University of Nairobi

A Matter of Knowledge

The Fall Armyworm and its Management in Giathenge, Kenya

Interdisciplinary Land Use and Natural Resource Management (5440-B3-3F18)

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Abstract

Among the various agricultural and socio-economic issues that Africa and Kenya face, another threat puts agriculture and food security at risk since 2017. The Fall Armyworm (*Spodoptera Frugiperda*) shows a highly destructive potential in warm climates like in Africa due to its fast distribution and its consumption of many economical crops. The pest is native to the Americas, where many control methods have been implemented in the agricultural practices of maize farmers to manage the pest.

In contrast, control of the FAW is still in the initial stage in Africa and Kenya. To control the pest adequately, the Kenyan government and the international community released an action plan which promotes the use of pesticides among other solutions. This paper aims on examining the active management process against the FAW and the potential of non-chemical pesticides control methods in the area of Giathenge in Othaya sub-county, Nyeri.

Results were collected through questionnaires and semi-structured interviews with farmers, pesticide retailers and a government official during our field trip. Findings revealed that control methods were limited to chemical pesticides and traditional methods (e.g. application of ash and soil). Lack of knowledge and organisation among the people lead to these limitations, while poor application of pesticides decreased the effectiveness of the latter. The community needs to cope with the FAW in the coming years, work collectively and take initiative to inform themselves in order to manage the pest efficiently. Moreover, the Kenyan government has to strengthen its position towards the FAW infestation, support the local community with all necessary means (financial subsidies, trainings) and create conditions for active collaboration. Despite the changes that should be done on a communal and individual level, people's positive attitude towards alternatives non-chemical control method leaves potential for an integrated pest management in the future.

Preface

This report was written as a part of the examination for the course ILRUNM – SLUSE at the Faculty of Science at the University of Copenhagen, in collaboration with Roskilde University and the University of Nairobi. The report is directed towards master students with natural and social science background, in addition to anyone with an interest in pest and disease management. This report was handed in the 06st of April 2018.

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Firstly, we would like to express our gratitude to those who made this field trip possible; all the instructors of the Wangari Maathai Institute, the University of Copenhagen and Roskilde University – Prof. Christian Pilegaard Hansen, Dr. Lise Tjørring, Prof. Mutembei, Dr. Kiemo and Prof. Muthama Nzioka that supervised our research.

We greatly appreciate the efforts of the chief and the community leaders in Othaya sub-county who created a pleasant and safe environment for us to implement our project.

Special thanks go to the villagers of Giathenge and particularly to the farmers that gave their time and answered our questions, supplying us with valuable information. We are also grateful to the representative of the Kenyan government, the Agricultural Officer in Othaya sub-county for taking the time to speak to us.

Finally, we are thankful to our Kenyan counterpart; Abel Kiprono, our host families; Mrs Martha Njake, Mrs Nancy Gikiri, Mrs Laura Waigwa, that supplied us with more than we could ask; our guides, Anthony & Agnes and our elder Myriam that provide us with knowledge and made the process of our research much easier.

The group including supervisors, translator and host family

List of Abbreviations

AO: Agricultural officer

CABI: Centre of Agriculture and Biosciences International

FAO: Food and Agriculture Organisation of the United Nations

FAW: Fall Armyworm

FGD: Focus Group Discussion

MALF: Minister of Agriculture, Livestock and Fishery

PO: Participatory Observation

PRA: Participatory Rural Appraisal

SSI: Semi Structured Interview

USAID: United States Agency for International Development

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1 Introduction

Pests[1] on agricultural crops negatively affect production, livelihoods and food security (Geddes , 1990). Sub-Saharan countries have a long history of being affected by pests (Geddes, 1990). Especially countries with a tropical climate provide a suitable environment for insect pests due to the lack of a cold winter. This enables and enhances the ability of insects to breed all year long (Hill, 1983). In general, estimations of pre-harvest yield losses caused by pests' aggregate to about 35% worldwide in the early 21st century and showed an increasing trend in the last decades (Bebber, Holmes, & Gurr, 2014; Oerke, 2006).

Crop production is hindered by yield losses through pests in Kenya as well. Grisley, (1997) estimated yield losses for maize and beans at 57% and 42% in the Central Highlands of Kenya. There are six major pests which affect agricultural crops in Kenya. These are *Thaumatotibia leucotreta* (false codling moth), *Liriomyza spp* (Leafminer fly), *Bemisia tabaci* (Tobacco whitefly), *Bactrocera invadens* (Diptera: Tephritidae), *Ralstonia solanacearum* (Bacterial wilt of potatoes) and *Tuta absoluta* (Tomato leaf miner) (Wahome, 2016).

Still recovering from the aftermaths of a heavy drought in 2016, Kenya experienced devastating impacts of the *Spodoptera frugiperda*, 'Fall Armyworm' (FAW) pest for the first time in 2017, leaving food security threatened (Devi, 2018; FAO, 2017). The FAW is an invasive migratory pest and native to tropical and subtropical regions of the Americas. First evidence of the FAW in Africa was found in 2016 in Central and Western African countries. It feeds on over 80 plant species and can cause tremendous destruction and yield reduction of major crops, especially on maize, if not managed adequately (CABI, 2018). FAO estimates that about 7 million bags of maize have been lost due to the FAW during the growing season of 2017 in Kenya (FAO, 2017).

FAW is significantly challenging in comparison to other insect pests. Its recent appearance in Kenya leaves knowledge gaps that could be elaborated through the various studies that have been undertaken in the Americas. In relation to that, many alternative control methods to pesticides have been tested. For example, the push-pull method intercrops maize with repellent plants surrounded by attracting ones. This technique has shown to be effective against the FAW in a study conducted in Kenya among other countries (Midega, Pittchar, Pickett, Hailu, & Khan, 2018). The FAW has many natural enemies in different life stages, both parasites and predators. This has been studied in the Americas and has indicated to reduce the infestation of the FAW (Hoballah et al., 2004). Moreover, efforts of creating resistant plants have been done but with contradicting results (Davis et al., 1995). Another well-known

[1] In this context, 'pest' is defined as the occurrence of damage to a plant through an insect (Hill, 1983)

method is the implementation of pheromone traps which have been tested in many places on the American continent. However, their effectiveness is a debated topic.

As already mentioned the FAW is a new pest in Kenya. Therefore, only few studies have been done about people's knowledge concerning the pest and its management. The case study in Giathenge, Nyeri County, Kenya gives us the opportunity to contribute to the available information about the FAW in the region. From the literature we found that the current government programme to manage the FAW pest in Kenya promotes the use of chemical pesticides. We hypothesise that the use of chemical pesticides has several disadvantages. Issues might arise eventually since ingredients of pesticides have been found to be toxic for humans and the environment. Exposure to toxic chemical pesticide ingredients is the most common health threat for farmers in developing countries (Konradsen et al., 2003). Furthermore, poor pesticide application can lead to economic drawbacks. Due to these reasons, sustainable agricultural practices need to be promoted in Kenya, and non-chemical pesticide alternatives should be taken into account (FAO, 2017). In relation to this, the research aims are:

1. To assess the extent of the *Spodoptera frugiperda* infestation in the study site of Giathenge in Nyeri County
2. To examine farmer', pesticide retailers' and government officials' present knowledge of the FAW pest.
3. To outline the origin and transfer of knowledge of the pest and control methods.
4. To understand which actions are taken to manage the FAW pest and why.

These objectives will help us to answer the following research question:

"What is the potential for non-chemical pesticide control methods of the FAW infestation in Giathenge?"

2 Background

2.1 Description of field site

Figure 1. Situation Map: Giathenge, Nyeri County, Kenya, Africa.

The research site is the village of Giathenge, Nyeri County, Othaya sub-county, located 120 km north of Nairobi (figure 1). The area is a tropical highland and most people in the area are of the ethnic group Gikuyu (Kenya-Information, 2018). The area possesses a high agricultural potential with fertile soils and a high amount of rainfall. It rains approximately 1,400 mm per year, however, it varies in geographical locations (Jaetzold & Schmidt, 1983). There are two rainy seasons, long rains from April to May and short rains from October to November (Jaetzold & Schmidt 1983). Agriculture is the main occupation in the region and the main cash crops are coffee and tea. However, most people are farming for subsistence purposes (kenyaInformation 2018). Houses are scattered around the slopes of the area are with an average size of 0.64 ha including fields for agriculture (Owuor et al. 2009).

2.2 Life Cycle and Biology of Spodoptera frugiperda

The *Spodoptera frugiperda* is a pest of the Lepidoptera order, native to the tropics and subtropics regions of the western hemisphere. The pest can consume a large number of leaves, stems and seeds of more than 80 plants, many of which are major economical crops such as maize, rice, sorghum (CABI, 2018). During summer the life cycle is completed in about 30 days, whereas in winter it is completed in 80 to 90 days (Capinera, 1999). The number of generations that a moth will have in a year is influenced by climatic conditions, however, a female can lay approximately 1500 to 2000 eggs during a year. The eggs are spherical with a diameter of 0.75 mm and during oviposition they are of green colour. Eggs are laid

in masses on the underside of leaves and their number usually vary between 100 and 200 per mass (J. Capinera, 1999). In temperatures of 20-30 degree Celsius the eggs will hatch within 2 to 3 days (CABI, 2018).

The larva has six different instars, which vary in appearance. The duration of the larval stage varies from 14 days in warmer environments to 30 days in colder environments. The mature larva has a reddish-brown head, a brownish body and an inverted Y shape of yellow colour in its face. It can be also recognised by the dark spots in the dorsal of its body (J. Capinera, 1999). In its mature stage it is around 3-4 cm long and has eight prolegs (CABI, 2018). Pupae are smaller than mature larvae and they usually grow in the soil at depths of 2 cm to 8 cm. Pupation takes around eight to nine days in warm climates and around 20 to 30 days in cold climates (J. Capinera, 1999).

The adult moth's body length is 1.6 cm and its wingspan 3.8 cm. The hind wings in both sexes are silver-white and have narrow dark borders (J. Capinera, 1999). Adults are more active during warm, humid evenings and females lay their eggs in the first four to five days of their life. Their average life span is 10 days, which can range from 7 to 21 days in relation to climate (J. Capinera, 1999). The pest can be significantly destructive in its larva stage and can reach high population numbers, while consuming almost all vegetation in its path and disperse in large numbers. Finally, in America the pest can move about 480 km per generation and use weather systems during migration (Sparks, 1986).

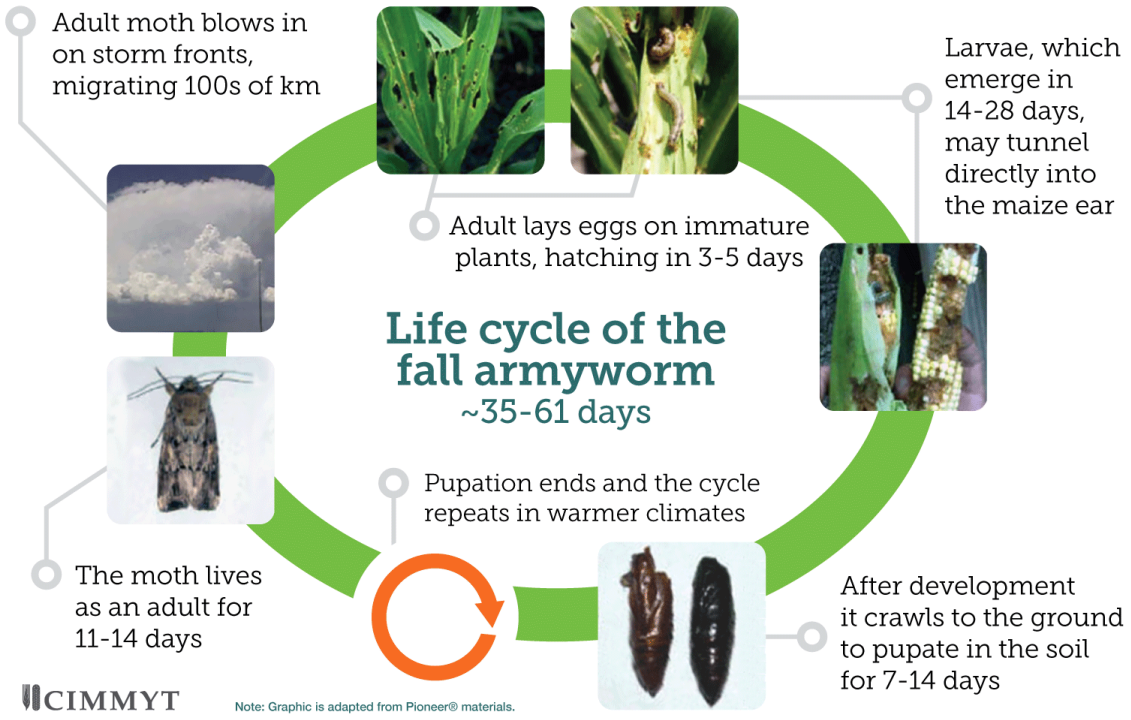

Figure 2. Description of the life cycle of the FAW (Wawa, 2017).

