an example of what has been done on ITM as best practices in the PA. They said that there is communal land in their PA. On that communal land, the community agreed and make area closure. Then they removed the queen from the land and they construct terraces. On terraces, they plant trees like *Croton macrostachyus*, vetiver grasses and commo grass. They avoid livestock encroaching on the land. They said the land is now rehabilitated. On the rehabilitated land the unemployed youth form cooperative and started beehives keeping and they began to make money and earn income. They are planning now to start cattle fattening. They said that this is a best practice and indicated that the solution to termite is rehabilitating the land by integrated termite management strategies.

From the observation data of best practices of termite management, Area Closure implemented by Sustainable Land Management project (here after SLM) in Muchucho Gyorgis, it is observed that the degraded land is rehabilitated within two years. They combined different methods to rehabilitate the land that is degraded by termites. They combined physical structures like terracing, micro basin and trench, and Biological structures like planting grevillea, vetiver grass, elephant grass, commo grass and other tree species that are tolerant to termite. As shown in figures below it rehabilitated within two years. Farmers said that termites continue to eat vetiver grass and commo grass, however, the grasses continued to grow and used as alternative food sources for termites.

Figure 9: Shows rehabilitated land by SLM project in Muchucho Gyorgis PA

Source: own field work 2017

4.5 Effects of termite infestation on household food and nutrition security

This section answers the last sub-research question ‘What are the effects of termite infestation on Food and nutrition security in Nedjo district? ‘. The research found that termite infestation has adverse effects on food and nutrition security of farmers in the district.

All of the respondents said that termite infestation has adverse effects on their household food security. Farmers reported that they stopped cultivating maize and teff on land infested by termites which have a direct impact on production of main staple crops for consumption. For some this resulted in serious food shortage forcing them to (seasonally) migrate to the neighbouring region of Benishangul-Gumuz region. Data obtained from key informant shows that 40% of the district farmers are migrating seasonally to farm in another region and the left 60% produce coffee as coping strategies. One of the respondent in Wegari Buna stated the effects of termite infestation as follows.

> '*I don't know how to tell you. We are buying food crops for consumption from the market as urban dwellers. We are farming, but we are buying. This is due to termites. This food shortage from year to year. This termite problem is not visible as lack of rainfall. Our production is not enough for family consumption. We are here by our soul, but we are migrated*'.

Another respondent in Wegari Buna also stated the effects of termites on household food security as follows.

> *'…reduce production; previously we used to produce six quintals from half a hectare, but now we produce about one quintal per half a hectare. We are unable to pay the cost of inputs. It damages trees which we were generating income from like coffee. We are unable to feed ourselves with products. We depend on the market, trading, seasonal migration to region 6, selling all livestock. Our enemy is termites.'*

Farmers said that they cope by migrating to Benishangul-Gumuz region, selling livestock, cultivating vegetables and tubers like yam, off-farm activities like gold mining and cultivating maize on wetland (however now a day's termite started to attack maize in cultivated in the wetland). They said that the wet land is also limited that is not accessible to every farmer.

5 CHAPTER FIVE ANALYSIS AND DISCUSSION

This chapter presents the analysis and discussion of the research findings. The chapter follows the sub-research questions as a logical structure to analyse and discuss the findings.

1. What is the level of knowledge and experiences of farmers about termite infestation and its causes in Nedjo district?
2. What are traditional termite control methods and good practices being used/employed by farmers and which ones are most effective?
3. What are the effects of chemical method of termite control in Nedjo district?
4. How can traditional and modern scientific methods of termite management be integrated?
5. What are the effects of termite infestation on Food and nutrition security in Nedjo district?

The chapter is structured as follows.

Section 5.1 presents the analysis and discussion on the level of knowledge and experiences of farmers about termite infestation and its causes in Nedjo district. Section 5.2 describes traditional termite control methods and good practices being used/employed by farmers and which ones are most effective. Section 5.3 presents the analysis and discussion of the effects of 'modern' chemical method of termite control in Nedjo district. Section 5.4 describes how traditional and other methods of termite management can be integrated. The final section, 5.5 presents the analysis and discussion of the effects of termite infestation on Food and nutrition security in Nedjo district.

5.1 Level of Knowledge on and Experiences of Farmers with Termite Management'

5.1.1 Causes of Termite Infestation

In the study area, farmers have a good knowledge about the history of termite infestation. They know the time and place the termite infestation started and the reason the infestation begins. They can identify which species affect more and what types of methods can be applied to different species they identified.

According to a study by Tenywa (2008) the depletion of the termite food because of deforestation and overgrazing is likely to increase termite damage to farmer's trees and crops. Mugerwa et al. (2011b) also found that farmers related overgrazing and deforestation to termite damage in Nakasongola District of Uganda (Mugerwa et al. 2011b). This study has found the same with farmers clearly seeing a linkage between deforestation, overgrazing and land degradation and crop loss due to termite infestation.

5.1.2 Susceptible crops to termites

In the study area, farmers were able to identify crops and trees which are susceptible to termites and which are resistant. It is identified that termites attack almost all cereal crops. However, the degree of susceptibility of these crops is not the same. They used this knowledge to decide types of crops and place to cultivate. They indicated that most susceptible crops to termites are maize, teff, and hot pepper. However, Sorghum, Finger millet, and haricot bean are relatively resistant crop as compared to maize, teff and hot pepper. This is in line with the study conducted in eastern Zambia with Sileshi et al. (2009) reporting that maize was rated by respondents as highly susceptible to termite damage.

The study in Nedjo District found that improved crop varieties are more susceptible than the local ones. This is also supported by the study conducted by (Legesse, H., et al., 2013). According to Haverty, M. and Sunden-Bylehn, A., (2000) also indigenous crops show resistant to termites while exotic are susceptible in Africa. They added that millet and sorghum are more tolerant than maize and groundnut.

The finding that improved crop varieties are more susceptible to termite damage has surprised the researcher as he expected improved varieties to be more tolerant to termites.

It is observed that maize and sorghum are highly attacked at their early stage by termites in Muchucho Gyorgis and Wegari Buna peasant association.

