



ADDIS ABABA UNIVERSITY

**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE
DEPARTMENT OF Zoological Sciences**

**Assessments of termites' impact on vegetation, crops and buildings
in Lalokile district, Kellem Wollega zone, western Ethiopia**

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Assessments of impact of termites on vegetation, crops and buildings in Lalokile district KellemWollega zone, West Ethiopia.

Abstract

Termites are social insects and can cause serious damage to buildings, forestry and wide range of crops including cash crops such as maize, wheat, groundnuts, sorghum, teff, and rice; and pastures, any material that incorporates cellulose from paper to building and fungi to fire trees. Termites also damage dam, and electrical faults in large cables in many of their distribution areas. The current status of termite damage on vegetation, crops and building was studied in Lalokile district, to assess the impacts of termites on vegetation, crops and buildings. Lalokile district is located in KellemWollaga Zone Western Ethiopia. It is 535 km away from Addis Ababa. Questionnaires and field observation were used for generating data. The damage that termite caused to different vegetation and the level at which the plants were damaged by termites were significantly different, and it was observed that large numbers of plants were damaged by termites in unprotected land than in protected. It was also investigated that large proportion the study area land was seriously damaged by termites. There was serious termite damage to crops that were resulted in annual yield loss of- after termite occurrence. It was observed that termites were causing fewer problems to vegetations around residences, while vegetations far from residences were observed to be seriously damaged due to fertilities of the soil around residences. In the area of higher population of livestock there was serious termite damage to the land. The impacts of termite were not only confined to vegetation and crops but also it was observed to cause serious damage to houses and fences at their late age (15-30 years) after construction. Cultural method of termites control such as: Queen Removal, flooding, smoking and nest destructions were observed to be practiced by majority of the study area peoples. In this area deforestation was the main reason to aggravate termite problem. Generally, the study area was seriously damaged by termites and causing different socio economic problems to the community, so to overcome these problems, the farmers should prevent and stop deforestation and overgrazing, developments agents should teach farmers to use different methods of termite control together and termite repellent plants should be planted in all lands to repel termites.

Keywords: Termites, field observation, damaged land, cultural methods, yield loss.

Chapter one

1. Introduction

1.1. Back Ground of the study

Termites are serious pests in tropical and subtropical Africa. They attack various field and horticultural crops. Termite damage pasture land which are primarily used for livestock production. Ethiopia is among the tropical countries where crops and pasture lands are severely damaged by termites. Many reports (Abduraman, 1990; B&M Development consultants, 1997; Gauchan et al., 1998) indicated that the problem is more severe in western Ethiopia.

In Ethiopia, there are 61 species of termites in 25 genera and four families, of which few are regarded as pests (Abdurhaman, 1990). B&M Development consultants (1997) report indicated that in the last 40-50 years, the damage caused by termites in western Ethiopia became more and more acute. Western Wollega has been known to suffer from increasing termite problems for the last 20 years and now spreading rapidly in eastern direction from the affected district of the west (Gauchan et al., 1998). The report underlined that the problem has become so complex that the farmers around Mendi, the major town of Manasibu district in western Ethiopia, have forced to abandon their land and move to less affected low land areas. It was possible to note from this that termite problem in Manasibu district has serious sociological implication. Cowie and Wood (1989) reported that the termites in western Ethiopia damaged maize and teff more than any other crops.

Termites by no means confine their attentions to dead plant tissues such as wood. Certain species of termites are serious pests of growing crops including living trees (Hickin, 1971). Many other insect pest species cause damage to various parts of the tree, but often they do not cause mortality (Logan et al., 1990; UNEP, 2000). However, termites are seldom as primary pests, only damaging the plant, shrub or trees when it has already been affected by fire, disease, drought, mechanical injury, bad planting or other insect pests (Harris, 1971; Hickin, 1971). Although, termites usually appear to be secondary pests, it does not make them of less importance. The initial defect affecting the plant is often of minor importance, after allowing ingress to termites, the effect may be the complete destruction of the plant or, at least, a reduction in its value as a crop (Hickin, 1971).

The extent to which termites are problems to trees and the nature of loss they cause are very much related to the geographic region concerned (Logan et al., 1990). In the tropical and subtropical regions of the world where rainfall is low and a dry savannah-type of situation has developed, termite attack appears most acute and this has caused serious problems in the development of nurseries and young tree plantations. Another phase of the problem is the susceptibility to termite of a popular group of tree species for the tropical planting, the *Eucalyptus* (Hickin, 1971). *Eucalyptus* is preferred as compared to other plants such as *Cassia*, *Albizia* and *Gmelina* species because of its more rapid growth potential (Harris, 1971). Eighteen termite species are recorded as damaging young trees in forest and plantation nurseries and there are a number of recorded instances of high percentage loss, even complete and total destruction of young trees, particularly *Eucalyptus* (Hickin, 1971). Moreover, Pearce (1997) noted that a high demand for timber in Africa has led to fast-growing trees such as *Eucalyptus*, being planted in poor soil areas where they are under stress and are therefore more susceptible to termites. The main obstacle to afforestation in the dry areas of Africa is said to be the presence of termites (Harris, 1971; Hickin, 1971). However, not all species of termites present in a locality are destructive to forestry (Nair, 2007). The species ranking as forestry pests vary in different tropical areas. In Africa, the genera, *Macrotermes* and *Odontotermes* are implicated as well as the species *Pseudacanthotermes militaris* in Uganda. Throughout tropical Africa, losses are due exclusively to members of the subfamily: Macrotermitinae, all of which are fungus growers with large nests in mounds or underground (Harris, 1971; Hickin, 1971). As elsewhere in Africa, termite damage in Ethiopia is generally greater in rain-fed than irrigated crops, during dry periods or drought than periods of regular rainfall, in plants under stress (e.g. newly transplanted forest tree seedlings) than healthy or vigorous plants and exotic (e.g. *Eucalyptus*, maize) than indigenous plants (Wood, 1986 & 1991). In western Ethiopia, termite damage on indigenous trees is insignificant. In contrast, serious damage is very common on exotic forestry trees, especially on *Eucalyptus*, one to three years after transplanting (Abdurahman, 1995). Soon after transplanting, seedlings suffer severely from moisture stress, because of soil compaction and low water holding capacity resulting from poor infiltration rates. The roots of such plants begin to dry out and this creates a favorable situation for termite infestation (Gauchan et al., 1998). In some localities up to 100% of *Eucalyptus* seedling loss is common (Abdurahman, 1995). In most areas of Uganda, an average of between 30 and 70% of planted *Eucalyptus* trees are killed by termites (Mazodze, 1995). Control of termites as forest pests involves both chemical and traditional

methods. Current chemical control methods employed are soil treatment, treatment of seedlings before transplanting and baiting techniques and the chemicals currently used include chlorpyrifos, imidacloprid and fipronil. In addition to the current chemical control methods employed, there are a number of alternatives, traditional control methods, largely relating to silvicultural practices or plantation management, which are also very important, and should be considered before chemical intervention is attempted. Many traditional methods of control of termites in forest plantations have a sound basis in the principles of ecology (UNEP 2000). Logan et al. (1990), UNEP (2000) and Abdurahman et al., (2010) have reviewed a wide range of control of termites in crops and forestry with non-chemical methods which include cultural and biological control.

Ecological dominance has long been displayed by termites due to their eusocial behavior (Engel et al., 2009). This advanced sociality is characterized by the creation of cast systems where groups of individuals specialize in tasks. The cast system is often divided into reproduction/brood care, foraging, and defense with the latter two offering a competitive advantage when mobilized efficiently, capable of outcompeting other species (Wilson, 1971; Engel et al., 2009). Success has allowed thousands of living species of termites to exist (Engel et al., 2009). Therefore, it is useful to group termites based on similarities in behavior. Feeding and nesting behavior are two common ways of classifying termites.

Termites will only colonize a cover system if the right resources are present for them to survive. There are a number of different classification schemes which have been used to group termites in terms of their feeding behavior. Although in tropical and subtropical ecosystems they are the principal consumers of the most abundant biomolecule on land (cellulose and lignocelluloses) (Engel et al., 2009), feeding behavior classes can be further subdivided. A number of studies have grouped feeding behaviors into five main classes: grass/litter feeders that consume grassy litter, grass and dung; wood feeders who gorge on dead/live wood in litter or standing form; soil-wood feeders that consume highly decomposed wood at the interface of soil; soil feeders that feed on humified materials within the soil; and polyphagous species who consume a range of organic materials (Gromadzki, 2008; Dawes, 2010; Braithwaite et al., 1988; Tayasu et al., 1998; Spain et al., 2010). In general, termite colonization and survival should only occur if the appropriate feeding resources and environmental conditions are present (Spain et al., 2010). In most instances initial colonizers are species that consume litter as this is the food resource

transported onto rehabilitated sites during soil profile reconstruction (Spain et al., 2010). As site evolution occurs over time other feeding resources become available allowing specialized wood and humus feeders to establish onsite through natural dispersal mechanisms, including the winged stage of the termite life cycle (Spain et al., 2010). Some termite species may even be extirpated from rehabilitated sites and replaced by others (Spain et al., 2010) making termite colonization seem like a succession process.

Termite nesting behavior is an important consideration when attempting to determine the effect termites might have on cover systems. There are four generally accepted classifications of termite nesting habits: hypogeal (below ground), wood, epigeal (mounds above ground), and arboreal (tree nests) (Eggleton et al., 2002).

1.2. Statement of the Problem

The study area is known for its vegetation. However, currently it would seem to be affected by various pests such as termites. This problem wouldn't seem to be at standstill. It is causing alarming problems on vegetation, crops and construction. As result of this, the society in the study area are suffering a lot from economic problems and losses of vegetation that result in climate change, and causing further problems to the area. So, knowledge and awareness about the status of termite effect in the study area is very essential for the development of management plan or control method. Thus, this study was designed to assess the status of termites on vegetation, crops and buildings and also to identify the main factors that aggravate the problems.

