ASSESSING INTEGRATED PEST MANAGEMENT AS A QUALITY AND FOOD SAFETY MANAGEMENT STRATEGY IN THE VEGETABLE SECTOR

A Case of Masvingo District, Zimbabwe

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By

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Dedication

This is a special dedication to my late mum**.** *'Mama'* you will always be my role model.

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Abbreviations

ACF	Action Contrella Faim
AGRITEX	Agricultural Technical and Extension Services Department
AIDS	Acquired Immunodeficiency Syndrome
CGIAR	Consultative Group on International Agricultural Research
DR & SS	Department of Research and Specialist Services
FAO	Food and Agricultural Organisation
FSPM	Food Security Program Manager
GAL	Government Analyst Laboratory
HACCP	Hazard Analysis Critical Control Point
HIV	Human Immunodeficiency Virus
HPC	Horticultural Promotion Council
IIRR	International Institute of Rural Reconstruction
IPM	Integrated pest management
KIT	Royal Tropical Institute
LIGs	Low input gardens
MOHCW	Ministry of Health and Child Welfare
NGOs	Non-governmental organisations
OECD	Organisation for Economic Cooperation and Development
PELUM	Participation for Ecological and Land Use Management
POs	Producer organisations
SADC	Southern African Development Community
SDO	Sustainable Development Officer
SP-IPM	System- wide Program on Integrated Pest Management
WHO	World Health Organisation

Abstract

Integrated pest management has been identified as one of the ways of managing food safety in vegetables by the Zimbabwean Ministry of Agriculture due to its potential to reduce pesticide residues. This study investigates the position of IPM in Masvingo district by way of assessing pest management practices and inquiry of stakeholders that are relevant and influential in IPM along vegetable chains.

A survey was done with 30 vegetable growers randomly selected from vegetable growing areas throughout Masvingo district using a questionnaire. Critical variables that were used to explore IPM utilisation amongst vegetable growers were pest management practices used, determinants of pest management practices, whether the grower had knowledge of and had received IPM training, market requirements in relation to production systems and knowledge of effects of pesticides on human health and the environment. The study also used views of stakeholders to ascertain the position and effectiveness of IPM in addressing pesticide residues for safety assurance in vegetable sector so as to find ways of enhancing IPM implementation. For these other stakeholders, key informant interviews guidance of checklists and focussed mainly on public extension provider AGRITEX, NGOs implementing projects on vegetable production and marketing and retailers (supermarkets and vegetable shops).

The study concluded that though chemical pesticide is the main pest management practice, vegetable growers in Masvingo district are aware of IPM concept from the perspective of safety management. Other conclusions that were made based on study findings were emergence of markets requiring IPM produced vegetables, importance of government policy to direct IPM implementation, limited use of quality and food safety assurance standards in the vegetable sector and inefficient monitoring of the already existing food safety regulations. The outcome of the study also suggests that stakeholders are in favour of IPM.

Recommendations were made that can contribute to up scaling of IPM concept utilisation in the vegetable sector for management of vegetable safety. There is need for training of public research and extension technical staff as study findings suggested a knowledge gap on the part of these stakeholders who are crucial for technology dissemination. Advocacy is required for various civic organisations such as producer organisations for policy formulation particularly concerned with IPM. Awareness is needed for consumers to be informed on the effects of pesticides on their health. Coordination and collaboration between stakeholders in the vegetable sector with roles to play in IPM need to be strengthened.

CHAPTER ONE: INTRODUCTION

1.1 Background

Agriculture occupies a central role in Zimbabwe contributing between 14 and 18% of Gross Domestic Product (GDP), 40% of national exports, 60% of raw materials to agro-industries and providing livelihood to over 70% of the population as well as employment for about a third in the formal labour force (Ministry of Agriculture, 2009).

The horticultural sector is a significant contributor of income for both small holder and large scale farmers in Zimbabwe. During the 1990s, fruits and vegetable sector was one of the rapidly growing sector as shown by increase in exports from about 20 000 tons in 1992 to about 80 000 tons in 2001. The total exports of fruits and vegetables have declined since then to about 50 000 tons in 2008. One of the critical contributing factors to that decline is the strict controlled EU produce markets whereby producing entities have to pass stringent compliance standards to be allowed access one of which pertains to chemical residues. (Ministry of Agriculture, 2009).

The value chain concept has become a pertinent point in agricultural development strategies after the realisation that in the past much attention was given on increasing production without adequate focus on markets and the role of effective supply chains (Vermeulen *et al.,* 2008). Stakeholders and actors in the vegetable sector in Zimbabwe need to realise the need for reliable pest management that will result in higher quality and safer vegetables for supplying both the domestic and foreign markets. It is anticipated that if efforts are made to produce safer vegetables it would not only protect public health, but also stimulate growth of the vegetable sector in Zimbabwe.

1.2 Problem definition

Farming systems in Zimbabwe harbour a range of crops grown under varied climatic conditions from subtropical to temperate. Apart from problems in water supply, limited government support for infrastructure development and limited financial capacity, production of vegetable crops in Zimbabwe is constrained by a range of pest, disease and weed problems. Among the agricultural crops, vegetables are the most vulnerable to pests and diseases which reduce both quality and quantity of vegetables produced. However, pest management in vegetable production in Zimbabwe is predominantly dependent on chemical pesticides which are viewed as a quick and easy solution to pest problems (Siziba *et al.*, 2003). As most vegetables require a good appearance to attract consumers, this causes vegetables to be subjected to more pesticide treatments as compared to other crops. In addition, most farmers use pesticide intensively, much more than instructed on the labels (Sibanda *et al*., 2000).

Now there is mounting evidence of the negative effects of chemical pesticides on human health and the environment and there is global wide concern of chemical residues on food including vegetables. Failure to produce and guarantee quality and safe products due to chemical residues is one of the non-tariff barriers to marketing considering not only the global but also the local trend whereby consumers are increasingly becoming conscious of health risks associated with pesticide residues. In order to compete and benefit on local, regional and international markets by local growers, there is need to produce products which conform to quality and safety standards required by the respective markets.

1.3 Justification of the study

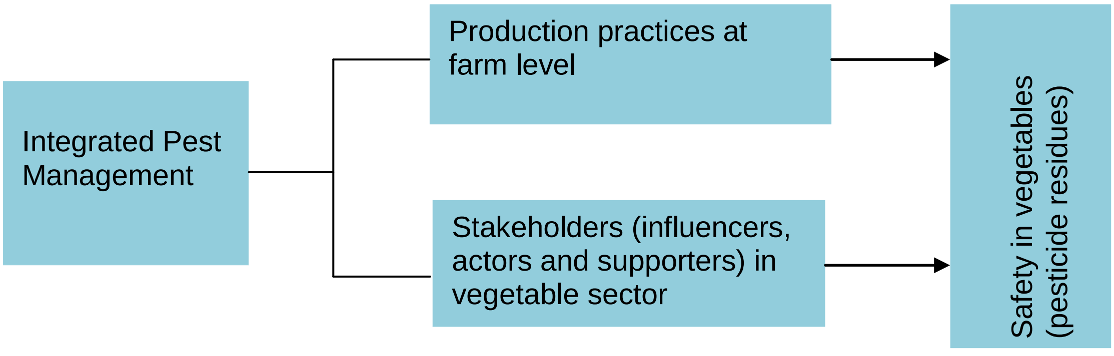
Food safety as an attribute of food quality is a critical issue for consumers who expect provision of safe food on the market and trust that governments in cooperation with private sector, civic organisations and scientific institutions can deliver it. Demand for safer food is increasing with urbanisation, with consumers becoming well off, living longer, and being able to recognise links between diet and healthiness and effects of pesticides along food chains. Agricultural Technical and Extension Services Department (AGRITEX) with the mandate of providing vegetable growers with advice on sustainable agriculture, recognizes the need for a whole chain approach to food safety. IPM has been acknowledged as one of the strategies that can ensure safety in vegetables in terms of reducing chemical residues (Ministry of Agriculture, 2009) hence an analysis of IPM in the vegetable sector can bring out insights and recommendations on how sustainable pest management can be achieved taking on board all relevant stakeholders leading to production of safe vegetables. AGRITEX has the mandate to implement crop related policies thus it is its responsibility as a public extension provider to train farmers on such aspects as crop production, safe application and handling of pesticide use, quality management and post harvest handling. In addition to provision of technical advice to growers, AGRITEX also play the role of linking vegetable growers to markets. The goal for AGRITEX as a supporter is to help farmers access higher income markets and improve livelihoods. This study will contribute to provision of empirical evidence of the *status quo* of IPM in Masvingo district as a quality and food safety management strategy in the vegetable sector from both perspectives of vegetable growers and key stakeholders in IPM in the sector.

So far, not much research had been done to investigate how and to what extent chain actors, supporters and influencers articulate IPM as a food safety management tactic in vegetables. Do the local vegetable market and networks play a role successfully in greening of vegetable production through IPM? What constraints exist that hinder transformation from pesticide addicted vegetable production system into more sustainable and safer alternatives such as IPM?

1.4 Conceptual framework

The research revolves around theories of value chain development, food quality and safety management and multi-stakeholder approach in the context of IPM in vegetable chains. The multi-stakeholder stance is critical in the undertaking of the research as in today's complex and highly interconnected world, chain development requires collaboration between different stakeholders (Van den berg *et al.*, 2008). Figure 1 highlights the conceptual framework.

Figure 1: Conceptual framework for the study



1.5 Objective of the study

The objective of the research is to ascertain the position and extent of utilisation of IPM as a food quality and safety management practice in the vegetable sector in Zimbabwe to have reduced pesticide residues in vegetables.

1.6 Research questions

Main Question 1. What is the current situation of IPM in vegetable sector?
Sub questions:
a) What pest management practices are currently used by vegetable growers?
b) To what extent do the pest management practices used exhibit IPM concept utilisation?
c) What factors influence choice of pest management practice in vegetable production?
d) What existing markets are in favour of IPM?

Main Question 2. What is required for implementation of IPM in the vegetable sector?
Sub questions:
a) What is the role of different stakeholders in the vegetable sector in IPM?
b) What are the institutional capacities of stakeholders in the vegetable sector in as far as IPM is concerned?
c) What policies and legal framework has been put in place to cater for food safety regarding pesticide use?
d) What factors facilitate and limit utilisation of IPM in the vegetable sector?

1.7 Definition of concepts

Integrated pest management - The combination of all relevant pest management techniques in reducing pest effect to acceptable levels in the context of socio-economic farming systems, protection of human health and the associated environment (FAO, 2002).

Pesticide - A substance used with the intention of preventing, attracting, destroying and controlling pests including unwanted plants or animals (Radcliffe *et al*., 2009).

Pesticide residue – Any specified substance in vegetables resulting from use of a pesticide (Codex Alimentarius Commission, 1998).

Value chain development – Strategies used to improve vegetable growers' participation in chain activities and involvement in management of the chain (Humphrey, 2006).

Quality – Meeting or exceeding consumers' expectations (Evans and Lindsay, 2005).

Food safety – Freedom from contaminants and sources of toxicity (chemical, physical, biological) injurious to health (Luning and Marcelis, 2009).

Stakeholder- Actors, supporters and influencers involved in supply or value chains (Vermeulen *et al*., 2008).

CHAPTER TWO: LITERATURE REVIEW

2.1 Vegetable production in Zimbabwe

Zimbabwe is situated in sub-Saharan Africa and experiences a subtropical climate that allows production of a wide range of vegetables throughout the year. Production is the starting point in every food chain and its performance determines the success of the processing and marketing industries. Vegetable are produced by both smallholder and large-scale commercial farmers who sell at local and export markets (AGRITEX, 1998).

Two groups of vegetables can be identified: Conventional, commonly occurring vegetables that are available at markets year-round include green beans, brassicas such as cabbage, cauliflower, and broccoli, carrot, cucurbits, Irish potato, lettuce, peas, pepper, sweet corn, and tomatoes. The production levels of these vegetables are shown in Table 1. In a second group are the traditional vegetables that are defined as crop plants that have been adopted and adapted to African dietary systems and used as relishes. This group includes crops that are not necessarily indigenous to Africa but have been in use since time immemorial as well as those indigenous to Africa. Examples of some of these traditional vegetables include pumpkin leaves, okra, cowpea leaves, and *Amaranthus* sp. leaves. These vegetables are either planted or emerge voluntarily after the onset of rain (Chigumira, 1997).

Vegetable production in the field may be rainfed and/or under irrigation or in glasshouses, on both large-scale or smallholder commercial farms. In some areas, communal irrigation schemes that support several smallholder farmers exist (Ministry of Agriculture, 2009).

Table 1: Trends in vegetable production in Zimbabwe

Year	Area (ha)	Production (tonnes)
1998	21097	120000
1999	22300	124000
2000	21422	122000
2001	20000	135000
2002	23213	133311
2003	22000	150000
2004	24244	156265
2005	31040	142817
2006	33120	178881
2007	23000	160000
2008	21175	105254
2009	25921	140119

Source: FAOSTAT, 2011

2.2 Pesticide use in vegetable production

Use of pesticides in agricultural production systems has two sides. On one hand it increases agricultural production and output through the reduction of pests and diseases and related crop loss. On the other hand, the continuous reliance on pesticides in agriculture poses serious threats to both human health and the environment. In Zimbabwe, and in many developing countries, chemical pesticides received a substantial amount of government support as they were seen as a means of reducing crop losses hence pesticide use has been widely recommended as the ultimate solution to get rid of the pest incidences in cropping systems (Siziba *et al.*, 2003).

The following are some of the problems of pesticide use in developing countries as noted by Dinham (2003):

- Farmers having not been trained on pesticide use
- Pesticides are not labelled or have complex instructions
- Farmers not knowing names of chemicals and use whatever available chemical instead of using the right pesticide for specific crops and pests.
- Farmers not affording protective clothing and equipment. If they do have the clothing and equipment it is not cleaned after use or separately from other clothes.
- Application timing and rates are poor, re-entry periods and harvest intervals are not known.
- Pesticide containers frequently used for storage, left in the open fields, water courses or ditches.
- Farmers not being able to distinguish between pests and beneficial insects and when a pest attack is likely to cause economic damage.

2.3 Effects of chemical pesticides on human health and the environment

Although the largest share of chemical pesticides are used and applied in developed nations, it has been shown that about 99% of pesticide poisoning incidences occur in developing countries with weak regulatory, health and education systems (World Bank, 2005). Chemical pesticides can pose hazards on human health and are associated with chronic and acute health issues such as cancer, leukaemia, skin diseases, neurological and cardiopulmonary disorders, while to the environment there can be contamination of air and water bodies both surface and ground. It has been noted that vegetables grown in most developing countries for domestic markets are rarely monitored for pesticide residues despite high levels of pesticide use compounded by the fact that in most countries there are no laboratories for testing even the simple residues (Lefferts, 1999).

