<u>Case Study</u>

Pesticides use in pest management: A case study of Ewaso Narok wetland small scale vegetable Farmers, Laikipia County, Kenya.

ABSTRACT

Small scale farmers in Ewaso Narok wetland in Kenya are largely horticultural farmers who grow vegetables such as tomatoes, kales, peas, chilies and onions for local consumption and exports. This study was conducted to assess Ewaso Narok wetland farmer's practices and knowledge concerning safety in pesticide use. A total of 86 farmers were purposively chosen and took part in the study based on an in-depth questionnaires and interviews. Insecticides (46%) and fungicides (49%) were the most commonly used pesticides. 76% of the farmers were aware of the various routes of pesticides entry into body. The use of personal protective equipments (PPEs) was inadequate as only 39% of the farmers used at least incomplete and inappropriate PPEs. Majority of the farmers (61%) wore their home clothes during pesticide handling. Only 25% of the farmers read pesticide labels before use. Some farmers (35%) reported to apply different pesticide as a cocktail mixture, a practice that was significantly dependent on the farmer's farming period ($p=0.013$). Farmers adopted unsafe pesticide waste disposal practices such as burying (54%), incineration (23%) and discarding (16%) of pesticide wastes in the open fields. Though young farmers with either secondary or tertiary education levels had better knowledge of pesticide risks to human health and environment, they reported inadequate and poor safety practices. A general poor pesticide practices was evident among farmers from storage, mixing, spraying to disposal of pesticide wastes. Inadequate pesticide knowledge was also realized amongst farmers. A comprehensive measures of reducing pesticide exposure and mitigating effects on human are vital. This may include pesticide management and safety trainings, regular surveillance programmes, enforcement of strict pesticide laws and adoption of integrated pest management (IPM) system in addition to good agricultural practices (GAP). Further studies of pesticide residues analysis on horticultural produce from the wetland in necessary to determine their safety. These findings will be shared by farmers to educate them on the need to adopt good pesticide practices.

Key words: Wetland, pesticides practices, pest management, PPEs.

INTRODUCTION

Horticultural farming is an emerging agricultural sub-sector that is experiencing the fastest growth in many global economies (Karungi *et al.*, 2011). In Kenya, horticultural farming is the second largest foreign earner, employing over 500,000 people directly and over 2 million people indirectly in the year 2015 (Tsimbiri *et al.*, 2015). The existing favorable prices and available market both locally and internationally further encourages the farmers to embrace horticultural farming as a common practice. Traditionally undisturbed riparian wetlands like Ewaso Narok in Kenya are quickly being turned into major sources for horticultural fresh produce (Kamiri *et al*., 2014). Since horticultural crops are highly prone to pests and disease destruction, their production is highly pesticide dependent in which various types of modern pesticides such as organophosphates, carbamates, synthetic pyrethroids, azoles, triazole, are used. These classes of pesticides though considered to exhibit low environmental persistence and high efficacy as described by Oyugi (2012) and Chebai (2014), they are highly toxic to both human and beneficial insects such as invertebrates, worker bees (Johnson *et al*., 2010; Fenik *et al*., 2011). Furthermore, various health illness in human has been linked to some of these pesticides namely; chronic neurotoxicity, mutagenicity, endocrine disruption, ecotoxicity and even carcinogenesis in some cases (Chowdhury *et al*., 2012). In trace amount, chlorpyrifos (organophosphate) has been linked to neurological disorder, attention deficit hyperactivity disorder and development disorder in fetus and children (Chowdhury *et al*., 2012). Carbamates such as carbofuran has been linked to serious reproductive abnormalities, while carbaryl results in nausea, vomiting, blurred vision, coma and death (Chowdhury *et al*., 2012).These pesticides are equally environmental contaminants for instance azinphos methyl and chlorpyrifos exposure are reported to have been the cause for the significant decrease of earthworms in South African orchards and predatory birds poisoning in USA, UK and Canada (Quinn *et al*., 2011).

Ewaso Narok wetland besides being an important ecological habitat, is also a major source of horticultural food products such as tomatoes, peas, french beans, chilies, kales, spinach and onions meant for both export and local markets (Thenya *et al*., 2011; Mwita, 2013). It's located in the semi-arid part of Laikipia County making it a major source of fresh water for domestic and wildlife use. In addition, the wetland act as a natural habitat to diverse flora and fauna including over 170 birds and 100 plants species originally documented to be present by Thenya (2001). Unregulated usage of pesticides to promote the horticultural produce within the wetland is likely to have unreparable destruction on the biodiversity such as killing of important insects and birds thus distabilising the food chain within the ecosystem (Macharia *et al*., 2009). The increase in human occupational exposure can not be ignored as a result of the failure by farmers to follow adopt to sound pests control practices, lack of training and awareness modern pesticide practices and inadequate surveillance on farmers pesticide usage. Wrong pesticide dosages, inadequate use of the recommended personal protective clothing and equipments, improper spraying methods and poor disposal of pesticide wastes are some of the areas that have led to high pesticide occupational exposure amongst farmers, consumers of the produce in addition to both animals and other populations living close to the sprayed farms.