2.3 Related studies concerning the Fall Armyworm

Several researches have been undertaken on maize and the FAW during the last 100 years, especially on the American continent (FAO, 2017). A widely used technology involves intercropping maize with repellent and attracting plants (push-pull method). In a recent study, which involved 250 farmers in the dry areas of Kenya, Uganda and Tanzania, researchers studied the effectiveness of a push-pull system by comparing it with a monoculture maize plantation. The push-pull method involved intercropping with the repellent plant *Desmodium intortum*, while using *Brachiaria* to create an attractive wall around the main crop (Midega et al., 2018) The results showed a reduction of 82.7% in the average number of larvae per plant, while the maize yields were 2.7 times higher compared to the monoculture maize plantations (C. Midega et al., 2018).

The importance of biodiversity in agricultural systems is widely recognised while native insects and pathogens can be significantly beneficial in agro-ecosystems (Gabriela Murúa, Molina-Ochoa, & Fidalgo, 2009) In relation to that, *S. frugiperda* has many natural enemies in different life stages, both parasites and predators, of which many have been studied in the Americas.

Research in Mexico (1999-2001) found parasitoids which can reduce the activity of FAW on maize and other plants (Hoballah et al., 2004). Parasites can be beneficial and contribute to both farmers (increase crop yield) and the plant by helping it to evolve defensive traits (M. Elena Hoballah et al., 2004). Furthermore, the introduction of natural enemies does not require a lot of effort and cost and does not harm the environment (Huis, 1981). On the other hand, only about a third of introduced biological control agents manage to establish themselves in a new environment (Nechols, n/a). This is related to genetic and environmental factors (Nechols, n/a). Moreover, it is possible that the imported species will not interact well with the native ones (Nechols, n/a). These are issues that cannot resolved by manipulating the environment, therefore the choice of the imported natural enemies should be done by considering all the potential implications (Nechols, n/a).

In Nicaragua and Latin America, the FAW infestation created yield losses of 30% to 60% respectively although a very small percentage (8%) of farmers used insecticide against it (Huis, 1981). The government recommended the use of insecticide and new maize varieties to reduce the infestation (Huis, 1981). Introducing new varieties can affect the physiological and phenotypic conditions of the plant that in turn can affect the development of the pest and its attacking patterns (Huis, 1981). Moreover, unsprayed ecosystems are richer in fauna which is beneficial against the FAW and more than 19 natural enemies were identified in Nicaragua (Huis, 1981). Despite that, natural enemies cannot always keep the infestation below acceptable economic thresholds (Huis, 1981).

Concerning the FAW, 99% of the farmers in Ethiopia and Kenya claimed that they know the FAW (Kumela et al., 2018). The source of information is mainly media and agricultural agents who are active in the area after its detection (Kumela et al., 2018).

The average rate of FAW infestation in Ethiopia was 32% and 47.3% in Kenya and created significant reduction of maize yields in both countries (Kumela et al., 2018). Farmers in all areas supported that the FAW infestation was more serious and devastating than other pests (e.g. stem borer) and they observed it mainly during its larvae stage (Kumela et al., 2018). In Ethiopia 25% combined chemical pesticides with handpicking, while in Kenya 39% used traditional control methods (e.g. soil application). Despite the fact that the state recommended specific pesticides, many farmers chose to use others. This is related to pure registration and distribution processes to get free pesticides. Furthermore, farmers are not used to apply chemical pesticides on maize in these countries (Kumela et al., 2018).
In Ethiopia, 14% of respondents stated that pesticides affect human health, while in Kenya 12% of people reported that maize deformation is the only negative effect in the use of pesticides (Kumela et al., 2018). According to this research, governments distributed free pesticides but no adequate training and spray equipment in these first actions against FAW (Kumela et al., 2018).

Many efforts have been made in the last decades to develop more resistant maize varieties to pests. For instance, the 'Mp' inbred and the CIMMYT/MBR maize varieties seem to be more resistant to FAW infestations (F. Davis et al., 1995). These varieties have stronger tissues, which are difficult for the larvae to consume while their nutritional value is lower (F. Davis et al., 1995). The use of pesticides and resistant maize varieties can be effective control methods, however, we cannot erase the possibility of the pest to develop resistant traits against them (Hoballah et al., 2004).

Pheromone traps are a prevention and scouting intervention that can help farmers and authorities to identify the presence of the FAW. Pheromone traps can detect and lure male flying pest species with the use of pheromones that are naturally emitted by females (FAO, 2018a; Johnson, 2018).

Results from research in Mexico showed that moths are usually more active during rainy seasons (Rojas, Virgen, & Malo, 2004). Moreover, a positive correlation between wind speed, temperature and trap captures was observed (Huis, 1981). It was also noticed that moths are more active from the 10th to the 41st day of the maize growth, which is the most sensible stage of the plant (Huis, 1981). In conclusion, climatic conditions can affect population numbers and specifically, heavy rains can kill the larvae and reduce moth population (Huis, 1981).

Crop rotation is a potential pest control method for insects with low mobility between growing seasons and with restricted host plant range (Stoner, 2012). However, not many pests follow this pattern, which reduces the effectiveness of the intervention (Stoner, 2012). The time of planting is another factor that small-scale farmers should consider to minimize the damage caused by pests (Zehnder, 2011). Planting at periods that the pest is not present, can reduce the damage by avoiding high population numbers. By planting early, crops can tolerate the damage better since they are stronger and more resistant when the

pest will be present (Groves, 2012). In fact, recent reports from Kenya support that late-planted maize had higher yield losses compared to early-planted maize (FAO, 2018a).

2.4 National Program to manage the FAW

As national food security is threatened by the infestation of the FAW, the Minister of Agriculture, Livestock and Fishery (MALF) took action in 2017 to tackle it. A multi-institutional team with experts from different institutions was introduced. Kenya participates in a project of 'early warning' and 'monitoring' funded by the USAID's Office of U.S. Foreign Disaster Assistance (USAID/OFDA). FAO provided the Kenyan government with about 500 pheromone traps and organised monitoring trainings for 400 farmers in 2017 (FAO, 2017).

The government program focuses on creating awareness and distributing knowledge on a national and county level regarding the identification and management of the FAW (Kenyan State Department of Agriculture, 2017). This is achieved through training of farmers, pesticide retailers and Agricultural Officers. Technical recommendations are also instructed and include early planting patterns or the use of pheromone mass traps (Kenyan State Department of Agriculture, 2017). The program recommends and gives information about chemical pesticides such as Diazinon or Alpha Cypermethrin (Kenyan State Department of Agriculture, 2017). However, a wide range of sustainable alternatives, are not mentioned in the programme.

3 Methodology

3.1 Observations and transect walk

We participated in daily activities of our host families, which helped us to have an inside view of the situation. These observations gave us the opportunities to ask informal questions which helped us to understand the social context of the field study. We worked at the research area during the beginning of the maize planting season and therefore not many maize plants could be observed. The first day the group (including guides and translators) decided to take a transect walk in order to have better understanding of the area and familiarize with people.

3.2 Questionnaires

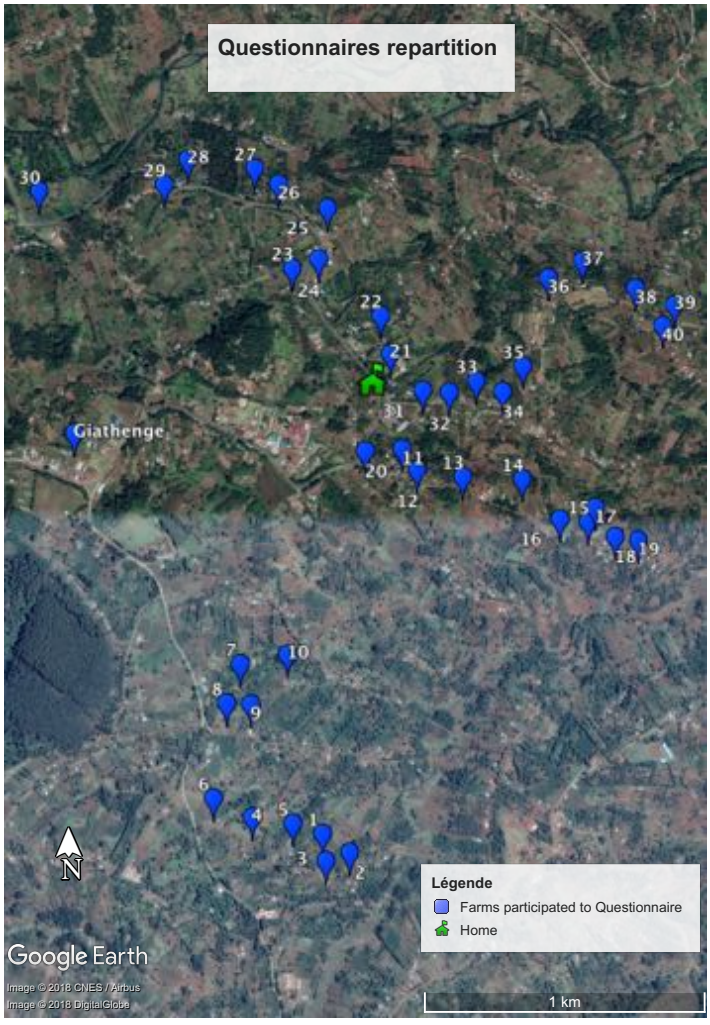

Figure 3. Distribution of questionnaires showed in blue (source: questionnaires).

General questionnaires are used to gather large amounts of data in a period of a short time, with the purpose to increase the understanding of a topic, to generate hypotheses (qualitative) or to test hypotheses, which have been previously made and to correlate data (quantitative) (FAO, 2018b).

For our case study a combinatorial questionnaire was used (qualitative and quantitative). The purpose was to discover the distribution and the farmer's awareness and knowledge concerning the FAW pest and if and which kinds of actions farmers take to manage it. Furthermore, conducting the questionnaires in the beginning of our research aimed at introducing us to the community. Moreover, we looked for possible correlations between age, farm size, control actions, FAW knowledge and maize yield losses. Questionnaires were distributed to 40 houses in the broader area of Giathenge by the following systematic sampling method. We followed this sampling

method because we had limited knowledge about the population of Giathenge and we wanted to disperse our sample unit throughout it (University of Arizona, 2018). We split in two genders mixed teams and by setting one of our host households as starting point we followed different directions. Then we identified long roads and started selecting samples every third house along our way. If we could not approach anybody in a house, we noted it and went to the next one.

The general questionnaire was undertaken in the second day of our fieldwork while in our first day we tested it in the house of one of our hosts. We did so, to get feedback especially on questions that are being perceived as being sensible such as the position in the household, education and age. Finally, the respondents for following semi-structured interviews were chosen from the questionnaires based on pre-prepared characteristics (see Appendix).

3.3 Semi-Structured Interviews

'Semi-structured interviews' (SSIs) are a qualitative data conducting method including open-ended and closed questions in which an interviewer wants to elicit information from a responder whom is given room to give answers in a conversational manner (Kvale, 1996). The aim of doing these interviews was to give the possibility to the respondents to get into some unexpected topics and give more details that seem important to them.

We examined elaborated perspectives from pest-affected farmers (8 SSIs), an Agricultural Officer (one SSI in Othaya) and pesticide retailers called Agrovets (5 SSIs in Giathenge and Othaya). Farmers whom we have been in contact with during the process of the questionnaire method were chosen as respondents for the SSIs based on the characteristics as being affected by the FAW, expressing interest about the topic and agreeing on an interview. All these SSIs were based on an interview guideline (see Appendix).

3.4 Participatory Rural Appraisal

The 'Participatory Rural Appraisal (PRA)' method is a participatory field-based tool, which is commonly carried out by a multidisciplinary team to collect information. It is characterised by a semi-structured procedure with the goal to identify a new hypothesis about rural life. Central points of a PRA are perceptions, attitudes and behaviours of the participants (McCracken, Rietbergen-McCracken, Pretty, & Conway, 1988; Narayanasamy, 2009). Since these three aspects go hand in hand with the acceptance of people concerning something new to them, we decided to use the PRA method as we were interested in the level of acceptance of people concerning alternative control methods against the FAW pest. Moreover, this will help us to develop a conclusion about our research question.

The PRA was held in the office of the Chief's assistant in Giathenge with 8 participants. Two translators assisted throughout the exercises.
The criteria for inviting people for the PRA were the following:

1. Person participated in the questionnaire survey
2. Person was affected by the FAW pest
3. Person expressed interest in more extensive collaboration with our research

The PRA session was divided into two different exercises, namely a participatory mapping exercise and a pairwise ranking exercise. Starting with the participatory mapping exercise, the purpose of this method was to create a framework for working collaboration between the participants including discussions in which every person felt comfortable. Barriers of illiteracy are removed, and space is given to the participants to express their knowledge. Furthermore, it is crucial for research to rely on local native knowledge since it has the ability to present a distinct and accurate perception and picture of the region (Alcorn, 2000; Narayanasamy, 2009).
The participants were randomly divided into two groups and were asked to draw the FAW infestation on a pre-prepared map of the area of Giathenge based on their own perceptions of the infested area and their seriousness. This process was followed by a second round of drawing, in which the participants were asked to indicate the chemical pesticides use of specific areas. Big circles were used to show heavy pesticide use, while small circles indicated less chemical pesticide use.