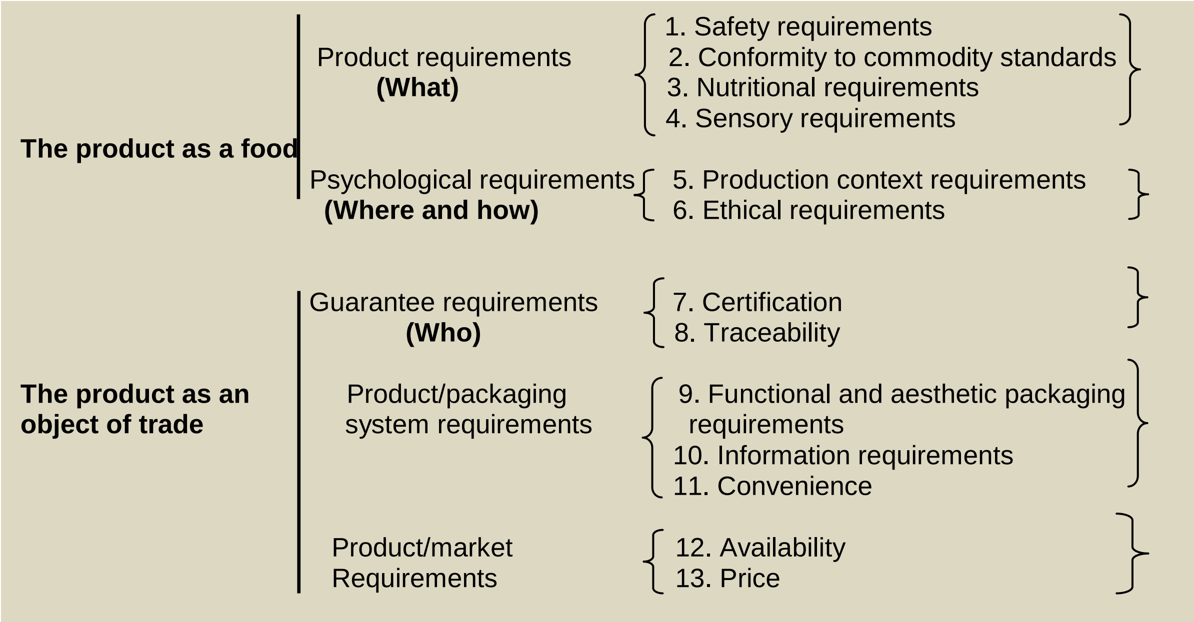
The following are some cases of effects of pesticides: In UK, 103 wild life deaths were reported in 2005 and this was attributed to pesticides mostly organophosphates and carbamates (Barnett *et al*., 2006). Contamination of irrigation water with herbicides due to accidental spillage into Tiaozi and Zhaosutai Rivers caused rice crop losses in Liaoning Province in China in 1997(Li *et al*., 2007). Effects of chemicals in Zimbabwe in terms of soil and water pollution have been reported in water bodies such as Lake Chivero, Kariba and Mutirikwi (Svotwa *et al.*, 2007).

2.4 Quality and safety in the vegetable sector

Generally, quality is defined as meeting or exceeding consumer expectations and several quality concept or models have been developed by different authors to allow quality analysis. However the concept of quality is more often than not confusing considering that people take quality in different outlooks depending on position and role in food production-marketing value chain (Evans and Lindsay, 2005).

According to Peri's (2006), analytical model, food quality has two parts: requirements of the food product itself and requirements of the product as a market object. Constituents of each part are shown in Figure 2. From the model, food safety is an important attribute of quality referring to absence of risks (chemical, physical and biological contaminants) to the consumer.

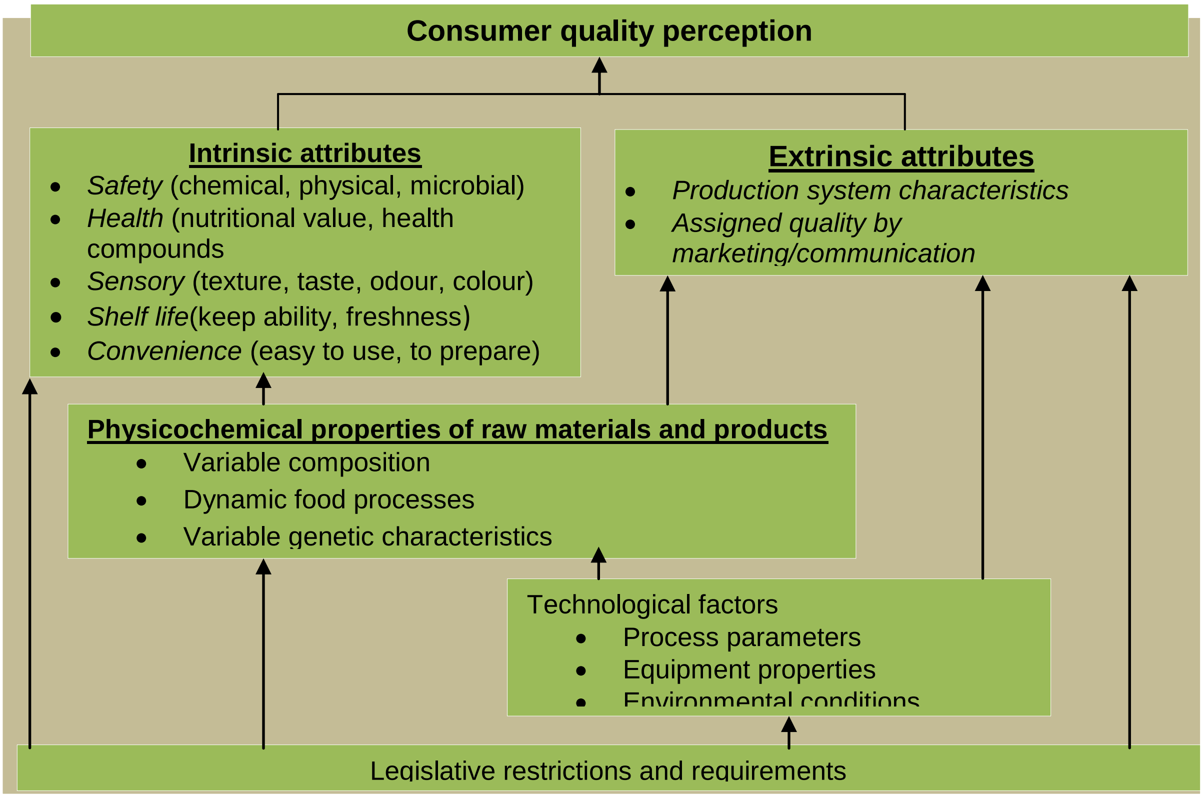
Figure 2: Food quality analytical model



Source: Peri, 2006

From Luning *et al*., (2002) perspective, quality is composed of intrinsic and extrinsic attributes which can influence food product acceptability by consumers. Intrinsic attributes relates to the physical product such as texture, colour, safety and nutritional aspects, extrinsic attributes are linked to production and marketing aspects of a particular food product for example production systems and brand name as shown in Figure 3.

Figure 3: Intrinsic-extrinsic quality model



Adopted from Luning and Marcelis, 2009

Looking at both models of quality outlined in Figure 2 and Figure 3, safety is a critical attribute that need to be taken care of and pesticides fall under the safety hazards. Increased recognition of the potential hazards arising from consumption of fresh produce has led to extensive research in the field, and the development of improved quality assurance systems for fresh produce. Food safety risks occur throughout the marketing chain. Produce is exposed to contamination during the handling, transportation, storage and retailing process. Consumers are vulnerable to unsafe food, which may not be apparent from the appearance of the food. This applies both to consumers in producer households and to consumers purchasing from market. According to Luning and Marcelis (2009), consumers usually pay a premium for a visible quality attribute as food safety is a hidden attribute which is frequently ignored by local consumers who in some instance s are not even aware of safety issues.

Major transnational food processing firms often had been key chain coordinators that determine food quality and safety standards but more recently, major retailers or even consumers are now active in imposing food quality and safety conventions in food chains (Oosterveer, 2007).

In order to help quality management in food production chains, several quality assurance guidelines have been developed some focussing on primary production while some are relevant for all actors in the entire supply or value chain. GlobalGap and Integrated quality assuarance systems are examples of standards that are explicitly meant for vegetable and fruit production while Codex Alimentarius guidelines, ISO 22000, Safe Quality Food (SQF) and Hazard Analysis Critical Control Point (HACCP) can be operated by any actor in the supply or value chain (Luning and Marcelis, 2009).

2.5 Integrated pest management concept

According to Meerman *et al*., (1997), Integrated Pest Management was developed during the 1970s to take care of the negative effects of pesticides particularly pest resistance to chemicals and effect of pesticides on health of farmers, farm workers and consumers.

There are many definitions of IPM, however, the following definition has been agreed by the Food and Agricultural Organisation (FAO), and is supported by international farmer organisations, plant protection industry and NGOs:

> *"Integrated pest management means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimise risks to human health and the environment."* (FAO, 2002).

From this definition, it implies that IPM is an approach of managing pests like insects, diseases, weeds and animals by combining appropriate cultural, physical, biological and chemical tactics that are safe, profitable and environmentally friendly as outlined by Ministry of Agriculture (2010).

2.5.1 IPM principles and components

When putting IPM into practice, it is a prerequisite to be able to identify insects, diseases and weeds and consequent assessment of pest abundance. The practising farmers need to have knowledge of biology and ecology of the pests attacking crops together with factors influencing pest incidences such as weather and natural enemies. Critical to know also are the types of pesticides that have to be used as a last resort regarding their toxicity levels and whether they are recommended for use on particular vegetables and specific pests.

Knowledge of the aspects outlined overleaf will help in making informed decisions on what management tactics to use (Dobson *et al.*, 2002) and these practical perspectives of IPM are outlined in Table 2. Thus IPM's ultimate goal is to suppress pest populations to levels that do not cause economic damage not complete eradication meaning that some pests have to be present and tolerated so that natural enemies will remain in the crop to suppress subsequent infestations and emphasises building on farmers' ability to find out what works best for them thereby improving their capacity to make informed decisions and empowering them in a bid to enhance their socio-economic status (Fliert, 1993).
In a nutshell, IPM has three compulsory components which are:

- *Monitoring* – Looking out for presence of pests, detecting, identifying and determining pest population levels timely.
- *Forecasting* – Predicting when certain pests will most likely to occur based on local conditions.
- *Determining thresholds* – Coming out with pest levels beyond which economic damage occur prompting action to be taken by growers.

Table 2: Steps in IPM operationalisation

Component	How to achieve the activity	Justification
Agro-ecosystem analysis	Sampling of the surrounding ecosystem	To monitor vegetable ecosystem so as to make informed decisions on pest management through ecological approach to avoid overuse of pesticide
Understanding life cycle of insect pests	Rearing of insect larvae in glass containers, nets or cups	To understand the biology of insects and the relationship between egg, larvae, pupae, adults and their development
Analysis of disease triangle	Discussions on incidence of vegetable diseases relating to variety resistance, environment and pathogens by both farmers and supporters	To understand vegetable diseases ecology
Pesticide label understanding	Reading and comparing different pesticides from the market	To understand the relationship between commercial, common names and active ingredients of pesticides. To identify fake and illegal pesticides
Knowing the toxicity of pesticides	Dipping vegetable leaves in high toxicity pesticides	To understand pesticide toxicities to animals and humans.
Knowledge of banned pesticides	Discussion on name lists of banned pesticides	To know pesticides which are forbidden for use on vegetables.
Understanding and knowing natural enemies	Exposing insect pest larvae to predatory natural enemies inside jars	To understand the role of natural enemies in controlling pests.
Knowledge and understanding of minimum interval between using pesticides and harvesting	Discussions on minimum intervals between using pesticides and harvesting	To understand the critical stages of possible pollution of vegetables by pesticides.

Source: Yang *et al.*, 2002.

The following are key prerequisites of an IPM approach as adopted from Republic of Kenya (2009):

i) Comprehension of farming system ecology (crops grown, pests and factors influencing development)

ii) Understanding of the economic aspects in the production system (infestation levels, market potential and product prices)

iii) Understanding of the socio-cultural behaviour of farmers in terms of decision making (preferences, behaviour towards risks).

iv) Inclusion of the farmers in analysing pest problems and management.

v) Agricultural policy framework and legislation conducive to sustainable IPM strategy.

2.5.2 IPM technologies, benefits and shortfalls

Management tactics of IPM comprises cultural (including physical and mechanical), biological and chemical methods. Cultural means techniques such as crop rotations, adjustment of planting times, planting disease free seed, optimum plant populations, rouging, stale seed bed technique, trap cropping, mulching, practising good sanitation and hygiene, removing overwintering sites and preventing seeding of weeds. Biological control is achieved in two ways by conservation of natural enemies (predators, parasitoids and pathogens) or inundative release of the parasites and predators. Chemical control in IPM systems is achieved by application of pesticides only when monitoring and thresholds have indicated need and due consideration is made on safe use of agro-chemicals (Dobson *et al.*, 2002). Growers need to purchase registered pesticides from reputable chemical dealers. Chemicals applied need to be pest specific in a bid to reduce the negative effect on beneficial species. The lowest recommended chemical rate has to be used and rotation of chemicals with different mode of action is a requirement to prevent development of pest resistance. It is mandatory for pesticides to be handled, stored and applied safely. In Zimbabwe, all pesticides used in the country have to be registered in terms of the Fertilizers, Farm Feeds and Remedies Act of 1996 (Ministry of Agriculture, 2010).

While the immediate aim of IPM is crop protection, there are other advantages of the approach. IPM aims to safeguard human health. As with any approach to improving food supply, it is concerned with providing consumers with nutritious products of good quality. IPM's contribution to human health is through reduction of inappropriate pesticides thereby cutting the risks of living with pesticides especially risks due to exposure to pesticides in and around the farm. There is also a reduction of pesticide residues on produce for consumers and less risk of soils, irrigation water and drinking water becoming contaminated. Another specific area in which IPM is contributing significantly to human health is through improved food safety by prevention of poisoning resulting from contamination of food, feed and the environment by chemical pesticides (SP-IPM, 2008).

IPM can be a cost-effective production approach offering competitiveness. Agrochemicals can be a financial burden on farmers and often beyond the economic reach of farmers especially smallholders. IPM as an expanding toolkit of cost-effective renewable options it can help farmers cut production losses without having to pay the high costs of non-renewable inputs. Since IPM is more knowledge and labour intensive compared with conventional use of pesticides, it implies that the economic attractiveness of IPM depends among other factors on the willingness of farmers to invest time in learning new methods of pest control that enable them to better understand agro-systems as the basis of sound pest management decisions. Another competitiveness that can be offered by IPM is the ability of farmers to meet public quality standards as with IPM it is easier for farmers to meet pesticide residue limits. The capacity to grow and sell high-value products, whether in local or export markets is increasingly recognized internationally as a key developmental driver (European Crop Protection Association, 2010).