1.3. Objectives of the study

1.3.1. General objective

To assess the effects of termites on vegetation and construction in Lalokiledistrict.

1.3.2. Specific objectives

1. To investigate the prevalence of termite in the study area
2. To identify the types of crops mainly affected by termites
3. To assess the awareness of the farmers of the study area to control termites
4. To examine types of buildingsthoseare mainly affected by termites
5. To evaluatethe main factor that aggravates termite problems.

1.4. Significance of the Study

The effects of pests on vegetation are the most important issue on agricultural sector in Ethiopia and also globally as pests eradicate or declining vegetation, crops, horticultures, and buildings. And these leads to different problems such as: shortage of food, drought, climate change, and different socioeconomic problems. Therefore, this study can serve as baseline information for concerned bodies who work on land management, plant conservation, food security and others. And also used as baseline data for other researchers who are interested in carrying out further studies in this study area and/or beyond.

Chapter 2

2. Literature review

2.1. Characteristics of termites

Termites are social insects which live as organized colonies in nest. Each colony is composed of morphologically differing castes. The head of termites is hypognathous or prognathous and their mouth parts are typically blattoid and mandibulated, but varying in different castes (Gullan and Cranston, 2000). In soldiers, the mouth part is highly modified into well-developed mandibles or into prolonged snout-like nasus, whereas in the numerous workers it is specialized for gnawing all sort of cellulose materials. Glandular secretions are also commonly used for defense by various termites' soldiers (Pearce, 1997). Compound eyes reduced in most cases and antennae are long and moniliform with varying numbers of segments among species. Termites possess a sub-cylindrical and soft body, whose abdomen is broadly joined with thorax. Pair segmented cerci is found on terminal segments of termites' abdomen. Because of their poor abdominal sclerotization, mainly in worker castes, termites appear white and as a result, they are often erroneously referred to as white ants, in the same parts of the world. However, they show many morphological and behavioral differences from ants. Termites have an incomplete metamorphosis whereas ants have complete metamorphosis. The most important behavioral feature that distinguishes termites from ants is that the male ant dies after its first nuptial flight and mating with the queen, but in termites the king lives as long as the queen does and mating occurs periodically (Wilson, 1971; Watson and Gay, 1991).

Reproduction in termites is through laying fertilized eggs by the queen. Since there is usually only one reproductively active couple in a colony at particular time, the individuals in that colony are derived from one pair parents (Howse, 1970; Gullan and Cranston, 2002). In some specialized termites, the abdomen of Queen gradually becomes swollen because of enlargement of ovaries and fat bodies. Mature queen with such physogastric abdomens is highly fecund and the size of their colonies is large (Wilson, 1971; Richardson and Davies, 1978). The egg laying capacity per day of a matured queen is 2000 to 3000 eggs in *Nasutitermes exitiosus*.

Developments in termites show three phases as it is not complete metamorphosis. The nymph increases in size as different nymphal instars in a series of molts towards its adult form without a quiescent pupal stage, internal development also keeps in steps with the external one (Harris, 1961).

2.2. Nest system and foraging in termites

New colonies of termites are formed following dispersal flights of the royal pairs, which usually take place synchronously in different colonies of species over a given area or district (Daly et al., 1998). On landing the royal pairs look for crack or gap in wood or moist area of soil in which to burrow (Pearce, 1997) and female evacuates a chamber where eggs are laid (Wood, 1988). The Queen and the king usually remain in the royal chamber, same times known as royal cell which becomes the focal point of the nest system.

The workers construct and enlarge the nest and foraging galleries that radiate away from the main nest toward the sources of food and water. Construction materials are largely composed of earth and wood mixed with saliva and fecal matter (Richards and Davies, 1978). Pearce (1978) reported that it had been suggested that nest building initially evolved as defense reaction in which the termites' faces were used to seal off intruders from nest. Living and foraging within a more or less controlled environment minimizes the probability of exposure to their natural enemies. It is also suggested that nests are essential in that they provide termites with stabilized optimum temperature and humidity (Harris, 1961). Termites constructs various nest types. They can be in wood, arboreal (attached to outer parts of woods), subterranean, or epigeal mound (Harris, 1961; Noirot, 1970; Pearce, 1997). Watson and Gay (1991) stated that the simplest form of nest is constructed by Kolotermitidae and Termopsidae in which the whole colony lives in chambers and galleries excavated within wood. In such case the termites get their nourishments from within the wood itself. Colonies in such types of nest characterized by their small size.

Arboreal types of nests are attached to outside of trees. In some cases they are connected to ground by covering galleries which descend the trunk. They may have regular structure of wood carton of fine texture with superficial envelope and are homogenous throughout, except for the harder and massive section that surround the royal cell (Noirot, 1970). Arboreal termites are found only in termitidae. Subterranean nests can be simple and diffuse structures of galleries with no sharp boundaries and network of chambers or may be complex type with a larger chamber connected by subterranean galleries (Noirot, 1970). Coptoterme, microcerotermes, nasutitermes, microtermes are some examples of termites groups known by constructing subterranean nests, at various degree of complexities. Subterranean termites pose greater pest threats compered to dry woody termites (Pearce, 1997).

Epigeal nests have subterranean bases, because the colony founders begin their new lives settling down in soil. It is after production of workers that the mound gradually grows by layers of soil and termite faeces (Gullan and Cranston, 2000). Mounds vary in shape, size and structures according to the type of the species, and within the same species in different climatic zone (Watson and Gay, 1991; Pearce, 1997).

From nests of different types, termites move about for foraging through associated galleries and runways in almost all cases. Foraging can be a long haul in some termites or within the nest, as in the dry wood termites. The workers move away from the main chamber, in most cases through galleries and runways, and in rare case out of galleries on surface on humid days or at night. The defensive caste is also out within the worker during foraging.

2.3. Termite biology and behavioral ecology

2.3.1. Termite colony structure and life cycle

Termites live in large communities and the colony members are of four castes: the reproductive (king and queen), soldiers and workers. In addition, colonies have a large number of young immature forms in all stages and of all castes (Collins, 1984). Each caste varies morphologically and behaviorally, but they have to live cooperatively or else the colony will die (Collins, 1984). The number of individuals and ratios of each caste in a colony is very difficult to determine and it varies between species and also depends on the age and size of the colony (Bignell and Eggleton, 1998). Large colonies may include a number of supplementary reproductive, producing eggs to augment or replace the founding queen (Edwards and Mill, 1986; Bignell and Eggleton, 1998).

The parent termites, the king and the queen are the functional reproductive. The queen's major role is to lay eggs. She develops an enlarged abdomen containing ovarioles and associated tissues, a condition known as being physogastric (Collins, 1984). The queen is also involved in pheromonal regulation of the production of each caste in a colony (Noirot and Noirot-Timothee, 1969).

Soldiers and workers are wingless and can be either sterile male or female. Soldiers usually represent one-tenth of the population at most (Harris, 1957). There are also termite genera that lack of this caste, such as *Anoplotermes* and *Protohamitermes*. Termites are the only social insects with a true soldier caste whose major role is only to defend the colony (Bignell and

Eggleton, 1998). For this reason, morphologically they are bigger in size and have defensive adaptations such as enlarged mandibles or stopper-like heads. In the subfamily Nasutitermitinae, the mandibles are reduced and non-functional. Instead the soldiers have anus, an elongated projection of the fontanelle and their way of defense is by squirting irritating chemical substances through it (Collins, 1984). Besides having mandibles and a sclerotized head, soldiers of some genera such as *Coptotermes* have a frontal gland that discharges a defensive secretion through a frontal pore (Richards and Davies, 1978). This secretion can be toxic or repellent to intruders, such as ants, or tacky and entangle their legs and antennae.

The worker caste is the most numerous and plays the major role in the survival of the colony.

They collect food, process the digesta, feed other castes and construct the mound or nest (Harris, 1957). All living termites, except the *Kalotermitidae*, are known to have a true worker caste.

In *Kalotermitidae*, there is no distinct worker caste and the work of the colony is done by immature adults, whose development is stopped temporarily according to the needs of the colony (Harris, 1957). Winged reproductive or alates of both sexes are produced in large number in a mature colony. These alates swarm out from mature nests at particular times of the year (often during or just before rains) (Bignell and Eggleton, 1998). They make short, often rather feeble, dispersal flights, and then pair-up the ground after the wings have been shed (dealation) (Bignell and Eggleton, 1998). The paired termites will then select a new nesting site and once they are established, mating takes place. The first batch of eggs is produced by the female within a few days.

Termites are hemimetabolus in their life cycle. The hatched young are translucent white and feeble at first, but very active from the moment they hatch (Edwards and Mill, 1986). These larvae are fed from nutrient-rich salivary secretions produced by the parents. They normally undergo a number of moults until they achieve the mature form as sterile workers or soldiers, depending to the needs of the colony (Harris, 1957). These developments are determined by extrinsic factors such as pheromones and hormones (Krishna, 1970). Usually, at the beginning of a colony foundation the entire larva become workers and after sometime, an occasional larvae is found with large head and jaws of quite a different shape, and this grows into a soldier (Harris, 1957). The colony grows slowly for many years, accompanied by a continuous increase in the number of individuals, enlargement of the nest and much building activity (Bignell and

Eggleton, 1998). Once the colony is well organized, larvae appear with wing buds, which later will become winged termites and the full cycle of development incomplete (Harris, 1957).