Kenya has in place elaborate laws and regulations to protect consumers and environment from pesticide use guided by the pest control products Act cap 346 of the Kenyan constitution. However, laxity in their implementation has resulted into some agricultural produce having pesticide residues above the recommended maximum residues levels, unethical agricultural practices leading to widespread human health complication, exploitation and degradation of environment (Wandiga, 2001; El-Wakeil *et al*., 2013). The nearly complete destruction of the entire coffee industry in 1980 and the mass destruction of maize in 1998 that resulted from the use of counterfeit pesticide formulations in Kenya were the worst ever global cases recorded and nearly brought the Kenya’s economy to its knees (Karingu and Karanja, 2013). This trend if not closely monitored will significantly affect food security and safety thus preventing the country from realizing its Sustainable Development Goals (SDGs). The potential destruction of Ewaso Narok wetland and impact of pesticide exposure on human health through continued pesticide application is of a prime concern. However, despite the extensive horticultural farming and pesticide use in Ewaso Narok Wetland, there is no published research that has been conducted to assess pesticide practices in terms of safety and management. This information is important in assessing both the ecological safety of the wetland in carrying out its natural functions and evaluating the level of human pesticide exposure based on practices within the wetland. The extensive use of pesticides and inadequate published research information present a research gap. This study assessed pesticide practices amongst small scale vegetable farmers in Ewaso Narok wetland, Laikipia County, Kenya.

MATERIAL AND METHODS

The study was conducted in Ewaso Narok wetland in Kenya found in a semi-arid grass land of Laikipia County known for frequent droughts and unreliable rainfall (Thuita Thenya, 2001). The wetland is lies between Longitude 36^{o}12’17’’ to 36^{o}45’16’’E and Latitude 0^{o}28’51’’N and 0^{o}7’28’’S with altitude ranging from 1780 to 1835m above the sea level and temperature varying between 20-37^{o}C. It covers an area of approximately 12km^{2} with a linear stretch of 12km. being in the arid and semi-arid area (ASAL), the wetland receives rainfall less than 500mm annually according to the information provided by WARMA Rumuruti weather station (2014). It is a riverine wetland with a rich biodiversity of flora and fauna and the main source of fresh water wildlife and entire surrounding population (Thenya, 2001; Amler *et al*., 2015).Field survey was conducted in the months of May to August, 2016 using a structured questionnaire consisting of both open and closed ended questions. A total of 86 farmers were purposive selected from each farm for the study. Only farmers who were using pesticides in their farms were allowed to participate in the study. Farmers were taken through the study requirements and made to sign the consent form before participating in the study. The questionnaire was formulated and pre-tested before administration. The survey was conducted through face-to-face interviews with farmers using a structured questionnaire which comprises of both open-ended, closed- ended and Linkert-scale questions. Interview were conducted in national swahili language and sometimes local kikuyu language by the help of a well-trained field assistant. The questionnaire consisted of the questions touching on the farmer’s personal data on age, gender, education and other key thematic areas to assess the level of pesticide management practices using past similar published studies as a guide (Zyoud *et al*., 2010). All the data collected were coded, and analyzed using Statistical Package for Social Sciences (SPSS) version 22. Descriptive analysis, farmer’s knowledge on general pesticide safety practices. Kruskal-Wallis and Mann-Whitney tests were used to investigate the significance relationship between farmer's socio-demographics (age, education and gender) on several pesticide practices. All the significance tests were carried out at 95% confidence level with only analysis giving a significance p-value less than 0.05 ($p<0.05$) being accepted to show significance differences.

RESULTS AND DISCUSSIONS

Ewaso Narok wetland Farmer's socio-demographics characteristics

Within all the three categories of age brackets (≤30, 31-50 and >50) years, there were more males (81.4%) than females (18.6%). Most (62.8%) farmers were between 31 to 50 years of age, 22.1% were 30 years and below while 15.1% were above 50 years old. Majority (66.3%) were literate having attained secondary education and above, 29.1% were semi-illiterate (primary education (class 1-8)) while 4.7% were illiterate (unable to read and write) with no formal education (Table 1). These results are comparable to 80% literacy levels reported in the study conducted by Shafiee *et al*. (2012). The number of illiterate farmers (4.7%) were however much lower than the 55% reported by Mengistie *et al* (2017). Adeola (2012) in a similar research categorized farmers using age groups as 25-55 years and >55 years which constituted 92.2% and 7.8% respectively. According to Adeola, 93% of the farmers were male and 7% female with 63.3% having at least primary education while 12.5% had no formal education.

Table 1 Socio-demographic background of farmers in Ewaso Narok wetland

Item		Frequency (F)	Percentage (%)
Education (N= 86)			
Illiterate (unable to read and write)		4	4.7
Primary (class 1-8)		25	29.1
Secondary level (a- level or form1-4)		40	46.5
Tertiary (colleges or university)		17	19.8
Age (years) (N= 86)	**Gender**		
≤30	Male	17	19.8
	Female	2	2.3
31-50	Male	48	55.8
	Female	6	7
>50	Male	10	11.6
	Female	3	3.5

Significance of farmer's socio-demographics on good pesticide practices

Kruskal-Wallis and Mann-Whitney tests were carried out to determine the significant influence the farmer's demographic characteristics (age, education and gender) on pesticide practices. The practices included; knowledge of pesticide residues entry routes of exposure into the human body, use of personal protective clothing and equipments (PPEs), mixing of different pesticide chemicals before use, disposal of empty pesticide containers, reading of pesticide labels before use, observation of pesticide safety intervals (pre-harvest and re-entry intervals) and the use of alternative pest control methods (Table 2).