After completing the first mapping exercise the second exercise, a brief description of seven alternative control methods (see Appendix) followed by a pairwise ranking exercise was executed. Pair-wise ranking methods are systematic tools that allow a prioritisation or a ranking list of problems or options after completion. This happens through each-to-each comparison (Tim Russell, 1997). This was useful to reach the goal of this exercise, which was to gain an understanding of the participant's acceptance concerning alternative control methods for the FAW pest besides chemical pesticide use. Furthermore, a prioritisation provides information about which control method is most likely to be implemented by the participants (Russel 1997).
Participants were asked to discuss about the presented alternative methods and to come up with possible questions. Finally, the exercise was accomplished. Every person was requested to mark their own preference by comparing each control method to each other on a pre-prepared poster.

3.5 Focus Group Discussion Methodology

Hennink defines 'focus group discussions' as a tool of qualitative research, which is characterised by interactive discussions between a group of preselected people with a common background. The

discussion is led by a moderator with the goal to gain an understanding of different points of view concerning a specific topic (Hennink, 2013).

Respondents for the 'Focus group discussion' were selected by the following criteria:

1. Participated in the PRA. This ensured that respondents have the same background as being familiar with maize farming and being affected by the FAW. As well, a comfortable working atmosphere was already created through the PRA, which is essential for the success of a focus group discussion.

As 8 people participated in the PRA session, we were able to form a focus group right after the completion of the PRA with the same people in the same location. Leading questions (see Appendix) were prepared beforehand to ensure a vital discussion. However, the discussion is based on the results of the PRA and was therefore shaped by its outcomes.

4 Results

4.1 Distribution of the FAW in Giathenge, Othaya sub-county

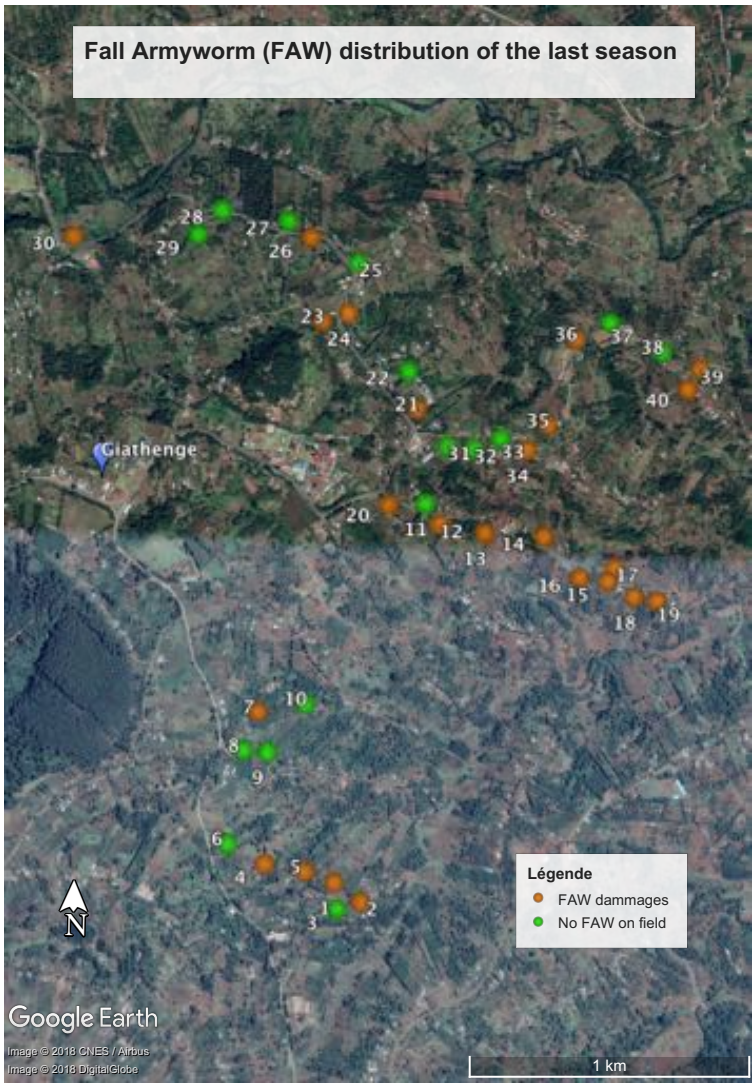

Figure 4 Distribution of FAW in the area of Giathenge. The orange bullets depict the infected households while green depict the non-infected households (source: questionnaires).

The first map (figure 4) shows the spatial distribution of the pest during the long rain season in 2017. Farmers who participated in the SSIs experienced problems with the FAW for the first time in 2017. The distribution follows a random pattern. However, one zone is more affected with only infested farms (numbers 12 to 20). The damages by the pest vary to a significant degree among households (source: Questionnaires).

The participatory mapping exercise showed the participant's perception of the distribution of the FAW infestation. Only a small area was marked as not infested. Areas were marked as less infested when they were sprayed with pesticides. However, not every infested area was sprayed with pesticides. Notes were

made if participants thought that a pesticide spray was applied too late to be effective. Both maps showed that the area of Giathenge was heavily affected by the FAW in 2017 and that the participants are aware or have their own perception of the geographical distribution, the pest's infestation and the extent of pesticide use.

4.2 Agricultural challenges and their impacts in Giathenge

Picture taken during conducting a questionnaire, where the woman explained and showed us how the FAW had destroyed all her maize.

The Agricultural Officer (AO) affirmed results from the maps, showing that the infestation of the FAW was extensive in the area of Giathenge. According to the AO, 80% of all farms in the region of Othaya (including the area of Giathenge) were infested. However, there were no statistics accessible to us, which quantified the infestation of the FAW and the losses it caused on maize yields. Nonetheless, other challenges intersperse with the problem of the FAW pest in the region which makes the quantification of maize yield losses caused only by the FAW difficult (source: SSIs & Questionnaires). Through the questionnaires and the SSIs, several farmers expressed an explicit concern and despair about maize yield losses due to the drought.

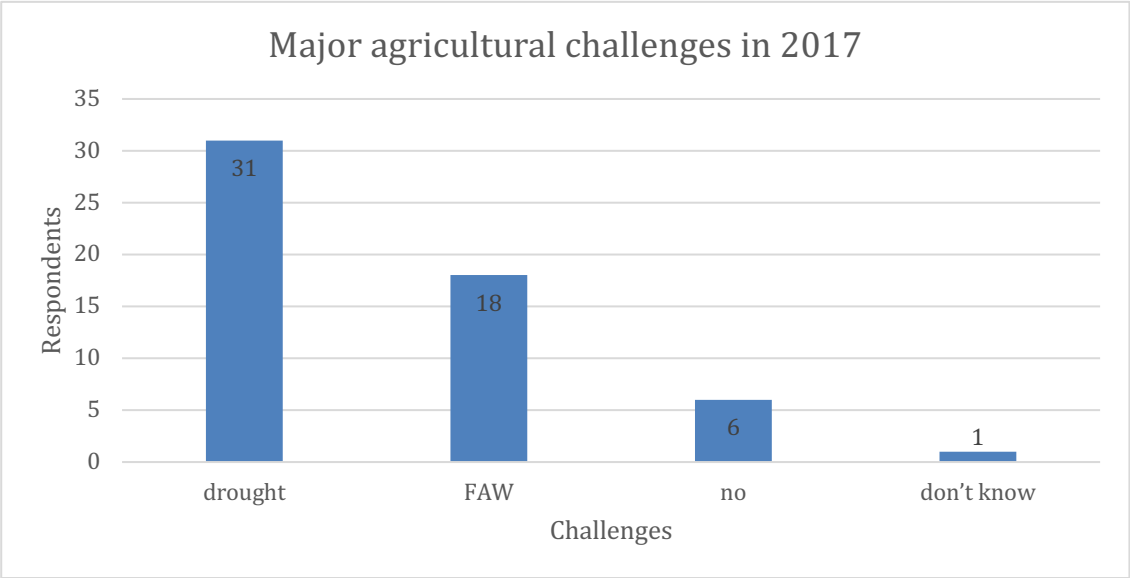

Figure 5. Farmers' perceptions on major agricultural challenges faced in 2017, given in percentage (source: questionnaires).

Figure 5 indicates that drought was regarded as the major challenge in 2017, while the second major challenge was the FAW pest. Finally, a small percentage (11%) stated that they did not face any major challenge last year. Farmers were free to set their own range of major challenges that they faced last year. We calculated the total number of the answers given defined as challenges. That resulted in 31 respondents indicating that drought was a major challenge, while 18 claimed FAW as a major challenge. Finally, only 6 people claimed that they did not face any major challenges in 2017.

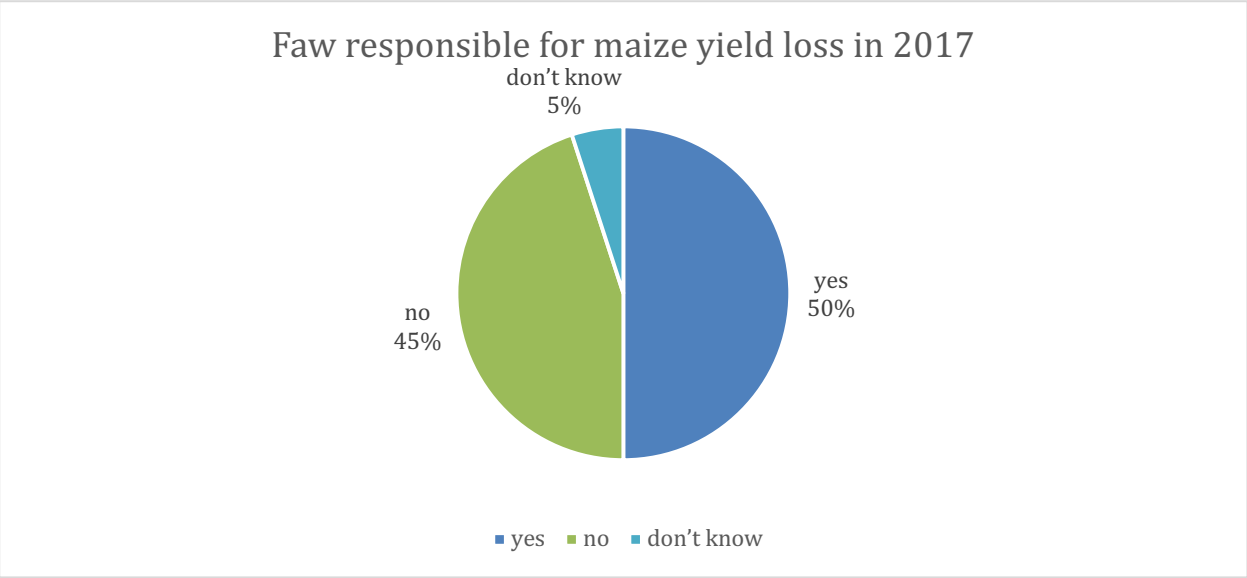

Figure 6. Pie chart indicating if people correlate FAW with yield losses last year (source: questionnaires).

By looking at figure 6, we can see that 50% believe that the FAW is responsible for the reduction of their yield. However, still a large percentage of 45% stated that the FAW is not responsible for maize yield losses. This result can be related to the lack of knowledge concerning the FAW that we observed in many farmer and to the significant low rainfall that the broader area of Othaya experienced in 2017.

Farmers also set concerns about yield losses of maize in a context of food security (source: SSIs). Figure 7 shows that all farmers grow maize for their own consumption which shows the importance maize in the region. In detail, 57% of the farmers grow maize exclusively for consumption while 43% use it additionally for selling, fodder and gifts (source: questionnaires). Moreover, several farmers stated in the SSIs that they had to buy maize or other food items to cope with the maize losses last season. Therefore, maize yield losses affect households on an economical level too.