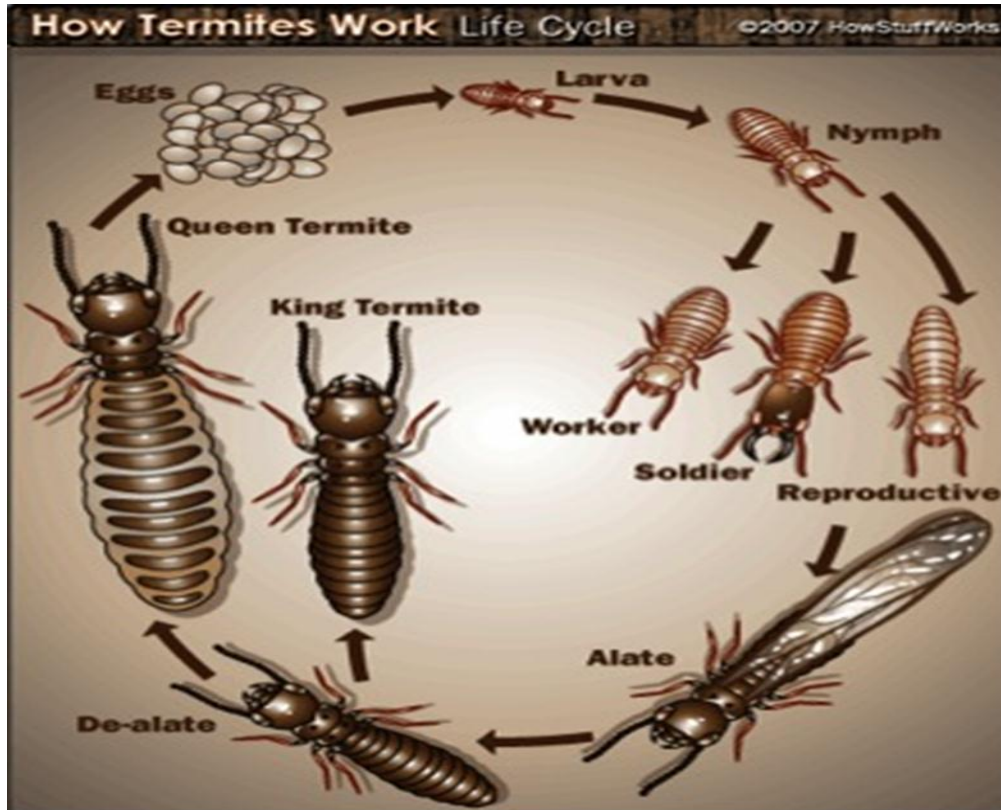


Figure 1. Life cycle of termites (<https://www.terminix.com/termite-control/life-cycle/>)

2.3.2. Communication in termite colony

To maintain the social structure of the colony, termite communication predominantly relies on the use of sophisticated chemical (pheromone) communication system (Higashi et al., 2000). There is wide range of categories of pheromones such as trail, alarm, aggregation, recruitment, mating, etc. The signals induce and modulate a wide range of individual's and collective behavioral responses such as territorial behavior, attendance of the reproductive and brood and foraging for food or searching for nesting sites. Each colony develops its own characteristics odor. An intruder is instantly recognized and an alarm pheromone is secreted that triggers the soldiers to attack. If a worker finds a new source of food, it lays a chemical trail for others to follow. The proportion of termites in each caste within the colony is also regulated chemically. Nymphs or immature can develop into workers, soldiers or reproductive adults depending on colony needs (Michael, 2000).

Sound is another means of communication. Soldiers and workers may bang their heads against the tunnels creating vibrations perceived by others in the colony and serving to mobilize the colony to defend itself. Mutual exchange of foods enhances recognition of colony members (Kamble, 2002).

2.3.3. Feeding and feeding groups of termites

Termite colony success depends on the adaptability to eat different foods. Although termites are soft-bodied insects, their hard, saw-toothed jaws work like shears and are able to bite off extremely small fragments of wood, a piece at a time. The characteristic food of termite, considered as a whole, is wood. Almost certainly termites are attracted to wood by its odor, which they are able to sense at some distance even through the soil. Many species, however, seldom if ever eat wood but concentrate upon grass and general plant debris. Almost all species of termites are detritivorous (Harris, 1957). They consume wide range of freshly dead or decaying plant material including dry grass, leaf litter, decaying wood, dung and humus. Living plant tissues, including lichen and mosses are taken by a few species.

Although cellulose is the major part of food in wood eating forms termites cannot digest it. This is because the glands in their digestive tract do not secrete cellulose digesting enzymes. But digestion is assisted by symbiont organisms in their tract.

Another feeding group that may be common and important in many tropical forests is the soil-feeding termites. Nonetheless, termite species can be categorized into six broad trophic categories according to their food, foraging galleries or columns, and biology (Martius, 1994; De Souza and Brown, 1994; Eggleton et al., 1995; 1996; 1997). The feeding categories are described below.

A. Wood-feeders (*Xylophagous*): are termites that feed on live wood and/or sound to partially decayed dead wood excluding extremely decayed and friable wood including branches still attached to trees. They may live in their feeding galleries which in some cases become colony centres (Eggleton et al., 1996, Wardell, 1987). The condition of wood taken is very important. This may include living trees (*Coptotermes*, *Schedorhinotermes* and *Microcerotermesdubius*), sound dead wood (*Kalotermitidae*), or fungus-attacked wood (*Nasutitermitinae*, some *Termitinae* and *Macrotermitinae*) (Wood, 1976; Collins, 1984). Most of these termites are arboreal (attached to trees), subterranean or epigeal nesters (Eggleton et al., 1997).

B. Wood/soil interface-feeders: termites that feed on extremely decayed wood that has lost its structure and has become friable and soil-like wood, the soil under logs or soil plastered to logs, or soil mixed with leaf litter in slit-root complexes (Eggleton et al., 1996; 1997). They are found in the Termitinae, Apicotermitinae and Nasutitermitinae sub families. Most of them nest within dead logs, build epigeal nest or form colony centres in the soil (Eggleton et al., 1996; 1997).

C. Soil-feeders (*Geophagous*): termites that feed on humus and upper mineral soil, with some degree of selection of silt and clay fractions. The vast majority of species in this group ingest topsoil rich in organic matter. They normally are distributed in the soil profile, in the organic litter layer (leaves and twigs) and in epigeal mounds (Eggleton et al., 1995; 1997). This form is found in many Termitinae (the Capritermes-group and Labritermes), several Nasutitermitinae (Subullitermes- group), and most Apicotermitinae (the Anoplotermes- group) (Wood, 1976; Eggleton et al., 1997). Soil feeders are very common and abundant in many tropical rain forests (Wood, 1976). In Southeast Asian regions, soil feeders are dominated by the Termitinae with small number of Nasutitermitinae and Apicotermitinae (Abe, 1987).

D. Grass-harvesters: termites that feed on living and dead grass. They will also take dung and may sometimes scavenge vertebrate corpses. They are mainly of the family Hodotermitidae, found only in savannah and deserts (Krishna, 1970).

E. Litter-feeders (*Humivorous*): termites that feed predominantly on leaf-litter and small wood items. Food sources are often taken back and stored temporarily in the nest.

This group includes some subterranean and other mound-building Macrotermitinae (with fungal association), as well as certain Nasutitermitinae that forage on the surface of the ground or litter layers (Eggleton et al., 1997; Collins, 1984). Genera such as *Laccessitermes* and *Longiditermes* are also known as arboreal foragers.

F. Micro-epiphyte-feeders: Termites of this group forage on mosses, algae, lichens and fungi on tree barks (Collins, 1988).

2.4. Termites as insects

Termites belong to the insect order Isoptera, and are characterized by their colonial behavior. They are often referred to as ‘white ants’, however, morphologically they are very different from the ants and other social Hymenopterans (bees and wasps). The word isoptera originated from

the Greek words, in which ‘ isos’ means equal and ‘ pteron’ means wing, and refers to the two pairs of identical wings in the adults (Harris, 1957). They are polymorphic, eusocial insects, living in large communities of several hundred to several million individuals, composed of reproductive (winged) forms together with numerous apterous sterile soldiers and workers. Their numerous colonies have great influence in ecosystems. The dominance of termites in tropical ecosystem is mainly related to their ability of utilizing dead plant material rich in cellulose (the most abundant organic matter on earth) (Peakins and Josens, 1978; Wood, 1986).

These social insects are found mainly in the tropics between 45° north and 45° south latitude.

These distribution areas cover two-thirds of the landmass, involving some 100 countries (Abdurahman, 1991). Termites hold two positions from the economic point of view. They can be very destructive, since they feed upon and often destroy various structures or materials that man utilizes i.e. wooden portions of buildings, furniture, books, utility poles, fence posts, many fabrics, and the like. Termites damage buildings, forestry and a wide range of crops including cash crops such as rubber, cocoa, coconut, oil plum, sugar cane, and cotton; and food crops such as maize, wheat, groundnuts, and rice; and pastures. Any material that incorporates cellulose can be devoured by termites, from paper to palaces and fungi to fir trees. Termites, in their quest for food, also destroy other material that stands in the way; this has led to breaks in dam linings, fires and electrical faults in large cables (SU and Scheffrahn, 1998).

However, on the other hand they are beneficial in that they assist in the conversion of dead trees and other plant products to substances that can be utilized by plants. Moreover, termites are important part of the food chain for many animals including man. They supply materials for many food chains, soil engineering (translocation and altering soils physically and chemically and maintaining soil fertility) (Lee and wood, 1971; Wood, 1988), providing a possible input of nitrogen through symbiotic fixation, methane gas release and carbon flux (Collins, 1984).

2.5. Termites as agricultural and structural pests

Termites can have significant impact on plantation and urban forestry as well as on agricultural tree crops and buildings (Cowie et al., 1989). Many other insect pest species cause damage to various parts of trees, but often do not cause mortality.

Some termite species, however, are able to kill apparently healthy trees and therefore, have the potential to cause much greater losses.

Even where termites do not cause damage to the bole, they attack the wood by consuming the heartwood and, thereby, hollowing the trunk and reducing the value of the tree as a source of timber. The extent to which termites are problems to trees and the nature of loss they cause are very much related to the geographic region concerned (Logan et al., 1990).