Table 2 Impacts of farmer's socio-demographics on good pesticide practices.

Pesticide practices Variables	**p-value**		
	Kruskal-Wallis test		Mann-Whitney test
	Age	Education	Gender
Mixing of different pesticide products	0.211	0.490	0.519
Rate risk of exposure during pesticide application	0.004	0.031	0.248
Knowledge of the routes of pesticide entry into the body	<0.001	0.007	0.029
Use of protective clothing during pesticide handling	0.007	0.005	0.132
Practices of alternative pests control mechanisms	1.000	1.000	1.000
Pesticide storage before and after use	0.757	0.074	0.007
Use of pesticide containers for other purposes	0.333	0.597	0.003
Disposal methods for pesticide containers	0.622	0.022	0.140
Observing pesticide safety intervals	0.273	0.009	0.208
Reading of pesticide labels before use	<0.001	0.003	0.482

α=0.05

a) Knowledge of pesticide exposure routes

Age ($p<0.001$), education ($p=0.007$) and gender ($p=0.029$) were found to have a significant influence on the farmer's knowledge of pesticide entry routes into the body ($p<0.05$). Majority (90.7%) of the farmers of age 30 to 50 years and 78.9% those who were 30 years and below correctly identified different routes namely; inhalation of vapours, dusts or mists (17%), skin/ eye contact with residues (15%), or ingestion (34%). However, 61.5% of the farmers above 50 years had no idea on the different pesticide entry routes into the human body. Most farmers (80.2%) who had better understanding of different pesticide entry routes had received some form of formal education. Their level of education was significantly proportional to the level of knowledge they had on the different pesticide entry routes ($p=0.007$). Among those with better understanding on the pesticide entry routes into the body 46.7% had primary, 84% secondary and 100% tertiary level of education. Majority (93%) of those who had no formal education their information on pesticide entry routes limited to ingestion of pesticide at high concentrations (100%). More male farmers (61.6%) were equally well informed of the pesticide entry routes than female farmers (18.6%. Furthermore, female farmers did not take part in pesticide mixing and spraying in the farms. In a similar study conducted by Jallow *et al*. (2017) among farmers in Kuwait, dermal (54%), inhalation (86%) and ingestion (42%) were the most common routes of pesticide exposures listed while 14% had no knowledge of how pesticides enters the human body. The rate of pesticide exposure was higher among the older (>50), illiterate and semi-illiterate farmers compared to the young (<50) and literate farmers. This finding concurs with a similar finding of a research carried out by Abong'o *et al*. (2014) and Mengistie *et al*. (2015). For example, out of the 24% of the farmers who did not know of the pesticide routes of exposure into human body, 70% had elementary education (semi-illiterate) or had no education background at all (illiterate). Furthermore, this group of farmers reported a number of acute pesticide poisoning symptoms like headache, dizziness, blurred vision and skin problems that they were experiencing after using pesticides

b) Use of personal protective clothing and equipments (PPEs)

The decision to use protective clothing was significantly influenced by the farmer's age (p=0.007) and education (p=0.005). Though none of the farmer reported to be using complete protective clothing during pesticide application, 47.4% of farmers aged 30 years and below and 46.3% aged 31 to 50 years old reported to be using some personal protective clothing and equipments (PPEs). However, all farmers above 50 years of age (100%) did not use any PPEs during pesticide application, instead they preferred using their home cloths during pesticide handling. Forty four (44%) and 60% of farmers with secondary and tertiary education respectively reported to be using at least one type of PPEs. However, 61.9% of the farmers who had primary education and below reported not to use any PPEs during pesticide handling. Though women did not take part in pesticide application, 81.4% reported that they have never wore any PPEs when accessing freshly sprayed farms. None of the farmers wore respirators and hand gloves during mixing and spraying of pesticides in the farms. Farmers reported discomfort (11%), inaccessibility (79%) and high cost (11%) of the various protective clothing and equipment as the reason for them not wearing the protective clothing and equipments, this concurred with the results reported by Jallow *et al*. (2017). Failure by farmers to use proper PPEs such as goggles and gloves during pesticide application presented a great risk of exposure to the farmers of Ewaso Narok wetland since the nose and eye serves as routes of exposure as documented by Mekonnen and Agonafir (2002). Though some farmers just ignored to observe basic pesticide safety rules like wearing appropriate protective gear and observing basic hygiene, the scenario was worse amongst the illiterate or semi-illiterate farmers. Most of the farmers who cared to wear at least incomplete personal protective clothing had at least secondary education level. This finding supports a similar findings by Wandiga, (2001), Yassin *et al*. (2002) and Bond *et al*. (2007) which emphasized on the importance of education literacy to good pesticide practices amongst farmers.