5.1.3 Termite Tolerant crops

Farmers were able to identify crops that are resistant to termites and cultivate these crops as coping strategies to termite infestation. The crops that are resistant to termites according to farmers are yam, sweet potato, local variety cabbage (*Brassica carinata*), Oromo Potatoes (*Coleus edulis*; its shape is similar to that of a human finger, thin and elongated, Xanthosoma sagittifolium (*Colocasia esculenta (L.)* Schott), and banana.

All FGDs participant in both PAs also stated that these crops are resistant to termites. However, this year termite started to attack yam now a day it began to cut its root/stem. They said that they are stopping farming cereal crops switching to these tolerant crops.

In line with the above findings Legesse, H., et al., (2013) revealed that tuber crops and vegetables have a higher resistant to termite attack which is in line with the above findings although they didn't identify specific tuber crops and vegetables.

5.1.4 Termite Resistant Trees, Shrubs and Grasses

Farmers in the study area were able to identify trees, shrubs and grasses that are resistant to termites. They used some of this trees to control termites by planting as fences, as shading for coffee and also they plant on terraces. These trees are *Croton macro Stach yus*,*Vernonia amygdalina*, *Acacia abyssinica*, *Cassia petersiana*, local name called '*ababo'*;red colour with white water in its body, it is planted in seedling of eucalyptus tree and coffee to control termites, and commo grass and vetiver grass.

Farmers mentioned the purpose of *Croton macrostachyus* is in termite control, and it is used for shading of coffee as well. Its leaf also resists termites; they said that they put its leaf under harvested crops like sorghum and teff before threshing.

Some of this trees are observed on communal land and farmers' field. In contrary to this findings, the study conducted by (Legesse, H., et al., 2013) reported that there is the seasonal severity of these trees and shrubs (broadened-leaf Croton, *Vernonia amygdalina*, *Acacia abyssinica*) and fruits like a banana to termites. This difference may be because of the farmers' perception, available grasses and the soil condition of the area.

Further research is needed on *Cassia petersiana and Local name abaaboo(Local name)*.

5.1.5 Farmers' knowledge on species and benefits of termites

Farmers can identify termites based on their body size, colour and activities in the study area. They said that knowing these termites help them to take control measures as different termite species need different control methods. According to them, there are three types of termites they differentiated. These are the big with a red head that forms a mound, the smaller with white colour and termite that has a wing. They said that the previous termites known to the area before termite infestation started are small and white but now the big one comes and cause damages. According to a study conducted in Diga, Ethiopia farmers classify termites into two species namely invaders (the subterranean termites) and termite those forming mound (Legesse, H., et al., 2013).

All most all of the respondents perceived that termite does not have benefit. Only a few of them said that that the previous white termites have benefits around forest area. Those who reported termite has benefits said that termite improves soil fertility by decomposing straws, maize stalks and grasses. Only one of the respondents heard that termite is eaten as food in some African countries like in Uganda.

In the study area termites are neither consumed for nutritional nor medicinal values. This is different from Selishi, G., et al., (2009) indicated that farmers have general knowledge of the benefits of termites in human nutrition. This is the reason why farmers in the area perceive termites as the enemy and their controlling strategies focus on killing termites rather than feeding termites. Therefore, capacity building activities are needed to create awareness among farmers in the study area on benefits of termites so that termite control strategy will focus on balancing the nature and getting benefits of termites by reducing its infestation.

5.2 Traditional termite control methods and its effectiveness

To cope with termite infestation, the farmers in the area took different traditional termites control methods. Some of the traditional methods practised by farmers are digging mound and queen removal, flooding, and smoking are the most frequently used traditional methods by farmers in the study area.

5.2.1 Digging mound and queen removal

All of the respondents in the study area reported that they practice queen removal as termite control strategies. Farmers said that they break mound by using traditional implements like hoe and shovel. This is in line with Mugerwa, S., et al. (2014) indicated that farmers employ different termite control methods aimed at destroying the colony that mitigate termite damage on vegetation and in an attempt to reduce termite densities by dig out the entire mound.

Farmers said that the queen always lies to the east of the mound. They said that they start breaking termite mound from the east direction to remove the queen. In both Wegari Buna and Muchucho Gyorgis, they dig 50-200 centimetres deep to get the queen. The depth differs from the mound to the other, and depends on the season. During the rainy season, it is not too deep. Farmers said that they can also estimate the year of the mound and the age of the queen by counting the line on the back of the queen. They said the age of the queen is equal to the line on its back.

Farmers said that queen removal alone might worsen termite infestation unless it is supplemented by chemical or other traditional methods. They said that it has either reserved queen or replace another since 2-3 queen might exist in a single mound. According to Logan et al. (1990) Success of termite, mound distraction has been limited due to various constraints including labour requirements and lack

of knowledge about termite biology although the researchers have advocated its success. This practice for mature colonies of the mound-building species, and It is overlooked for non-mound forming species (e.g., many *Odontotermes* and *Microtermes* spp.).

Another problem raised by FGD participants indicated that termites in the area stopped forming mound above the ground recently. They said that termites are hiding by forming mounds underground. This makes termite mound distraction and queen removal challenge as termite control.

Farmers said that they started to spray chemicals on the ground especially on teff, one day before sowing to control termites that do not form a mound.

It is observed on farmers' field that farmers dig the mound and remove queens where termites are disappeared from the mound. Farmers said that these methods are laborious and time-consuming. Therefore, termite mound drilling technology should be introduced to the area. Framers suggest that these methods should be supplemented with other termite control methods to be effective. This is in line with Mugerwa, S., et al. (2014) stated that mound destruction on land such as grazing lands is costly and labour intensive. Termite mound driller technology other than physically digging out the queen directing the chemicals to the queen chambers may be developed

5.2.2 Flooding

All of the farmers in both in Wegari Buna and Muchucho Gyorgis PA are apply flooding for termite control. They said that it is an effective method. However, it is used only for mound forming termites not used for subterranean termites. It is also applicable only during the rainy season and depends on the slope of the land. Flooding is done mostly after removing queen. This method is observed on farmers' field. Although this method is perceived as the most effective traditional termite control method by farmers, care should be given as this method may lead to soil erosion. Pearce (1997) indicated that it is possible to reduce termite population by facilitating flooding to enter in the mounds of termites. This may lead to the disturbance of members of the colony by suffocation. However, care should be given when flooding termite mound because it might cause soil erosion.