Termites feed on wood and serve an important function in nature by converting dead trees into organic matter. Unfortunately, the wood in building is equally appetizing to termites and they cause serious damage to residential and commercial buildings (Wood and Sands, 1977; Wood et al., 1980). In many of their distribution areas, termite pests pose serious threat to agricultural crops, forest seedlings, range lands and wooden structures (Wood, 1986). They often infest buildings and damage lumber, wood panel, flooring, sheetrock, wall paper, plastics, paper products, and fabric made of plant fibers. The most serious damage is the loss of structural strength. Other costly losses include attacks on flooring, carpeting, art work, books, clothing, furniture and valuable papers. The annual economic cost of structural damage to buildings from termites in urban area is about \$ 15-20 billion dollars worldwide. When this is combined with the cost of damage to agricultural and forestry resources, the overall cost to the society is over \$ 30 billion dollars per year (Geer, 2005).

Within the wide limits of their geographical distribution, termites will destroy any unprotected timber used in construction work or as fittings, unless it has been rendered unpalatable or is naturally resistant to termites (Harris, 1971). Termites can tunnel through mud and known to tunnel through mortar between bricks and thatching in African houses are expected to last for only 5-6 years (Pearce, 1997).

Termites are very serious pests in several parts of Ethiopia, particularly in the western parts of the country. They cause considerable damage on agricultural crops, range lands, forestry seedlings and wooden structures such as rural houses, stores, fences and bridges crossing streams (Abdurahman, 2000). Gauchan et al. (1998) in their study of termite situation in west Wollega reported that the houses made of wood can only last for about 2-3 years. About 61 species of termites belonging to 25 genera and four families have been recorded in the country. Only few of these are important pests of agricultural crops, forestry seedlings, rangelands and wooden structures. The rest are harmless, feeding either on dead plant materials, dung or soil organic matter. The major termite species that cause damage on wooden structures belong to the fungus-

growing subfamilies and to the genera *Macrotermes*, *Odontotermes*, *Pseudacanthotermes*, *Microtermes* and *Ancistrotermes*.

The fungus growing forms depend on the fungus cultivated within the nest for digestion of their food (Abdurahman, 2000).

Abdurahman (1990) reported that in western Ethiopia thatched roof huts are destroyed in less than five years and corrugated iron roof houses in less than eight years. Many wooden structures in the same area require maintenance every year. This undesirable consequence of repeated rebuilding of wood straw thatch houses leads to excessive clearing of native woodland and forest. The vicious cycle of cause and effect of the termite problem negatively affects the socio-economic situation of the population of the area. As a result trees are cut frequently to replace the structures destroyed by termites which would in turn lead to deforestation, erosion and environmental degradation.

Temperature and humidity are the main factors affecting termites in buildings. The equilibrium moisture content of wood is affected by temperature and water vapor in the air. Pearce (1997) produced predictions for the dry-wood termites' hazard to tropical and subtropical buildings in coastal regions of Africa. He found that sea fogs and early morning dews in semi-desert coastal regions provide water for building soil runways. As the temperature is often low at this time, termites can even forage on the outside of the runways.

The general picture of termite damage to buildings is straight forward; the worker termites remove all palatable wood excepting only the outer layers which are left to provide the shelter and freedom from disturbance that are necessary to termites. Dry-wood termites eat out galleries in the timber and these provide accommodation for the king and the queen, the soldiers, and the various young stages of the community. The community is found in the vicinity of maximum feeding activity at any time. In the course of time, their galleries coalesce to form large cavities (Harris, 1971). Subterranean termites fix nests from which the workers move out in search of food, and to which they return with their spoil. Distances of one hundred yards (30 meters) may be travelled by the small workers with their loads of wood. Communities of these termites number many thousands of individuals, and those which make the distinctive large mounds in the tropics are estimated to run into millions. For this reason, the rapidity and scale of their attack

on new buildings is much more spectacular than that of dry wood termites whose colony is consist of only a few hundred individuals (Harris, 1971).

Termites can cause direct physical damage often affecting the structural support of crop plants. For example, fungus growing termites, *Microtermes*, *Ancistrotermes*, *Macrotermes*, *Allodoterme*s and *Pseudoacanthotermes* species are the predominant pests of maize in Southern Africa (Sands, 1977; Uys, 2002). They can also cause indirect damages by interfering with the food crops and water supply, causing the eventual death of part, of all, of the plant (Pearce, 1997). Hickin (1971) stated that termites by no means confine their attentions to dead plant tissues such as wood. In many parts of the world termite species are serious pests of growing crops including living trees. Guachan et al. (1998) described that termites cause widespread damages to a great variety of crops in tropical Africa. The damages can occur from the seedlings to harvest and usually occur every year; as termites form almost stable population and foraging by various combinations of several species occurs throughout the year.

The author reported that termites lowered the yield of maize, sorghum, teff, millet and beans in Manasibu district (west Wollega, Ethiopia).

Termites primarily feed on dead grasses' litter and much of the small amounts of dry grass biomass to such low level that grass consumption by termites result in the denudation of the area. Massive termite damage was observed in grazing land in Manasibu and Jarso districts that led to degradation of the pasture land (Wood, 1986). Degradation of pasture land is the consequence of lack of fodder and erosion. Lack of fodder leads to, weak animals that are: susceptible to diseases, give low milk and meat yield, and are weak in traction. Lack of fodder also leads to overgrazing. Animals trampling on overgrazed land again results in surface soil compaction. Since infiltration in compact soil is very low it would lead to high runoff, and subsequent erosion.

Wood (1986) observed *Macrotermes subhyalinus*, *Pseudacanthotermes mititaris* and several species of *Odontotermes* feeding on dry grass in west Wollega. He concluded that overgrazing was an important and possibly the major factor for termites' damage to the range land in west Wollega, Ethiopia. Termites damage to the growing trees fall into two distinct divisions- damage to the seedlings in the nursery and young trees in the field, and damage to the mature trees in the natural habitat, in plantations and as specimens in towns or botanical gardens. Resistance to

termites attack is apparent as a character of the wood in some species of trees, but while still young, the trees have not had time to develop this trait and are just as liable to damage as any other tree (Harris, 1971).

Plantations in wet places are not usually subject to much termite damage, but in dry countries it is common to find that termites are the main obstacles to afforestation (Harris, 1971). Throughout tropical Africa (south of the Sahara), damage is caused mainly by ground dwelling termites whose nests contain fungus gardens, mound-builders and subterranean- nesting species together. Wood (1986) reported that: 1) the problem of damage to forestry trees in Ethiopia is confined to exotic trees, particularly Eucalyptus planted in the low areas (i.e. altitudes less than 2000m), 2) the damage is mainly caused by *Macrotermes*, *Odontotermes*, *Pseudoacanthotermes*, *Ancistrotermes* and *Microtermes* which attack either nursery seedlings or seedling trees of up to 3 years after transplanting, 3) losses are severe and in some areas total.

Similarly, termites often burrow through non-cellulose materials that lie in their path. Pearce (1997) pointed that plastics are often eaten by termites and this causes leakage in plastic pipes and power cuts in cables. Hickin (1971) explained the reasons to remove obstacles from the path leading towards cellulose otherwise it is certain that plastic and allied materials do not serve in any way as a source of nutrition for termites.

In general, the following general principles can be derived from published works (Wood, 1996). The likelihood of damage is greater in exotic rather than indigenous crops, in rain-fed rather than irrigated crops and in crops under stress rather than healthy and vigorous crops. Damage occurs from seedling to maturity in annual and perennial crops and forestry trees.

Losses occur throughout the tropics, but particularly in Africa and Indo-Malasia where the major pest species belong to the *Macrotermitinae* (fungus growing termites), particularly *Microtermes*, *Macrotermes* and *Odontotermes*. These species have semi-permanent nest systems throughout farmers' field and are a potential threat every year. Damage varies from superficial damage to dead parts of the plant (e.g. outer bark) to penetration of root systems, stems and death of the plant. Yield losses of up to 20% are common and localized losses can exceed 50%. Crops suffering greatest losses are wheat, maize, sugar cane, groundnuts, cotton some vegetables and locally in West Africa and South America, Cassava and Yam. Some perennial crops such as

cocoa, coconut and rubber suffer low-level, localized damage but throughout the tropics tea are infested by a wide range of Kalotermitidae, particularly Kalotermes in South America and Asia.

It should be emphasized that the majority of termite species in farmers' fields do not damage crops (Cowie et al., 1989).

Exotic forestry trees have been increasingly incorporated into agricultural enterprises and there are wide spread losses of Eucalyptus in South America, Africa and India and Pinus in South America and northern Australia. The termites causing greatest losses are Macrotermitinae in Africa and IndoMalaysia, Mastotermes in Australia and Comitermes and Procomitermes in South America.

Termites are serious pests of agricultural crops and rural houses in Ethiopia. Some attempts were made to control termites on crops. However, termite problem on rural houses is a neglected area regardless of the intensity of the problem which at times results in total collapses of newly constructed houses.

Surveys were conducted in three districts of the Central Rift Valley of Ethiopia in 2012 to collect preliminary information on status of termite infestation to rural houses, and total of 58 houses were inspected in the three districts of which 91% were infested at different levels at less than 10 years of age after construction (Daniel and Emanu, 2014). Over half of the homeowners used pre-construction preventive measures such as plastic sheet cover and painting with used engine oil. Even though termite infestation was common and serious, only 35% of the homeowners took post construction preventive measures mainly because of lack of knowledge on the problem (Daniel and Emanu, 2014). The post construction termite control methods used in the study area were removing or scratching mud tubes from the infested parts and painting of the houses with used engine oil. There was no evidence of using synthetic chemicals for the management of termites on rural houses. The local government officials or Development Agents were not aware of termite problems in rural houses as the problem was only seen as a secondary problem. Termites have a great impact on local houses leading to frequent repairing and rebuilding in the Central Rift Valley of Ethiopia. This damage will eventually lead to deforestation and environmental degradation in addition to its economic impact and spread of the termites (Daniel and Emanu, 2014).