c) Mixing different pesticide products before spraying

The decision to mix different pesticide products for a single application was not significantly dependent on any of the farmer's socio-demographic variables of age (p=0.211), education (p=0.490) and gender (p=0.519) respectively. About 21.1% of farmers aged 30years or below, 42.6% of farmers aged 31 to 50 years and 46.2% of farmers aged above 50 years respectively, reported to have mixed at least two different pesticide products before use. A similar finding reported by Halimatunsadiah *et al*. (2016) while Mengistie et al. (2017) reported 87% of farmers mixing two pesticides before application. Farmers preferred to mix different pesticides and apply the chemicals as concoction believing that the mixture was more effective than applying single chemicals. Those who embraced this practice reported this was a way of saving time and paying the hired sprayer less than when only one chemical was sprayed at a time. Majority (96%) of all farmers had only one tank in their farms where all pesticides are prepared from before application without cleaning off the previous chemicals. It was observed that mixing of different pesticides and using them as concoction was mainly practiced by farmers with long farming experience mostly above 10 years. Unsafe practices such as mixing of different pesticide products noted during the study can be related to lack of training. Pesticide labels do not contain information on the mixing or using of pesticides as a cocktail mixture. Thus, mixing different pesticide products and applying the pesticide as a cocktail mixture can present adverse effect on human health and environment (Halimatunsadiah *et al*., 2016). The efficacy of the individual pesticides could also be reduced significantly as a results of the chemical ingredients incompatibility and possible chemical reaction as reported by Hamby *et al*. (2015).

d) Disposal of empty pesticide containers

Education was the only key variable that was found to significantly influence the choice of disposal methods for empty pesticide containers (p=0.022). Some educated farmers who had secondary (58%) and tertiary (62%) education had their pesticide wastes kept in dug pits before being burned in the open fields or buried within the farm. Majority of the farmers having primary education and below (98%) had their wastes thrown all over the farms. However, it was evident that most farmers (97%) had not received proper training on safe pesticide waste disposal methods. The rest of the farmers had no specific method for waste disposal, hence their wastes were either thrown away (28.6%) of burnt (38.1%). Some farmers (20%) also were re-using pesticide containers to perform other farm activities such as watering seedlings a practice that was significantly prevalent among female farmers (p=0.003). Farmers who were seen to be more knowledgeable on pesticide safety did little to ensure their safety during pesticide waste disposal. Even those who reported to carryout disposal through burning or burying of waste did not follow the right procedure. Pesticide containers were buried without protecting the wastes from possible leaching into the underground water. Burning was done in the open further exposing the nearby workers to toxic fumes. Jallow *et al*. (2017) explains that unsafe pesticide waste disposal methods was a recipe to the increased pesticide levels in agricultural produce, water and soil contamination further increasing the risk of exposure to both human and wetland health. Unsafe pesticide waste disposal methods by farmers has continued to raise lots of safety concerns as reported by Shafiee *et al*. (2012 and Jallow *et al*. (2017). Furthermore, re-use of pesticide containers for other domestic purposes as observed during this study could only help to aggravate the situation of pesticide exposures within Ewaso Narok wetland.

e) Reading of pesticide labels and observation of safety intervals

Age (p=<0.001) and education (0.003) equally had a significant influence on the farmers ability to read pesticide labels before use ($p < 0.050$). Farmers of all age categories such as; 30 years and below (94.7%), 31-50 years (98.1%) and above 50 years (61.5%) reported to read pesticide labels before use. Majority of farmers with secondary (82%) and tertiary (100%) education levels said they normally read pesticide labels before use. However, 85% of farmers with primary and 98% of farmers with no formal education said they did not read the pesticide labels before use. Some of the reasons given for not reading pesticides labels before use included; low level of education (60%) making it difficult to read and understand the meaning of the information on the labels, small and unfriendly fonts used (30%), while 10% did not just care about the labels. Majority of farmers with secondary (92%) and tertiary (100%) education levels had knowledge of two pesticide safety intervals such as re-entry interval (REI) and pre-harvest interval (PHI). However, it was observed that these intervals were not observed strictly as the vegetables especially tomatoes were sold whenever the buyer was available. Most farmers (85%) having primary education and below did not observe the safety intervals. Similarly, Jallow *et al*. (2017) in their study reported 70% of farmers not reading or following instructions on pesticide labels. Halimatunsadiah *et al*. (2016) states that failure to comply with the pesticide safety intervals such as PHI is likely to lead to high pesticide residues levels in vegetables above the recommended maximum residues levels (MRLs). Furthermore, Inonda *et al*. (2015) in their research reported that adherence to the recommended pesticide safety intervals such as pre-harvest interval (PHI) resulted in 99% reduction of pesticide residues concentrations in vegetables. To minimize the effects of pests and diseases on farm crops, farmers embraced the alternative pest control methods such as rotational farming (57%) and intercropping (43%). This practice was however not significantly dependent on any of the farmer's socio-demographics (p=1.000) as this was considered a common practice.