IPM contributes to protection of the environment through enhancing existing ecosystems instead of ignoring or undermining them. IPM minimises use of chemical pesticides although these products remain integral to IPM and frequently play a key role in plant protection only when necessary. Biodiversity is maintained especially the protection of non-target organisms both above and below ground. The negative effects of broad-spectrum pesticides over the years are a major reason for increasing public mistrust of synthetic chemicals in agriculture. IPM research offers a range of bio pesticides and botanicals as alternatives to synthetic pesticides, but even with these options it calls for appropriate training of end users to ensure both judicious application of the products and maximum benefits (SP-IPM, 2008).

2.5.3 IPM in vegetable production

Integrated pest management has gained much popularity and is believed to be one of the best solutions to pesticide residue related problems in vegetables worldwide. In China for example, pesticide residues used to be an impediment in sustainable vegetable production. Through the support of international organisations such as FAO, a shift was made towards implementation of IPM programs in vegetables around year 2000 using the farmer field school approach. Light traps, use of yellow cards and sex pheromones are non-chemical pest control strategies that are widely used by vegetable growers in China in IPM systems (Yang *et al.*, 2007). IPM studies that have been done in China have shown IPM to be a success in reducing pesticide residues and most vegetables that are grown through monitored IPM systems end up being labelled as safe produce through local IPM associations (Fu and Liu, 2006). From a chain perspective, this confers to safety management thus assurance of quality and market reliability on the part of the producers. Taking Netherlands for example, over 90% of all cucumbers, tomatoes, sweet peppers and eggplants are estimated to be produced under IPM (Radcliffe *et al*., 2009).

2.6 IPM and pesticide policies and legislation

World-wide, it has been commonly agreed that injudicious use of pesticides have negative effects on human health and the environment which has resulted in formulation of policies and legal frameworks which have an impact on implementation and utilisation of IPM strategies in food production. Some of the policies are described below:

World Bank Operational Policy on Pest Management (OP 4.09 1998)

The rising public concern that The World Bank's agricultural intensification projects were contributing to increased use of pesticides prompted the bank to come up with a policy on IPM. The policy has three two main parts in view of IPM which are technical cooperation between developing countries and increased information dissemination.

FAO International Plant Convention 1952

This is an international treaty that is meant to prevent introduction and spread of plant pests and therefore promote relevant measures to manage and control them.

World Food Security and Plan of Action 1996

This declaration promotes regional collaboration in control of plant and animal pests using integrated pest management practices.

Codex Alimentarius

Codex principles require that any sector of the food chain must operate alongside general principles of food hygiene and appropriate food safety legislation at that specific chain level must be followed. According to the Codex, certain conditions are needed regarding raw materials, equipment, personal hygiene and sanitation (Codex Alimentarius Commission, 1998).

In Zimbabwe, pesticide use is mainly governed by the Pesticide Regulations of the Fertilisers, Farm Feeds and Remedies Act Chapter 18:12 of 1977 and to some extent by the Hazardous Substances Act Chapter 15:05. Whilst the former stipulates the procedures to be followed during registration and use of a pesticide, the latter legislation requires pesticides to be classified according to the hazard they cause. Under the Pesticide Regulations, all pesticides have to go through thorough screening and have to be registered before importation and use in the country. The Plant Protection Institute of the Department of Research and Specialist Services (DR&SS) administers pesticide registration and has the mandate to oversee importation and testing of all pesticides (Mlambo, 1985).

2.7 Multi-stakeholder approach in IPM systems for quality and food safety in vegetables

A value chain is present when all stakeholders in that particular chain work towards creation of value along the chain as indicated by Van den Berg *et al.*, (2008). Furthermore, Henriksen *et al*., (2010) asserts that the value chain concept encompasses issues of coordination, strategies for cooperation and power relationship of the various stakeholders in the chain. This entails that both the public and private sector have pivotal roles to play to ensure safety in vegetable chains from production to consumption and Table 3 is an outline of the different roles. Governments are required to create the enabling environment for chain development through policy formulation and creation of regulations that provide a framework for actors and supporters in chains.

Table 3: Stakeholder roles in food quality and safety management in supply chains

Public sector	Private sector
• **Policy and regulatory environment** -Adopting food safety legislation and standards appropriate for local conditions -Following international dialogues • **Awareness building and promotion of good agricultural practices** -Support and carrying out consumer awareness campaigns on food safety -Promote good agricultural practices to be integrated into extension programmes -Invest in necessary laboratory infrastructure and accredit private laboratories	• **Good management practices** -Implementation of management practices (good agricultural practices, hazard analysis and critical control point) -Where viable obtain formal certification • **Traceability** -Develop systems and procedures for enabling traceability in vegetable chains • **Training, advisory and conformity assessment services** -Offering training and strengthen human capital and management systems to horticulture and government related to quality and food safety management. • **Collective action** -Adoption of agricultural codes of practice

Source: World Bank, 2008

In the domain of green and safe food production, market governance consists of more and pro-active roles of producers, retailers and consumers. These private mechanisms play a critical role in provision of safer and higher quality produce, for example retailer driven quality and safety assurance schemes such as GlobalGap and Community Support Agriculture for Organic Farming are notable arrangements working in OECD countries (Thompson and Coskuner-Balli, 2007). Most empirical studies focussing on food safety conventions draw their conclusions from western agri-food networks and research mostly in Europe has clarified that food safety concerns have become critical drivers for re-organisation of food chains and food safety policies (Knowles and McEachern, 2007). According to Kjaernes and Poppe (2005), countries differ greatly in institutional arrangements on food safety but what is required is a strong alignment between state regulation and market provisions.

CHAPTER THREE: METHODOLOGY

3.1 Study Area

The research was done in Masvingo district of Masvingo Province in the south eastern part of the country (Figure 4). Masvingo is one of the ten provinces in Zimbabwe nine of which are Mashonaland Central, Mashonaland West, Mashonaland East, Matebeleland North, Matebeleland South, Midlands, Manicaland, Bulawayo and Harare. Location of Masvingo district is indicated by an arrow on the map below.

Figure 4: Location of Masvingo district in Zimbabwe.

Source: World of Maps, 2007

Masvingo province was primarily selected because it is the working province of the researcher. In Masvingo Province there are seven administrative districts of which Masvingo district is the bread basket of the province due to its favourable climatic conditions suited for growth not only for vegetables but also other field crops like maize, soya beans and groundnuts.

According to Vincent and Thomas (1960), Zimbabwe is divided into five agro-ecological regions based mainly on effective rainfall. The rainfall patterns and crop production progressively deteriorate from region 1 to 5 as shown on Table 4. The proportion of regions in Masvingo district are 7% region 3, 82% region 4 and 11% region 5 and for this reason, Masvingo comes out to be the largest vegetable producing district in the province (Table 5).

Table 4: Agro-ecological zones of Zimbabwe

Natural Region	Area (km^2)	Rainfall (mm $year^{-1}$)	Farming system
I	5 835	>1000	Specialised and diversified
II	72 745	800 – 1000	Intensive farming
III	67 690	650 -800	Semi- intensive farming
IV	128 370	450 – 650	Semi- extensive farming
V	112 810	<450	Extensive farming

Source: Vincent and Thomas, 1960

Table 5: Masvingo province vegetable production area (ha)

	Bikita	**Chiredzi**	**Chivi**	**Gutu**	**Masvingo**	**Mwenezi**	**Zaka**	**TOTAL(ha)**
Tomato	20	3	3	46	62	4	15	**153**
Onion	6	1	2	27	55	2	21	**114**
Cabbage	14	-		36	62	1	31	**144**
Rape	27	4	3	12	87	1	6	**140**
Kale	28	5	4	20	108	5	77	**247**
Butternut	-	-	-	-	5	-	1	**6**
Garlic	-	-	-	-	17	-	-	**17**
Spinach	1	-	-	-	10	-	-	**10**
Broccoli	-	-	-	-	6	-	-	**6**
Cauliflower	-	-	-	-	5	-	-	**5**
Cucumber	-	-	-	-	5	-	-	**5**
Eggplant	-	-	-	-	3	-	-	**3**
Lettuce	-	-	-	-	7	-	-	**7**
Beetroot	-	-	-	-	6	-	-	**6**
Carrots	5	-	1	2	10	-	-	**11**
Green beans	-	-	-	-	10	-	-	**10**
TOTAL(ha)	**95**	**13**	**12**	**141**	**458**	**13**	**151**	**883**

Source: AGRITEX, 2011a

3.2 Background of research methodology

Desk study was utilised to get data from existing literature that was necessary as the building block of this research before setting off for field work. Sources of information for this method include text books, PhD theses, scientific journals and publications, Ministry of Agriculture reports, departmental documents and reports, NGO reports, seminar proceedings and internet. Primary field data through field survey, key informant interviews and discussions formed the basis of the research. A combination of survey, case study and desk study was done for content analysis from varied sources a research technique described as triangulation by Verschuren and Doorewaard (2010).

3.3 Primary data collection

Primary data collection was done through a survey of vegetable growers and case studies of both public and private institutions crucial in implementing IPM in the vegetable sector. Data collection was done in four weeks. The first week was concerned with sorting out logistics for field work and pre-testing of survey questionnaire while the other three weeks were devoted for questionnaire administration, carrying out of discussions with key informants and data entry.

3.3.1 Survey

A survey was used to collect data from vegetable growers in Masvingo district in order to generate a wider scope of information related to IPM across the district. A list of potential respondents (vegetable growers) was compiled and 30 farmers were randomly selected of which 15 were from resettlement sector, 9 from communal sector and 6 from large scale sector. Initially 33 samples were selected out of the sampling frame to cater for non responses due to some circumstances beyond the researcher's control for example absence of vegetable grower. Hence the extra 3 catered for those non-predictable situations that might arise. When the sample was in place, the researcher communicated with extension staff in wards where there were farmers to be interviewed so that the field staff would be aware of intension and purpose of survey.

Face to face interviews were done using a semi-structured questionnaire consisting of both closed and open ended questions. Inclusion of open-ended questions in the questionnaire was crucial in providing detailed comments from the respondents in aspects that required a deep understanding not to so as not to rely on pre-coded data. The farmer questionnaire (Appendix 1) focused on pest management practices used, constraints in pest management, knowledge and skills on safe use of pesticides, IPM and quality management of vegetables, knowledge of health and environmental effects of chemical pesticides and views on IPM. Farmers were also asked on the challenges for going the IPM way to ensure safety in vegetables. Out of the 30 farmers surveyed, 28 questionnaires were filled with the researcher while the other 2 were filled by the farmers themselves.

The researcher did questionnaire administration with the assistance of AGRITEX provincial horticulturalist. Before undertaking questionnaire administration, the researcher held a meeting with the Provincial Horticulturalist to explain and clarify questions so that the questionnaire would be understood in the same way. The survey questionnaire was pretested with 4 respondents before start of the study to enable errors, omissions and unclear/confusing questions to be identified and adjustments were made on some questions accordingly. Upon arrival at a growers' homestead or field, introduction would be made to the farmer and the researcher would explain the purpose of the visit. The researcher stressed to the respondents that the information collected was crucial as it would lead to understanding of safety in vegetable sector relating to pesticide and bring out challenges of IPM adoption from the perspective of the producers.

3.3.2 Case study

Another method that was used in this study was case study in which key stakeholders were interviewed with the help of checklists (Appendix 2-4). After identification of relevant key informants, the researcher made telephone calls to notify the respective organisations about the research and to place appointments to hold discussions. This was followed by a written note outlining questions of focus so that the key informants would prepare beforehand in a bid to save time both on the side of the researcher and the key informants. Discussions were done either with individual personnel or as a group of key informants at organisational level to have in-depth understanding of role of institution in IPM, ascertain if any programs are in place in view of IPM, capacity of service providers and actors in the vegetable sector within IPM context and to cross check reliability of information gathered using other methods such as departmental reports. Interviews with the following key informants were done with the help of checklists:

i)AGRITEX- AGRITEX as a government agent mandated to implement agricultural policies related to all crops in Zimbabwe has the main function of providing technical advisory services to farmers hence an important stakeholder in vegetable sector (Appendix 2). Discussions were done with Provincial Agricultural Extension Officer (PAEO), District Agricultural Extension Officer (DAEO) and District horticulturalist of Masvingo district.
These key informants from AGRITEX were selected as they are influential people in terms of agricultural technology development and dissemination in their particular district. Interviews with AGRITEX were done to get an understanding of their views on IPM, institutional capacity (knowledge and skills in IPM, safe use of pesticides, food safety aspect related to pesticide residues) and markets supplied with vegetables and requirements. Included in the discussions were issues pertaining to effects of current agricultural policies on implementation of IPM and what they think need to be done to improve development of IPM for quality and food safety management in the vegetable sector.

ii)Producer organisations with representation in Masvingo District: Zimbabwe Farmers Union (ZFU), Zimbabwe Commercial Farmers Union (ZCFU) and Commercial Farmers' Union (CFU). These producer organisations were selected as they are important stakeholders in vegetable sector with a diverse of functions: advocating for policy formulation, change or reformation, mobilising farmers, providing technical support to producers, providing different information to affiliates and linking farmers to markets so their position needed to be understood in terms of programs in place related to IPM and safe use of pesticides, linkages with other stakeholders pertaining to IPM and opinions on policy and strategies to development (Appendix 3). For this purpose, a discussion was done with the Chief Executive officer of ZFU, Programs Development Officer from ZCFU and Provincial Chairman of CFU.

iii)Horticulturalist from CARE International in Zimbabwe (NGO). CARE was selected as it is an important stakeholder in the vegetable sector particularly when it comes to facilitating technology development through farmer and stakeholder training and linking farmers to various markets.

Initially the researcher had identified the Programs Manager as the key informant but was referred to the horticulturalist who is responsible for coordination of all horticultural projects in addition to being the knowledge person in the subject of IPM. In this view, an in depth discussion was done which aimed to address questions regarding whether the organisation has any programs/projects with IPM focus, the exact role of CARE in IPM, institutional capacity in implementing IPM, any linkages existing with other organisations public or private in IPM context and stakeholder's opinion of IPM (Appendix 3).

iv)Sustainable Development Officer (SDO) from CARITAS Zimbabwe. The organisation was purposively selected as it is an NGO popular in Masvingo district with focus on sustainable agricultural production. The interview done with the key informant was aimed to find answers to the same questions as for (iii) above

v)Action Contrella Faim (ACF). This NGO was selected in the study due to its participation in horticultural related projects including vegetable production and marketing. An appointment was made with the Food Security Programme Manager (FSPM) in the organisation, but fortunate enough he went on to invite the marketing officer and field officer attached to the gardening projects. A discussion was then done with three officers from Action Contrella Faim with the same agenda as with other supporters.

vi)In the retailing sector, discussions were done with quality control/or marketing personnel in the fruits and vegetable department from Spar Balmain, TM, OK and Tsungai [supermarkets] and QET and Recent Farm Produce [specifically fruit and vegetable shops] (Appendix 4). As these retailers constitute part of the private sector and markets for vegetable growers, a comprehension of market requirements pertaining to pesticide use at production needed to be understood and information regarding to whether there are price premiums paid to vegetables produced with minimum pesticide use. The study also sort to establish linkages if any with producers and what kind of linkages.

vii)Horticulturalist -Horticultural Promotion Council
A discussion was done through the telephone with this key informant. The organisation was selected as it is responsible for steering or promotional agent of the horticulture sector. Main focus of the discussion was on any projects with IPM focus being promoted, organisational capacities, any linkages and what the organisation's views on IPM development/upgrading strategies for food safety in vegetable sector (Appendix 3).