2.6. Termite classification

There are seven extant families of termites (Pearce, 1997) in the order Isoptera: Mastotermitidae, Kalotermitidae, Hodotermitidae, Termopsidae, Serritermitidae, Rhinotermitidae and Termitidae. These families are divided into 14 sub families, 270 genera and over 2000 species (Kambhampati et al., 1996). Based on the composition of the symbiontmicrobiota in the gut, termites are divided into two groups, ‘ lower termites’ and ‘ higher termites’, where lower termites house flagellate protozoans and bacteria. Higher termites house a variety of prokaryotic microbes, but no flagellates. Some Termitinae also house cellulolytic amoebae. The different termite families are described as follows.

- **Mastotermitidae**

They are represented by *Mastotermes darwiniensis* Forggatt, a single living species. It is confined to Australia and New Guinea. These species usually nest in the trees and stumps, but can be very destructive to buildings as well as trees and crops including sugar cane (Lamb, 1974).

- **Kalotermitidae**

Species in this family are often referred to as the dry wood termites (from their nesting habit, in sound wood) and believed to be a sister group to Rhinotermitidae and Termitidae (Kambhampati et al., 1996). This is the largest family of lower termites, with 25 genera and 350 species (Krishna, 1970; Wood, 1986). These termites occur in small numbers in rain forests, mainly confined to dead limbs and trunks in the forest canopy (Collins, 1988). Many species in this family are serious pests of forest products. Soldiers normally have robust, phragmotic heads, which are of particular value in blocking and defending nest galleries (Collins, 1988).

- **Hodotermitidae**

The Hodotermitidae are called harvester termites (Harris, 1971). They are small groups of subterranean species. Found in drier parts of Africa and the Middle East. They forage the above ground part of grasses which are cut and stored in underground nests (Lamb, 1974).

- **Rhinotermitidae**

Rhinotermitids are the most important family of lower termites and are often referred to as damp wood termites. They are found in standing or fallen trunks and limbs, and can cause severe damage to timber and living trees (Collins, 1988).

- **Termopsidae**

These are damp-wood termites and usually found in standing trees or fallen logs. Very few of them are pests (Lamb, 1974). The Termopsidae, a small family of termites living in damp, rotten wood, partially or wholly buried underground, have a scattered, essentially temperate distribution and are rarely pests (Logan et al., 1990).

- **Termitidae**

The family Termitidae contains three-quarters of all known species, comprising four subfamilies: Macrotermitinae, Apicotermitinae, Termitinae, and Nasutitermitinae (Wood, 1986; Collins, 1988). Members of this family are often termed as the higher termites as they possess more advanced features (Pearce, 1997). They are mainly wood or grass eaters with subterranean habits and many are mound builders. One of the most important sub-families is the Macrotermitinae. Genera in this sub-family are known to cultivate species of the symbiotic basidiomycete fungus *Termitomyces* on faecal combs within their nests. These termites have high weight-specific consumption rates and a correspondingly greater impact on decomposition processes than other termites. Macrotermitinae are known to originate from Africa.

- **Serritermitidae**

These are subterranean termites which were previously categorised under Rhinotermitidae. There are monotypic subfamily Serritermitinae from Brazil has recently been elevated to full family status, serritermitidae (Emerson and Krishna, 1975)

2.7. Types of termite damage to crops

Types of termite damage to crop were varied from plant to plant and also found to be depend on foraging behavior of the termites. Subterranean termites which were small in size were observed foraging frequently in stems. Such damaged was limited to maize and sorghum (Ofga, 2004). Stem cutting at surface level by subterranean termites caused severe threats to maize and teff in Manasibudistrict(Ofga, 2004).Termites also foraged on plants of under covering soil sheet,

foraging by termites on outer part of plants under soil sheeting was observed in Manasibu District during rainy season more frequently in sunny day this mode of foraging increase on set of dry season (Ofga, 2004).

2.8. Geographical distribution

Termites are mainly tropical and subtropical insects extend up to 45° N and 50° S (Harris, 1970; Kooyman and Onck, 1987; Wood, 1988). According to Pearce (1997), the number, species and nest varieties of termites increase toward the equator. The portion of the earth in which they occur over two-third of the land mass involving some 100 countries with over three million human population (Wood and Johnson, 1986, cited in Abdurahman, 1990). Therefore, it is evident that termites are more abundant in the resource-rich and economic-poor tropical nations. In same way as abundance of termites decrease with increased latitudes, they are rarely found at latitudes above 3000m (Wood, 1988).

Bouillon (1970) stated that the Ethiopian zoogeographical region appears the richest in genera as well as species of termites and it is known for its endemic fauna. Of 570 species in the region 87.5% are considered endemic.

2.9. Termite situation in Ethiopia

Ethiopia is among the countries known for their termite fauna in tropical Africa. The Ethiopian zoogeographical region, in general the richest fauna and has been center of origin for many species (Bouillon, 1970). Ethiopia is also the countries in tropical Africa which are known for their termite fauna.

Cowie et al., (1990) cited in Abdurahman (1991) reported that the Ethiopian termites fauna consists of 61 species belonging to 25 genera and 4 families. Only very few of these are regarded as pest of different resources, such as agricultural crops, forestry seedling and pasture lands (Abdurahman, 1991). The four families composed of pest species in Ethiopia are Kalotermitidae, Hodotermitidae, Rhinotermitidae and Termitidae (Abdurahman, 1991). Species feeding on dead plant materials, soil organic matter, or herbivore dung are found among the termites in Ethiopia.

Cowie and Wood (1989) reported that the Ethiopian fauna consists of species, which are widely distributed in sub-Saharan Africa. They noted that the majority of Ethiopian termites are found in macrotermitinae and it is these, which constitute the most serious threat to agriculture, forestry and rural buildings whereas the Nasutitermitinae eat only dead grass and appear harmless in

Ethiopia. Wood (1986) visited some parts of Ethiopia, which had been reported by Ethiopian Ministry of Agriculture to be infested by termites. These parts are sedamo, Gamogofa, Illubabor, Harge, Shoa, and kefa areas.

2.10. Problems of termites and their control in western Ethiopia

Almost all major annual crops grown in western Ethiopia are attacked by one or more species of termites, either at one stage of development or throughout growth stages (Abdurahman, 1990). Tree seedlings are also attacked by termites. It is common practice in western Ethiopia to build house, fence and stores using untreated wood and grass without proper stone foundations. As the result subterranean termites can easily attack the constructional materials. Brigs crossing streams are also destroyed by termites in the region. Houses survived for only about five to eight years after construction (Abdurahman, 1990). It is evident that frequent cutting of trees, in any attempt to replace miscellaneous constructional materials, which are destroyed by this pests, would unfortunately lead to deforestation and erosion and subsequent ecological disasters. B&M Development consultants (1997) stated that massive termite damage were observed in grazing land in Manasibu district, which leads to degradation of pastureland and consequent overgrazing on the only available forage, and eventual erosion. Wood (1986a; 1986b) reviewed from his observation and from consistent reports of Ethiopian Ministry of Agriculture that termite poses series treats to Agricultural products, pasturelands and tree seedlings, in the western parts of the nation.

Damage is generally greater in exotic plants than indigenous plants, rain feed plants than irrigated one, during dry season than irregular rain fall, in plants under stress than healthy and vigorous plants, and in low lands than high land areas (Guachan et al., 1998). They reported that the far west Wollega zone of Oromia region has been known to suffer from increasing termite problems for the last 20 years, but it has been intensified in more recent years and was reportedly spreading rapidly in eastern direction, from the more affected districts in the west.

Abdurahman(1990) noted by citing Manasibu district Administrator (personal communication) that the first termite damage report came in 1938 from Around Kiltu Kara, small town in Manasibu district, Western Ethiopia. The magnitude of the problem is not similar throughout west wollega; it appears that Manasibu, Nedjo-Jorso, Ayra-Gulliso and Ghimbi were the most seriously affected districts (Abdurahman, 1990). The problems becomes so complex that the farmers from the area have abandoned their lands and moved to low land areas, were termite

problems was thought to be less severe (Abdurahman, 1990; D&B Development consultants, 1997). The farmers that migrated to low land areas reached 6% of the total farm population (Abdurahman, 1990).

Termite control method used by farmers in western Ethiopia includes both traditional and chemical approaches. Flooding mounds, queen removal and burning straw in excavated top parts of mounds are among cultural methods. Western synod branch based at Chalia participated in queen removal method of termite control by offering financial support. Another mound poisoning campaign was also under taken by Ministry of coffee and development, in Manasibu, Ghimbi, Ayra-Gulliso, and partially in Nedjo-jarso and Yubdo district during 1988 crop season (Abdurahman, 1990).

2.11. Farmers' knowledge, perceptions and management practices of termites

Farmers in the central rift valley of Ethiopia mentioned 19 major different kinds of pest problems that faced in growing crops irrespective of pest, the majority of the farmers considered porcupine (94%), followed by termites (69%), and foxes (56%) as major pest of crops, thus the inclusion of termites by majority of the respondents in the list of pest of standing crops, is indicative that termites are important pest in the central rift valley of Ethiopia, (Daniel and Emana, 2015). However farmers were not aware of the existence of different species of termites, and they simply know termites as single entity. Even they were not aware of the existence of minute species, *microtermes*, which were common in their crop fields, and also cause some damage. However they recognize that a colony consisted of castes which they mention, some of them using certain features as: Queen (haadhoo-mother), soldiers (diimtuukannamaciniintu-red colored which bites human) and alates by flying behaviors (roobaanjiraattuu-the one appear during rain)(Daniel and Emana, 2015).

All the farmers in the central rift valley of Ethiopia reported the presence of epigeal mound in their farm lands and that mound were constructed by termites. Some also mentioned that termites could be found in non-mound areas (Daniel and Emana, 2015).

Haricot beans and maize were the most susceptible crops to termites in central rift valley of Ethiopia, (Daniel and Emana, 2015), they also reported that damage on maize plants commence at maturity stage and continues until harvested, besides their perception of the commencements of termite damage to crop at maturity stages, farmers in the central rift valley of Ethiopia viewed

that termites damage was highly localized even in the same field, the result imply that termite damaged showed both spatial and temporal variation governed by certain factors. Only few farmers of the study areas were used cultural management practice to control termites and no farmers used chemicals.