5.2.3 Smoking with crop residues, hot pepper and cow dung

Farmers in both Wegari Buna and Muchucho Gyorgis reported that they control termites traditionally by firing termite mound, especially during summer season after digging and removing queen. Most of them fire mound with crop residues like teff straws, hot pepper and cow dung. They said that this method is useful, but it is not as flooding. Excavating the top parts of the mounds and burning straw can suffocate and kill the colony (Guachan et al., 1998). In an experiment conducted in Uganda, a decrease in termite damage to rangeland by using cow dung has been demonstrated (Tenywa, 2008). The research also suggests further research on the effectiveness of cow dung to reduce termite damage.

5.2.4 Applying wood ash, hot local alcohol residues (*called 'Atala Araqe' in Afaan Oromo*), gas or salts

Farmers said that they either apply wood ash, hot local alcohol residues *(called 'Atala Araqe' in Afaan Oromo)*, gas or sometimes salts to a termite mound. They said that this method is effective however gas and salts are expensive. The FGD participants also stated that this method is effective.

According to a study conducted by Sileshi et al. (2008b), wood ash is one of the frequently used practices for termite control eastern and southern Zambia. Logan et al. (1990) summarise reports

about the use of wood ash for termite control. However, the mechanism by which ash protects against termites is unclear. Variations also exist on the effectiveness of ash (Nkunika 1998).

Apart from wood ash some of the farmers apply salts, gas and hot local alcohol residues. However further investigation is needed on the effectiveness of these methods and its effects on soil.

5.2.5 Planting termite tolerant trees, herbs and grasses

Farmers in the area differentiated termite resistant trees in the study area. They mentioned that planting termite resistant tree is an effective method for termites that are not forming a mound. Farmers said that they plant these trees as shading for coffee or fencing for the crop.

Farmers said that commo grass is as tolerant grasses to termites. They indicated that commo grass continues to grow after cut by termites. It covers many areas of land in a short period and avoids soil erosion so that the soil becomes fertile. Farmers reported that planting commo grass is an effective method as it has a multi-purpose. One of the key informants said that commo grass is alternative food sources for termites. FGD participants said that commo grass is best option to control termites that do not form a mound. This grass is widely used and sown in the study area as termite control strategies.

The key informant reported that vetiver grass is used full to control termites, especially on terraces. It continues to grow even if cut by termites. This is in line with the research conducted in South-West Nigeria (Ewetola, E.A., et al., 2017) vetiver is being planted for termite control or as ornamentals. They recommended that there should be awareness creation to form an eco-friendly IPM Scheme for termites on the capacities of vetiver grass as a compatible strategy with chemical control on farmlands.

Farmers in Wegari Buna and Muchucho Gyorgis identified another herb locally called *abaaboo*, which is red, they said they plant this herb between rows of maize and around their home as fences to control termites. Further research is needed to prove its effectiveness in termite control.

5.3 Effects of chemical methods of termite control

All of the farmers in both districts apply chemical for poisoning termite mound. They said they were started applying chemicals to control termites during Derg regime. The chemicals used during that time were malathion, Alderline and DDT. This finding is in line with Langewald et al. (2003) stated that Organochlorines, which are regarded as persistent organic pollutants (POPs) have been widely used for termite control until recently. The search for alternative insecticides has increased with the banning of POPs.

According to FGD participants and key informants, the chemical method is the last options for termite control. In the study area, farmers said that they would like to apply chemical for immediate action. Positive and negative effects of chemical control methods were discussed with farmers and experts in the study area.

5.3.1 Positive effects chemical method

According to respondents and key informants, the chemical method is the best option where cultural methods are not effective and for immediate action. Farmers said that they prefer chemicals due to the severity of termites for immediate action. They said that chemical method is effective methods for termites those forming mound, but now termites stopped forming mound above ground it started.

5.3.2 Negative effects chemical method

According to key informants and FGD participants, the adverse effects of termites are due to lack of personal protective equipment(PPE). Farmers said that they recognized soil physical change where the chemical is used for termite control.

Key informants reported that predators like Aardvark and ants are killed when the chemical method is used. According to Pomeroy et al. (1991) and Peveling et al. (2003) animals such as aardvark eat termite as food sources. Therefore, when termite mound is poisoned, it has effects on this animal that might be used to control termites are predators of termites.

As noted by Sileshi, G., et al.(2009) Termite control by pesticides is likely to have adverse effects on the environment and human health in at least three ways. First, direct exposure of farm families to pesticides could occur because people who apply pesticides do not take precautions or wear personal protective equipment. Second, people could also be exposed to pesticide residues by consuming termites and mushrooms from a treated termite mound. Third, Through consumption of soil from the treated mound, children and women can be exposed to pesticides. Also, It may pose risks on non-target organisms that inhabit termite mound or consume the soil. Although carbamates are regarded as no toxic to mammals; they are extremely toxic to the bird.

The problem with the chemical application is related to the way the mound is dug. In addition, since they dig the mound, traditionally it is not easy to cover the hole of mound immediately after application of the chemical.

FGD participants in Muchucho Gyorgis reported that chemical method of termite control worsens termite infestation, they said that when they poison one mound, it forms other two or three mounds around the area. This will need further investigation whether chemical control methods worsen termite infestation or not.

Termite control method by the chemical has an impact on the environment and human welfare and have also largely ignored or perceived as localised problems. Termites mound is often the primary source of apprehension and targets for application of pesticides and other control measures. As noted by (Sileshi, G., et al., 2009). Farmers said they started to spray a chemical on the ground to control subterranean termites. Therefore, people started spraying on the ground. This could worsen the effects of chemical methods on the environment and human.

5.4 Integrated termite management practised by farmers

All respondents in both Wegari Buna and Muchucho Gyorgis said that they practice a combination of traditional, chemical and biological termite control methods. They indicated that no single method is effective by itself. They integrate all methods they think useful to control termites.

All FGD participants stated that combining these all methods are the most effective methods for termite control even for a long-term solution for termite problem. However, they said that combining this all methods needs labour, energy and time.