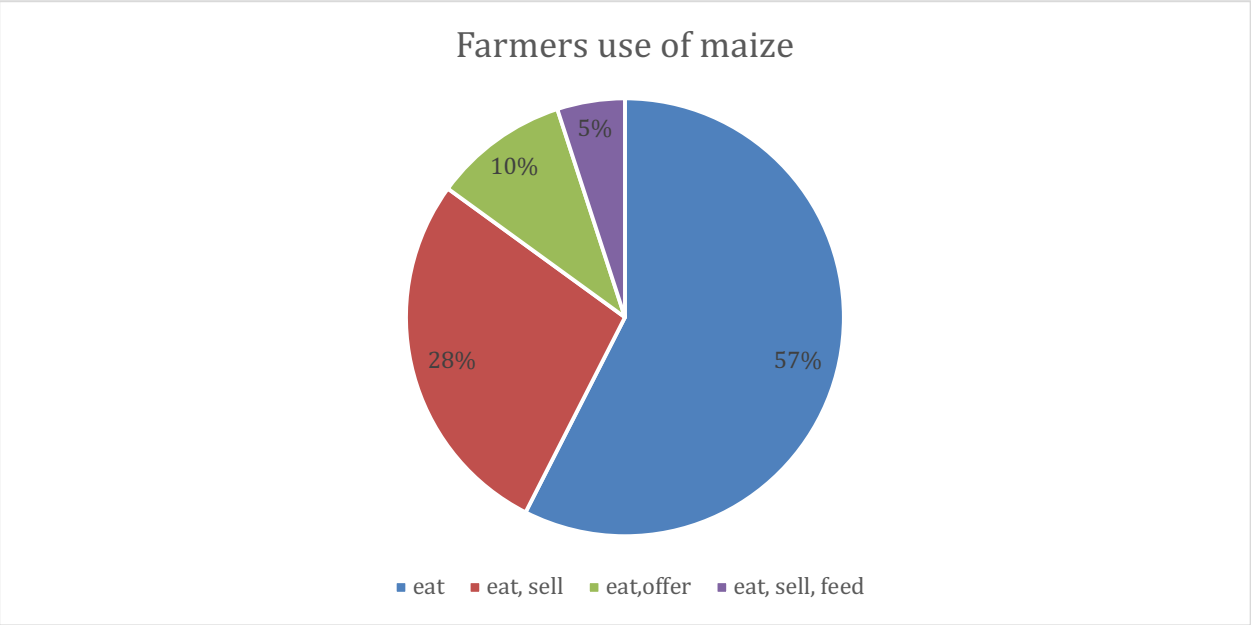

Figure 7. Different uses of maize in Giathenge in percentage (source: questionnaires).

4.3 Farmers, Agrovets, Agricultural Officers and their knowledge about the FAW

In general, we found from the questionnaires and the SSIs that the knowledge of farmers concerning the pest was limited, especially about its life cycle and its spread. This is perceived as a problem by farmers and they do not feel that their knowledge is sufficient enough to control the pest in the coming season (source: SSIs).

For example, one farmer was afraid that the eggs of FAW were hiding in the maize seeds that she planted (source: SSI number 3). Another person told us about a theory discussed among farmers that a kind of locust pest attacking the trees, might fall down and transform into the FAW (Source: SSI number 5). Nonetheless, interviewees of the SSIs were certain of their ability to identify the FAW as the cause of the experienced problems on maize. They could distinguish it from other pests due to its extensive damage on maize and its high caterpillar numbers.

The interviewed Agrovets knowledge concerning the control of FAW was limited to the information printed on the pesticide bottles. They made statements concerning the effectiveness of a certain pesticide based on reports from customers or own experiences. However, Agrovets stated that most pesticides which work on other pests are not effective against the FAW (source: SSI with Agrovets 1 and 3).

It has to be noted that the AOs get their knowledge transferred directly by pesticide companies. The officer states her opinion that “the FAW is not a more serious threat than previous caterpillar pests in the area” (source: SSI AO). Related to that, she is confident that the issue will be managed soon. In addition, she was not aware that the FAW pest is a long-term pest problem in South America.

Concerning the knowledge about pesticides, farmers were in general not sure about how they work. For example, there was no consent if the pesticides kill the FAW in different life stages or just “push” it

away from the sprayed area (source: PO & SSI). However, none of the farmers had observed dead worms after spraying.

By looking at the results of the questionnaire concerning socio-economic factors, we found that there is no significant correlation between age, educational level, civil status, gender, household position and knowledge concerning the FAW pest.

4.4 Information transfer in Giathenge

Through triangulation from participatory observations and the SSIs with different data providers, the process of knowledge transfer concerning the FAW pest in the region of Giathenge could be outlined. According to the Agriculture Officer (AO) "a lot has been done to inform people about the available training seminars and the pest" (source: SSI AO). Information posters and brochures were given out and put up in public places by government officials, such as in the Assistant Chief's office in Giathenge and in churches. The posters are issued by the pesticide company, Syngenta and include a brief manual on how to identify the FAW with a series of photos. Furthermore, the poster recommends two pesticides[2] to fight the FAW and suggests spraying early in the morning or late in the evening and night. It also recommends that spraying should be commenced directly after detecting the FAW for the first time.

Information is mainly distributed through television and radio. Both kinds of media broadcast information on how to manage the FAW in Kikuyu and English. In addition, a meeting has been organised by the Department of Crop Production, Othaya sub-county, in order to train and inform farmers about the FAW (source: SSI AO). However, contradicting information was found concerning this topic. The AO stated that many farmers participated in these meetings, while farmers stated the opposite (source: SSI AO & PO). Moreover, farmers were advised to report any FAW infestation at the agricultural office. If reported, pesticide samples were given out, either on farms or directly in the office, with a brief explanation on how to use it. This is an indication of responsibility moving from the government to another actor. As one of the farmers described: *"Nowadays, there are no field officers visiting farms and advising farmers on agricultural issues anymore, such as pest management"* (source: SSI number 1).

4.5 Pest management and organisation challenges in Giathenge

Farmers lack organisation including a representative and the wish for such an organisation/union was expressed (source: FGD). Improved information transfer from government officials to farmers is expected by an active union of farmers. Furthermore, a union can gain attention from the government faster, which is important to manage pests at an early stage and limit their negative impacts. However,

[2] Product names: Voliam Targo & Match

such a union has not been founded yet, since most farmers have limited time available and are already involved in other associations (source: FGD).

Moreover, people expressed their conviction that limited AOs are available in the region nowadays. Participants would like to see 'field officers' visiting their farms, advising and collaborating with them like they did in the past (source: SSIs & PO). This could reduce the gap of knowledge and save farmers time, since they would not need to go to the agricultural office to report an infestation and receive related information. Finally, participants stated that the government is responsible for providing solutions and take rapid actions to tackle the FAW and other agricultural issues (source: FGD).

The AO explained that the national government is responsible for providing the financial resources for distributing knowledge and implementing various control methods in the county, such as pheromone traps. The AO states that: "The national government is not giving enough money to the county government and therefore our resources are limited".

4.6 Control methods against the FAW pest.

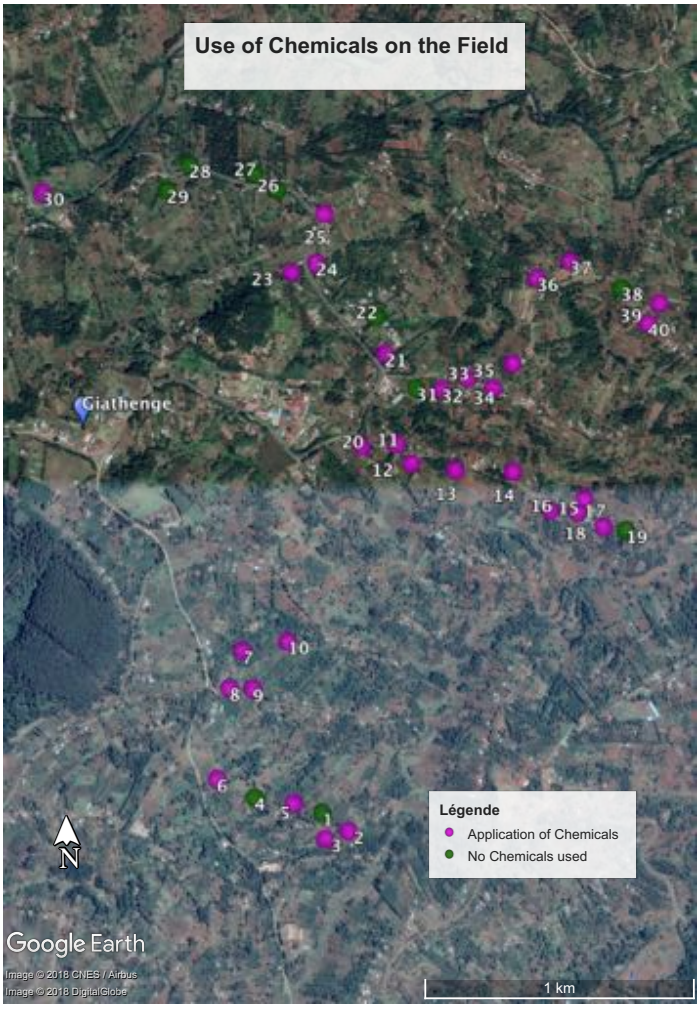

Figure 8. Use of Chemicals on the study site showed in purple (source: questionnaires)

Data from the questionnaires and the SSIs with farmers showed that chemical pesticides are the most prevalent and favoured method to control the FAW. However most of the questionnaire respondents did not take any special action against the FAW (see figure 8). The only alternative methods used were traditional control methods. These included:

1. Applying ash on maize plants
2. Applying soil on maize plants
3. Applying a water mixture of boiled tobacco with 'piri-piri' chillies on maize plants

However, statements concerning the effectiveness of these methods differ and are blurred since they were usually used in addition to chemical pesticides.
Furthermore, interviewees did not specify how these methods fight the FAW and if their application altered in response to the FAW.

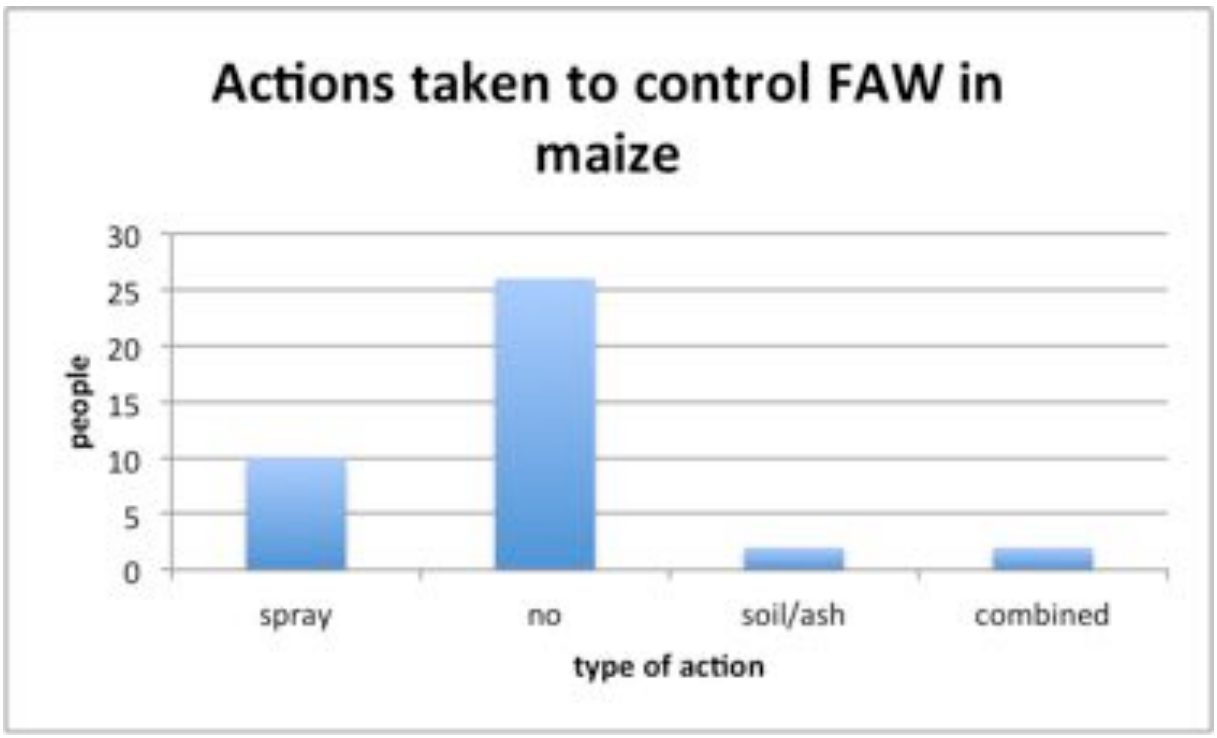

Figure 9. Indicates the actions taken to specifically control the FAW on maize (source: questionnaires).

Figure 9 shows that the majority of farmers (26 out of 40) did not take any special actions against the FAW. This includes all the respondents with and without any infestation. This result does not highlight if people took actions to prevent the pest before being infested and if people had an infestation but did not take any special action. Moreover, the figure shows that 10 of the respondents claimed that they sprayed their maize plantations with chemical pesticides to control the FAW. Only 2 of them used

traditional methods such as the application of ash and soil. This graph includes answers of all the participants from the questionnaires, so farmers with and without worms on their maize.

In response to the FAW infestation, the government distributed free chemical samples to the community after the problem was reported. Only a few farmers received these samples, while the distribution was not in time to fight the FAW sufficiently (source: FGD & SSIs). It is uncertain if the distribution will continue. As the AO says: "the FAW is not the only issue the Agriculture office has to deal with'' (source: SSI AO). In addition, the officer believes that people living in the research area have the financial capacities to buy their own pesticides. On the contrary, farmers expected more help from the government and believed that earlier distribution of pesticides would be helpful (source: SSI).

4.7 Acceptance of alternative pest control methods

The pairwise ranking exercise allowed us to rank the seven presented alternative control methods (see table 1). The rank list, which gives information about the prioritisation of the different control methods is headed by 'crop rotation' with a score of 40, followed by 'early planting' with a score of 38 and 'promote biodiversity/ push-pull' with a score of 31. The alternative methods with the lowest score are 'early warning' with a score of 12 and 'pheromone traps' with a score of 4.