Daniel and Eman (2017) reported that farmers in central rift valley of Ethiopia were considered termites as one of the major problems in growing tree seedlings and this is basically in agreement with Silashiet.,al(2008) who reported similar results with evidence. However damage of termites on tree seedlings, even on the most susceptible exotic plant, *Eucalyptus* was very low

Chapter 3

3. Materials and Methods

3.1. Description of the study area

The study was conducted in La Lokile district. Lalo Kile district is located in the western part of Ethiopia, Oromia regional state, Kellem Wollega Zone. It is 535 km away from Addis Ababa to the West. The total area of the district is about 40382 hectares. It is bordered by Yubdo in the east, Dale Sadi in the west, Ayira in the north and Darimu in the south. From the three vicinities, Ayira and Yubdo are currently under the administration of West Wollega Zone and Darimu is under the administration of Ilu Aba Bor zones.

Lalo Kile has an average temperature of 22.5°C and average rainfall of 1550mm. The altitude of Lalo Kile district is ranged between 1000 and 1500 meters above sea level.

The major soil type of the study area is sand and loam. Lalo Kile is famous for its production of cereal crops. The major ones are millet, sorghum, teff, maize and oil seeds such as sesame, and sunflower. In addition to cereal crops and oil seeds, Lalo Kile is known for its production of cash crops such as coffee. Selection of the district was made together with the department of Agricultural development of the Kellem Wollega Zone, and study sites/kebeles/ was selected from the district purposively. The reason for selecting the district for the purpose of the study was long history of termite infestation and related complaint of the community at the study site about the termite problem. Accordingly, the three kebeles in which the investigation was made include: Degen-Dumuga, Menjeso-Juru and Nano-Jeno. The study period was between December 2017 and June 2018.

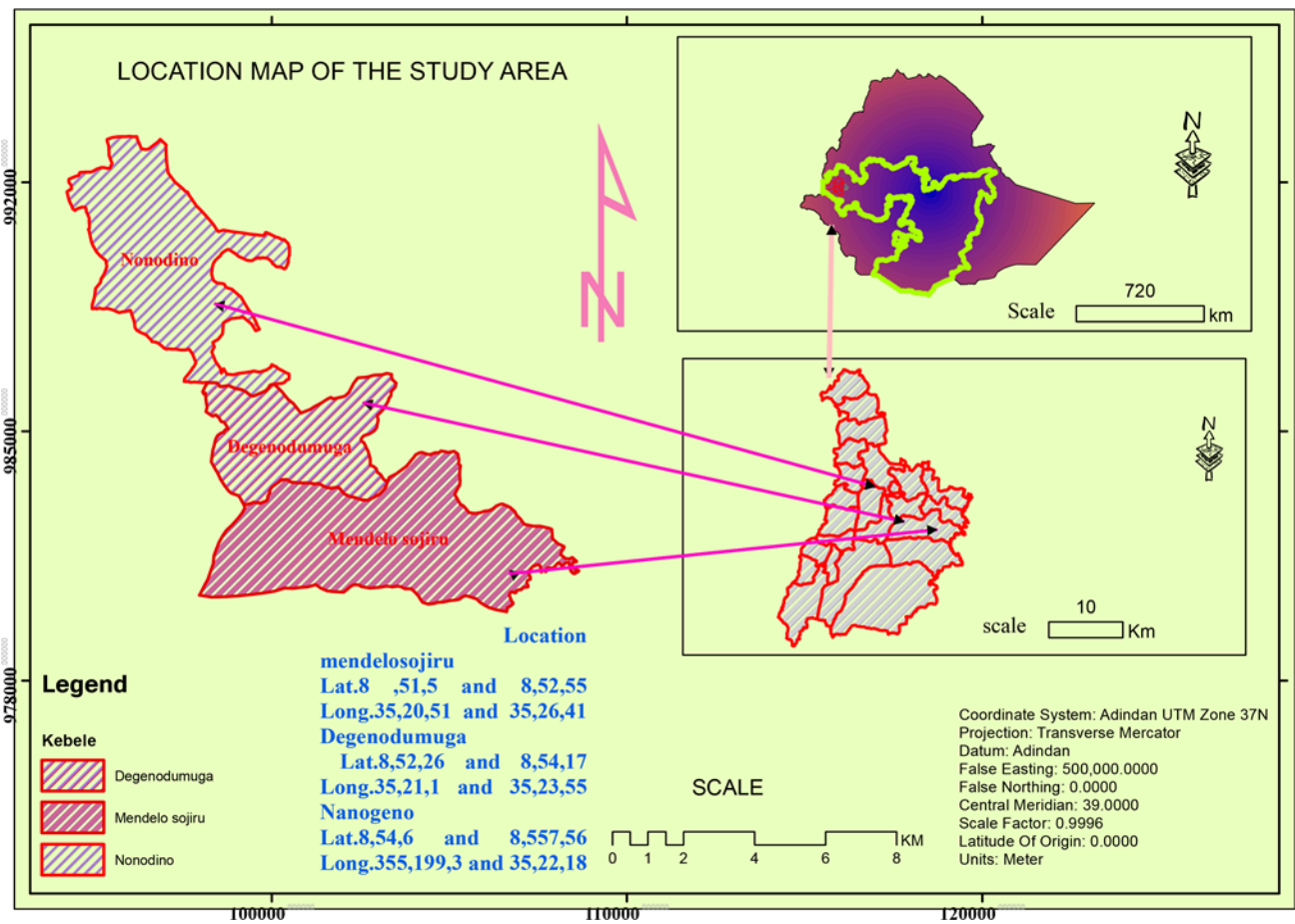


Figure 2. Map of the Study area

3.2. Procedures

Materials that were used during the study period include digital camera, data sheet, books, pens, pencils, Microsoft excels and GIS software.

Preliminary survey had before conducting the actual research to make the actual study easier. As a result of this, preliminary survey was conducted in the study area from the first week of November 2017 to December 2017 to collect data of the study area, such as rain fall, soil type, temperature, topography, the actual size of the study area.

The necessary information needed for the purpose of the study was collected through different methods accordingly.

- ✓ Prepared questionnaires for the purpose of the study were translated to Afan Oromo and presented for 60 selected farmers to get base line information on the problems caused by termites to vegetation, crops and buildings.
- ✓ Three protected and unprotected areas, one from each kebeles were taken and transect lines were made across the areas. And then every damaged and undamaged plant along the lines was counted to compare the level of termite's damage to vegetation in protected and unprotected areas.
- ✓ Secondary data about the size of crop land and range land were taken from District agricultural office; field survey was conducted to investigate the proportion of damaged land size.

3.3. Termite damage level investigation on crops, building, protected land and unprotected vegetation

Questionnaires were used to get base line information on the problems caused by termites to vegetation. The questionnaires were translated to Afan Oromo and presented to 60farmers twenty from each kebeles. The sixty farmers were selected purposively.

Assessment of damage caused to vegetation was done in the field. The localities/areas/ in which the assessment was done were selected within the three kebeles by the help of kebeles officials. Damage was estimated following the method of Abdurrahman (1990). He checked plant cut by termite among 20 consecutive plants per sampling site in each randomly selected five sites per field at approximately 10m intervals diagonally across the field. However, in this study three

protected and unprotected areas (600m^2) one from each Keble were taken and transect lines were made across the areas, all damaged and undamaged plants along the transect lines were counted. The total counts of damaged plants obtained were divided by total plants population along the transect lines and taken as percentage of damaged plant of the selected area. The mean of the damaged plants in the three areas represented damage of that study area, and used for the comparison of the severity of the damage in protected and unprotected areas.

For the purpose of estimating the total size of damaged land of the study area, basic information about the total size of crop land and range land of the study area Keble's were gathered from district agricultural officials. Then field observation was made to measure the total size of damaged land.

3.4. Data Analysis

The data were collected by structured questionnaire and field observation in order to generate information. Then, these data were analyzed using percentages to quantify numerical data relating to the study results.

Chapter 4

4. Results and Discussion

4.1. Results

4.1.1 Topography of the study area

The study area was mostly known by non-uniform topography and forest was confined around river banks/stream/. It is highly eroded in hill side eroded area (Plate 1). No termite infestation was encountered around river banks. The soil looks compact, dry and brown in color. Alates termites were encountered during the rainy days of the study period. Both mound forming and non-mound forming termites were common in the study area.



Plate 1. Topography of the study area

4.1.2. Termite damage level investigation on protected land and unprotected vegetation

Damaged plants were encountered frequently in unprotected areas than protected areas. It was observed that 63.53% of the plants in unprotected areas were damaged (Table1). The variations among the kebelas are no significant.

Table 1. Percentage of damaged plants in protected land and unprotected lands

Keble	Protected area			Unprotected		
	Total count	Damaged	%	Total count	damaged	%
Dogono-Dumuga	136	31	22.79	85	57	67.05
Manjoso-Jurru	159	29	18.23	89	53	59.55
Nano-Jeno	164	37	22.56	92	59	64.31
Total	459	97	21.00	266	169	63.53

Many attacked plants were observed in unprotected areas than in protected and also its severity is very high to the plants in unprotected areas (Plate 2a & b).



Protected area (a)



Unprotected area (b)

Plate 2. Termite damage level investigation in the field

4.1.3 Investigation of damaged land of the study area

From total areas of study area lands (470 hectares), 249 hectares (52.9%) were seriously damaged (Figure 2). The variations among the kebeles are very significant. Accordingly Dogono-Dumuga was the very seriously damaged area while Nano-Jeno was the less damaged area (plate 3a, 3b&3c).