Key informants reported that in Nedjo District, they practice different integrated termite management strategies like planting termite resistant crops such as finger millet and improved sweet potato, soil and water conservation structures like soil bund and terraces at the same time they also practice queen removal. This is in line with Emana and Gure (1997) indicated that environmental rehabilitation, chemical treatment, use of lodging resistant crops, queen removal aided by flooding and chemical

poisoning and use of some botanical plants are some of the components to be integrated for effective control of termites.

Furthermore, from the observation of SLM project best practices in Muchucho Gyorgis, the degraded land is rehabilitated within two years. They combine different physical structures like terraces, micro basin and trench, and Biological structures like planting grevillea, vetiver grass, elephant grass, commo grass and other tree species that are tolerant to termite. Termites continue to eat vetiver grass and commo grass, however, the grasses continued to grow and used as alternative food sources for termites. This best practice needs to be further scale up in the district.

Farmers' capacity building is considered as one pillar of integrated termite management strategies by SLM project. According to Legesse, H., et al. (2013) both biophysical and socioeconomic factors should be taken into account for Integrated Termite Management Strategies. Capacity building is necessary for terms of the underlying factors and the way they are related to both farmers and extension workers.

5.5 Effects of termite infestation on household food and nutrition security

All of the respondents said that termite infestation has adverse effects on their household food security. They said that they stop cultivating mainly maize and teff. Due to this their production and productivity is reduced. This is in line with to Tadese, A. (1998,) reported 45, 50 and 18 % yield losses of cereal crops due to termites at Bako, Didesa, and Asossa, respectively. Farmers said that, the land was becoming less productive, and cost of production and farm inputs was also increased due to increased demand for inorganic fertilisers to improve the poor soil fertility caused by termites.

Farmers said that they faced food shortage and forced to migrate to a neighbouring region, Benishangul-Gumuz region, key informants reported that about 40% of the district farmers are migrating seasonally to farm in other places. They said previously they cope the problem by cultivating maize on wetland however they said that now termite started to attack maize cultivated in the wetland.

A study conducted by Legesse, H., et al. (2013) in Diga District supports the above findings. They reported that termites contributed a lot to poor agricultural productivity and poor soil fertility that leads to increasing of the out migration of the community. They also noted that 75% of the household interviewed reported that they faced food shortage and all household in different wealth category faced food shortages. Household food security has been increasingly under threat with increasing termite infestation that reduces crop productivity and livestock production. Farmers have adopted different coping strategies like reducing the quantity of food per day, selling of animals and other productive assets.

6 CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions and recommendation of the report based on the findings and discussion of the research. The chapter is structured as section 6.1 conclusions and section 6.2 recommendations based on the research findings.

6.1 CONCLUSIONS

The main causes of termite infestation in the study area are deforestation, overgrazing and in-appropriate soil and water conservation practices. Farmers mentioned that the severity of termite infestation intensifies with increased land degradation and soil acidity. Farmers emphasised that in particular poor soil and water conservation practices lead to land degradation.

The study also found that farmers were able to identify termite susceptible and resistant crops, trees, herbs and grasses. The most susceptible crops to termite damage are maize, teff, and hot pepper. Sorghum, finger millet, and haricot bean are however relatively resistant crops. The termite resistant crops that are resistant to termites according to farmers are yam, sweet potato, local variety cabbage (*Brassica carinata*), Oromo Potatoes (*Coleus edulis*; its shape is similar to that of a human finger), thin and elongated, Xanthosoma sagittifolium (*Colocasia esculenta (L.)* Schott), and banana. The trees that are resistant to termites are *Croton macro Stach yus*, *Vernonia amygdalina*, *Acacia abyssinica*, *Cassia petersiana* (local name is 'ababo'; red colour with white water in its body, it is planted in seedling of eucalyptus tree and coffee to control termites).

Farmers in the area differentiated termite resistant trees in the study area. They mentioned that planting of trees to protect crops is effective for subterranean termites. They plant these trees as shading for another plant or fencing. For example, all of them plant Gravillae, *Croton macrostachyus*, *Vernonia amygdalina* and acacia abyssinica as shading for coffee and termite control in the area.

Commo grass is also reported as resistant to termites. They indicated that commo grass continues to grow even if cut by termites. Commo grass grows fast and can cover large parts of land in a short period of time thereby avoiding soil erosion and maintaining the fertile top soils. The farmers reported that planting commo grass is an effective method as it has a multi-purpose for soil fertility. It also served as alternative food sources for termites. Another advantage of commo grass raised by FGD participant is also as it is best option control termites that do not form a mound. This grass is widely used and sown in the study area as termite control strategies; however further research is required on its evidence-based effectiveness in termite control. Another potential grass for controlling termites is Vetiver grass.

Study findings revealed that only very few farmers have knowledge on the benefits of certain types of termites. All most all of the respondents believed that termite does not have any benefit. This explains why farmers in the area perceive termites as the enemy and that their controlling strategies focus on killing termites. Therefore, capacity building activities are needed to create awareness among farmers in the study area on ecological benefits of termites so that termite control strategy will focus on balancing the nature and getting benefits of termites by reducing its infestation.

To cope with termite infestation, the farmers in the Nedjo District practice different traditional control methods. The most important of these are digging mound and queen removal, flooding and smoking are the most frequently used traditional methods by farmers in the study area.

According to farmers in the study area, queen removal method alone is not sufficient for termite control. They indicated that it worsens the situation if it is not supplemented by chemical or other

traditional methods. They explained that termite colonies have either a reserve queen or simply replace the queen as a typical mount has 2 to 3 queens. Farmer's methods to control termites are laborious and time-consuming. Therefore, it is recommended that termite mound drilling technology be introduced to the area. Framers suggested that this method is to be supplemented with other termite control methods to be effective. That means termites are hiding by forming mounds underground. This makes mound distraction and queen removal a challenge.

All of the farmers in both in Wegari Buna and Muchucho Gyorgis PA are using flooding as traditional termite control method. They mentioned that it is a relatively effective method and with better results as compared to the use of chemicals. However, flooding is used only for mound forming termites not used for subterranean termites. It is also only applicable during the rainy season and depends on the slope of the land. Although this method is perceived as the most effective traditional termite control method, care should be given as this may lead to land degradation and soil erosion.