3.4 Research framework

As different sources on information were utilised during the study to find answers to the research question, Figure 5 illustrates the research framework work while a summary for sources of information for specific research questions is outlined in Table 6.

Figure 5: Research framework for IPM in vegetable sector

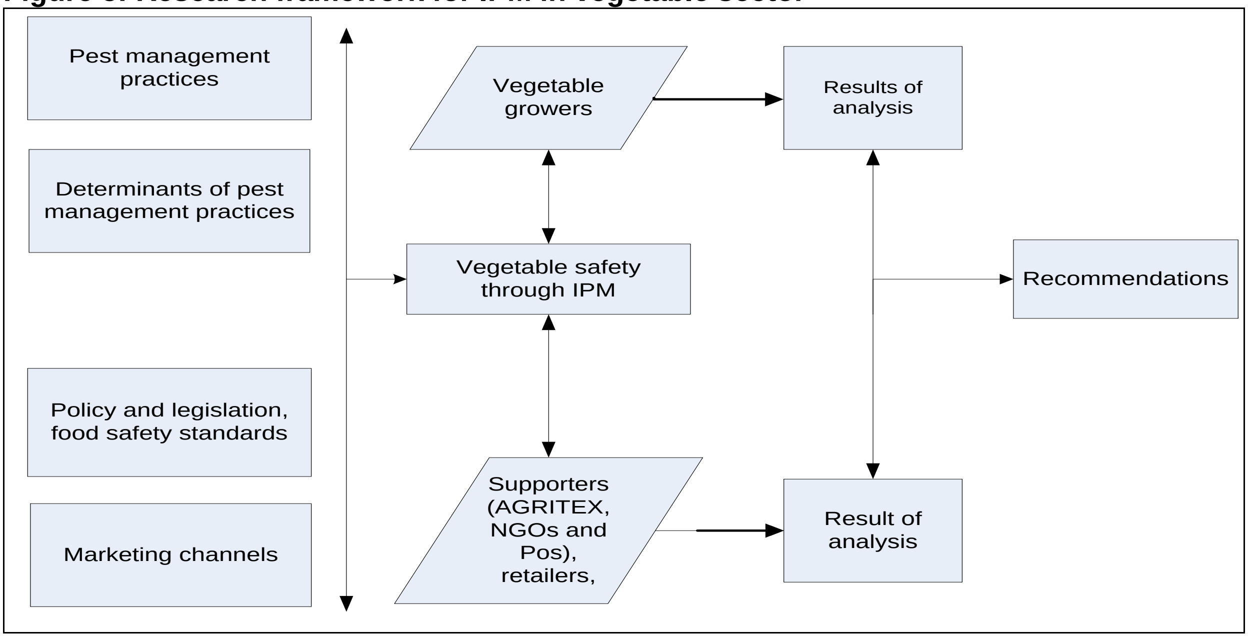


Table 6: Summary of data sources

Research sub question	Information gathered	Source
1 a)	Pest management practices used in vegetable sector	Survey
1b)	Linkage between pest management practices and IPM	Survey
1c)	Determinants of pest management techniques	Survey, key informants
1d)	Markets recognising IPM as a quality and food safety management strategy	Survey, key informants
2a)	Roles of stakeholders in vegetable sector in IPM	Key informants, survey, literature
2b)	Capacity of stakeholders in implementing IPM in vegetable sector	Key informant discussions
2c)	Policies and legislation in support of IPM for safety in vegetables	key informants, literature
2d)	Driving and hindering factors for IPM utilisation in vegetable sector	Survey, key informants, literature

3.5 Data Analysis

Data collected from survey were coded and analysed using SPSS. From SPSS descriptive frequencies were mostly reported based on the percentage of farmers' responses. Input of key informants from the case studies was processed by grouping and structuring responses for a particular question. PEST/SWOT matrix was used for analysing the whole vegetable sector in the context of IPM technology utilisation for pesticide residue management.

3.6 Limitations

The sample size (30 farmers) that was utilised for the survey was small and statistically results in a large sampling error. Consumers who are an important stakeholder in the vegetable sector were not part of the study. From the consumers' perspective, first hand information pertaining to levels of awareness on vegetable quality and safety in relation to pesticide residues and indications on whether consumers would be willing to pay different prices depending on pest management regimes would be derived.

CHAPTER FOUR: RESULTS

4.1 Background information of vegetable growers

The survey research indicated 0.77 to be the average area where vegetables are grown with 80% of the respondents grow vegetables on an area of less than a hectare (Table 7).The average number of years that the interviewed farmers had been into vegetable production was 15 years and 53% (n=16) of the farmers interviewed indicated that they have 15 or more years experience in growing vegetables.

Table 7: Descriptive frequencies for area (ha) on which vegetables are grown in Masvingo district

Area (ha)	Number of vegetable farmers	%	Cumulative %
0.0045	3	10	10
0.05	1	3.3	13
0.1	11	36.7	50
0.15	1	3.3	53.3
0.2	5	16.7	70
0.3	1	3.3	73.3
0.4	1	3.3	76.7
0.5	1	3.3	80.0
1.5	1	3.3	83.3
2.0	2	6.7	90
3.5	1	3.3	93.3
4.5	1	3.3	96.7
6.0	1	3.3	**100**
TOTAL	**30**	**100**	

4.2 Vegetables grown and pests of economic importance

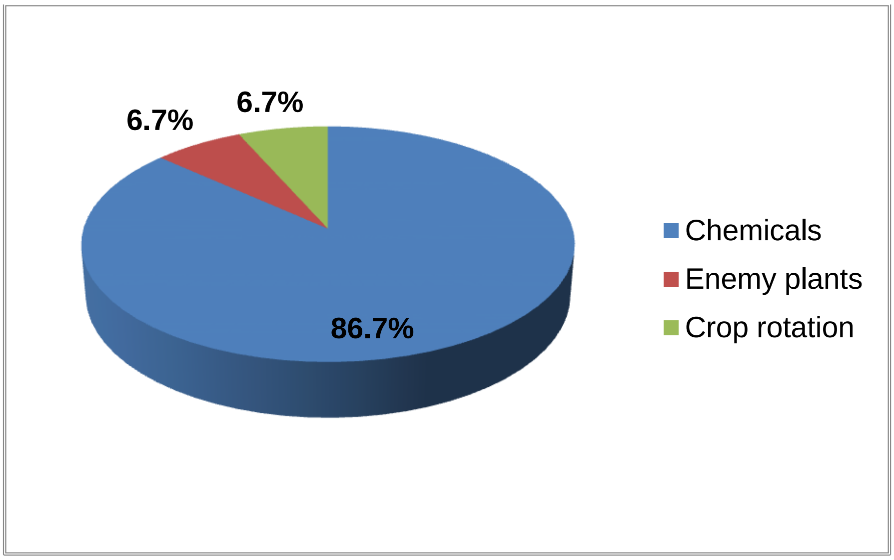
The main vegetables that were mentioned by the farmers include kale, rape, tomatoes, onion, butternut, spinach, cabbage and carrots and these were mentioned by 93.3% (n=28) of the interviewed farmers. High value vegetables consisting of broccoli, cauliflower, green beans, cucumber, garlic, beetroot, lettuce and eggplant were mentioned by 6.7% of the interviewed growers in addition to the common vegetables. All the farmers interviewed mentioned growing at least one leafy vegetable while 80% (n=24) of the farmers mentioned growing of tomatoes. Out of the 30 interviewed vegetable growers, 43.3% (n=13) and 56.7% (n=17) indicated that they grow vegetables during the winter season and throughout the year respectively. Major pests as revealed from the survey comprise aphids, African bollworm, cabbage moth, cabbage webworm, caterpillars, cutworms, diamond back moth, flea beetle, leaf miner, spider mites, semiloopers, thrips, whitefly and white grubs. Problematic diseases include Anthracnose, bacterial speck, bacterial spot, *Botrytis*, damping off, Downey mildew, early blight, late blight, leaf spot, powdery mildew, *Septoria* leaf spot and stem canker.

4.3 Pest management practices

4.3.1 Techniques used for pest control

The study looked at the following variables of pest management practices: chemical pesticides, enemy plants, crop rotation, biological control, light traps and manual removal. From the survey, the dominant pest and disease management option came up to be chemical as indicated by 86.7% (n=26) of the respondents (Figure 6). Crop rotation and use of enemy plants were also some of the pest management practices that were pointed out with each scoring 6.7% (n= 2). Other pest control methods that did not have any responses are biological control, light traps and manual removal. From the sampled vegetable growers 6.7% (n=2) indicated that they no longer use pesticides in vegetables the reason being that they have gone organic as they supply Flamboyant Hotel in Masvingo City which requires organic produce.

Figure 6: Dominant pest management practices



A Spearman Rank Order Correlation (Appendix 7) was done to determine the relationship between 30 growers' number of years they have been growing vegetables and the dominant pest management practice. There was a weak positive correlation which was not statistically significant ($r_s = 0.111$, p= 0.560).

Despite use of pesticides being the major pest management practice mentioned by the farmers, most of the growers utilised some techniques as part of their vegetable management that can be interpreted as an IPM strategy. These techniques include chemical rotations to prevent resistance, crop monitoring, washing insects off plants, rouging and ploughing in debris although the last two were not listed in the questionnaire. The most popular pesticides used by the growers are listed in Table 8 overleaf. Out of the 30 growers interviewed, 6.7% of the vegetable growers interviewed mentioned use of Fenkill, a chemical that is not recommended for use in vegetables but in cotton.

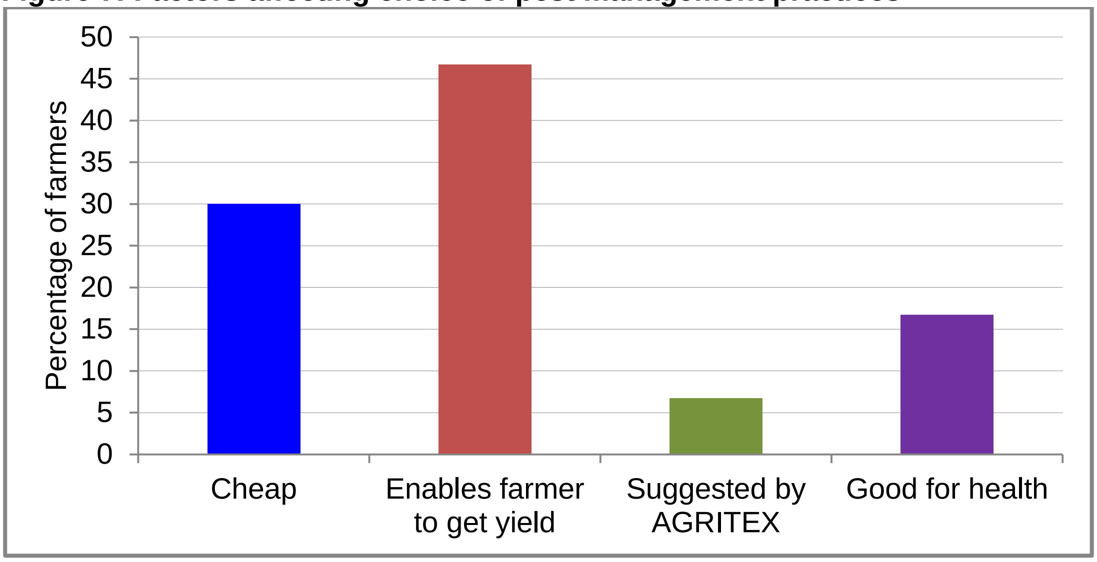
Table 8: Pesticides used in vegetable production in Masvingo District

Pesticide	Active Ingredient	% of growers using the pesticide
Copper oxychloride 85WP	Copper oxychloride	83.3
Carbaryl 85WP	Carbaryl	76.7
Dithane M 45	Mancozeb	73.3
Dimethoate 40EC	Dimethoate	60
Garden n' care	Carbaryl/Copper oxychloride/malathion	60
Malathion	Malathion	56.7
Agridust/Vegidust	Copper oxychloride/malathion/sulphur	50
Mitac	Amitraz	36.7
Fenkill	Fenvelarate	6.7
Leybacid	Fenthion	30
Furadan	Carbofuran	16.6

4.3.2 Factors affecting choice of pest control practice

The main consideration for use of a particular pest control practice by vegetable growers from the survey was whether the method enables the farmer to get yield as indicated by 46.7%(n=14) of the respondents, followed by cost effectiveness of the pest control method with 30% of the respondents noting it as an important factor. Effect of control method on human health and suggestions by AGRITEX were other reasons for choice of particular pest management practices as shown on Figure 7. Other possible factors for choosing pest control method that were not selected were: 'suggested by other farmers, suggested by NGOs, good for the environment and imitating others'.

Figure 7: Factors affecting choice of pest management practices



4.3.3 IPM knowledge by farmers and training sources

From the 30 vegetable growers who were interviewed, 73.3% (n=22) gave the response that they have knowledge of IPM and also have received basic training on IPM. On the other hand, 26.7% who indicated that they do not have IPM knowledge had not received IPM training. Out of those trained, AGRITEX and NGOs like CARITAS, Action Contrella Faim and CARE International were the main sources of training as highlighted in Table 9.

Out of the surveyed vegetable farmers, 70% (n=21) keep records of pest management activities, 96.7% (n=29) understand and practice scouting and 56.7% (n=17) can differentiate between pests and beneficial insects.

Table 9: IPM training sources of vegetable growers in Masvingo district

Source of training	**Number of farmers who indicated training source**	**%**
AGRITEX	15	50.0
NGOs	5	16.7
Farmer groups	1	3.3
Other sources	1	3.3
Total trained	22	73.3
Not trained	8	26.7
Grand Total	**30**	**100**

An Independent sample t-test was run to determine if there was a difference in the average area put on vegetables between growers who had knowledge of IPM and those who did not have IPM knowledge. Results (Appendix 8) showed that there was a significant difference at 95% confidence interval (Sig (2-tailed) = 0.024).

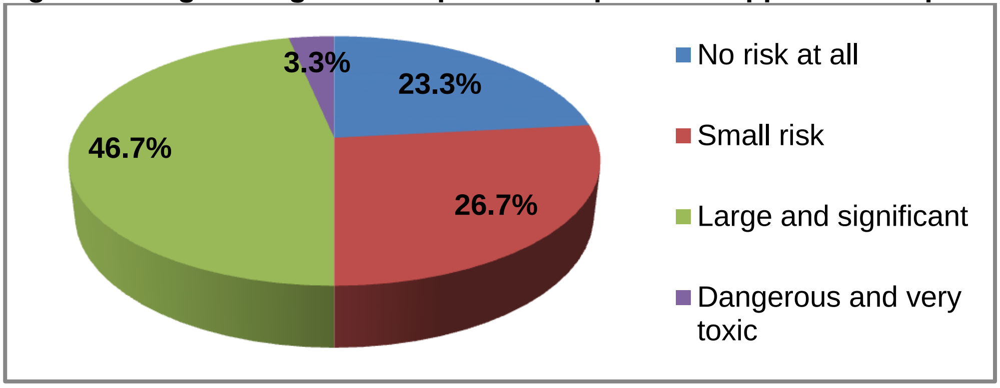
From the survey, it is clear that most of the farmers have received training on safe use and handling of pesticides and use of protective clothing and equipment. This is evidenced by a 90% (n=27) positive response in terms of training on the topic and 86.7% (n=26) of the respondents acknowledging application of pesticides when it is necessary to do so as opposed to routine application of pesticides in vegetables with a score of 13.3%.