Farmer's knowledge on pesticide use and practices

a) Farmer's knowledge on pesticide products used on vegetables in the local market

Most farmers (89%) were able to mention names of pesticides they were using at the time of the study namely; coragen, ivory, master etc. This was similar to the 92% of farmers who knew the names of pesticides they were using in a research conducted by Mengistie *et al*. (2017). The list of pesticide products available in Rumuruti market was important in identifying if there are any banned or restricted products being used by farmers. The possible uncontrolled pesticides accessibility by farmers in the study area is a huge threat to both human and the entire wetland ecosystem. Some of the pesticide which are considered to extremely or highly toxic to both human and environment have such as aldicarb and azinphos methyl have had their use banned in most industrialized countries including European countries (WHO, 2004) . Chlorpyrifos, fenpropathrin and diazinon are classified as highly hazardous pesticides (HHPs) thus their use is restricted and not allowed on vegetables (Grube *et al*., 2011; PCPB, 2017).

b) Farmer's pesticide storage practices

Thirty six percent (36%) of farmers stored unused pesticides in their residential houses for safety purposes. Out of these 36%, majority (67%) had pesticides stored in store-rooms, 14% hanged the pesticides on the roof or walls, 5% had pesticides in their bedrooms or under their beds, 8% had pesticides kept in their living rooms while 6% had pesticides kept in the kitchen. Store rooms, wall or roof storage are accessible to most members of the family including children presenting the risks of accidental or suicidal pesticide poisoning of the family members. Jallow *et al*. (2017) reported a similar findings where farmers stored their pesticides in open shade (34%), open field (30%), animal house (15%), inside refrigerator with other items (8%) and living areas (20%). Though, 63% of farmers stored pesticides together with other farm tools such as knapsack sprayers and water pumps in the small structures built within the farms, some farmers lived, slept and even cooked in those structures sometimes with their families increasing the risk of exposure. Mengistie *et al*. (2017) in their study reported the main pesticide storage areas by farmers to include own house (32%) and farm structures (57%). Tsimbiri *et al*. (2015) reports that no part of the population is completely safe from the effects of pesticides whether from intended nor un-intended exposure due to poor pesticide storage practices. The most vulnerable part of this population are farmers and their family members due to poor storage at home and in farm structures.

c) Knowledge of pesticide effect on human health and environment

Possibly due to inadequate training, 80% of farmers could not relate any serious health condition to pesticide poisoning. The main common pesticide poisoning symptoms reported by farmers were headache (47%) and dizziness (20%). This could be related to the inadequate use of personal protective clothing and failure to used respiratory equipments. Pesticide inhalation as the main route of pesticide exposure among farmers in the study area. (Table 3).

Table 3 Acute pesticide poisoning symptoms reported by farmworkers

Symptoms	Frequency	Percentage (%)
Excessive sweating	2	2
Hand tremor	3	4
Convulsion staggering	1	1
Nausea / vomiting	1	1
Narrow pupils/ miosis	6	7

Blurred vision	3	4
Headache	40	47
Dizziness	17	20
Irregular heartbeat	2	2
Skin rushes	9	11
Sleeplessness/ insomnia	2	2

Shafiee *et al*. (2012) reported dizziness (57.1%) and cough (44.3%) as the main pesticide poisoning symptoms linked to failure by farmers to use proper personal protective clothing. This was emphasized by Jallow *et al*. (2017) who reported headache (82%), dizziness (41%), nausea (49%) and skin problem (58%) as the main symptoms of acute pesticide poisoning among farmers after pesticide use.

d) Knowledge of common vegetables Pests and diseases at Ewaso Narok wetland

Leaf miner (88%) and thrips (84%) were the most common vegetable pests listed by farmers. However the mealybug (2%) and cutworms (5%) were least reported. Omolo, (2011) list the common horticultural pests mentioned by farmers during his study in rift valley and central Kenya as thrips (19%), aphid (23%) and mealy bugs (23%) among others. Halimatunsadiah *et al*. (2016) and Moncada (2001) reported several insects pests namely cutworms, thrips, aphids, caterpillars, leafminer and diamond back moth as having been mentioned by farmers during the studies (figure 1). Majority of farmers (75%) were able to list some of the diseases that normally affect their tomato farms. early blight and late blight were mentioned by most farmers (43.9%) while powdery mildew, root rot and grey mold was least mentioned by only 2.3% of farmers (figure 2).