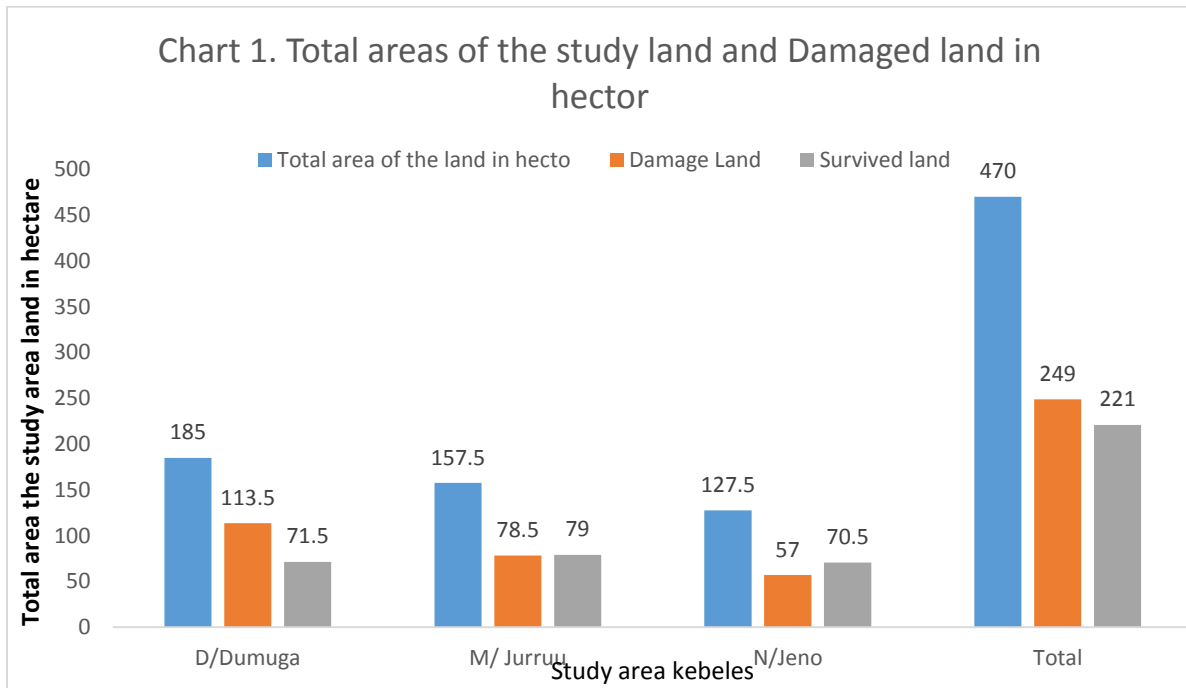


Figure 3. Total area of study area and damaged land in hectare

During field observation the level at which the study area lands were damage, were observed to be much damaged, and from these 61.2% of the damaged land was in Dogono-Dumuga (Plate 3).



Plate 3. Highly damaged area in Dogono-Dumuga Kebele

Ongoing projects was encountered in range lands and crop lands and it was observed that terrace were making by study area community with the collaboration of focal person who works on sustainable land management/SLM/ to maintain damaged land by termites and other factors(Plate4). Even though the plan of the project was very helpful in maintaining the damaged area, the communities were reluctant to participate in the work and only few community members observed to participate on the work.



Plate 4. Observation to ongoing work done to maintain damaged land

4.1.4 The major crops of the study areas

Millet, sorghum, maize and teff were observed to be the major crops of the study areas. However, majority of local people (71.66%) were used to grow millet and sorghum, only teff and maize were observed to be grown by few peoples (5%)(Table 2).

Table 2. Responses on the types of crops grown in the study area

Responses	No of respondents	% of respondents
Millet and sorghum	43	71.7
Millet and maize	5	8.30
Maize and teff	3	5.00
Teff and sorghum	4	6.70
Millet and teff	5	8.30
Total	60	

4.1.5 The most frequently damaged crops by termites

Millet, maize, teff and sorghum were observed to be damaged, by termites. About 62% of local people replied that, millet, teff and were the most frequently damaged crops by termites, while sorghum was the least damaged crop (Table 3).

Table 3. Responses on the types of crops most frequently damaged by termites

Mostly damaged crops	No of respondents	%of respondents
Millet, Maize, teff	37	62
Maize	10	17
Teff,	10	17
Sorghum	3	4

4.1.6 Investigating Growth stages at which the crops damaged by termites

Millet, teff and maize were damaged at all growth stages. About 93.33% of the local people said millet, teff and maize were damaged at all growth stages, but sorghum was observed to be damaged only at early and middle growth stage (Table 4).

Table 4. The growth stage at which the crops were damaged

Crops	Responses	No of respondents	Respondents in%
Millet,teff, maize	At early, middle and harvesting stage	56	93.33
Sorghum	At early & middle stage	4	6.66

4.1.7 Distances of crop land from residences and termites infestation

It was observed that the far the farm is away from residences the more damage and impact by termites. About 85% of the local people said termites impact increase when crop land is far away from residence. Only 15% of them were replied that as there is no any relationship between distance of crop land and termite infestation. (Table5).

Table 5. Relationship b/n distance of crop land from residences and termite infestation.

As farm land far from residences termite impact	No of respondents	% of respondents
Increase	51	85
Decrease	-	-
No relation	9	15

4.1.8 Investigating the relationship b/nlivestock population and termite impacts on range land

It was observed that there was positive correlation between livestock population and termite damage on range land. About 93.33% of the local people said that termite damage increases proportionally with increase in livestock population, and few of the respondents (5%) replied as; there were no relationbetween livestock population and termite damage on range land (Table6).

Table 6. Relation b/n livestock and termite impacts on range land

Responses	No of respondents	% of respondents
Have positive relationships	56	93.33
No relation	3	5
More serious in protected land	1	1.666

It was observed that termite infestation was less around residences due to fertilities of the soil around the residences. About 86% of the local people said termite infestation was less around residences due to fertilities of the soil around the residences, and others (14%) explained as, other factors were reason for high termite infestation as farm land far from residences (Table 7).

Table 7. The reason why termites' infestation were less around residences.

Reason	% of respondents
Soil fertilities	86
Topography of the land	5
Change in climate	9

4.1.9 Annual yield before termite occurrence and after termite occurrence

All of the respondents stated that they were experienced big difference in annual yield per hectare, when production of these crops before and after occurrences termite were compared. Even though there were no significant differences among the crops in annual yield loss, millet was the leading crop of the study area in yield loss and sorghum was the least in yield loss (Figure 4).

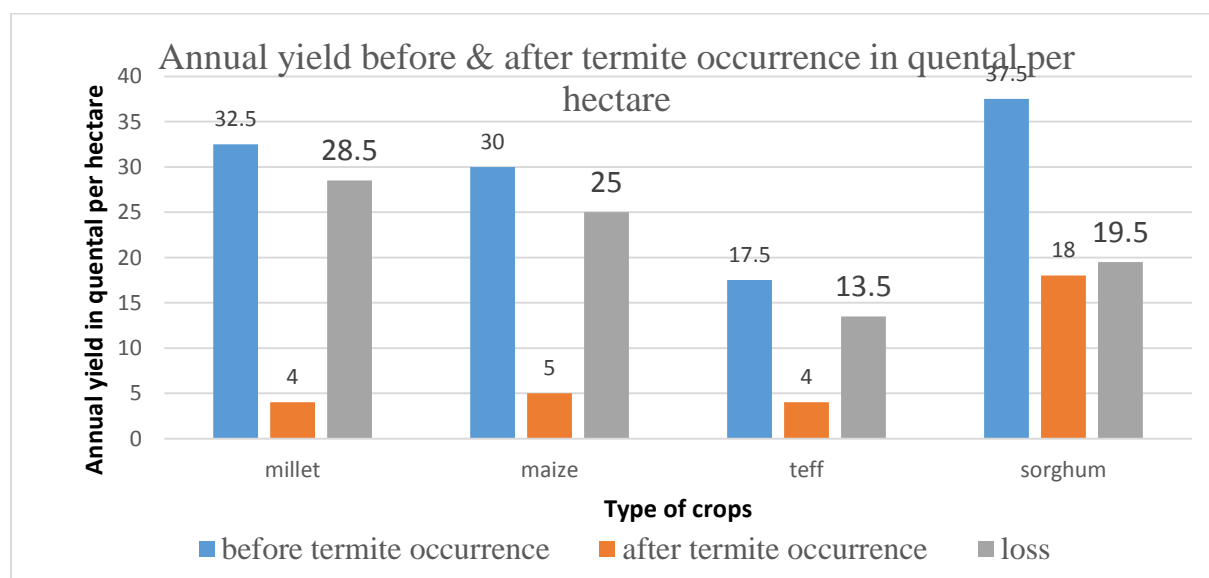


Figure 4. Annual yield before and after termite occurrence.

4.1.10 Main reason for annual yield reduction

Even though majority of the respondents (77%) said that the reason for such reduction in annual yield was termite infestation, the remaining (23%) argued that the erosion and soil infertilities also played significant role in addition to termite infestation in reducing annual yield.

Table 8. Reason for annual yield reduction.

Responses	No of respondents	% of respondents
Termites	46	76.66
Erosion and soil infertilities	14	23.333

4.1.11 Investigating impacts of termites damage on buildings

Houses and fences were observed to be damaged by termites. About 90% of the local people said both houses and fences were damaged by termites; however few (10%)of the respondents were experienced that, only theirhouse or fences were damaged by termites (Table9).

Table 9. Types of building most frequently damaged by termites.

Responses	No of respondents	% of responses
House	4	6.70
Fences	2	3.30
Both House and fences	54	90.00

Wall and roof of the houses were observed to be most frequently damaged by termites at their late age. About 85% of the local people said wall and roof were the most frequently damaged parts of the house. And some were experienced termite damage that were affect only roof or wall of houses (Figure 5).