All the vegetable farmers interviewed (n=30) indicated that when purchasing pesticides, information is always available pertaining to how to use the chemical, pests controlled by that specific chemical and dosages. Whilst 96.7% (n=29) of the interviewed farmers indicated that they can read and understand instructions on pesticides, all interviewees responded that they are conversant with pre-harvest withdrawal periods and also highlighted that they follow the harvesting intervals all the time.

4.3.4 Effects of pesticides

The interviewed farmers were asked about their opinions on the following statement: '*Pesticides can affect human and animal health, the environment and contamination of water systems'* and all the 30 interviewed farmers concurred with the statement. From the survey results, 56.7% (n=17) of the respondents indicated availability of protective clothing out of which 64.7 % (n=11) indicated that the protective clothing is in good condition while the remaining 35.3% (n=6) had an indication that the protective clothing is in fair condition. However in some instances, important equipment such as goggles and respirator would be missing. From the survey, farmers had the opinion that they are exposed to risks when they are applying pesticides and the scores are as follows: 3.3% (n=1) dangerous and very toxic risk, 46.7% (n=14) large and significant risk, 26.7% (n=8) small risk and 23.3% (n=7) no risk at all (Figure 8).

Figure 8 : Vegetable growers' opinions on pesticide application exposure risks



Risks of pesticides were not only confined to farmers themselves as 6.7% (n=2), 13.3% (n=4) and 6.7% (n=2) of the respondents indicated that they have witnessed pesticide related contamination of water bodies, death of livestock and sickness and death of human beings respectively.

4.4 Value placed on IPM for vegetable safety by stakeholders in the sector

4.4.1 Legal and policy framework

Literature search and discussions with key informants revealed that in Zimbabwe there is no policy framework that strictly focuses on sustainable production systems such as IPM. Examples of legislation used in Zimbabwe to ensure food safety in the food supply chain are highlighted in Table 10.

Table 10: Regulations used in Zimbabwe for food safety monitoring

Value chain stage	Potential hazard	Monitoring organisation	Legislation
Input supply	Contaminated water, pastures, genetically modified inputs	Biosafety Board of Zimbabwe(BBZ)	Research Amendment Act 1998
	Banned pesticides	DR & SS, Ministry of Health and Child Welfare (MOHCW)	Public Health Act Chapter 15:09
Primary production	Biologicals in genetically modified foods	BBZ	Research Amendment Act 1998
Primary food processing	Physical, biological and chemical contaminants	MOHCW, Government Analyst Laboratory (GAL), local authorities	Public Health Act Chapter 15:09
Secondary food processing	Biological, physical and chemical contaminants	MOHCW, local authorities	Food and Food Standards Act
Food distribution	Physical, biological and chemical	MOHCW, GAL, BBZ	Public Health Act Chapter 15:09, Food and Food Standards Act Chapter 15:04, Research Amendment Act 1998
Retailing and catering	Physical, biological and chemical	MOHCW, GAL, local authorities	Public Health Act Chapter 15:09, Food and Food Standards Act Chapter 15:04, by-laws

Source: FAO and WHO, 2005

When asked the question on effects of agricultural policy on IPM implementation in the vegetable sector, the PAEO of Masvingo Province said:

> *'Until government have formulated policy specifically tackling sustainable agriculture production systems, it will take time for our farmers to adopt environmentally friendly and safer methods like IPM*', (PAEO, Masvingo Province).

To support the same point of absence of policy, the SDO from CARITAS had this to say:

> '*If there is no policy framework, it is very difficult to instigate change hence there is need for strong advocacy for policy formulation, reform regarding sustainable agriculture incorporating such techniques as IPM.'*

4.4.2 IPM extension and technical support in vegetable sector

AGRITEX

The organisation's mandate according to the client service charter is to provide technical advisory services to farmers across all agricultural sectors in Zimbabwe. Now as a leading supporter in training farmers on agricultural technologies, AGRITEX staff does not have adequate capacity not only in IPM but a number of critical skills as explained by the PAEO of Masvingo Province:

> *'The economic hardships the country had been facing over the past decade severely affected extension in Zimbabwe. We experienced massive brain drain such that over 80% of extension staff on the ground are not equipped enough in many technical respects.' (PAEO, Masvingo Province)*

From a departmental training needs assessment that is periodically done every three months in March, June, September and December by AGRITEX to identify gaps in skills for extension staff, results obtained for Masvingo district are shown in Table 11.

Table 11: Training needs for Masvingo district technical/field staff

Item/topic	Total Number of staff	Number of staff trained	Number of staff who need training	Number who require refresher course
Knapsack sprayer calibration	125	112	13	57
IPM Concept	125	41	84	28
Safe Use of pesticides	125	125	-	55
Vegetable Nursery Management	125	100	25	10
Vegetable Pest and Disease Identification and Control	125	109	16	37
Post harvest Handling	125	65	60	41
Quality and Food safety Management in Vegetables	125	50	100	13

Source: AGRITEX, 2011b

Discussions done with key informants and review of organisational documents and reports indicated existence of programs and projects in place in the scope of vegetable quality and food safety management with a focus on IPM and the findings are described below.

NGOs active in vegetable sector

CARITAS Zimbabwe – Key informant interviews with this organisation revealed that as a supporter of agricultural sector, it focuses on advocating for sustainable practices of production of which IPM is one of its thematic areas. Asked on the institutional capacity, the Sustainable Development Officer in CARITAS indicated that the organisation is competent enough when it comes to knowledge and skills training in IPM. The officer went on to say that CARITAS is a member of Participation for Ecological and Land Use Management (PELUM) which is a network consisting of 10 countries in Africa with sustainable agricultural as its core business. Besides offering technical support to beneficiaries of its programs, CARITAS is active in linking vegetable producers to markets that calls for produce with reduced pesticides. The SDO indicated that in Masvingo District, they have supported setting up of gardens in the small holder sector in which IPM principles are strictly adhered to. Mention was also made of the importance of reduced pesticides in vegetables for the people infected with HIV/AIDS as synthetic pesticides can adversely affect the already weakened immune systems by the SDO. Thus from the discussion people affected and infected with HIV/AIDS were another target group of CARITAS garden projects.

Action Contrella Faim – A discussion with the personnel from this institution revealed that currently there is a low input gardens (LIGs) project being implemented in three districts of Masvingo Province which are Masvingo, Chivi and Gutu which directly hinges on IPM. Beneficiaries of LIGs are supplied with vegetable seeds, fertilisers and garden tools including hoes and watering cans. In the LIGs project, vegetables can be produced either organically or using IPM as the goal is to have vegetables with lower pesticide residues. The study further showed that ACF does not only provide technical production advice to farmers but also links farmers to markets that require vegetables produced with minimum use of pesticides. These markets include Flamboyant Hotel, Chevron Hotel, Spar Balmain, and OK Supermarket. The FSPM said that the institutional ability of ACF in IPM, food safety topics was strong as all the personnel undergo training upon getting employed by the organisation and he indicated that the organisation holds workshops and refresher courses so that the staff are kept updated with technological developments.

CARE International in Zimbabwe – A discussion done with the horticulturalist from this organisation revealed that besides provision of extension support to producers, the organisation do market research as a way of leveraging livelihoods of farmers such that they do not just produce without a clearly defined market for selling the produce to. The horticulturalist highlighted that IPM is part of CARE institutional policy hence a compulsory component in all projects implemented by the organisation involving vegetable production and marketing.

The organisational capacity of CARE in IPM was said to be strong but more capacity building is required in food safety issues and quality standards. On answering the question on what can be done to spearhead IPM implementation in vegetable sector, the horticulturalist was quoted saying:

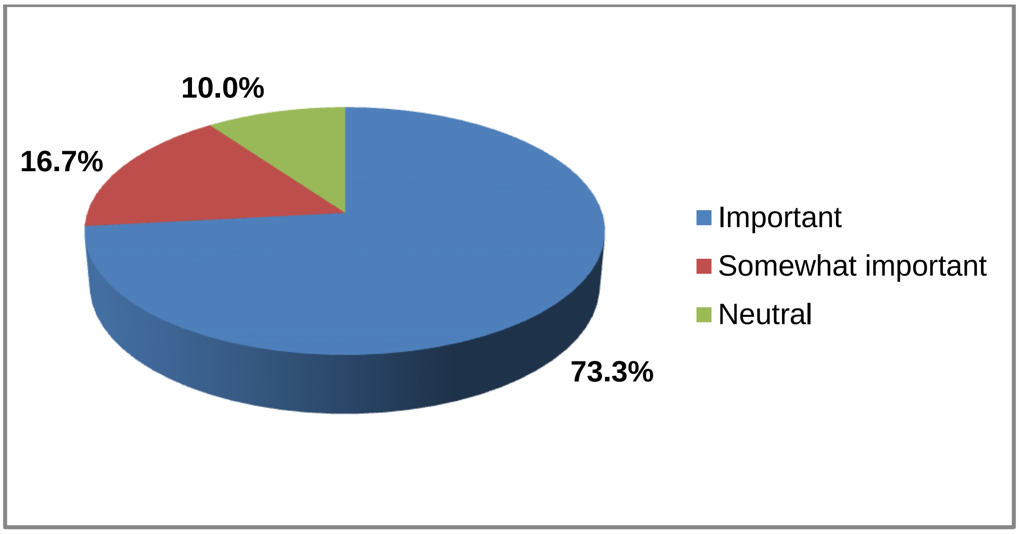
> *'Awareness to the consumer on dangers of pesticides can be a major driver to influence vegetable production systems that calls for reduced pesticide use. Another issue is that stakeholder linkages in most developmental issues in the agricultural sector are very weak, such that there is need for strengthened coordination and communication among development partners'.*

Producer organisations
ZFU, ZCFU and CFU as producer organisations came together and with the support of European Union (EU) are running a project which has been dubbed the 'Union Project'. The project covers 13 out of 54 districts in Zimbabwe of which Masvingo district is one of them. Vegetable producers are supplied with a full package of inputs in a contract system, technical advice and linked to markets. The Union Project employs agricultural consultants who train farmers on good agricultural practices including IPM and monitor production to ensure that the market requirements are met.

From the survey, 63.3% (n=19) of the farmers confirmed that they received training on quality and food safety related to pesticide residues while 36.7% (n=11) indicated that they did not receive any training. From those trained farmers, 63.2% (n=12) said they received that training from AGRITEX, 31.6% (n=6) from NGOs and only 5.3% (n=1) received the training from an agricultural institution. None of the respondents indicated producer organisations and pesticide suppliers as sources of training.

Out of the 30 respondents in the survey, 73.3% (n=22) indicated that they are aware of importance vegetable quality importance pertaining to pesticide residues, 16.7% (n=5) indicating that vegetable quality is to some extend important while 10% (n=3) of the respondents were neutral on question (see Figure 9).

Figure 9: Vegetable growers' rating on importance of quality related to pesticide residues



A Kruskal Wallis test (Appendix 9) that was done to determine if there is a difference in rating of vegetable quality between pest control methods indicated that there is no significant difference (p=0.452) in ranking of vegetable quality related to pesticide residues between dominant pest control method.

4.4.3 Vegetable marketing channels and market requirements

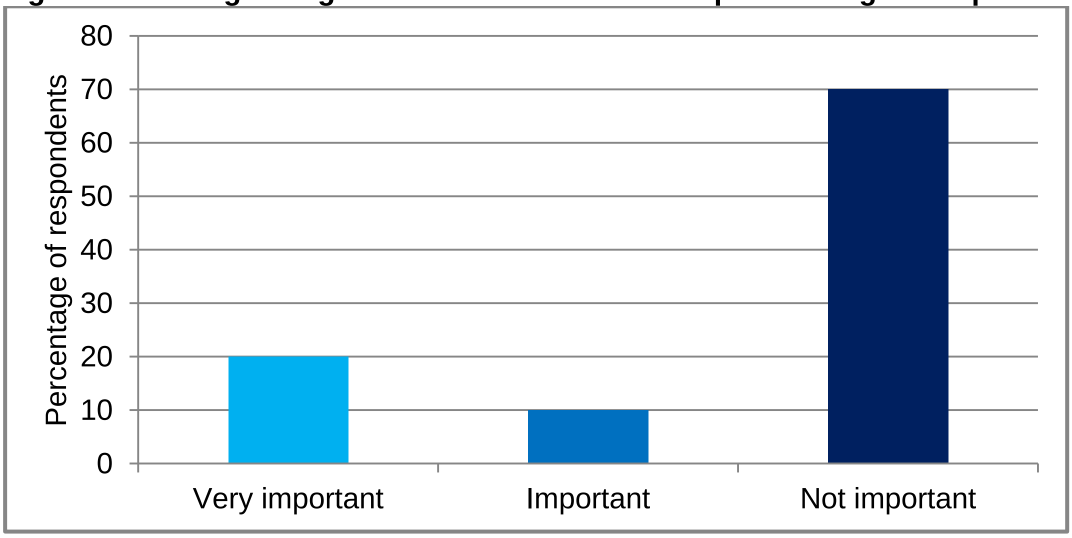
From the study, different markets where pointed out by the vegetable growers and these are highlighted in Table 12 and (also highlighted in Appendix 6) together with the market requirements.

Table 12: Market channels for vegetable producers in Masvingo district

Responses pertaining to market channel		**Responses pertaining to market requirements**	
Market channel	% of producers using channel	Market requirement	% of producers who indicated requirement
Local and farm gate	60.0	External quality and appearance	86.7
Masvingo City	66.7		
Institutions (Hotels, hospitals, boarding schools)	13.3	Hidden quality with regard to production system (IPM/organic)	13.3
Retailers and fast food shops.	20.0		

Markets that are particular to vegetable safety with regard to pesticide residues according to research findings include institutions such as Chevron Hotel, Flamboyant Hotel, Great Zimbabwe Hotel and retail outlets like OK Supermarket, TM Supermarket, Spar Balmain Supermarket, Recent Farm Produce and Chicken Inn. Retail vegetable shops such as QET Enterprises, Tsungai Supermarket and vegetable vendors from Masvingo City mostly look at the external appearance of the vegetable and simply trust the producers that the vegetables they sell are safe pertaining to pesticides as revealed from discussions done with personnel from respective shops and vegetable growers. The external vegetable quality attributes include long and undamaged leaves in case of leafy vegetables, unshrivelled vegetables and vegetables without noticeable insects or diseases. On responding to the question *'Do market requirements influence decision on pest control method?'*, a total of 30% (n=9) indicated that market requirements were important in influencing pest management method while 70% indicated that market requirements were not important in decision making of pest management method (Figure 10).