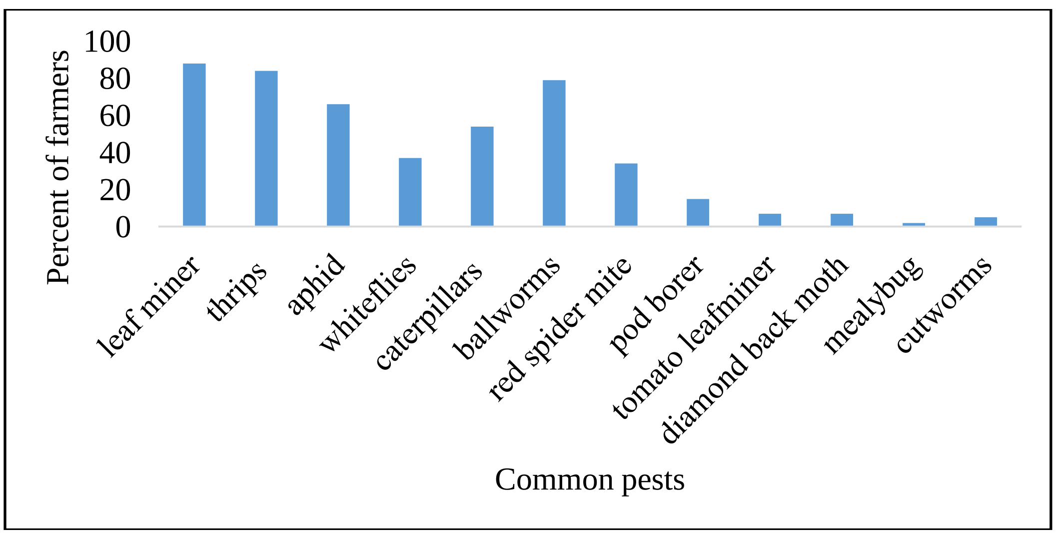

Figure 1 Common pests listed as a threat to tomato and kales production

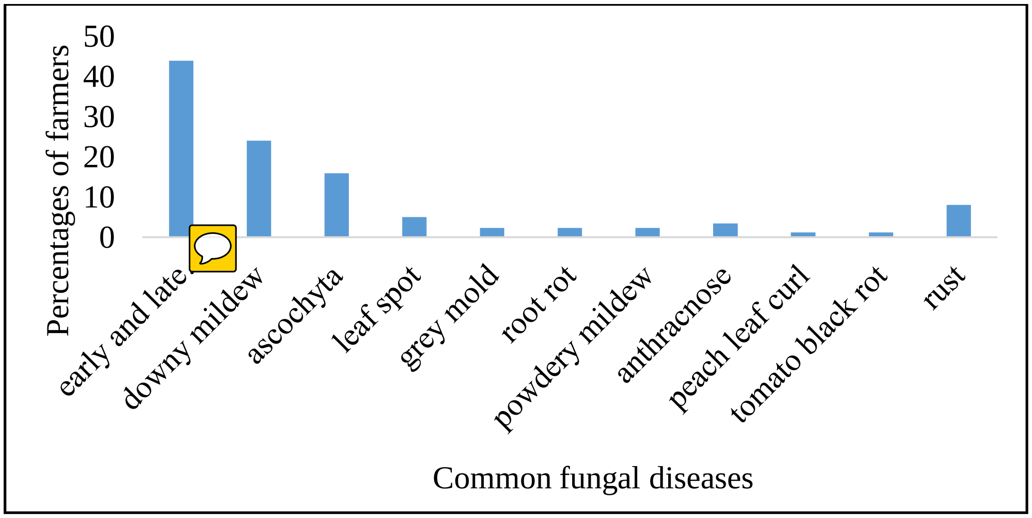

Figure 2 Common fungal diseases listed as a threat to tomato and kales

Insecticides (51%) and fungicides (42%) were the most widely used pesticides in the tomato and kales farms. However, few farmers reported to have used acaricides (4%), miticide (1%) on their tomatoes. Herbicides were not used since the farm workers were relied upon to hand-pluck any weed sighted within the farm. The list of pesticide products reported by farmers to be in use at the time of the survey is provided in appendix . Knowing the type of pests/ disease is important to the farmer as it helps select the type of insecticide to be acquired and used. Some farmers (34%) could not differentiate between diseases and pests thus they kept referring to the pests or diseases in Swahili language as *dudu* or *magonjwa*. Furthermore, some farmers could not differentiate between pests and diseases. This was evident when some farmers reported *tuta absoluta* as a new fungal disease instead of a pest pointing to the possibility of guess work while buying pesticide to curb its effect. A similar results was obtained by Mengistie *et al*. (2015). Most pesticides are very specific and systematic thus may not be useful when applied on the crops for the purpose of controlling pest/ disease that it is not meant for. The choice of pesticide used in the crop field should be largely influenced by the type of pests and diseases in the crop field or neighboring fields. Being able to identify the type of pests or fungal diseases in the farms was therefore important in reducing possible misuse of pesticides. During the survey, farmers with at least secondary education reported to use pesticides in their farms only when there is pest (s) and disease (s) attack on their crops or in the neighboring farms. However, farmers with primary education and below did not peg pesticide usage on the crop attack by pests or diseases.

e) Training and awareness of farmers on good pesticide practices

Majority of farmers (88%) who took part in this study had not received any formal training on good pesticide practices. World Health Organization (WHO) and Agricultural Food Organization (FAO) recommends that any person handling pesticides must be trained on sound pesticide practices (FAO/WHO, 2014). Millard *et al*. (2004) in their study emphasized on the importance of both formal and informal training in the enhancement of farmer's knowledge on pesticide safety. This lack of training contributed to the poor knowledge and wrong perception of some farmers on sound pesticide practices in Ewaso Narok wetland seen on the level of safety precautions reported. Incomplete use of personal protective clothing, poor pesticide disposal mechanism, wrong spraying equipments, mixing of different pesticide chemicals as a way of saving time and reducing cost of labour, failure to observe pesticide safety intervals, smoking and drinking during pesticide application are some of the poor pesticide practices that are directly linked to lack of proper training. Lack of awareness was evident among the farmers since some of the farmers who were able to read were reluctant to read the package labels on safety of pesticides. A similar findings were reported by Mekonnen and Agonafir (2002) and Jallow *et al.*, (2017).