Farmers in both Wegari Buna and Muchucho Gyorgis reported that they control termites traditionally by firing termite mounds, especially during summer season after digging and removing the queen. Most of the farmers smoking mound with crop residues like teff straws, hot pepper, and cow dung.

Some of the farmers apply either wood ash, hot local alcohol residues *(called 'Atala Araqe' in Afaan Oromo)*, gas or sometimes salts to a termite mound. They said that this method is also effective but gas and salts are expensive and therefore this is not their preferred method. However further study is needed on the effectiveness of these methods and its effects on soil.

The study identified the chemicals being used to control termites in the District, they are Diazinon, endosulfan (thiosulfate), and Dursban 45%. One key informant reported that nowadays they used mostly Dursban 45%. However, these chemicals are costly, and they are not available on the market so that farmers cannot access them easily. According to FGDs and key informants, these chemicals are the last option in termite control for immediate action.

The study also revealed that chemical method has both positive and negative effects. According to respondents and key informants, the chemical method is the best option for immediate action where the termite infestation is high (mound forming termites). It also has an advantage where cultural methods are not effective. Farmers prefer chemicals as an effective method for mound forming termites; the problem is that now termites stop forming mound above ground it started to form underground.

According to key informants and FGD participants, the adverse effects of chemical control method are due to lack of personal protective equipment. It has a side effect on farmers during application. It causes air and water pollution, the soil becomes hard and arduous for seed germination. Predators which feed on termites, like Aardvark and ants which used termites as food sources, are killed when the chemical is applied. The chemicals aslo harm the soils and result in deteriorating soil physical properties, and kills soil micro organism. The effects on animals and human beings has not been studied but it is clear that chemicals are not treated and applied properly.

The problem with the chemical application is related to the way the mound is dug. If it is drilled with driller its effects can be reduced by immediately covering the hole. This is why this study recommends the introduction of a mechanic driller in the area. However, since farmers dig the mound in a traditional way it is difficult to cover the gap immediately after application of the chemical. As mentioned before termites now stop building mounds and therefore it has become harder to control termites by the chemical method. Therefore, people have started spraying on the ground but this is highly to have a very negative impact on the environment and human being.

Farmers indicated that no single method is effective by itself. Farmers therefore practice a combination of traditional, chemical and biological control methods in the study area. They integrate all methods they think useful to control termites. For instance, they said that when they dig the mound and remove the queen, they immediately either apply chemical or smoke or flood the pit. Farmers have started to construct terraces and plant it with t commo grass to protect their crops. All FGD participants voiced combining all methods is the most effective method for termite control now and for the future. But farmers also mentioned that combining these methods requires labour, money and time.

Furthermore, Key informants noted that Integrated termite management is the best option to control termites. In the District, they practice different integrated termite management strategies like planting termite resistant crops such as finger millet and improved sweet potato and termite resistant trees like commo grass and vetiver grass, soil and water conservation structures like soil bund and terracing at the same time they also practice queen removal. Sometimes when the severity of termite is high, they apply chemical on nursery site. They emphasised that chemical method is the last option. Capacity building is also another strategy that needs to be integrated to termite management.

The study investigated that termite infestation has negative effects on household food security of the study area. The effects of termite infestation on household food security result shown in the above table. Accordingly, 10 of the respondents (33.3 %) said termite infestation has a very strong effect on household food security whereas the majority of them 18 of the interviewees (60 %) replied that termite infestation has a strong effect on their household food security. Only two respondents (6.7) responded that it has an average effect. None of the respondents replied as termite has no or low effects on their food security.

They said all of them faced food shortages from year to year due to termite infestation. They reported that they stopped farming cereal crops on their land mainly maize and teff. Due to this their production and productivity is reduced, the land was becoming less productive, and cost of production and farm inputs was also increased due to growing demand for inorganic fertilisers to improve the poor soil fertility caused by termites. Some of the respondents reported that they faced food shortage and forced to migrate to a neighbouring region, Benishangul-Gumuz region, Data obtained from key informant shows that 40% of the district farmers are migrating seasonally to farm in other places. Some of them drop out children from school to send them to off-farm activities due to food shortage. Previously they cope up the problem by cultivating maize on wetland however they said that now termite started to attacking maize grown in the wetland.

The findings of this study show that farmers have a good knowledge and understanding of both termite infestation history and causes of termite infestation. Farmers in the study area know the time and place where the termite infestation started and the reasons for the infestations. Farmers are also knowledgeable on and can identify which termite species affect their crops and what types of methods can be applied to different species they identified.

6.2 RECOMMENDATIONS

The research was initiated with the objective to provide information to BAERC on the role of farmers' indigenous knowledge and experiences on causes of termite infestation and control methods to enable BAERC to develop integrated termite management practices combining both indigenous knowledge and modern scientific insights in improved termite control. Based on the above findings the following recommendations are presented for Bako Agricultural Engineering Research Centre (the commissioner of this research), Nedjo District Bureau of Agriculture and Natural Resources, Agricultural Research Centers and Wollega University.

Bako Agricultural Engineering Research Center

- **Adapting and Integrating of farmers' familiar subterranean termite control methods to modern soil and water conservation practices:** BAERC needs to integrate commo grasses and vetiver grass with modern soil and water conservation practices like terracing and soil bund. Integrated termite management strategies should focus on rehabilitating the degraded land while the strategies should create income for farmers.

- **Introducing termite mound driller technology:** It is needed to introduce termite mound drilling technology to the district so that the driller saves time and reduce the drudgery of digging termite mound.

- **Modifying/adapting chemical applicator to termite mound:** It is better to adapt the technology that used to apply the chemicals to termite mound. This can reduces the negative effects of the chemical during chemical application.

Nedjo District Bureau of Agriculture and Natural Resources

- **Scaling up of Sustainable Land Management best practices (Area Closure):** It is better to scale up area closure SLM project best practices in the district for areas that are highly degraded. It is better to design area closure in a way that creates income for farmers so that it increases the community's participation. This can be done by integrating income generating activities like beekeeping and cattle fattening on the area closure. This will also solve the effect of termite infestation on household food security situation in the district.