Figure 10: Rating of vegetable market influence on pest management practice



Whilst there are some clearly defined markets mentioned overleaf that are becoming particular in how vegetables are produced relating to pesticide use, there are not yet price differentials between conventionally produced vegetables and vegetables produced following IPM principles or organic produce. Asked on how then retailers make sure that the vegetables they sell are safe, the quality control person (fruits and vegetables) in Spar Balmain Supermarket had this to say:

> *"As a business entity, we are into contracts with specific vegetable growers. It does not only end there but we inspect all the contracted vegetables from nursery until harvesting time. We also inspect the surrounding areas of the growing environment. Specifications are made regarding pesticides that must be used by the contracted growers. Spar Balmain engaged in this linkage with vegetable growers to cater for the globally increasing growing public concern on effects of chemicals on health. Presently the farmer does not need to be certified to any quality standard but basic good agricultural practices have to be followed"* (Quality Control Personnel, Spar Balmain).

A discussion that was held with OK Supermarket quality control officer revealed that the supermarket gets all its vegetable supplies from FAVCO. FAVCO is a fruit and vegetable wholesaler which sells both to local (Zimbabwe), regional (within SADC) and international markets (mostly United Kingdom). The discussion further revealed that FAVCO is into contract farming with GlobalGap certified growers who are mostly concentrated around Harare City. Thus to ensure safety regarding pesticide residues in the vegetables sold, OK depends on FAVCO and there is no spot buying of vegetables and fruits.

4.4.4 Stakeholder linkages

The study revealed that stakeholder linkages in the vegetable sector with regard not only to IPM but across most programs are weak. It was revealed that most organisations do their projects on their own with minimum communication with other relevant stakeholders.

4.4.5 Opinions of stakeholders on IPM

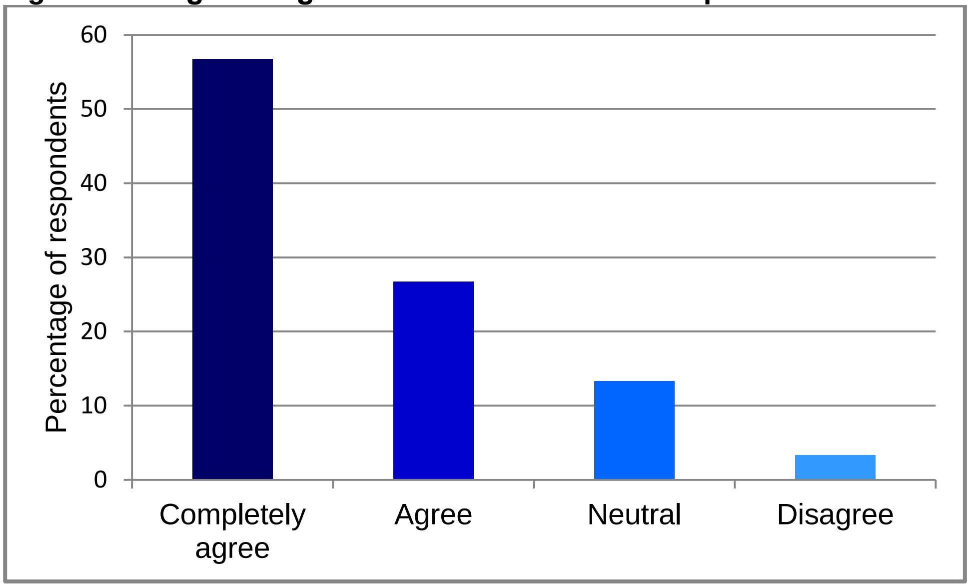
Discussions with various respondents and informants on IPM revealed that there is a common idea and vision amongst stakeholders on the concept as one of the practices of ensuring food safety in vegetables.

From the discussions done with Masvingo district horticulturalist about his views on IPM, he stated that:

> *'IPM is quite a noble idea in as much as food safety is concerned but there are a lot of misconceptions when it comes to applicability of IPM components and activities. While some farmers might be already practising it, it is difficult to judge whether they are doing it or not. Also the concept is very knowledge intensive it thereby implying that both extension support and the farmers need to be capacitated knowledge wise'* (Horticulturalist, AGRITEX Masvingo District).

More than half of the interviewed vegetable growers (83.3%, n=25) had the indication that they agree with the concept of IPM in vegetable production while only 3.3% (n=1) highlighted being in disagreement with IPM idea (see Figure 11).

Figure 11: Vegetable growers' views on IPM concept



On stakeholder checklists (Appendix 2-4), there was a question on opinion of stakeholder on idea of IPM for pesticide residue management and the response given by each key informant are shown in Table 13.

Table 13: Stakeholders' opinions on IPM

Stakeholder	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
AGRITEX	X				
ZFU	X				
CFU	X				
ZCFU	X				
CARE		X			
CARITAS	X				
Action Contrella Faim	X				
Spar Balmain	X				
OK Zimbabwe	X				
Tsungai Supermarket		X			
Recent Farm Produce		X			
QET Enterprises			X		
HPC	X				

4.5 Constraints of implementing IPM in the vegetable sector

Discussions with different stakeholders in the vegetable sector revealed a number of challenges to adoption of IPM and the emerging issues are as follows:

- The market looks at external quality and not the intrinsic value of the vegetables thus growers are worried of the end product quality which is perceived to be poorer for IPM produced vegetables than conventionally produced.
- For IPM to work effectively it requires vigilance or inclusion of the whole farming community. It is difficult to maintain IPM strategies when some growers are practising while others are not
- Limited knowledge or complete ignorance of IPM by both extension personnel and vegetable growers
- Compatibility of synthetic pesticides in IPM scenario is difficult to predict
- Growers are afraid of unforeseen problems for example new pest outbreaks
- Absence of premiums for IPM produced vegetables though there is reliable market
- Limited purchasing power of consumers
- Limited knowledge and use of food safety management standards such as Global Gap, Hazard Analysis Critical Control Point in vegetable chains in Zimbabwe
- Limited education and awareness on the part of the vegetable consumers on effects of pesticide residues on health
- Absence of government policy addressing IPM specifically
- Weak linkages amongst stakeholders when looking at chain development strategies

4.6 Requirements for increased IPM utilisation as food safety management technique

As part of the discussions, key informants were asked on what is necessary for spearheading and improving adoption of IPM for safety. The following is a compilation of the interviewees' answers:

- Advocating for policy formulation.
- Incorporation of IPM in agricultural curriculum
- Consumer awareness so that they become knowledgeable on the effects of pesticides on their health.
- Networking of different stakeholders to have a common goal
- Advocating for change of mindset on the part of producers through intensive training and demonstrations from extension service providers.
- Compulsory training of ground extension staff on IPM, quality standards and certification schemes dealing with food safety in fresh produce.
- Joint research of partners in the vegetable sector pertaining to IPM.
- Introducing social, ecological and product quality standards and appropriate codes of conduct in the vegetable sector.

4.7 PEST/SWOT analysis of IPM in the vegetable sector

From survey results and discussions with key informants, the internal and institutional environment of the vegetable sector in the context of IPM was analysed and main issues that came up are summarised in Table 14.

Table 14: PEST/SWOT matrix of IPM use in vegetable sector

	Strengths	Weaknesses	Opportunities	Threats
Political	-Acknowledgment of IPM by the Ministry of Agriculture		-International policies and legislations that support IPM from which to get policy formulation guidance	-Absence of policy directed at sustainable production means including IPM -Limited legislation covering food safety
Economic	-Coverage of all farming areas with AGRITEX staff	-Limited financial capacity by the government to fund research -Limited consumer purchasing power.	-Steadily improving economic situation of the country	-Absence of price differentials between conventionally and IPM/organically produced vegetables
Social	-Emerging consciousness on of vegetable safety by retail sector -Existing farmer groups that can be used to foster IPM concept training.	-Weak strategic partnerships amongst chain actors and supporters -Risk aversiveness of both growers and some extension personnel	-Presence of functional producer organisations for policy advocacy -Existing GAP standards that can be benchmarked	-Limited awareness on the part of consumers
Technological	-Existence of projects with IPM focuses which can be learning points.	-Limited knowledge amongst AGRITEX staff	-Presence of agricultural research and training institutions with infrastructure.	-Limited number of laboratories for testing pesticide residues

CHAPTER FIVE: DISCUSSION

5.1 Vegetables grown and pests of economic importance

Not many growers are engaged in production of high value vegetables as these need more attention compared with other conventional vegetables even in terms of pest and disease management. Outweighing of vegetable production throughout the year by seasonal production can be explained by the fact that during the winter season, the relatively lower temperatures will not be conducive for rapid development.

Knowledge of and ability to identify pests and diseases is critical for growers so that the appropriate management practice can be used to articulate a certain pest. This ability to identify pests and differentiate between pests and beneficial insects is one of the basic requirements of IPM production system and judicious use of pesticides is only possible when a grower can positively identify pests and have clear knowledge of the biology of that particular pest (Radcliffe *et al*., 2009).

5.2 Pest management practices

From survey results, 86.7% of the respondents indicated use of pesticides as the main pest management practice in vegetable production. The results might imply that vegetable growers depend largely on chemical pesticides for pest management. Siziba *et al*., (2003)' findings confirms the study results when he concluded that pest management in Zimbabwe as in most developing countries is dominated by chemical control. Farming practices in most areas including pest management are strongly influenced by longstanding experience hence the point of risk aversiveness. Research in other countries has shown that growers and chain supporters especially extension service providers have become accustomed to pesticides that generally perform up to expectation hence are not willing to try other methods of pest management (Radcliffe *et al*., 2009). According to World Bank (2005), from its experience in IPM programs there are non-price factors that have been shown to contribute to continued dependence on chemicals and these include training and extension biased towards pesticides historically and weak pest management policies. Choosing a pest management practice was shown to be primarily determined by effectiveness of the technique in terms of enabling a grower to get yield so that the grower can sell something in order to get a living.

Use of enemy plants indicated by 6.7% of respondents in survey is a cheaper method of pest management considering that the plants would be locally available. Crop rotation also indicated by 6.7% of respondents is a non-chemical method which is cheaper based on the fact that there is no monetary value attached to the option.

Other pest control methods are deemed to be expensive and sometimes difficult to acquire for example, bio pesticides. In the Zimbabwean context, there is limited experience and exposure of growers to bio control agents especially in small holder sector as explained by the PAEO of Masvingo Province hence utilisation of such techniques for safety management is still rare. Absence of price incentives for IPM produced vegetables on the market is an important hindrance to adoption of IPM as majority of growers especially small holders and in irrigation scheme depends solely on vegetable production for livelihoods and cannot afford to risk trying another method but only use pesticides which they are used to.

A Spearman Rank Order Correlation (Appendix 7) that was run to determine relationship between number of years in vegetable production and pest management showed a weak positive correlation which was not significant(r_S=0.111, p =0.560) and this possibly imply that pest management practices are not influenced by time period the farmer had been engaged in vegetable production. A Kruskal Wallis test that did not yield significant difference on rating of vegetable quality importance between pest management practices might imply that regardless of pest management practice, vegetable growers know the need for safety in vegetables they produce.

In Zimbabwe, each pesticide has a triangle colour coding on its label which shows how dangerous a pesticide is to people and livestock based on its toxicity. The colour categories are defined below:

Green triangle pesticides – These are classified as ‘Harmful if swallowed’ and are the least toxic group. These products can e used in the home, garden and in buildings and can be displayed directly on a shop shelf and sold over the counter.

Amber triangle pesticides – These are classed as ‘Poison’. Products with this colour code can be used in agriculture, gardens and around buildings not inside, can be displayed on a shop shelf and sold to any customer.

Red triangle pesticides – These are classified as ‘Dangerous Poison’. These products though they can be use in agriculture, gardens and around buildings (not inside), they can only be sold if kept in a special section where there is no direct public access.

Purple triangle pesticides – These are classed as ‘Very Dangerous Poison’. These can be used in field crops but not in vegetables and homes. Products with this colour code can only be bought by persons with pesticide licence.

Pesticides mentioned to be used in vegetables from the research survey (Table 4.2) have green triangle except Dimethoate with amber triangle and Furadan with purple triangle (see meanings of triangle colours explained above and Appendix 5b). This concurs to some extent with recommendations in Zimbabwe where farmers are encouraged to use pesticides with green triangle where possible as these have a lower toxicity level to both the grower and subsequent consumers of produce thereby ensuring safety (Dobson *et al*., 2002). This means that vegetable growers are knowledgeable about the effects of the pesticides they use in the production of vegetables. Use of chemicals with amber and purple triangle and chemicals not recommended in vegetables for example Fenkill which was mentioned by 6.7% of the vegetable growers surveyed might be caused by lack of knowledge on type of chemical to use on what pest.

According to the study findings, 73.3% of the interviewed vegetable growers indicated reception of training on IPM, training on safe use and handling of pesticides quality management from state and non-state actors and supporters. Again 86.7% of the interviewed growers claimed using pesticides when necessary, all of them acknowledging understanding of pre-harvest intervals and following then all the time. These findings imply that though the widely used pest management practice in vegetables is pesticide usage, it is not lack of information *per se* on the part of the farmers (normally a hindrance in chain development and food safety management) which is a limiting factor to use of IPM for reduction of pesticide residues in vegetables but a number of other intermingling factors some of which have been explained above.

From the interviewed farmers, 70% said that they keep records of pest management activities especially pesticide applications. The main reason cited for record keeping were mainly for future predictions of what and how much chemicals had been used on what crop. In IPM systems, record keeping is an essential and compulsory component which is not only done for predictions but also to facilitate traceability of the vegetables from field to table to ensure that the vegetables are in conformity with phytosanitary quality and safety standards (FAO, 2010). Considering the reasons for record keeping obtained in the research, tracing and tracking seems not yet to be in use along vegetable chains in Masvingo district.Limited purchasing power of Zimbabwean consumers was highlighted by the SDO from CARITAS as one of restraining factors hindering utilisation of IPM for safety insurance not only in the vegetable sector but throughout all food chains.

Humphrey (2009)'s arguments support this as he identified challenges that need overcoming when developing quality and food safety standards in a bid to maintain integrity of the standards or control systems. Tantamount to note are implementation costs like capital investments and costs of training personnel. Now limited purchasing power becomes an impediment for chain actors involved as they have to ascertain whether they will incur all the costs or share them with the consumer. The last option is however less likely to be followed in a scenario of low consumer purchasing power.

Effects of pesticides

From the survey, 56.7% of the respondents said that they own protective clothing and equipment for use when applying pesticides while 43.7% do not have but even amongst growers who have protective clothing, there are some who do not have full kits. This might possibly explain why 76.7% of the interviewed growers had the opinion that they were exposed to risk during application of pesticides though with varying magnitudes ranging from small to dangerous and toxic risks. The main probable reason for growers not having safety clothing might be limited financial resources considering the economic hardships Zimbabwe had been and still experiencing (Ministry of Agriculture, 2009) where most farmers would be striving to have food on the table other things being considered as luxury.