Some farmers depended on pesticide vendors who were equally not adequately knowledgeable and the absent agricultural extension officers to explain to them the safety measures to take when handling pesticides also contributed to possible poor practices. Past researchers underscored the importance of farmer's level of knowledge on pesticide as a key determinant on the level of safe or unsafe pesticide practices. Mengistie *et al*. (2015) and Yassin *et al*. (2002) explains that high knowledge on the impact of pesticide on human health and environment has been linked to improved pesticide safety practices. Ouédraogo *et al*. (2011) however, linked the poor knowledge on the potential risks of pesticides to human health and environment among Burkina Faso pesticide sprayers to the high level of illiteracy which stood at 80%. It is evident that illiteracy levels and lack of awareness and training of Ewaso Narok wetland vegetable farmers on safe pesticide practices is a major contributor to the poor pesticide practices. Application of wrong pesticide dosages on tomatoes and kales by farmers could not be ruled out. During the study it was notes that farmers could not ascertained that they usually mix the right pesticide chemicals for application on the crops. This was evident by the use of uncalibrated containers and manual knapsack sprayers presented during the study. Application of wrong pesticide dosages was a recipe for either pesticide overdose or under dose leading to wastages and high residue levels in the food produce and environment contamination. Risk of pests and disease causing vectors developing resistance to the chemical pesticide due to under-dose could be a major threat to horticultural production. The use of manual knapsack sprayers are not considered safe since they are prone to leakages. This may expose the sprayers to pesticide poisoning through skin contact and even inhalation. As observed during the study, most of the knapsack sprayers available for use in the farms were worn out mostly as a result of wear and tear. This was discovered through the observed leakages, poor atomization through the nozzles, nozzle blockage

CONCLUSIONS AND RECOMMENDATIONS

a) Conclusions

The findings of this study provides important information on the current pesticide practices and contamination status of Ewaso Narok wetland ecosystem including two largely consumed vegetables within the wetland. Generally, poor pesticide practices was evident starting from storage, mixing, spraying, disposal of pesticide empty containers to use of adequate personal protective clothing and equipments (PPEs). As a result, occupational pesticide exposure among farmers was on the rise and influenced mainly by the use of improper storage facilities, lack of training on pesticide safety practices, the use of faulty or wrong spraying equipments such as leaking knapsack sprayers, failure to use complete protective clothing and equipments. Farmer's level of education, poor disposal methods of pesticide wastes equally contributed to pesticide

b) Recommendations

From the findings of this study, the following recommendations were made;

1. More awareness creation, strengthening of the agricultural extension services and training of farmers on good pesticide practices should be undertaken as a way of reducing mis-use of pesticide in Ewaso Narok wetland.
2. Adoption of Good Agricultural Practices (GAP) and integrated pests management (IPM) skills by farmers and periodic surveillance are necessary as a key to embracing alternative pest control methods and reducing synthetic pesticide use in the wetland and dangers that comes with pesticide use.
3. For further studies, a comprehensive studies to evaluate pesticide residues levels in horticultural produce grown in Ewaso Narok wetland and to determine their possible impact on environment and human health is highly is necessary.

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Appendix

CONSENT FORM AND QUESTIONNAIRE

Ewaso Narok wetland agricultural pesticides survey.

Name of the Respondent____

Village ___________________ County___________Mobile number: ________________

I Peter B.M. Otieno Ngolo (I56/CE/27737/2013) a student at Kenyatta University, undertaking Masters of Science project at Rumuruti wetland with an aim of evaluating the level of farmer's exposure on the sound pesticides management in terms of potential risks and safety. Determining the types/ range of pesticides used by farmers within the wetland and carrying out the screening of the levels of these pesticides residues within the wetland ecosystem. The results of this survey are solely meant for educational purposes and not for profit making and as such any **participation** on this study shall be purely on **voluntary basis** with **no financial benefits** attached. This study has been authorized by express permission of Kenyatta University Board of Postgraduate studies. I am inviting you to be part of this study. Your participation is voluntary and has no immediate financial benefits. The outcomes of this study will be shared with the farmers.

If you agree to participate in the study, you will be:

1. Asked questions about the types of exposure you have on sound pesticides management which include safety precautions, first aid mechanisms and waste disposal by means of filling or being assisted to fill in a questionnaire.
2. Requested to provide a list of pesticides that you use in your farm on different crops and the pest / disease they help control.
3. Requested to allow us pick Kales and soil samples from your farm for the laboratory analysis of the pesticides levels.

By signing this form you are consenting to be part of the study/survey. Should you need more information you can contact **Peter B. M. Otieno Ngolo, Tel. number: +254720627109.** If you change your mind about taking part in the study, you are free to do so but we encourage you to participate. If you wish, all your information will be kept confidential. Please let us know your preferred choice (Y) (N).

I declare that the study/survey team has given me all the information I need about the study in a language that I understand and that I have been given a chance to ask all the questions I may have had and that these have been answered to my satisfaction. I voluntarily consent to participate in the study/survey.