- Nedjo District Bureau of Agriculture and Natural Resources needs to provide Personal Protective Equipment (PPE) for farmers and development agents for chemical application and training them in use and care of the PPE to reduce the negative effects of the chemical during application.

- **Encouraging farmers to cultivate vegetables and tubers that are resistant to termites**. This can be done through Farmers to Farmers Learning by arranging farm visit to vegetables and tubers that are resistant to termites.

Agricultural Research Centers and Wolllega University

- **Adapting termite resistant maize and sorghum variety:** It s important for of Agricultural Research Centers and Wollega University to take in to account the adaptation of termite resistant maize and sorghum improved varieties because improved maize and sorghum varieties are susceptible to termites in the district.

- Further study is needed on the effectiveness of applying salts and gases to termite mound as tradtional termite control method and its effects on soil.

- Further research is also needed on effectiveness of *Cassia petersiana(Raamsoo in Afaan Oromoo) and abaaboo (Local name in Afan Oromo)* which are identified by farmers in Negjo district to be termite resistant shrubs.

REFERENCES

Abdurrahman, A., 1991. Recent Advances in biology, ecology and control of termites, CEE Proceedings, the annual meeting of the committee Ethiopian entomologists, Addis Ababa.

Assefa, G. 1990. Maize Stalk Borer Research in Ethiopia. Proc. of the 10th CEE Annual Meeting. February 7 - 9, 1990, Addis Ababa, Ethiopia

Assefa, Y., Van den Berg, J. and Conlong, D.E., 2008. Farmers' perceptions of sugarcane stem borers and farm management practices in the Amhara region of Ethiopia. *International Journal of Pest Management*, pp.219-226.

Berkes, F., 2008. Traditional Ecological Knowledge. Document available at (http://umanitoba.ca).

Black, H.I.J. and Okwakol, M.J.N., 1997. Agricultural intensification, soil biodiversity and agroecosystem function in the tropics: the role of termites. *Applied soil ecology*, *6*(1), pp.37-53.

Dennis, S.H., 1981. Agricultural insects of the tropics and their control. Second edition. Press Syndicate of the University of Cambridge. New York.169-177.

Donald JB., Dweight MD., 1970. Introduction to the study of insects. Third edition. Holt, Rinehart and Winston INC, 152-158.

Ewetola, E.A., Babarinde, S.A., Omirin, T. and Ojewole, D.O., 2017. Farmers' perception of the usefulness of vetiver grass for termite control on Ogbomoso Agricultural Zone farmlands, south-western Nigeria. *Journal of King Saud University-Science*. Accessed from http://ac.els-cdn.com/S1018364716305754/1-s2.0-S1018364716305754-main.pdf?_tid=6a0e7cd4-88ec-11e7-b7ef-00000aacb362&acdnat=1503593643_2665cc8fd228b3a4b2f3d6b4c114adff

Fenemore, P.G., 2006. *Applied entomology*. New Age International. (P) Ltd publishers. 200-203.

Forsyth, J., 1966. Agricultural insects of Ghana. *Agricultural insects of Ghana*. Ghana Universities Press, Accra.76-78.

Gauchan, D.; Ayo-Odongo, J.; Vaughan, K.; Lemma, G. and Mulugata, N. (1998). A participatory systems analysis of the termite situation in West Wellega, Oromia region, Ethiopia: Working Document Series 68, ICRA, Wageningen, The Netherlands.

Getu, E. and Kumissa, G., 1997. A Strategy for a Sustainable Control of Termite in Manasibu Wereda (West Wellega) a Document Prepared by B & M Development Consultants PLC for the Ethiopian Evangelical Church Mekane Yesus-Western Snod.

Hickin, N.E., 1971. *Termites-a world problem. London, UK, Hutchinson*.

Laws, S., Harper, C., Jones, N. and Hill, D.S., 1987. *Agricultural insect pests of temperate regions and their control*. CUP Archive. Third edition. Press Syndicate of the University of Cambridge. New York. Pp 99, 525.

Langewald, J., Mitchell, J.D.N.K., Maniania, N.K. and Kooyman, C., 2003. Microbial control of termites in Africa. *biological Control in IPM Systems in Africa (Neuenschwander, P., borgemeister, C., Langewald, J. Eds.), Cromwell Press, trowbridge, UK*, pp.227-242.

Laws, S., Harper, C., Jones, N. and Marcus, R., 2013. *Research for development: A practical guide*. Sage.

Lee, K.E. and Wood, T.G., 1971. *Termites and soils. London, UK, Academic Press*.

Legesse, H., Taye, H., Geleta, N., Swaans, K., Fikadu, D., Zziwa, E. and Peden, D., 2013. Integrated termite management in degraded crop land in Diga district, Ethiopia. ILRI.

Logan, J.W., Cowie, R.H. and Wood, T.G., 1990. Termite (Isoptera) control in agriculture and forestry by non-chemical methods. *Bulletin of Entomological Research*, *80*, p.330.
London, UK: Overseas Development Institute.

Malaisse, F., 1978. High termitaria. In *Biogeography and ecology of Southern Africa* (pp. 1279-1300). Springer Netherlands.

Melaku Getahun, J., 2016. Oromo Indigenous Knowledge and Practices in Natural Resources Management: Land, Forest, and Water in Focus. *J Ecosys Ecograph*, *6*, p.181.

Mitchell, J.D., 2002. Termites as pests of crops, forestry, rangeland and structures in southern Africa and their control. *Sociobiology*, *40*(1), pp.47-69.

Mosissa, R., Jimma, W. and Bekele, R., 2017. Knowledge Management Strategy for Indigenous Knowledge on Land Use and Agricultural Development in Western Ethiopia. Available at https://www.researchgate.net/profile/Worku_Jimma/publication/312096039_Knowledge_Management_Strategy_for_Indigenous_Knowledge_on_Land_Use_and_Agricultural_Development_in_Western_Ethiopia/links/587f43b908ae9a860ff6e1cc/Knowledge-Management-Strategy-for-Indigenous-Knowledge-on-Land-Use-and-Agricultural-Development-in-Western-Ethiopia.pdf

Mugerwa, S., Mpairwe, D., Zziwa, E., Swaans, K. and Peden, D., 2014. Integrated termite management for improved rainwater management: A synthesis of selected African experiences. NBDC Technical Report 9. Nairobi, Kenya: ILRI. Available at https://cgspace.cgiar.org/bitstream/handle/10568/35474/NBDC_technical_report9.pdf?sequence=4&isAllowed=y

Mugerwa, S., Mpairwe, D., Zziwa, E., Swaans, K. and Peden, D., 2014. Integrated termite management for improved rainwater management: A synthesis of selected African experiences.