Table 1. Shows results gathered during PRA the pairwise ranking exercise (source: PRA)

	Resistant varieties	Promote Biodiversity (push-pull)	Monitoring	Pheromone Traps	Early Warning (SMS)	Crop Rotation	Early Planting	Score of method in column	Rank of method in column
Resistant Varieties								24	4
Promote Biodiversity (push-pull)	6 2							27	3
Monitoring	2 6	0 8						16	5
Pheromone Traps	0 8	0 8	1 7					3	7
Early Warning (SMS)	3 5	0 8	2 6	6 2				12	6
Crop Rotation	8 0	7 1	7 1	8 0	8 0			44	1
Early Planting	5 3	8 0	8 0	7 1	7 1	3 5		38	2

The participants of the FGD showed consensus of ranking 'crop rotation' as their favourite control method and gave several reasons for it. Favouring crop rotation is based on their perception that the FAW dies during the period in which maize is not planted (short rain season from October to December). Furthermore, they stated that crop rotation is easy to implement, since it does not require skills that go beyond people's present farming knowledge and does not involve extraordinary expenditures. Lastly, 'crop rotation' is being preferred due to the fact that the maize harvest in the short rain season is not as fruitful as in the long rain season.

People rely more on the yields of the long rain season (source: SSI & FGD). This means that relinquishing from planting maize in the short rain season is conceivable from the point of subsistence demands. In general, low costs and easy implementation are major factors for farmers that define the potential of the implementation of a new alternative control method. Although the SSIs showed that opinions on the subject vary. For example, one farmer felt ready to fight the FAW and ready to change whatever crop is not profitable for her (source: SSI number 5). Whereas other farmers mentioned that they couldn't imagine themselves to not growing maize, since is an important part of their diet (source: SSI number 1).

4.8 Interaction in the Community

One farmer expressed her opinion that pesticide samples were not equally distributed by the government, as she said: "some people are favoured" (source: SSI number 2). The community does not exchange ideas and knowledge regarding the FAW pest or how to manage it. In general, it's not usual to help neighbours if it is not a friend or a member of the family (source: PO & SSIs). Moreover, one farmer mentioned that people would gossip about people, who have enough money to buy chemical pesticide spray and who did not (source: SSI number 1). Money was considered to be a sensitive topic to talk about (source: SSIs).

Nonetheless, several people expressed their concerns for the rest of the community regarding food security due to the FAW pest. The most drastic statement expressed that: "there is no future for maize farming the area if the problem will not be solved" (source: SSI number 6).

5 Discussion

5.1 Reflection on methods

5.1.1 Sampling and selecting respondents

Several people were not found on their property to answer our questionnaires since we did not make appointments beforehand. In this case, the neighbour house was approached. Moreover, before conducting the questionnaire we needed to figure out which person in the household was responsible for the maize farming. This was achieved by our elder or translators without any problems. Furthermore, due to practical reasons, SSI respondents were limited to farmers who were affected by the FAW. However, it might have been interesting to conduct interviews with non-affected farmers as well, to examine the reason why this person was not affected. Moreover, the questions found in the questionnaires, did not allow us to find any strong correlations between knowledge, actions against the FAW and socio-economic factors. However, if questions had been phrased differently it might have shown correlations between these variables.

5.1.2 Language and Translation

Translation and wording of the questionnaires did not show any barriers and respondents were able to give their answers clearly. This was due to the sufficient and competent work of our translators.

Nonetheless, we experienced some language barriers during the SSI with the AO. The interview was held in English. However, some answers were difficult to understand due to fast paced speaking, low voice and a strong accent. An interview in Kikuyu did not seem appropriate for this occasion as the AO started the conversation in English. We might have missed out on information as we felt it was impolite to ask questions again if we did not understand her in the first place.

5.1.3 Atmosphere and Locations of Data Collection

The SSI with the AO was conducted in her office, which was rather small compared to the number of researchers and interpreters who participated in the SSI. Therefore, a tense atmosphere might have been created for the AO. However, the respondent did not seem to feel intimidated.

The data collection setting was more problematic while doing the SSIs with farmers. Due to the fact that most respondents invited us in their house, it occurred that other people were present. This often resulted in statements and interferences which made it hard to focus on the interviewee's words. At some points translation was difficult for the interpreters when discussions involved more persons. Furthermore, the respondent might have been influenced by statements of other people or felt intimidated to speak freely. It might have been better to agree on a private room, to avoid distractions during the interviews.

Agrovets in Othaya were very busy and therefore owners did not find the time to answer in a focused way. Furthermore, two respondents asked us if the interview was paid.

The atmosphere during the PRA mapping exercise was friendly and all people participated in the discussion. Agreements during the map the exercise were made in a fairly short time. The way we divided participants into groups did not respect to mix people from different areas. Therefore, the two groups consisted of people from the same area.
The PRA pairwise exercise took too long since every person was asked to state his or her preference individually for each method. However, the participants did not show fatigue or disinterest due to this fact. In general, people were open and showed interest to participate in our research.

5.1.4 Sensible Topics During Research

Adjustments were made on questions which were considered as sensible after testing the questionnaire with one of our hosts. In addition, question number 2.3 (civil status) was not asked anymore after finding out that several respondents felt uncomfortable giving their answer (especially widowed people). Furthermore, several farmers found question number 2.4 (age question) difficult to answer which caused a slightly uncomfortable laughter in some cases. Therefore, this information was gathered through the translators in an indirect way and then included in the questionnaire. Moreover, respondents in the Agrovets seemed to feel uncomfortable to answer our questions. Therefore, we conclude that the topic was considered to be sensible for them.

5.1.5 Data Reliability

There was no maize growing in the area at the time of the case study, hence no FAWs were observed (except for one farm). If the case study would have been conducted during the maize growing season, we might have come to different results. For example, during growing seasons the direct observation of the infestation would be possible. The fact that FAW is new to the area and arrived in a year with a severe drought makes the quantification of the damage caused by FAW more difficult.

Errors in questionnaires are defined as differences between the respondent's answer and a 'true' answer (Lavrakas, 2008). Question number 3.3 (number of maize bags harvested per season) in the questionnaire relied on the estimation of the respondent which lead to striking variation in the responses. Subjectivity might have blurred the accuracy of the answer, since the question concerning the maize harvest is connected to the overall farm productivity and therefore the farmers' ability and skills in agriculture. It is possible that respondents exaggerated their answer concerning the number of bags harvested to leave an impression of being a successful farmer. This could explain the huge variety in the responses, that sometimes did not match the field size. Since the FAW infestation happened during the last rainy season of 2017, we cannot exclude that people misremembered details and numbers.

Leading questions occurred during the SSIs (e.g. 'Would you like to receive more information about the FAW pest'). Leading questions might lead to false statements that do not reflect the true thoughts and personality of the respondents. Therefore, they should be excluded (Swann, Giuliano, & Wegner, 1982).

Several difficulties arose during the pairwise ranking exercise that might have influenced its results. For example, the presentation of the alternative control methods was demanding for the farmers. These control methods were new to most participants, while there was not enough time to explain them in detail. As a result, we cannot be certain that all aspects were understood. Details might have been lost due to translation as well This could explain the lack of questions and discussion after the presentation. Based on this, stated preferences of methods reflected a superficial decision made in the heat of the moment. Moreover, a distinct reflection on the methods was not possible for the respondents. Therefore, it is doubtful how valid our results are and in how far they represent the real preferences of the participants.

5.2 Reflection on results

5.2.1 Governmental action plan: limitations and influences of pesticide companies

As the government promotes the use pesticides (source: SSI AO), it is not likely that farmers will reduce their application in the coming years in the region. This is underlined by the fact that the authorities collaborate with pesticide companies with the goal of gaining knowledge and releasing official recommendations. This may dismiss or overlook alternative pest control methods since pesticide companies promote their own interest: selling chemical pesticides.

The fact that information posters are issued by Syngenta implies that the government shifted their responsibility to another actor for any potential pesticide related issues.

Our findings, that several non-pesticide control methods are included in the government plan, were not visible in the region during our field trip (source: SSIs & PO). This might be the outcome of the mentioned collaboration. Officials would gain a broader knowledge if they were trained by independent educational institutions or researchers without the interference of business priorities. Farmers are at the end of this one-sided knowledge-transfer system and face disadvantages such as lack of knowledge concerning alternative control methods.

Next to pesticide use, the government plan suggests the use of crop rotation which is also suggested on a county level by the AO (source: SSI AO). However, literature showed that pests with a high mobility, and a high range of host plants like the FAW, cannot be controlled to a significant degree by the use of crop rotation (Stoner, 2012). The pairwise ranking exercise therefore reflects a lack of knowledge since crop rotation was participant favoured method.

The government is planning to introduce pheromone traps in the region of Giathenge in the next maize growing season (source: SSI AO). However, this could be hindered by financial issues during the implementation in relation to the limited resources that the national government provides in the county (source: SSI AO).

5.2.2 Organisation and farmers' knowledge

Supported by the Teshome Kumela (2018) study, we find that the majority of the questionnaire respondents (31 out of 40) heard about the FAW and were able to recognise it from pictures that we showed during the questionnaires.

Our research showed that the officials in the region of the Othaya are aware of the governmental program and try to implement it (source: SSIs & AO). Therefore, the governmental plan and a knowledge-transfer system are active in the region. However, we do not know how many people are reached by the program. Knowledge concerning the FAW reaches farmers mainly through media and posters/brochures and not through the available training programs. This is because the effort and the time that is needed to gain information from the media is much lower than from attending trainings. In accordance to that, Kumela (2018) supports that knowledge transfer systems like media, posters and training are used by the authorities to distribute information (source: SSI AO).

Lack of participation in meetings which provide detailed information about the FAW might be related to the limited knowledge that the majority of farmers have. A knowledge gap about the life cycle of the FAW makes it difficult for farmers to distinguish it from other pests. That leads to inappropriate control methods, such as applying pesticides, which are not designed to control the FAW. Thus, an important part of the knowledge, which is tried to be transferred by the government is either not distributed in a sufficient way or lost during the communication process.

Lack of organisation among the farmers and the involved agents (authorities) significantly reduced the communication and the knowledge that is exchanged. As a result, farmers have to report infestations by themselves. This makes it difficult for the government to quantify and qualify the infestation extent and to target the help needed. A union of farmers, that would represent people's opinions, issues and requests could raise government awareness and trigger actions faster. Participants expressed that a representative and the reintroduction of field officers could be beneficial for them (source: FGD).

5.2.3 Yield losses due to the FAW in Kenya in comparison to other pests

As mentioned in the introduction, the average yield loss in the Central Highlands of Kenya due to pests, is summing up to approximately 57% for maize (Grisley, 1997). Compared to our research, the farmers stated that the yields losses on maize due to the FAW infestation were bigger compared to other pests and in some cases summed up to 100% (source: SSIs). The high infestation rates of the FAW on maize

and its highly destructive potential is confirmed by both, Capinera, (1999) and by the SSIs findings of our research.

Differences in yield losses compared to other pests in Africa are related to the fact that the FAW is a new pest in Kenya and therefore management practices are still in an initial stage. The process of planning management actions took time while the pest kept spreading. During our research, people stated that the FAW is more aggressive and challenging than other pests in the past (SSIs). As mentioned in the literature review, all farmers in Ethiopia and Kenya supported that the FAW infestation is more serious and devastating than for example, a Stem borer *(Maliarpha separatella)* infestation (Teshome Kumela et al., 2018).

The results of our case study show that the FAW poses a threat on food security in the region of Giathenge, since maize is a staple food for the people. (Devi, 2018) supports this observation in a study on the FAW undertaken in southern Africa.

Striking is, that yield losses from other countries, for example Nicaragua as described by Van Huis (1981), are significantly lower than what our research showed. In our case study, the yield losses due to the FAW summed up to 100% for some farmers, while the yield losses in Nicaragua were about 30-60% (Huis, 1981) However, exaggeration of our respondents and differences in geographical conditions (e.g. presence of natural enemies) could be the reason for this significant variation. A general conclusion that the FAW is causing more yield losses in Africa than in America should therefore not be made.

5.2.4 Inappropriate Pesticide Application in the Region of Giathenge

Two of our respondents in the SSIs revealed that they experienced health problems in the form of allergy due to pesticide use. This stands in contrast with findings of Kumela (2018) who did not observe any health complaints by Kenyan farmers about chemical pesticides. However, Agrovet number 1 revealed that many farmers complained about skin irritations after applying a specific chemical pesticide against the FAW. This fact stresses the importance of providing knowledge on adequate and safe pesticide use. Spraying in a constructive manner could reduce the amount sprayed and thereby save farmer's money while minimizing the environmental and health risks. Similarly, appropriate application of pesticides in regard of time, amount and allocation can increase their effectiveness. The poor application of chemical spray on maize might be related to the fact that maize did not face many pests in the past and people are not used to spray it (source: PO). Kumela's (2018) findings on non-chemical pesticide control methods confirm our findings that applying soil or a tobacco mixture on maize is a practice that can be found in Kenyan agriculture.

Our results showed that farmers are relying on maize for subsistence purpose to a great extent which could imply their willingness to use more pesticides in order to save their harvest. However, we cannot be certain that the use of specialised pesticides against the FAW on both maize and other crops can help to control FAW in our case study.