____

Name of the person giving consent Signature Date

____

SECTION A: PERSONAL DETAILS

KENYATTA UNIVERSITY	Ewaso Narok Wetland Agricultural Pesticide Study	
	Farmers questionnaire	Farm code: Date: Enumerator

Farmer's level of education: Sex: Age:

SECTION B: RESOURCE UTILIZATION AND PRODUCTION

1. What is the approximate size of your farm in acres? 0 – 1ha 1 – 5 ha over 5 ha
2. For how long have you been farming? Less than 1 year 1year 2- 5 years 5 – 10 years 0ver 10 years
3. What types of crops do you plant in your farm? (Maize, kales (Sukuma wiki), spinach, tomatoes, cabbages etc.) Maize Kales (Sukuma wiki) Spinach Cabbages Tomatoes f) French beans Others specify
4. How long have you been using pesticides on your farm? 0 – 2 years 2 – 5 years 5 – 10 years Over ten years
5. At what stage of crop life do you apply the pesticides? During planting, weeding storage)
6. Have you ever received formal training on pesticide practices? Yes No if you have not received any training, do you have access to someone who provides such training? Yes No If YES, who?
7. When you buy pesticides, does it happen sometimes that the container(s) has no label? Never happen It does happen sometimes Often I don't know
8. What influences your decision while choosing pesticide to use on your crops/ farm Supplier (vendors and Agrovet) Commercial sources of information (advertisements, labels on the container) Fellow farmers Income media

9. Do you mix different brands of pesticides before application? Yes ☐ No ☐
10. What is the main reason why you mix the pesticides this way? Unsure about the quality of pesticides ☐ Uncertain about the effectiveness of pesticides for a particular pest☐. Advice by retailers/ suppliers ☐ Following the suggestion of others ☐ Other reason (please specify)
11. What kind of chemical means of plant protection (pesticides) have you been using, for which crops, pests /diseases, and how much?

Product/trade name	Frequency daily/Weekly/ monthly	Which crop being treated	Target/pest weed/ disease	Results

12. Who is the main person with the responsibility of applying the pesticide in the farm?
Respondent ☐ Farm owner ☐ other family members ☐ Hired applicator ☐
13. On a scale of 1-5, how much risk do you think you are exposed to while using pesticides on this farm? No risk at all ☐ Some small risks ☐ A medium amount of risk ☐ A large and significant amount of risk ☐ Dangerous and very toxic risks ☐ I don't know ☐
14. Do you know how pesticide chemicals can get into your body system (routes) Yes ☐ No ☐ If yes please give examples (inhalation, skin contact, oral, etc.?)
15. Do you wear protective clothing when applying pesticides? Yes ☐ No ☐
If no why? Please pick one: too expensive ☐ not available ☐ uncomfortable ☐ If yes, check one or more of the following;

PPE	**YES**	**NO**	**I DON'T KNOW**
Gloves			
Face masks			
Overalls			
Eye glasses			
Boots/shoes			
Long pants			
Long sleeve shirt			
Respirator			

16. How do you apply the pesticides on your crops? With hand pump ☐ with tractor ☐ with brush ☐ with leaves ☐
17. Do you currently practice any pest control techniques to reduce the need of using pesticides? Yes ☐ No ☐ If YES, which methods do you use: Organic production ☐ Biological control ☐ Mechanical-physical techniques ☐ Rotation of crop ☐
18. In your opinion, can you rate how harmful the chemical (synthetic) pesticides are for the environment and health? If yes, please specify; not harmful ☐ moderately harmful ☐ Very harmful ☐
19. When using pesticides or being exposed to them have you experienced (check one or more of the following):

Symptoms	**Yes**	**No**	**I don't know**
Excessive sweating			
Hand tremor			
Convulsion Staggering			
Excessive salivation			
Narrow pupils/miosis			
Blurred vision			
Headache			
Dizziness			
Irregular heartbeat			
Skin rashes			
Diarrhea			
Difficulty breathing			
Sleeplessness/insomnia			
Nausea/vomiting			

20. How do you store pesticides before and after use? in their original containers ☐ In my own containers ☐ in my storage room ☐ in the house ☐ farm house ☐ others ……………………………………………………….
21. Are the pesticide containers used for other purposes afterwards? Yes ☐ No ☐

If yes, are you aware that you should not do this? Yes ☐ No ☐

22. How are the containers or packages disposed of? Thrown in open field ☐ Buried ☐ Burnt ☐ Put in rubbish/trash ☐
23. From whom do you receive consultations about the right use and storage of pesticides? From retailer ☐ from consultancy services ☐ from fellow farmers ☐ others (please specify)
24. Are there agricultural extension services in Rumuruti? Yes ☐ No ☐
    If yes, are the service or advices by these extension officers available to you? Yes ☐ No ☐
25. How many times do you apply pesticides in your farm crops before harvesting?
    Once ☐ twice ☐ thrice ☐ more than thrice ☐
26. Do you observe pesticide safety intervals? Yes ☐ No. ☐ If yes, list the pesticide safety intervals
27. Do you read the label of pesticide product container before use? Yes ☐ No ☐
28. Rate the effectiveness of pesticide use in your farm Excellent ☐ Good ☐
    Fair ☐ Poor ☐