5.3 Valuing of IPM by stakeholders

Ensuring food safety in the vegetable sector like in all other food chains requires the action and cooperation of all relevant stakeholders as suggested by the expression '*from the stable to the table'*.

Policy and regulations on IPM

The non-existence of policy on IPM in Zimbabwe was mentioned by key informants as one of the setbacks in IPM use in vegetables for regulating pesticide residues. According to Vermeulen *et al*., (2008) public policy has a critical role to play in chain development moves as it not only sets the institutional context in which to operate but also affect interactions between public and private sectors. Policy formulation directed towards IPM was emphasised by the SDO of CARITAS on responding to a question on what could be done to enable improvement in uptake of IPM in the vegetable sector. He said that, *'If there is no policy framework, it is very difficult to instigate change hence there is need for strong advocacy for policy formulation or reform regarding sustainable agriculture incorporating such techniques as IPM.*' The policy notion is also supported by Overseas Development Institute (1999) after assessment of IPM projects who found out that IPM interventions are most likely to be successful when stakeholder support is backed with government policy to promote farmer adoption of sustainable production practices.

Though from a value chain approach, there is need to look at food safety issues from input supply through processing stages until consumption level, in Zimbabwe there is less focus of legislation on upstream levels of food chain which are the input supply and the primary production levels.

Most legal tools used to monitor food safety mainly focus on primary food processing, food distribution and catering of processed and unprocessed food (Table 10) with the Research and Amendment Act of 1998 operating at input and production levels of the supply chains in addition to enforcement activities being fragmented (FAO and WHO, 2005) giving a high chance of default by chain actors. Implementation of IPM in farming systems is even emphasized by World Bank in its operational policy WB OP 4.09 which supports safe, effective and environmentally friendly pest management practices further clarifying importance of national IPM policy for enhancing adoption of the concept.

Reliability and effectiveness of food safety policy and regulations depend among other factors on competent, qualified and trained inspectors along food chains coupled with laboratory network to monitor pesticide residues and to support inspection and surveillance systems. Research findings showed that there is only one public laboratory in the whole of Zimbabwe where pesticide residues can be tested. This existing public laboratory is not adequate and convenient enough for testing of pesticide residues across the country necessitating need for more laboratories.

Quality assurance schemes

It was noted from key informant interviews that there are no codes of practice that need to be followed by vegetable producers especially for the domestic market which has been indicated to be a drawback in IPM technology utilisation. The Zimbabwean government through relevant agencies need to develop codes of practice, promote consumer education on food safety issues such as pesticide residue effect to create awareness. According to FAO (2008), it was noted that governments especially in developing countries (Zimbabwe being one) find it difficult to develop quality and safety standards. If quality assurance standards are in place, they can guarantee that quality attributes including safety, reliability and service are being realised and confidence is provided to consumers (Luning and Marcelis, 2009). While voluntary quality assurance schemes can be a driver in IPM practices adoption, they can be costly to implement considering the level of most vegetable farmers in the wake of economy hardships the country had been and is going through.

Extension support on IPM

AGRITEX (government department) was shown to be the leader in extension service provision in IPM issues. Radcliffe *et al*. (2009) highlighted that it is governmental agencies that should be at the forefront in research and implementation of IPM, stimulating other control methods besides chemicals by activities such as funding research and capacity building of extension staff through intensive training. From a departmental perspective, a substantial number of ground staff require training on IPM and food safety management topics. The economic hardships that Zimbabwe had been going through since early 2000s caused brain drain not only in the agriculture sector but across most sectors of the economy as outlined by Ministry of Agriculture (2009). Experienced personnel migrated to neighbouring countries and abroad in search of greener pastures. A fast track agricultural training programme running for 14 months instead of the conventional 36 months was implemented in 2005 by the Ministry of Agriculture to fill the gaps of extension personnel at grass roots level. Most of the beneficiaries of the 14 month training programme do not have adequate technical knowledge and hands on experience.

NGO projects focusing on value chain development activities like IPM had been recently implemented in Zimbabwe as previously many projects were focussing on food aid to address food shortages that had been experienced in the country from about early 2000s onwards as Zimbabwe which used to be a bread basket of Southern African Development Community (SADC) is now a net food importer (Ministry of Agriculture, 2009). In support of this the FSPO from ACF said, '*As ACF, work on sustainable and safer production systems (particularly LIGs) began in 2008 after the government made on NGOs to make a shift from handing out food aid to more developmental interventions'*. Although the institutional capacities of CARITAS, CARE and ACF are strong in terms of IPM concept and food safety management, the coverage of projects in terms of number of beneficiaries in projects would be limited as NGOs depend mostly on donor funds for their activities hence cannot afford to support all the farmers in the wards. Also NGO projects tend to be targeted at vulnerable groups for example people affected and infected with HIV/AIDS and orphans. Thus not all vegetable producers will be reached hence this might be contributing to limited uptake of IPM. NGOs projects run for specified period of time such that it was noted that when the project life ends farmers revert back to their usual practices they are used to ().NGO personnel go through intensive training when they get employed and continue to be trained in various topics during project lives such that most of the staff are highly knowledgeable.

Producer organisations such as ZFU, ZCFU and CFU have been mentioned in section 4.4.2 as implementing a project that has IPM as its key component. The producer organisations can be instrumental in not only improvement of quality and safety in vegetable chains but also in formalising the chains. Producer organisations are fundamental stakeholders in the development processes and need to continue strengthening and organising members targeting at sustainable and safer production systems such as IPM. This will go a long way in complementing government efforts of free extension services offered by AGRITEX.

5.4 Vegetable marketing channels

There are two distinct markets of vegetables that were revealed: market without consideration of pest management practice and one requiring organic or IPM produced vegetables. Retailers and food processors had been shown to contribute positively towards change in pest control measures as had been experienced in Europe and North America (Radcliffe *et al*., 2009). This trend is filtering into the Zimbabwean retailing sector evidenced by supermarkets like Spar Balmain and OK Zimbabwe dealing with organic vegetable producers or those who follow IPM concept. Hotels like Chevron, Flamboyant and Great Zimbabwe are requiring vegetables produced organically or with IPM methods as they have a wide clientele base hence need to satisfy all of them – putting the consumer first.

Lack of price differentials between conventionally and IPM produced vegetables has been mentioned as a factor against increased adoption of IPM in vegetable chains. As explained by the horticulturalist of AGRITEX (Masvingo district), price incentives can be a driver as the producer will have justification for investing in say more time and extra labour for activities such as thorough scouting. As these vegetable growers are into business, they have to follow production systems which are economically viable for them. Though these markets do not offer price incentives for IPM or organically produced produce, the growers are assured of reliable market offering market security during periods of market glut.

From study results, none of the vegetable growers indicated selling vegetable to export markets implying that the farmers cannot meet export requirements that are strict on pesticide residues. Quality and safety standards such as GlobalGap and SQF (Safe Quality Food) are now a requirement by vegetable importers the world over to control food safety and certification of production processes and facilities is demanded by export markets (Jahn *et al*., 2004). Now for producers in developing countries like Zimbabwe especially smallholders, they are mostly exclude from those value chains due to high costs of certification. Vellema and Boselie, 2003 support this as they noted that change in standards and certification schemes tended to exclude smallholder farmers in accessing export markets because of the investment costs implied.

5.5 Stakeholder linkages

The fundamental aspect of value chain development focus on relations and linkages (Henriksen *et al.,* 2010) and these linkages among different groups in the sector or chains can either be formal or informal. The Union Project which came out of joint efforts of producer organisations ZFU, ZCFU and CFU as outlined in section 4.4 is a kind of such linkages where by vegetable growers affiliated to the different organisations are directly linked to private firms such as FAVCO which requires vegetables produced following good agricultural practices with IPM being a compulsory concept to note.

Although linkages exist between stakeholders in the vegetable sector in IPM context, it was revealed from key informant interviews that most of the linkages are weak. There is need for strengthening public-private partnerships as it had been shown that strong relationships between stakeholders in value chains promote chain development (Richter, 2005).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From survey results, it can be concluded that vegetable growers in Masvingo district have knowledge of IPM and have received training on IPM, safe use of pesticides, quality and safety management.

Chemical pesticide use is the main pest management technique in vegetable production despite training and awareness on the part of vegetable growers resulting from a number of interacting price and non- price factors. From the findings, it can be concluded that vegetable quality and food safety issues in relation to pesticide residues is known by vegetable growers. IPM practices are being implemented to some extent by vegetable growers especially crop rotations, scouting, record keeping, observance of pre-harvest intervals and knowledge and ability to differentiate between pests and beneficial natural enemies. From the study it can be concluded that even though vegetable growers have knowledge of IPM, there are various price and non-price factors that are limiting full utilisation and implementation of IPM at farm level.

Public extension service provider (AGRITEX) in the field of crops is not fully equipped with necessary skills and knowledge for up scaling and implementing IPM programs although this seem to be conflicting with level of knowledge amongst vegetable growers. The economic hardships that hit Zimbabwe since early 2000s have resulted in high staff turnover and brain drain.

Presence of IPM policy and legislation is an important requirement for adoption of IPM as pinpointed in the research findings. Though currently the focus of most agricultural policies is on addressing food security issues considering the economic and political situation of the country, sustainable agriculture policy formulation is possible in the long run.

Another conclusion that can be drawn from the findings of the study is that quality assurance systems are not developed in the vegetable industry especially for domestic market. Standards have been indicated to be in place for those growers who produce for export. Food safety regulations that already exist to cater for primary production chain level are not enforced and efficiently monitored.

Study findings revealed that coordination and collaboration in IPM related activities among chain actors is not strong and there is not much consumer awareness on hazards and risks associated with pesticide residues in vegetables

6.2 Recommendations

Based on the findings from the study, recommendations can be made that can contribute to development of vegetable sector through use of IPM technologies for safety management.

Considering the IPM knowledge gap existing amongst public extension service providers as highlighted in the challenges of IPM technology utilisation, there is a need to strengthen institutional capacity within research and extension services. This can be achieved by including IPM in in-service training programs of AGRITEX and DR & SS. Training courses can be also arranged with a few participants at a time in districts focussing on such as IPM and food safety management and good agricultural practices topics. This kind of training to enhance technical skill capacity can also be done to within producer organisations.

Continually building farmer capacity to apply knowledge intensive farming practices through intensive farmer training and demonstrations is required in order for the producers to have a wider choice on IPM options. Capacity building will improve farmer technical skills and market access as entrepreneurs to engage as value chain actors. This is in line with information management which can improve position of the growers in the chain (KIT *et al*., 2006). IPM when implemented effectively can assure that both the product and production processes satisfy the consumer.

Development agents such as AGRITEX and NGOs must encourage vegetable growers to be organised especially in irrigation schemes or community gardens. If farmers are organised, it is becomes convenient and simpler for development agents to disseminate information than in situations where producers are scattered. For IPM programs to be effective and efficient, community understanding is a necessity especially in most smallholder set ups where producers will be clustered. Organisation of farmers can also be achieved through engaging vegetable growers in contract farming so that in a specific area, the same type of vegetables would be grown at a specific time. There is need to promote entrepreneurial attitudes amongst farmers so that IPM is implemented based on vegetables required by the market.

At farm level, vegetable growers need to be supported to implement quality control systems that for example GAP (Good Agricultural Practices) that makes it compulsory for the farmers to follow IPM. In the long run the farmers might be assisted to get certification so that they will be able to access export markets. Quality control schemes might also strengthen vertical relationships between the vegetable growers and buyers of produce.

Building the skills and knowledge of civil society like consumer groups, producer organisations to shape and advocate for food safety policies as civil society can play a role in shaping production systems. Consumer education to create awareness on effects of pesticide residues in vegetable might be one of the driving forces for change in pest management in favour of IPM. To this effect, there is need for policy formulation within the context of sustainable agriculture but at the same time addressing food safety issues.

Development of a horticultural code of practice can help to provide guidance and minimum requirements that need to be followed by all growers involved in vegetable production and marketing as this can be a step in chain development in line with upgrading IPM technology utilisation.

Vertical and horizontal linkages within the vegetable sector need to be improved and strengthened. This can be achieved by joint research, training workshops, and setting up of committees or working groups in the context of IPM.

IPM can be utilised for food quality and safety management (pesticide residues) in the vegetable sector in Zimbabwe if all relevant stakeholders put their efforts together for the benefit of the producers.

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APPENDICES

Appendix 1

Questionnaire for vegetable growers

1. What area (ha) do you grow vegetables?..................

2. How long have you been growing vegetables (years)?........................

3. List of vegetables that you grow, major insect pests and diseases and control method

Vegetable	Insect pest	Control method	Disease	Control method

4. Which pest management practices do you mainly use in vegetable production?
a) Chemical pesticides b) Enemy plants c) Crop rotation
d) Biological control e) Light traps f) Manual removal
g) Other (specify)

5. Reason(s) for using pest management practices mentioned in Question 4:
a) Cost (cheap) b) Enables farmer to get yield
c) Suggested by other farmers d) Suggested by extension officers
e) Suggested by NGOs f) Good for health (quality and safety)
g) Good for environment h) Imitating others

6. Do you have knowledge of IPM concept? a) Yes b) No

7. Have you ever received any formal training on IPM? a) Yes b) No

8. If the answer to the above question is yes, who was the main source of information?
a) AGRITEX b) NGOs c) Farmers' organisation
d) Farmers' group e) Other (Specify)

9. Do you keep records of every activity on pests, diseases and action taken for management of those pests/diseases? a) Yes b) No

10. Do you know and understand what scouting is all about? a) Yes b) No

11. Can you differentiate between pests and beneficial insects? a) Yes b) No

12. If you use chemical pesticides, when do you spray?
a) Routine spraying b) When necessary

13. Have you ever received basic training on pesticide application and safe handling of pesticides? a) Yes b) No

14. If yes did the training include use of protective equipment and clothing when applying chemicals? a) Yes b) No

15. From whom did you receive the above training?
a) AGRITEX b) NGOs
c) Farmers' Organisation (ZFU, ZCFU) c) Pesticide suppliers
e) Other farmers

16. What is the status of protective clothing in terms of?
Availability a) Available b) Not available
Condition a) Good b) Fair c) Bad
Cleanliness a) Clean b) Dirty

17. When you are buying pesticides are you supplied with information pertaining to use of that particular pesticide (pamphlets, instructions)? a) Yes b) No

18. Do you read and understand the instructions and procedures before using pesticides?
a) Yes b) No

19. Are you aware of pre-harvest withdrawal periods? a)Yes b) No

20. How often do you follow pre-harvest withdrawal periods after pesticide application?
a) Every time b) Sometimes c) Not at all

21. What do you say about the following statement? Pesticides can affect human and animal health, the environment and water systems:
a) Strongly agree b) Agree c) Disagree d) Strongly disagree.