6 Conclusion

The FAW pest is a considerable threat to maize farming in the region of Giathenge. We have observed an extensive infestation that significantly reduced farmer's yields in 2017 and threatened food security. Furthermore, other problems such as droughts affect the agricultural productivity in the region and intensify the situation.

The research revealed that farmer's knowledge about the FAW is limited and not sufficient to manage the pest adequately. Furthermore, government's actions are in an initial stage and did not successfully tackle the FAW infestation.

Farmer's knowledge originates mainly from observations on their fields, the media, posters and brochures. The knowledge transfer is, however, flawed in the region, as many farmers are left with a knowledge gap about the FAW.

The agricultural officers gain knowledge on a regional level by training organised by pesticide companies. Pesticide retailers showed limited knowledge about the FAW and the products they sell to combat the pest.

Chemical pesticides are the most prevalent control method against the FAW in the region of Giathenge mainly due to government promotion and their availability in Agrovets. Nonetheless, inappropriate pesticide use was reported in the interviews and discrepancies were found between used pesticides and the ones recommended by the government. There were no alternative control methods found besides traditional control methods, like applying ash and soil on maize.

The potential of non-chemical control methods in Giathenge is determined by the available knowledge of farmers and officials along communication and collaboration between them. These factors that were significantly low. The implementation of an integrated pest management is a slow process that requires labour and time efforts. However, it can be beneficial for both the environment and the community. The participating farmers showed interest to learn about new alternative control methods, a factor which is important to define their potential. Therefore, we conclude that implementing non-chemical pest control methods are possible if the mentioned barriers are managed in the region.

7 Recommendations and Future Perspectives

Maize farmers in the region have to realise that the FAW will be a problem affecting their agricultural practices from now on, since it is unlikely to exterminate the pest. Therefore, several recommendations can be made that would help the community to manage the pest in the future.

Farmers should actively participate and take initiatives to inform themselves on how to manage the pest effectively. This could reduce the problem of missing information. Implementing a union of farmers in the community could improve the communication among the farmers but also between farmers and the government. Furthermore, it could strengthen the position of farmers towards the government and arouse attention to their problems.

The government should define effective control methods against the pest and put the bases for adequate communication, to ensure the success of the plan. Moreover, if financial constraints are limiting the integration of alternative control methods by farmers, financial support from the government should be considered. In addition, it is important that the government strive to gain diverse knowledge, and not only training from pesticide companies. The area of Giathenge and its farmers could benefit from an integrated pest management in the future. Therefore, considering and learning about non-chemical alternative control methods should be the first step in order to reduce the use of chemical pesticides and their drawbacks.

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9 Appendices

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Final Synopsis

Control methods strategies against the pest “Fall Armyworm” in Nyeri County, Kenya

Interdisciplinary Land Use and Natural Resource Management (5440-B3-3F18)

23.02.2018

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Abbreviations

CABI: Centre for Agriculture and Biosciences International

FAO: Food and Agriculture Organization of the United Nations

FAW: Fall Armyworm

KALRO: Kenya Agricultural & Livestock Research Organization

KEPHIS: Kenya Plant Health Inspectorate Service

PCPB: Pest Control Products Board

ICIPE: International Centre of Insect Physiology and Ecology

Introduction

Pests[3] on agricultural crops, which negatively affect production, livelihoods and food security have been part of the history of sub-saharan countries including Kenya (Geddes, 1990). Production levels of staple crops are hindered by yield losses through pests in the highlands of Kenya. Grisley (1997) estimated yield losses for maize and beans at 57% and 42% in the Central Highlands of Kenya, which shows the relative importance of pests. As James Wahome (2016), the 'Acting General Manager' of the 'Phytosanitary Services' at Kenya Plant Health Inspectorate Services (Kephis) explains, there can be six common major pests outlined, which affect agricultural crops in Kenya. Among these pests are the Thaumatotibia leucotreta, Liriomyza spp, Bemisia tabaci, Bactrocera invadens, Ralstonia solanacearum and Tuta absoluta (Wahome, 2016). However, African countries including Kenya have to face a new threat for their agricultural production. Still recovering from the aftermaths of a heavy drought in 2016, Kenya experienced devastating impacts of the Spodoptera Frugiperda, 'Fall Armyworm' (FAW) pest for the first time in 2017 (FAO, 2017). The FAW is a migratory pest and native to tropic and subtropic regions of the Americas. First evidence of the FAW in Africa was found in 2016 in Central and Western African countries. It feeds on over 80 plant species and can cause tremendous destruction and yield reduction of major crops such as maize, if not managed adequately (CABI, 2018).

Food security and livelihoods are endangered by the FAW in Kenya, as maize is the main staple crop for many smallholder farmers in Kenya and in Nyeri County, the area of the field study (FAO, 2017b). The FAW prefers to feed on maize. Action is needed urgently to manage the impacts of the pest and to keep them low. As a part of this management, scientific assessments of the agricultural, economic and social impacts of the FAW pest in Kenya are necessary (FAO, 2017b). Moreover, these assessments are scarce until now due to the recency of the pest in Africa and farmers lack of knowledge on how to manage the pest efficiently. This leaves a knowledge gap about which or if measures are currently operating in the region of Nyeri to enhance knowledge concerning the pest. This shall be focused in the field study (FAO, 2017b).

However, as national food security is due to the FAW pest an explicit concern, political actions to tackle the FAW infestation in Kenya were launched by the 'Ministry of Agriculture, Livestock and Fishery' in 2017. It introduced an multi-institutional team with experts of institutions of the 'Kenya Agricultural & Livestock Research Organization' (KALRO), the 'Kenya Plant Health Inspectorate Service' (KEPHIS), the 'Centre for Agriculture and Biosciences International' (CABI), the 'Pest Control Products Board' (PCPB), the 'International Centre of Insect Physiology and Ecology' (ICIPE), the 'Plant Protection Services' and the 'State Department of Agriculture of Kenya'. Since then studies concerning the FAW pest in Kenya are scarce, the governmental programme emphasises the buildup of capacities on a

[3] In this context, 'pest' is defined as the occurrence of damage to a plant through an insect (Hill, 1983)

national and county level concerning monitoring, problem identification and management (Kenyan State Department of Agriculture, 2017). This takes place through trainings for public and private service providers, sellers and applicants of pesticides, researchers, farmers and the public. Part of these training programmes aims to provide knowledge on how to detect the FAW as part of an early warning system, which is complemented by monitoring the plants to recognize early stage damages. Furthermore, technical skills are being instructed. These include recommendations of early planting patterns or the use of pheromone mass traps (Kenyan State Department of Agriculture, 2017). Although the programme includes the knowledge transfer of chemical pesticide use, such as Diazinon or Alpha Cypermethrin, alternative, sustainable, non-chemical pesticide methods are not included in the teaching programme, a fact that create questions to what extent farmers are aware of non-chemical pesticide management methods and if they are applied (Kenyan State Department of Agriculture, 2017).

As programmes, which are carried out to tackle the FAW pest in Kenya include the distribution of chemical pesticides to maize farmers, who are not accustomed to applying pesticides in maize farming. Issues might arise eventually, since ingredients of pesticides have shown to be toxic for the human health and the environment (Damalas, 2011). Exposure to toxic chemical pesticide ingredients is the most common health threat for farmers in developing countries (Konradsen, 2003). Furthermore, poor pesticide application can lead to environmental and economical drawbacks and should therefore be of concern. Due to these reasons, sustainable agricultural practices need to be promoted in Kenya, and non-chemical pesticide alternatives should be taken into account (FAO, 2017b). To contribute to a more sustainable pest management approach, the research question of the field trip is: What is the potential of non-chemical-pesticide adaptive methods of the FAW infestation in Giathenge (Nyeri)?

As mentioned above different control methods can be used against the FAW attacks and though the fall Armyworm may be relatively new in Africa, it is a well-known pest on the American continents (FAO,2017). Therefore, it can be useful to take a look at methods already being used in preventing the FAW infestation.
Some existing management practices can be adopted directly, after a validation performed by tests (FAO,2017b). The use of pesticides is the most common response to FAW infestations but probably not the most suitable one. Most smallholders in Africa do not apply pesticides in maize farming and the introduction of pesticides in maize might lead the production to be economically unsustainable, as continuously buying pesticides will increase the expenses of the production (FAO, 2017b). Moreover, pesticides negatively affect the distribution and diversity of natural enemies of the FAW, enemies that would naturally help regulate the FAW population (FAO, 2017b). And as already mentioned, chemical pesticides can be harmful for humans and the environment.

There are several alternative methods to chemical pesticides:

Biological pesticides: There are different biological pesticides that can substitute the use of chemical insecticides. These pesticides are usually by-products of parasites and pathogens and have been applied in many American countries with high efficiency against FAW. At the time, there are not available papers in the application of biological pesticides in the African region and Kenya, however, FAO and other agents are planning to promote integrated pest management practices in the long term.

Push-pull method: According to Midega et al. (2017) a study in Kenya showed that the damage from the FAW on the plants decreased and the yield of maize got significantly higher, when using a push-pull method. This can be achieved by intercropping grasses that will either repel or attract the pest.

Introducing natural enemies: The FAW has a variety of natural enemies, predators, parasitoids and pathogens, that attacks the FAW in different stages of its life cycle. Natural enemies can be important in order to control the pest (Cabi, 2018). There are a lot of natural enemies of the FAW. The complication with introduction of these are depending on the particular case and if the specific species are indigenous to the area or not.

Hybrid plants, GMCs: Cross-pollinated and genetic modified plants that have been introduced mainly in the Americas, seems to effectively regulate the density of FAW in maize (e.g. Bacillus thuringiensis maize) (Chilcutt el al., 2006).

Pheromone traps: Pheromone traps are considered an effective tool to detect the arriving of the FAW and other pests and thereby act as an early warning system. Pheromone traps can be helpful in tracking migration patterns of FAW´s and monitoring of the speed in which the pest is spreading. (FAO,2017).

These different alternatives might serve a more economical and environmental sustainable way, to control pests in small-scale maize farming in Kenya. Before any changes are done it is important to consider the complications and pitfalls existing in the various methods.

Nevertheless, there is no literature to be found in whether the governmental programme is active in the region around Othaya in Nyeri, which will be the location area of the field study. Thus, it is going to be essential to examine the knowledge of farmers concerning the FAW pest to understand why and how certain pest management methods are used.

Methodology

The study is interested in gaining a deeper understanding of people's thinking concerning pest stresses and how a community as a whole reacts in such a situation. Different actors such as farmers, pesticide retailers or state officials are affected differently by the pest and therefore perceptions of the pest will presumably differ. As we assume a close link between the perception of the pest and the acceptance of management methods, the field study aims at examining the link between perceptions and actions and look at the potentials of alternative non-chemical pesticide management methods. We are a group of

people from various academic backgrounds and cultural traditions, thus our approach on the field will be a combination of diverse methods. The field study will give us knowledge from indigenous people but also from each other under various conditions. In order to answer our research question and objectives, the following section is describing our proposed methods. The high number of persons in our group will allow us to split in different groups for work tasks. However, that means we need to have a good communication between members and write down all the information we receive.

Participatory observation

During all the fieldwork in appropriate moments, some observations may be done in various forms. To participate in the everyday life is a good way to gain information and some practices/behaviors that might not be conducted through interviews or questionnaires because they not always happen on a verbal level. If possible and with the agreement of the person, notes can be taken during the observation. Otherwise a moment should be taken afterwards to have a written path in order to share the information with the other members of the group. This method can provide, for example, information about the knowledge of the farmers concerning the pest and also about practices, that farmers execute but do not expect to influence the pest. Nevertheless, these practices can be relevant for our report.

Questionnaire

Questionnaires will be the first main step of our data collecting. The questionnaires will be conducted with the help of an interpreter to translate the written questions and then in reverse to translate the answer of the respondent. The group's target will be the farmers themselves with a goal of approximately 40 participants. This aims at answering various of our objectives. First, it will give us an idea of the repartition of the pest on the land and how it impacts the household and assess the maize losses. Secondly, it will bring us an idea of the knowledge of the farmers about the pest and how they gained this knowledge. Finally, questions will be asked about actions taken to control the pest and if the farmers use pesticides.

Semi-Structured Interview

The semi-structured interview will be conducted with three different group of actors. The first one is, in continuity with questionnaires, with the group of farmers. The questionnaires will help as a support to conduct the interviews and choose a smaller group of participants (5-10 Interviews) who are of our interest to answer our objectives. The objectives we attend to answer with this method is focusing on a deeper overview of the farmers' knowledge about the pest, the control methods applied and their limitations or advantages. As well it will be observed if the pest influences the food security of the household in respect of economical, changes of habits or/and others unknown aspects.

The second group of actors will consist of a representative of the government with a number of approximately 2-3 interviewees. Those interviews aim at learning about a more general point of view and at trying to understand the position of the government, if for example they provide some help to the farmers to control the pest. The last group will be interviewed will be pesticide resellers with again approximately 2-3 interviews. The focus of those interviews will be on learning what they advise to control the pest and their knowledge of it.