Mugerwa, S., Nyangito, M., Mpairwe, D. and Nderitu, J., 2011c. Effect of biotic and abiotic factors on composition and foraging intensity of subterranean termites. *African Journal of Environmental Science and Technology*, *5*(8), pp.579-588.

Mugerwa, S., Nyangito, M., Nderitu, J., Bakuneta, C., Mpairwe, D. and Zziwa, E., 2011b. Farmers ethno-ecological knowledge of the termite problem in semi-arid Nakasongola. *African Journal of Agricultural Research*, *6*(13), pp.3183-3191.

Mugerwa12, S., Nyangito, M., Mpairwe, D., Bakuneeta, C., Nderitu, J. and Zziwa13, E., 2011a. Termite assemblage structure on grazing lands in semi-arid Nakasongola.

Nair, K.S., 2007. *Tropical forest insect pests: ecology, impact, and management*. Cambridge University Press. New York, 218-236.

NDBANR, 2016. Nedjo District Bureau of Agriculture and Natural Resources annual report.

Nkunika, P.O.Y., 1998. Termite survey, identification, damage and control in southern province. *Land Management and Conservation Farming, Soil Conservation and Agro forestry Extension Report, Lusaka, Zambia*.

Nyeko, P. and Olubayo, F.M., 2005. *Participatory assessment of farmers' experiences of termite problems in agroforestry in Tororo District, Uganda*. Overseas development institute (ODI). Agricultural research and extension network (AgREN).

Pearce, M.J., 1997. *Termites: biology and pest management*. Cab International. New York.

Pomeroy, D.E., Bagine, R.K. and Darlington, J.P.E.C., 1991. Fungus-growing termites in East African savannas. *African Wildlife: Research and Management*, pp.41-50.

Rist, S. and Dahdouh-Guebas, F., 2006. Ethnosciences—A step towards the integration of scientific and indigenous forms of knowledge in the management of natural resources for the future. *Environment, Development and Sustainability*, *8*(4), pp.467-493.

Rouland-Lefevre, C. and Mora, P., 2002. Control of Ancistrotermes guineensis Silvestri (Termitidae: Macrotermitinae), a pest of sugarcane in Chad. *International journal of pest management*, *48*(1), pp.81-86.

Samal, P.K., Dhyani, P.P. and Dollo, M., 2010. Indigenous medicinal practices of Bhotia tribal community in Indian Central Himalaya. *Indian Journal of Traditional Knowledge,* 9(1), pp 140-144.

Sekamatte, B., Latigo, M. and Russell-Smith, A., 2001. The potential of protein-and sugar-based baits to enhance predatory ant activity and reduce termite damage to maize in Uganda. *Crop Protection*, *20*(8), pp.653-662.

Sekamatte, B.M., Ogenga-Latigo, M. and Russell-Smith, A., 2003. Effects of maize–legume intercrops on termite damage to maize, activity of predatory ants and maize yields in Uganda. *Crop Protection*, *22*(1), pp.87-93.

Sileshi, G., Mafongoya, P.L., Kwesiga, F. and Nkunika, P., 2005. Termite damage to maize grown in agroforestry systems, traditional fallows and monoculture on nitrogen-limited soils in eastern Zambia. *Agricultural and Forest Entomology*, *7*(1), pp.61-69.

Sileshi, G., Akinnifesi, F.K., Ajayi, O.C., Chakeredza, S., Mng'omba, S. and Nyoka, B.I., 2008a. Towards sustainable management of soil biodiversity in agricultural landscapes in Africa. *Biodiversity*, *9*(1-2), pp.64-67.

Sileshi, G., Nyeko, P., Nkunika, P., Sekematte, B., Akinnifesi, F. and Ajayi, O., 2009. Integrating ethno-ecological and scientific knowledge of termites for sustainable termite management and human welfare in Africa. *Ecology and Society*, *14*(1).

Sileshi, G.W., Kuntashula, E., Matakala, P. and Nkunika, P.O., 2008b. Farmers' perceptions of tree mortality, pests and pest management practices in agroforestry in Malawi, Mozambique and Zambia. *Agroforestry systems*, *72*(2), pp.87-101.

Su, N.Y. and Scheffrahn, R.H., 1998. A review of subterranean termite control practices and prospects for integrated pest management programmes. *Integrated Pest Management Reviews*, *3*(1), pp.1-13.

Tadese, A., 1998. Control strategies and future needs for research on insect pests of maize in Ethiopia. pp. 291 - 305.

Tenywa, G., 2008. Thousands homeless as termites turn Nakasongola into a desert. *The New Vision*, *24*. Available at: http://www.newvision.co.ug/D/9/36/635585?highlight&q=termite.

Tripathi, N. and Bhattarya, S., 2004. Integrating indigenous knowledge and GIS for participatory natural resource management: state of the practice. *The electronic journal of information systems in developing countries*, *17*.

UNEP,2008. Indigenous Knowledge in Disaster Management in Africa, Nairobi, Kenya, 108 pp

Warren, D.M., 1996. Indigenous knowledge, biodiversity conservation and development. *Sustainable development in third world countries: Applied and theoretical perspectives*, pp.81-88. http://www.ciesin.org/docs/004-173/004-173.html

APENDICES

Appendix 1: Data collection tools/guides

a. Semi-structured interview guide

Background of the Respondent (Date, ID, Place)

1. Level of knowledge and experiences of farmers on termite infestation

- How is severity of termite infestation in your farm?
- When did the termites infestation started?
- What do you think are the major causes for termite infestation?
- What factors do you think worsen termite damage on farmlands?
- Can you identify the termite species?
- How is susceptibility of crops to termite? Are there crop varieties susceptible than the other?
- What do you think are the benefits termites?