22. When controlling pests and diseases in vegetables using pesticides, how much risk do you think you are exposed to?
a) No risk at all b) Small risks c) Large and significant risk
d) Dangerous and very toxic risks e) Do not know

23. Have you ever heard or witnessed any pesticide related accident/s below in your local area?
23.1 Water contamination a) Yes b) No
23.2 If yes describe the accident..
23.3 Death of animals for example livestock, fish, birds. a) Yes b) No
23.4 If yes describe the accident..............................
23.5 Sickness or death of people a) Yes b) No
23.6 If yes describe the accident..

24. Which pesticides do you use in vegetable production for pest and disease management?

25.Have you ever received any training on quality, food safety pertaining to pesticide residues? a) Yes b) No

26. If yes from who did you receive the training?
a) AGRITEX b) NGOs
c) Farmers' Organisation (ZFU, ZCFU) d) Pesticide suppliers
e) Other farmers

27. How do you rate the importance of vegetable quality in relation to pesticide residues?
a) Important b) Somewhat important c) Neutral
d) Somewhat unimportant e) Unimportant

28. What constraints do you face in pest management and control?

29. What marketing channels do you use for the vegetables grown and what requirements do you have to fulfil to get access to those markets?

Vegetable	Market	Market requirements

30. Do you think the market requirements influence decision on pest control method you use on vegetables? a) Very important b) Important c) Not important

30.Has there been a change in the marketing channels through which you sell your vegetables for the past 3 -5 years? a) Yes b) No

32. If yes what have been the changes and what are the benefits or challenges of those changes?

33. What is your opinion on the idea of IPM?
a) Completely agree b) agree c) neutral d) disagree e) completely disagree

34. What do you think should be done to improve the status of integrated pest management in the vegetable sector?

Appendix 2

Checklist for AGRITEX

1. What is the role of AGRITEX in IPM and to what extent is the role fulfilled?

2. What is the institutional capacity of AGRITEX in IPM issues?

3. What is required for the organisation to uplift IPM concept in vegetable sector?

4. What cooperation exists between the organisation and other supporters of vegetable sector in IPM related issues?

5. What is the opinion of stakeholder on the concept of IPM as a quality and food safety management strategy? Totally agree 1 2 3 4 5 completely disagree

6. What can be done to develop and spearhead IPM, sustainable pesticide use in vegetable sector?

Appendix 3

Checklist for producer organisations and NGOs

1. What is the role of the organisation in Integrated Pest Management and management of quality and food safety in the vegetable industry?

2. Are there any programs or projects that are in place pertaining to IPM and sustainability in the vegetable sector?

3. What is the capacity of the institution in terms of knowledge and skills in IPM, food safety and what are the gaps?

4. What linkages and cooperation exist with other extension support and research institutions in implementing or improving IPM and food safety in the vegetable sector.

5. Is there cooperation of institution with private actors (input providers, vegetable growers/cooperatives, collectors, exporters of vegetables) in pest management, IPM, food safety?

6. What is the opinion of stakeholder on the concept of IPM as a quality and food safety management strategy? Totally agree 1 2 3 4 5 completely disagree

7. What can be done to develop and spearhead IPM, sustainable pesticide use in vegetable sector?

Appendix 4

Checklist for retailers of vegetables (supermarkets and vegetable shops)

1. Sources of vegetables

2. Existence organisational quality and safety standards - Quality criteria regarding pesticide residues (MRLs).

3. Pricing aspects whether any price premiums for vegetables grown under different conditions (pertaining to pesticide use).

4. Any linkages with vegetable producers and or vegetable traders (vertical integration) pertaining to pest management practice.

5. What is the opinion of the retailer on idea of IPM as a food safety management strategy in vegetable sector?
Totally agree 1 2 3 4 5 Totally disagree

Appendix 5a

Major pests and diseases of vegetables and pesticide recommendations in Zimbabwe

Pest/disease name	Pesticide number
Pests	
Aphid	3, 6, 8, 9, 10, 12, 16, 19, 24, 27, 30, 31, 32, 34, 35, 36, 38
Bagrada bug	34, 39
African bollworm	12, 25, 31, 35,38
Cabbage moth	3, 6, 8, 13, 19, 25, 39
Cabbage webworm	No specific recommendations
Caterpillar	6
Cutworm	21, 23, 25, 28
Diamond back moth	1, 4, 12
Flea beetle	No specific recommendations
Leaf miner	15, 26, 35
Spider mites	7, 9, 11, 14, 16, 17, 18, 19, 24, 26, 27, 30
Semilooper	12, 25, 29, 31, 34, 35
Thrips	11, 19
Whitefly	2, 12, 20, 21
White grub	28
Diseases	
Anthracnose	No specific recommendations
Bacterial speck	No specific recommendations
Bacterial spot	No specific recommendations
Botrytis	57
Damping off	69
Downey mildew	55, 58, 64, 70
Early blight	52, 53, 54, 55, 56, 60, 61, 63, 64, 66, 67, 70
Late blight	51, 53, 54, 55, 56, 58, 60, 61, 63, 64, 70
Leaf spot	51, 53, 54, 63, 64, 70
Powdery mildew	59, 65
Rhizoctonia	68, 69
Septoria leaf spot	No specific recommendations
Soil borne fungi	62, 69
Stem canker	57

Source: Dobson *et al*., 2002

Appendix 5b

Pesticides registered in Zimbabwe for pest control on vegetables

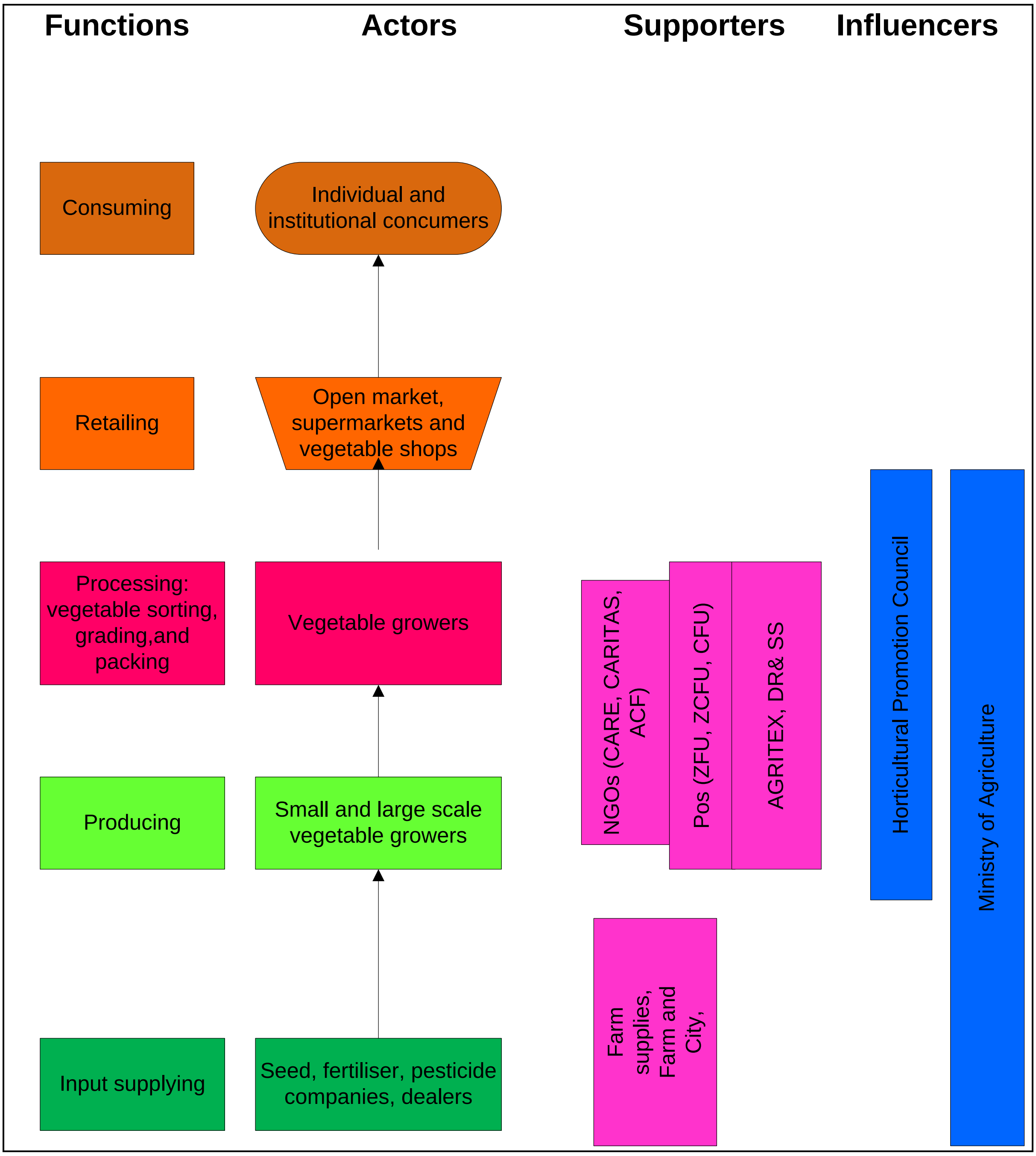
Number and triangle colour	Pesticide active ingredient	Brand name of registered formulations	Oral LD 50of most toxic formulation	Pre-harvest interval (days)
Pesticides for insect pests				
1 ▲	Bacillus thuringiensis	Biobit	Non toxic	Not stated
2 ▲	Fatty acids	Natural	Non toxic	Not stated
3 ▲	Pyrethrins	Garden insecticides	68667	Not stated
4 ▲	Lufenuron	Match 50EC	4000	14
5 ▲	Pyrnethrozine	Chess 25 WP	23280	3
6 ▲	Carbaryl/Pyrethrins	Pyspray Garden and Vegetable	20000	1
7 ▲	Clofentezine	Apollo 50EC	10400	4
8 ▲	Carbaryl/Copper oxychloride/malathion	Guard 'N' Care	10000	14
9 ▲	Sulphur/copper oxychloride/malathion	Vegidust	7630	14
10 ▲	Thiamethoxam	Actara 25 WG	6252	3
11 ▲	Sulphur	Dusting sulphur	6250	Not stated
12 ▲	Deltamethrin	Decis 2.5 FW	5400	1
13 ▲	Tetrachlorvinphos	Gardona 50WP	5000	1
14 ▲	Propargite	Omite 30 WP	4746	4
15 ▲	Cyromazine	Trigard	4516	3
16 ▲	Diazinon	Diazinon 30 EC	4157	14
17 ▲	Amitras	Mitac 20	3250	3
18 ▲	Dicofol	Kelthane 18.5 EC Dicofol 18.5 EC	3216	7
19 ▲	Malathion	Malathion 1/5 dust Malathion 25 WP	2750	7
20 ▲	Imidachloprid	Confidor 200 SL	2250	Not stated
21 ▲	Cypermethrin	Ripcord	1250	4
22 ▲	Lambdacyhalothrin	Karate	1120	Not stated
23 ▲	Fluvalinate	Mavrik	1044	Not stated
24 ▲	Dimethoate	Dimethoate 40 EC	968	14
25 ▲	Carbaryl	Carbaryl 85WP	588	7
26 ▲	Abamectin	Dynamec	556	3
27 ▲	Thiometon	Ekatin 25EC	292	7

28	Chlorpyrifos	Dursban 4 E	281	4
29	Trichlorfon	Dipterex 95 SP	263	3
30	Oxydemeton-methyl	Metasystox (R) 25 EC	200	21
31	Endosulfan	Thiodan 50WP	140	1
32	Demeton-S-Methyl	Metasystox(i) 25EC	120	10
33	Carbofuran	Curater 10G Furadan 10G	80	At planting
34	Dichlorvos	Dedevap 1000	50	2
35	Methamidophos	Tamaron 600SL	26	21
36	Disulfoton	Disyston 5 Gran	20	42 – at planting
37	Fenamiphos	Nemacur 10 Gran	15	Pre-planting
38	Mevinphos	Phosdrin	13	4
39	Parathion	Parathion 25WP Parathion 50EC	4	21
Pesticides for diseases				
51	Captan	Captan 50WP	18000	7
52	Procymidone	Sumisdes 50WP	13500	7
53	Metiram	Polyram Combi	12500	3
54	Sulphur/mancozeb	Flower power	10400	3
55	Carbaryl/copper oxychloride/malathion	Guard 'N' Care	10000	Check label
56	Chlorothalonil	Bravo 500	10000	3
57	Dicloran	Allisan 50 WP	8080	1
58	Metalaxyl/mancozeb	Ridomil MZ 72 WP	7900	7
59	Sulphur/copper oxychloride/malathion	Agridust, Vegidust	7630	14
60	Propineb	Antrocol 70 WP	7140	3
61	Propineb/cymoxanil	Milraz 75 WP	7140	7
62	Quintozene	Quintozene 75WP	6660	Soil treatment
63	Captafol	Captafol 80WP	6250	2
64	Mancozeb	Mancozeb flowable Dithane M45	6250	3
65	Sulphur	Dusting sulphur	6250	Check label
66	Difenoconazole	Score 250EC	5812	14
67	Anilazine	Dyrene 75 WP	3599	5
68	Thiram	Agri seed dressing	Seed dressing	
69	Thiram	Thiram 80 WP	3250	Seed dressing
70	Copper oxychloride	Copper oxychloride 85 WP	824	3

Source: Dobson *et al.*, 2002

Appendix 6

Chain map for vegetable sector in Masvingo district (Zimbabwe)



Appendix 7

Statistical tests

Correlations between number of years in vegetable production and pest management practice.

Correlations

			How long have you been growing vegetables?	What is the dominant pest control method?
Spearman's rho	How long have you been growing vegetables?	Correlation Coefficient	1.000	.111
		Sig. (2-tailed)	.	.560
		N	30	30
	What is the dominant pest control method?	Correlation Coefficient	.111	1.000
		Sig. (2-tailed)	.560	.
		N	30	30

Appendix 8

Independent T-test for differences between area grown vegetables and knowledge of IPM

Group Statistics

	Do you have knowledge of IPM?	N	Mean	Std. Deviation	Std. Error Mean
What area is grown vegetables	Yes	22	.411977	1.2541095	.2673770
	No	8	1.743750E0	1.6255631	.5747233

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
What area is grown vegetables	Equal variances assumed	2.724	.110	-2.378	28	.024	-1.3317727	.5600639	-2.4790117	-.1845337
	Equal variances not assumed			-2.101	10.199	.061	-1.3317727	.6338749	-2.7404117	.0768663

Appendix 9

Kruskal Wallis test for testing difference in ranking of quality in relation to pesticide residues between pest management practices

Ranks

	What is the dominant pest control method?	N	Mean Rank
How do you rate vegetable quality in relation to pesticide residues?	Chemical	26	16.12
	Enemy plants	2	11.50
	Crop rotation	2	11.50
	Total	30	

Test Statistics[a,b]

	How do you rate vegetable quality in relation to pesticide residues?
Chi-Square	1.586
Df	2
Asymp. Sig.	.452

a. Kruskal Wallis Test

b. Grouping Variable: What is the dominant pest control method?