Map using a GPS

Closely linked with the questionnaires and the interviews 2 distinct map will be made. The first map will be a GPS point map representing the area where we saw the FAW or that the farmers told us having some. As mentioned, these observations will be done during the questionnaires and the interviews but could also be done during some participatory observations. The second map is also a GPS map but this time with various colors points representing the different methods used to control the pest. These two maps have the purpose to answer the repartition of the pest objective in addition to represent geographically the distribution of the various methods.

Participatory Rural Appraisal (PRA)

The PRA method will help us to have a better representation of our field area, gain valuable knowledge about the control method with a perspective of a group of people from the indigenous community. The two PRA will take place during a meeting we will organise. The first PRA method is a mapping exercise of the area where they live with the position of the maize field. Then we will ask them to draw where pest touched the area and finally add the control methods they take/took.

The second PRA exercise is a ranking type with pairwise table. We will first explain simply using some pictures of some methods already applied in other places (that could be some methods they already use) to the guests of the meeting. Then, they will have to fill the table comparing two methods which one they think being the best in their case. It will be followed by a small discussion about the reasons they choose such method more than another. This method aims to show us the acceptance of the various methods and the pros and cons.

Focus Group

A focus group will follow the PRA method with the same group of people. We will ask the people who were interviewed to come and open to who is interesting to the topic. We hope that the practical exercises before will lead the people to an open discussion. The discussion will focus on the future plan the farmers wish to take and observe how they want to organize themselves in order to control the pest. What are the barriers to implement such methods and will show us if some sources of knowledge are more influential than others?

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Appendix

Matrix

Research Question(s)	**Objectives**	**Sub-Questions**	**Data Required**	**Methods**	**Equipment**
What is the potential of non-chemical pesticide adaptive methods of the FAW infestation in Giathenge?	Assessment of the distribution of the pest on the field	1. Where the pest is observed? 2. Do certain geographical factors influence the extent of the pest? 3. When was the pest first discover in the area?	Geographical conditions	Mapping Questionnaire PRA mapping Participatory observation Interview	GPS Pen and paper
	Assessment of maize yield losses due to Spodoptera frugiperda infestation and other parameters	1. What is the economic impact of the lost yield? How much money do people lose? 2. Is the food security in the area threatened due to the pest? 3. What kind of other parameters (pest) can induce a loss in the maize field? Is it possible to isolate yield losses due to the pest from other causes?	Numbers of yield and losses (in percentage or estimates/ perceptions) 1 2 3 Ask farmer and government	Interview Focus Group Questionnaire	GPS Pen and paper Audio recorder?
	Assessment of present knowledge of the farmers concerning the pest	1. How do actors identify the pest 2. What do they know about the pest biology (life cycle)?		Interview Questionnaire	Pen and paper Audio recorder
	Assessment of the origin of the recommendations of knowledge / actions /pesticides	1. Who is providing knowledge? 2. How is knowledge transferred? 3. Are there differences in the quality of provided knowledge?	Programme brochures	Participatory observation Interview Focus Group	

	What actions are taken to manage the pest by individuals and why?	1. Who is using which strategies due to which reasons (access, costs, knowledge)? Why do they differ? 2. Assessment of the success of the applied strategies 3. Where are pesticides used?	Prices of pesticides Interviews	Questionnaire Interview PRA comparative Mapping Participatory observation	Poster/ material to illustrate
	What are the alternative methods to control and prevent the FAW (to substitute chemical pesticides) and how is the acceptance of famers on these alternatives?	1. Push pull systems 2. Pheromone traps 3. Communication platform (prevention method)? 4. Biological control 5. Natural enemies 6.Is their application possible? What are the costs? Will they be beneficial for farmers?	Studies from different countries	Questionnaires Interviews PRA and Focus group Participatory observation	Audio recorder Pen and paper
	(How is the communal life affected by the pest?)	*1. Do people feel left alone with the problem?* *2. How do people assign responsibility concerning the pest (management or maybe cause)?* *3. Do management actions of some affect others? Do people work together or do conflicts arise?* *4. How does the community react as a whole?*		*PRA* *Focus group* *Interviews*	*Posters/ material to illustrate* *Audio recorder*

Timetable

	Friday 2	Saturday 3	Sunday 4	Monday 5	Tuesday 6	Wednesday 7
Goal of the day						
Person in charge of the day	Iason	Laura	Simon	Manon	Iason	Laura
Morning	Travelling from Nairobi	Wangari Maathai Day	Church	Questionnaires + GPS Points / Contact government and pesticide company	Interview government /pesticide	Interview government /pesticide
Lunch						
Afternoon	Exploring area, meeting new friends and observatory methods	Questionnaire + GPS Points	Questionnaires + GPS Points	More Questionnaire? / analzing data we have for interview	Interview government /pesticide	Interview farmer
Dinner						
Evening	Meeting and Test the Questionnaires	Meeting	Meeting	Meeting	Meeting	Meeting

	Thursday 8	Friday 9	Saturday10	Sunday 11	Monday 12	Tuesday 13
Goal of the day						
Person in charge of the day	Simon	Manon	Iason	Laura	Simon	Manon
Morning	Interview farmer	Interview farmer	Interview farmer	Church ?	Feedback in Othaya	Back to Nairobi
Lunch						
Afternoon	Interview farmer	Interview farmer	Focus group + PRA of dfrawing			
Dinner						
Evening	Meeting	Meeting	Meeting	Meeting	Farewell party	

Questionnaire concerning the Fall Armyworm infestation in Giathenge, Kenya

For the surveyors: Remember to inform the respondents thoroughly about the purpose (topic, how the data will be used, learning purpose). Introduce yourself and present the goal of the survey. It makes sense to ask the respondent before conducting the interview if they grow maize on their land to avoid wasting time giving out questionnaires to people who do not grow maize.

1. General information

GPS point:	Interviewer:
Date and time:	Translator:
Interview number:	

2. Background information about the respondents

2.1. What is your full name (optional) ?

2.2. What year were you born/ how old are you?

2.3. How many persons live in your house?

2.4. What is your position in your household?

2.5. How many years did you go to school?

2.6. What is your occupation/job?

3. Respondents interconnection with the FAW pest

3.1. Do you use any pesticide?

3.2. How many bags/kg/other measurements of maize do you usually harvest (estimation)?

3.3. What do you do with your maize (Circle more than one answer if needed)?

a. Eat it
b. Sell it
c. Trade it
d. Others: _____

3.4. Did you experience significant maize yield losses last year?

a. Yes
b. No
c. Do not know

3.4.1 If yes, can you estimate your maize yield losses (bags or other named measurement method)?

3.4.2 If yes, were your maize yield losses bigger compared to other years?

a. Yes
b. No
c. Do not know

4. Respondents knowledge concerning the FAW pest

4.1. Do you know the Fall Armyworm? (Picture)

a. Yes
b. No

4.2. Have you seen it on your fields?

a. Yes
b. No
c. Do not know

4.3. If yes, do you think it is responsible for your maize yield losses?

a. Yes
b. No
c. Do not know

5. Respondents actions to manage the FAW infestation

5.1. Did you ever take actions to manage yield losses on your maize fields?

a. Yes
b. No

5.1.2. If yes which management methods do or did you use?

5.2. Did you ever take special actions to manage the FAW pest?

a. Yes
b. No

5.2.1 If yes, do or did you use any of these control methods?:

a. Chemical pesticide
b. Others:

c. Do not know

6. Further contact

6.1. Would you agree to do an interview concerning the topic?

a. Yes
b. No

6.2 If yes, how can we contact you? Telephone number?

For the surveyor: Ask if the respondent has some questions and don't forget to thanks for taking some time for the survey.

Surveyor's notes:

Semi-Structured Interviews Guide

How do we select interviewees based on results of the questionnaires?
Proposed number of interviewees: 5-10 persons
Selection criteria:

1. Must be affected by the Fall Armyworm pest (based on own perception)
2. Takes actions to manage the pest
3. Does not take action to manage the pest
4. Gave consent to do an interview in questionnaire

Number 2 and 3 allows us to form 'groups' of people that might be compared.

Leading question for the SSIs with farmers (order might change during interview)

1. Introduce our project and our research goal
2. How do you experience the worms presence?
3. When did you observed it for the first time?
4. Is it different from other pests that you experienced?
5. Can you identify the Fall Armyworm? How do you do it?
6. Do you have knowledge about its life cycle? (Moths and caterpillars look, where and when they lay their eggs? About its rapid distribution in the field)
7. How do you control the pest in the field? Do you use preventive methods? Do you use monitoring methods?
8. How did you choose the management method that you are applying and why? How did you learn them? Do they success?
9. If not already stated: Do you use pesticides? What is their price? Do you consider them to be expensive? Where do you buy them? How do you apply them? Who showed you to use them? Do you think they are effective against the pest?
10. For farmers who do not apply any method yet: Why are you not taking actions to control the pest yet? Costs, knowledge, labour time?
11. How did the yield losses/ the pest affect the food supply for your household? What did you do to compensate the losses? (Eating less, taking other jobs to earn money etc.)
12. Do you know other people in the community that are affected by the pest? Do you help each other? Did somebody help you?

How do we select interviewees, who are working or owning pesticide shops?
Proposed number of interviewees: 2-5
Selection criteria:

1. Owning or working in a chemical pesticide retail shop
2. Willing to speak with us

Leading questions for the SSIs with pesticide shop owners/ workers (order might change)

1. Introduce our project and our research goal
2. Have you heard of the Fall Armyworm pest?
3. When did you first hear about it? When did it come to this region?
4. Can you identify it or distinguish from other pests? What do you know about its life cycle? (Moths and caterpillars look, where and when they lay their eggs? About its rapid distribution in the field)
5. Where did you get your knowledge about the pest?
6. Is it different from other pests? Do you recommend a specific pesticide do fight it? Did the demand or sale for chemical pesticides go up to fight it?
7. Do you only sell pesticides, or do you also give advice to farmers on how to use them? If yes, how does your advice look like?
8. Is there other methods that can be used with (chemical) pesticides?
9. Do you recommend only pesticides?

How do we select interviewees, who are governmental official?
Proposed number of interviewees: As many as available
Selection criteria:

1. Is a governmental official working in the agricultural field?

Leading questions for the SSIs with governmental officials (order might change)

1. Introduce our project and our research goal
2. When was the pest first observed in the region?
3. Is it different from other pests in relation to yield losses, distribution?
4. What do you think about the pest? How does it affect the region (Nyeri, Othaya) and its farmers?
5. Have you/ the government quantified the impacts of the pest? (economical losses, yield losses)
6. How do you evaluate the knowledge of the farmers about the pest? Do they know enough to deal with it?
7. Is there a plan active in the region? To what extent? (Does this control programme differ from other programmes in the past/ compared to the pests?)
8. Do the governmental actors provide/ distribute enough information and money to the farmers to control the pest?
9. What do you think about pesticides use? Do you consider it a long-term solution?
10. What is the next step? Dow do you plan to control the pest in the future?
11. Do you believe the future plan will be effective and why?

Plan for the PRA-Mapping

- Make different groups
- Let these group do maps of the area including their maize fields and worm attacks and the various methods applied.
- This will take place in different steps.
- After and during we will discuss the results of the maps and the methods used in the community and why and how it works.

Material needed:

Big papers, markers in different colors, beverages and snacks

Plan PRA: Pair-wise ranking /compare alternative control methods

Q. Which is method is the best

	GMO/Hybrid	Push-pull	Pheromone traps	introduce natural enemies	early warning social app
GMO/Hybrid					
Push-pull					
Pheromone traps					
introduce natural enemies					
early warning social app					

Plan for the focus group discussion

- Discussion of future plans / desires or what is most likely to be taken into consideration
- What are the complications with the implementations of the different methods

Appendix 2
Updated Questionnaire concerning the Fall Armyworm infestation in Giathenge, Kenya

For the surveyors: Remember to inform the respondents thoroughly about the purpose (topic, how the data will be used, learning purpose). Introduce yourself and present the goal of the survey. It makes sense to ask the respondent before conducting the interview if they grow maize on their land to avoid wasting time giving out questionnaires to people who do not grow maize.

We are students of Copenhagen University and Nairobi university. And we are here to investigate the pest FAW on maize and possible solutions against the pest . All of the answers will stay NN

1. General information

GPS point:	Interviewer:
Date and time:	Translator:
Interview number:	

2. Background information about the respondents

2.1. How many persons live in your house?

2.2 How long have you lived here?

2.3. What are you civil status
-Married
-Single
-Widow
-Divorced

2.4. When were you born? Year?

2.5. What is your position in your household?
- head of household
-other

2.6. What is you level of education?

2.7. What is your occupation/job?

2.8. Do you have other sources of incomes?
Ex. pension, business

2.9. How much land do you own?

2.10. How much of your land is rented?

3. Respondents interconnection with the FAW pest

3.1. Did you use any chemical pesticides last year?
If yes: on which crops?
Coffee
Maize
Other Veggies

3.2. how many acres/m2 of maize field do have?

3.3. How many bags/kg/other measurements of maize do you usually harvest (estimation)?

3.4. how many times a year do you harvests maize? and when?