2. Traditional termite control methods and its effectiveness

- What are traditional methods being practicing to control termite infestation?
- Why are you practicing these methods?
- How you started practicing? Explain how it works?
- From these methods, which ones were successful? How?
- Why do you think they are effective? /why not?
- Could you mention please the strength and limitations of these methods

3. Effects of chemical method of termite control

- Which type of chemical you are using for termite control?
- Do you think chemical control method of termite infestation is effective?
- How many years the termite probably reappear at the same mound after applying chemical?
- What do you think are advantages of chemical control method?
- Could you mention the negative effects of chemical control methods?
- How can these effects be reduced?

4. Integrated termite management

- Have you practiced a combination of different termite management practices? How?
- Do you think of integrated termite management is a best approach? Why?
- How could these methods be integrated with the traditional methods you mentioned above?
- Do you think it is effective? How?

5. Impact of termite infestation on Food and Nutrition Security

- Did you ever face food shortage?
- Do you think termite infestation was the reason of food shortage? How?
- How does termite infestation affect your household's food and nutrition security? Why? Explain.

- What was your coping mechanism?

Thank you very much for your cooperation.

b. FGD Topic Guide

Date _____Time: Start_____ End_____
Peasant Association/place_____
Number of participants' _____ (men) _____ (women)

1. How long has been termite infestation become severe in this PA?
2. What were your responses to the problem?
3. What do you think are the major causes of termite infestation in this Peasant Associations? Why?
4. How you differentiate termite species?

5. Which types of termite species are difficult to control? Why?
6. What control methods are being practiced? (Local/indigenous solutions). Which are effective and which are not and why?
7. Do control strategies vary by termite species? If yes, which control strategies are effective for which species?
8. Do you think chemical control methods are effective? Why?
9. What do you think should be done to make it effective?
10. What could be done to make termites control methods effective?
11. How does termite infestation affect household food security in this PA? what was coping strategies?
12. Any other idea you want to add

c. Key informant interview guide

Date _____ Time: Start_____ End_____
PA/place _____ Office_____
Name of KI_____

1. General description of Nedjo district
2. How is severity of termite infestation in your district?
3. When has termite infestation started in the area? What do you think are its major causes?
4. What strategies does the community use to control the problem? (Local solutions) which are effective and which are not and why?
5. What strategies/interventions/controlling methods did the government and/or NGOs implement? Which are effective and which are not and why?
6. From where did farmers get chemical for termite control? Which types?
7. Do you think it is effective?
8. Are there botanicals and predators that are effective for control?
9. How can we integrate these strategies for termite management?
10. What are the major consequences of the termite problem to the community? Is there change over time?
11. What copping strategies the community has used?
12. Type of existing local institutions and type of collective action for termite management? Any good practices
13. What are the social, economic and environmental impacts of the termites in this district? (Outmigration, food insecurity etc.)

d. Observation checklist

Date:
Time: Start_____ End_____
Peasant Association/place: _____

- Area affected by termite infestation (grazing land/crop)
- Possible indicators for the causes of termite infestations in the PA
- Degraded land due to termite infestation
- Good practices/termite control strategies in the area (integrated) if any

Appendix 2: Some of the pictures from field work during data collection



a) Interview with KII



b) PRA


c) FGD



d) SSI

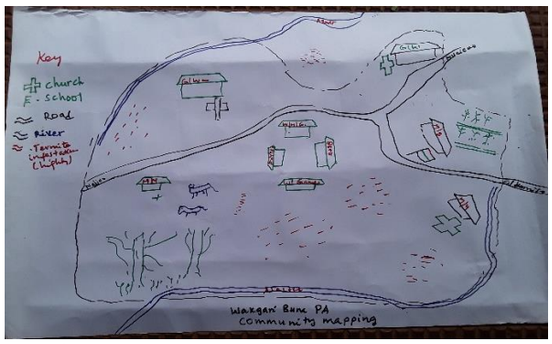


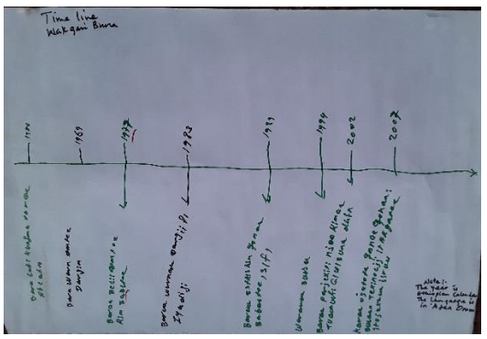
e) Observation

Source: own field work, 2017

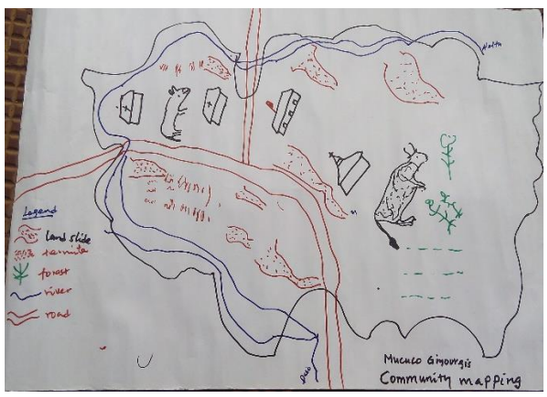
Annex 3: PRA results

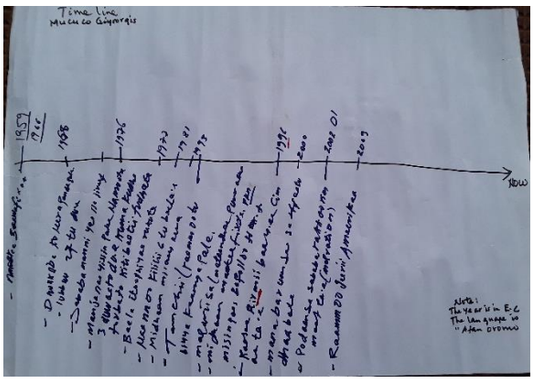
Note: The year on history time line below is in Ethiopian Calendar and the language is written in Afan Oromo





a) Wegari Buna Community mapping and History timeline





b) Muchucho Gyorgis Community mapping and History timeline