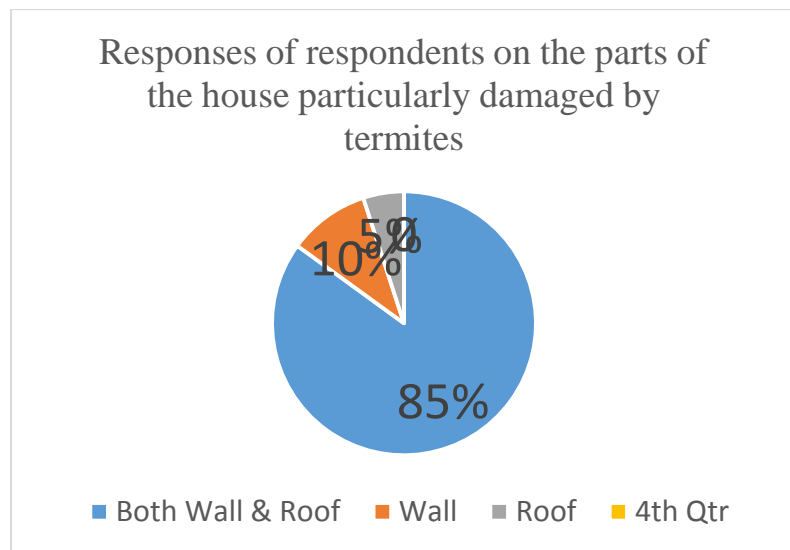


Figure 5. Responses on the parts of house most frequently damaged

4.1.12 investigating factors aggravating termite problems

Cutting trees, opening of forest for agriculture and overgrazing were observed to be the major factors in aggravating termite problems. 65% of the local people said cutting trees, opening of forest for agricultural and overgrazing were main factors in aggravating termite problem in study area, and about 35% of the respondent replied that, as there were other factors to aggravated termite problems in the study areas. (Table10).

Table 10. Factors which had aggravated termite problem and their future effect.

Factors	No of respondents	% of respondents
Cutting trees and opening of forests for agricultures&overgrazing	39	65%
Climatic change	5	8.3%
Increase in termite population	16	26.7%

4.1.13 investigating types of termites found in the study area

Both mound forming and none mound forming termites were observed to be the types of termites most frequently occurred in the area. About 88% of local people said both mound forming and none-mound forming termites were frequently causes serious damage to vegetation and building, but few of the respondents (12%) replied that damaged caused to vegetation were only confined to mound forming or non-mound forming but not both (Table.11).

Table 11. **The types of termites most frequently occurred in their surroundings.**

Responses	No of respondents	% of respondents
Mound forming termites	2	3.33
Non-mound forming termites	5	8.33
Both mound forming and non-mound forming	53	88.33

4.1.14 Investigating practices of the community to control termites

Cultural method such as: Queen Removal, flooding and smoking were observed to be major practice of termite control. About 90% of the local people said cultural methods were used to control or minimize termite damage; however 10% of them were observed to practice, chemicals, cultural and biological (Figure 6).

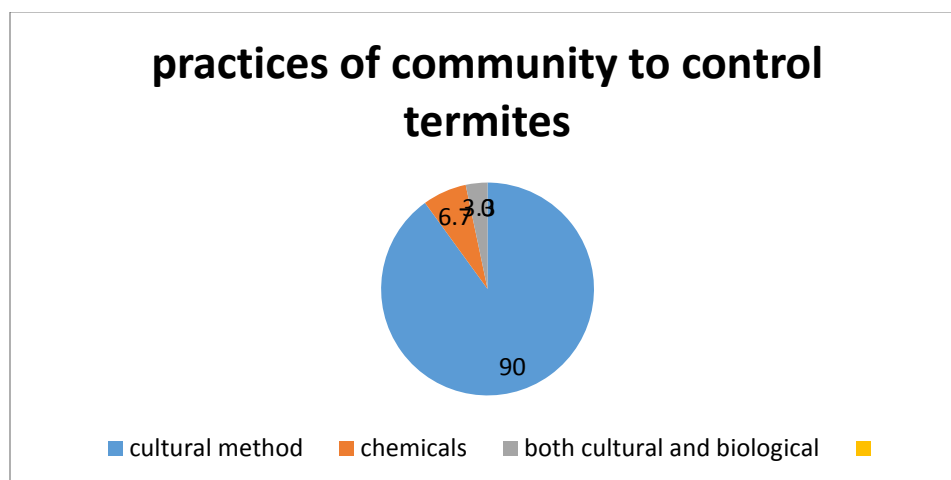


Figure 6. **Method of termite control**

4.2. Discussion

The study was conducted to assess the impacts of termites on crops, vegetation and buildings, and the results revealed that, there were seriously damage of termites to crops, vegetation, range land and buildings. Both subterranean/non-mound forming/and epigeal /mound-forming/ termites were widely distributed throughout the study area on field crops and range land. This findings in contrary to that of Ofga(2004) who reported that subterranean termites in general, epigeal termites in particular was the most widely distributed termite species in field crops of Manasibu district.

To investigate the impacts of termite three protected and three unprotected land (600m^2) were taken and transect lines were made across the selected areas. Every plants at intervals of one meter along the lines were counted, the total counts of the damaged plants were divided to the total counts of plants along the transect lines and were taken as percentage of damaged plants of the study areas, thus the study result revealed that 63.53% of plants were damaged in unprotected range lands than protected one. This finding agreed with that of Ofga (2004) who reported that protected range land had save plants/high vegetation cover per m^2 than unprotected range lands.

For the purpose of investigating the total size of damaged land, data of total area of the study kebeles was taken from district agricultural offices and field observation was made, and it was observed that 52.97% of the study areas were damaged seriously.

The results of the study revealed that, Millet, sorghum, maize and teff were grown by the community in the study area, among these millet, maize and teff were grown by majority of them (62%).

To investigate the impacts of termites on cops, the annual yield per hectare before termite occurrence and after termite occurrence were compared by using the formula $\frac{Y}{X} \times 100$, (where Y is farmers yield loss due to termites and X is farmers estimated potential yield without termite attack). And investigated that annual yield loss of crops were experienced by the community. The extent to which the crops were damaged by termites in the study area was not significantly different from each other. The percent of yield of yield loss of crops were: millet 87.69%, maize 83.33%, teff 77.14% and sorghum 52%. This study result indicated that millet was the most heavily damaged crop of the study area. The reason for such reduction in annual yield of the study area crops was highly confined withtermite

infestation (77%) the remaining 23% the respondents explained that erosion and soil infertilities also played significant role in addition to termite infestation this result agreed with Ofga (2004) reported that termites infestation was the main reason for annual yield loss in Manasibu district.

Majority of the respondents (93.33%) explained that millet, teff and maize were damaged at all of their development stages, this agreed with Daniel and Eman, (2015), reported that damage on maize plants commence at maturity stage and continues until harvested. Moreover it agreed with Abdurrahman (1990) stated that almost all major annual crops grown in Ethiopia are attacked by one or more species of termites either at one stage of the development or throughout growth stage.

Less termite attack was observed in plants grown closer to the residences and the plants were very healthy/field observation this finding is agreed with that of Daniel and Eamana (2015) reported that, farmers in the central rift valley of Ethiopia viewed that termites damage was highly localized even in the same field, and Ofga (2004) reported that as there were less termite infestation around residences than far away. The result implies that termite damaged showed both spatial and temporal variation governed by certain factors. Also the study result revealed as there is strong positive relationship between populations of livestock and termites impacts on range land and this agrees with B&M Developmental consultant(1971) stated that massive termite damage were observed in grazing land in Manasibu district.

In this study it was also identified that termite problems were not only confined with crops and vegetation but also observed to be serious problems of buildings, and this is agreed with finding of Daniel and Eman (2014) who reported that total of 58 houses were inspected in the three districts of Central Rift valley of Ethiopia and 91% were infested at less than 10 years of age, after construction. Majority of the respondents (90%) explained that the wall and roof of houses were most frequently damaged by termites at their late age (15-30) after construction. And this is differing to Abdurahaman (1990) stated that houses survived for only about 5-8 years after construction in Manasibu district and Daniel and Eman(2014)reported that in the Central Rift Valley of Ethiopia 91% of the houses were infested at less than 10 years of age after construction.

Almost all of them (90%), local people developed and practiced varies cultural methods to control termites and this is agree with Ofga (2004), and in contrary with that of Daniel and

Emana (2015) stated that Only few farmers of the Central Rift Valley of Ethiopia were used cultural management practice to control termites and no farmers used chemicals. Generally deforestation was the main factor to aggravated termite problems in the study area (46.66% of the respondents' response).

Chapter 5

5. Conclusion and recommendation

5.1. Conclusion.

The study area was mostly known by non-uniform topography and forest was confined around river banks/stream/. It is highly eroded in hill sides.

It was revealed by this study both subterranean/non-mound forming/ and epigeal/mound-forming/ termites were prevalent in Lalo kile district.

When protected and unprotected land was compared for the purpose of investigating percentage of damaged plants, it was found to be higher in unprotected land. This indicated that termite damage to plant was relatively higher in unprotected area. Field investigation was done to investigate the size of damaged land and it was observed that the half of the study areas land where damaged by termites mainly around hillsides and grazing land. Relatively there were less termite infestations to plants closer to residences than plants far from residences because of the fertilities of the soil around residences.

Millet, maize, teff and sorghum were known to be cultivated in the study area, however millet, and sorghum were cultivated by majority of the community. The level at which these crops were loss their yield showed little differences. Millet was the most seriously damaged crop by termites in the study area, damaged caused to millet considered as yield loss, maize was next to millet in percentage of yield loss, but sorghum was the last in yield loss in the study area. Damage was caused to Millet, maize and teff by termites at all their development stages.

Termites have been causing serious problem to house and fences especially during their late after construction.

In general to control these problems of termites ‘majority of the community of the study area were practiced cultural methods of termite controls, such as: queen removal, nest destructions, flooding and smoking.

5.2. Recommendation

- ❖ During this study it was observed that the activities of termites were high on eroded, bare and grazing land. Therefore mechanisms stopping erosion, stopping deforestation and grazing should be implemented.
- ❖ Development agents should teach farmers to use different methods of termite controls.
- ❖ Termite repellent plants should be planted in all lands to repel termites.
- ❖ Chemicals that used to control termites should be presented for farmers.

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