3.5 Do you have different varieties of maize?

3.6. What do you do with your maize (Circle more than one answer if needed)?
a. Eat it
b. Sell it
c. Trade it
d. Others: _____

3.7. Do you use any fertilizer?
-yes
-no

3.7.1 If yes: what kind?

3.8. Did you experience significant maize yield losses last year?
a. Yes
b. No
c. Do not know

3.8. What were the main challenges that coursed the losses last year?

3.9 If yes, were your maize yield losses bigger compared to other years?
a. Yes
b. No
c. Do not know

4. Respondents knowledge concerning the FAW pest

4.1. Do you know the Fall Armyworm? (Picture)
a. Yes
b. No

4.2. Have you seen it on your fields?
a. Yes

b. No
c. Do not know
d. Neighbours
4.3. If yes, do you think it is responsible for your yield losses on maize?
a. Yes
b. No
c. Do not know

5. Respondents actions to manage the FAW infestation

5.1. Did you take actions to manage yield losses on your maize fields last year?
a. Yes
b. No

5.1.2. If yes which management methods do or did you use?

5.2. Did you ever take special actions to manage the FAW pest?
a. Yes
b. No

5.2.1 If yes, do or did you use any of these control methods to manage the FAW pest?:
a. Chemical pesticide
b. Other
c. Do not know

6. Further contact

6.1. Would you agree to do an interview concerning the topic?
a. Yes
b. No

6.2 If yes, how can we contact you? Telephone number?

What is your name ?

For the surveyor: Ask if the respondent has some questions and don't forget to thanks for taking some time for the survey.

Surveyor's notes:

Appendix 3

Semi-Structured Interviews Guide

How do we select interviewees based on results of the questionnaires?
Proposed number of interviewees: 5-10 persons
Selection criteria:
1. Must be affected by the Fall Armyworm pest (based on own perception)
2. Takes actions to manage the pest
3. Does not take action to manage the pest
4. Gave consent to do an interview in questionnaire

Number 2 and 3 allows us to form 'groups' of people that might be compared.

Updated guiding questions for the SSIs with farmers (order might change during interview)

1. Introduce our project and our research goal

2. How do you experience the worms presence?

3. When did you observed it for the first time?

4. Is it different from other pests that you experienced?

5. Can you identify the Fall Armyworm? How do you do it?

6. Do you have knowledge about its life cycle? (Moths and caterpillars look, where and when they lay their eggs? About its rapid distribution in the field)

7. How do you control the pest in the field? Do you use preventive methods? Do you use monitoring methods?

8. How did you choose the management method that you are applying and why? How did you learn them? Do they success?

9. If not already stated: Do you use pesticides? What is their price? Do you consider them to be expensive? Where do you buy them? How do you apply them? Who showed you to use them? Do you think they are effective against the pest?

10. For farmers who do not apply any method yet: Why are you not taking actions to control the pest yet? Costs, knowledge, labour time?

11. How did the yield losses/ the pest affect the food supply for your household? What did you do to compensate the losses? (Eating less, taking other jobs to earn money etc.)

12. Do you know other people in the community that are affected by the pest? Do you help each other? Did somebody help you?

13. Did you report the infestation to an official?

14. Why do you think are you affected?

How do we select interviewees, who are working or owning pesticide shops?

Proposed number of interviewees: 2-5
Selection criteria:

1. Owning or working in a chemical pesticide retail shop
2. Willing to speak with us

Updated guiding questions for the SSIs with pesticide shop owners/ workers (order might change)

1. Introduce our project and our research goal

2. Have you heard of the Fall Armyworm pest?

3. When did you first hear about it? When did it come to this region?

4. Can you identify it or distinguish from other pests? What do you know about its life cycle? (Moths and caterpillars look, where and when they lay their eggs? About its rapid distribution in the field)

5. Where did you get your knowledge about the pest, maize seeds and pesticides?

6. Is it different from other pests? Do you recommend a specific pesticide do fight it? Did the demand or sale for chemical pesticides go up to fight it?

7. Do you only sell pesticides, or do you also give advice to farmers on how to use them? If yes, how does your advice look like?

8. Is there other methods that can be used with (chemical) pesticides?

9. Do you recommend only pesticides?

10. Do you think some maize varieties are more resistant?

11. Who decides the price of the pesticides?

12. Did many people buy pesticides to fight the FAW?

13. Do you think pesticides are affordable for everyone?

14. What do you think about biological control methods?

How do we select interviewees, who are governmental official?

Proposed number of interviewees: As many as available
Selection criteria:

1. Is a governmental official working in the agricultural field?

Updated guiding questions for the SSIs with governmental officials (order might change)

1. Introduce our project and our research goal
2. When was the pest first observed in the region?
3. Is it different from other pests in relation to yield losses, distribution?
4. What do you think about the pest? How does it affect the region (Nyeri, Othaya) and its farmers?
5. Have you/ the government quantified the impacts of the pest? (economical losses, yield losses)
6. How do you evaluate the knowledge of the farmers about the pest? Do they know enough to deal with it?
7. Is there a plan active in the region? To what extent? (Does this control programme differ from other programmes in the past/ compared to the pests?)
8. Do the governmental actors provide/ distribute enough information and money to the farmers to control the pest? What about the pesticide samples?
9. What do you think about pesticides use? Do you consider it a long-term solution?
10. What is the next step? Dow do you plan to control the pest in the future?
11. Do you believe the future plan will be effective and why?
12. Do you think there are disadvantages in the use of pesticides?
13. Do you know/promote other methods?
14. Are there other agricultural organizations active in the region? (e.g. FIPS Africa, CABI)
15. If yes. How do they work? What kind of help do they provide? Are they in contract with the government?

Appendix 4

Updated PRA plan

Plan for the PRA-Mapping

- Make different groups
- Let these group do maps of the area including their maize fields and worm attacks and the various methods applied.
- This will take place in different steps.
- After and during we will discuss the results of the maps and the methods used in the community and why and how it works.

Material needed:

Big papers, markers in different colors, beverages and snacks

Plan PRA: Pair-wise ranking /compare alternative control methods

Q. Which is method is the best

	Resistant varieties	Promote biodiversity (push-pull)	Monitoring	Pheromone traps	Early warning social app (sms)	Crop rotation	Earlu planting
Resistant varieties							
Promote biodiversitz (push-pull)							
Monitoring							
Pheromone traps							
Early warning social app (app)							
Crop rotation							
Early warning social app							

Updated Focus Group Discussion

Following subjects will be discussed:

- Future plans for fighting the FAW pest
- Which alternative control methods is most likely to be taken into account, and why.
- Advantages and disadvantages
- Collaboration – working together in monitoring the FAW pest

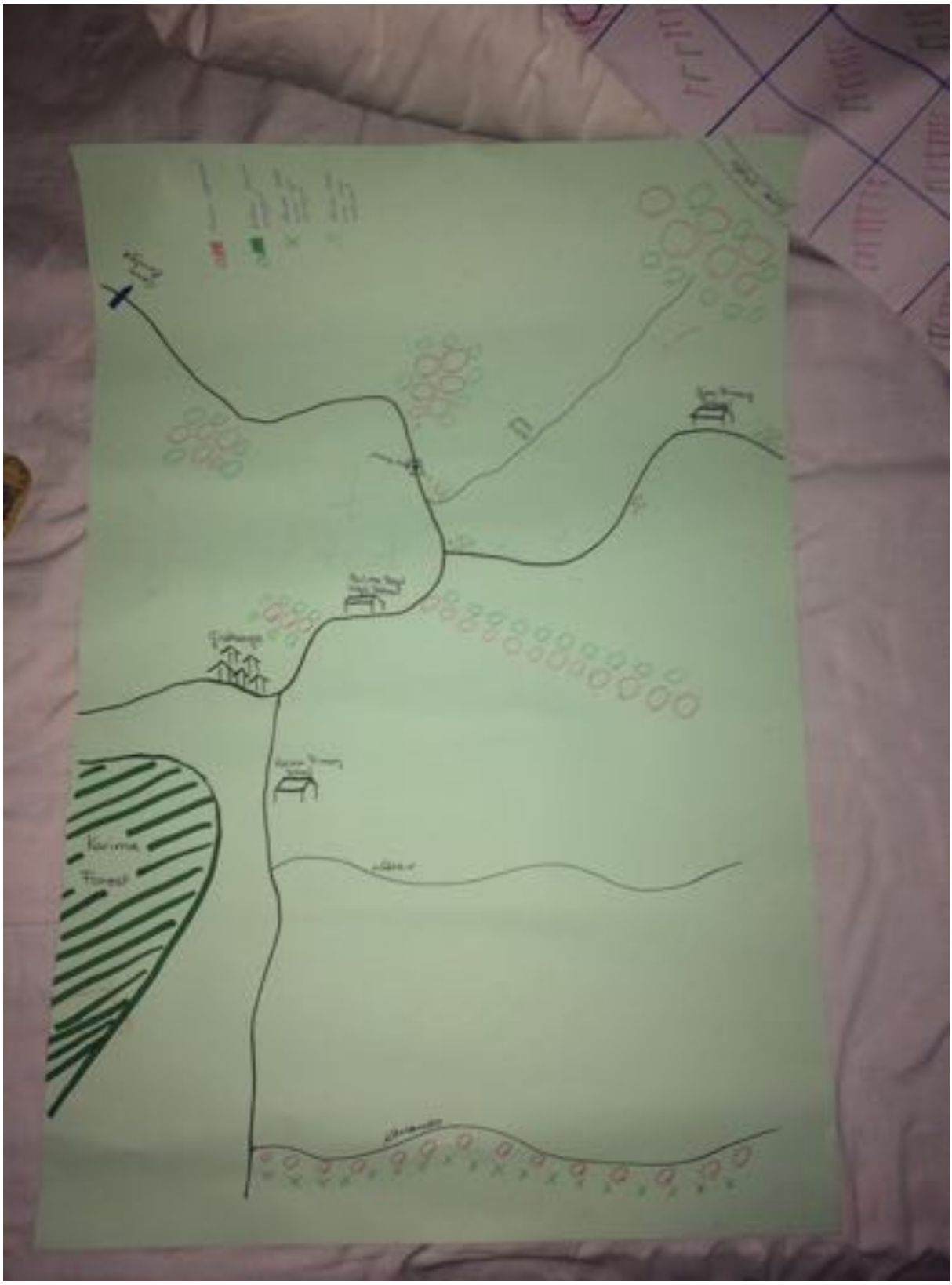

Figure 10. Map made during PRA mapping exercise

Appendix 5

Overview of applied methods

Overview of applied methods	
40	Questionnaires
1	Pilot Test of Questionnaire
1	Observation
1	Transect Walk
8	Semi-Structured Interviews with Farmers
5	Semi-Structured Interviews with Agrovets
1	Semi-Structured Interview with Officer
2	Participatory Rural Appraisal exercises
1	Focus Group meeting

Appendix 6

Overview of the conducted SSIs

Interview number 1
Name: Jacke
Date: 06/03/2018

Interview number 2
Name: Margaret 1
Date: 06/03/2018

Interview number 3
Name: Myryam
Date: 06/03/2018

Interview number 4
Name: Benson
Date: 07/03/2018

Interview number 5
Name: Lucy
Date: 06/03/2018

Interview number 6
Name: Agnes
Date: 06/03/2018

Interview number 7
Name Margaret 2
Date: 07/03/2018

Interview number 8
Name: Rose
Date: 06/03/2018

Interview number 9
Name: Agricultural Officer
Date: 07/06/2018

Interview number 10
Name: Agrovet 1
Date: 07/03/2018

Interview number 11
Name: Agrovet 2
Date: 07/03/2018

Interview number 12
Name: Agrovet 3
Date: 07/03/2018

Interview number 13
Name: Agrovet 4
Date: 07/03/2018

Interview number 14
Name: Agrovet 5
Date: 07/03/2018

Appendix 7

Research Design

This single-case study took place from the 2th to 12th of March 2018 in the region around the settlement of Giathenge, which is in the Kenyan County of Nyeri.The research relied on a combination of quantitative and qualitative data collection methods to maximize the credibility of the research findings and to complement possible strengths or weaknesses of a specific data collection method (Johnson et al. 2003 p. 299).
The research included 40 questionnaires with farmers, semi-structured interviews with 7 farmers, 5 agro-vets and one 'Agricultural Officer'. In addition to this, participant observation was being carried out during our stay at different times.

Data Providers

Three different data/ information providers were selected to be part of the research to ensure a variety of background knowledge, opinions and interests. These three data providers were farmers in the area of Giathenge, so called Agro-vets in Giathenge and Othaya, which are pesticide selling shops and the 'Agricultural Officer' of the region of Othaya, who is also responsible for the region around Giathenge.

Data Collection

Data was collected by two groups. One group consisted of two Danish students, one elder and one translator, while the other group consisted of two Danish students, one Kenyan student and one translator.
Either the elder or the translator introduced our research topic, when approaching new data providers. This happened in Swahili for the purpose of building up trust, since most interviews took place in the private homes of farmers. The interview with the Agricultural Officer was the only exception and the research introduction was held in English. The data collection was either done in English or in Swahili and translators were played an essential role in this process.

Appendix 8

Recommendation Posters

Figure 11. Posters presented during the feedback session