MINISTRY OF AGRICULTURE FORESTRY AND FOOD SECURITY

WEST AFRICA AGRICULTURAL TRANSFORMATION PROJECT (WAATP)

A PEST MANAGEMENT PLAN (PMP)

FOR SIERRA LEONE

MAY 2018

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APPENDICES

LIST OF ABBREVIATIONS/ACRONYMS

ABCs	Agricultural Business Centres
Bt	*Bacillus thuringiensis*
CMVD	Cassava Mosaic Virus Disease
CPS	Crop Protection Service
DAOs	District Agriculture Officers
ECOWAS	Economic Community of West African States
EPA-SL	Environmental Protection Agency of Sierra Leone
EPA-USA	Environmental Protection Agency-USA
EU	European Union
FAO	Food and Agricultural Organisation of the UN
FAW	Fall Armyworm
FBOs	Farmer Based Organisation
FFS	Farmers Field School
FMD	Foot-and-mouth disease
GM	Green Muscle (Metarhizium annisopliae)
IITA	International Institute of Tropical Agriculture
IPM	Integrated Pest Management

IPPC	International Plant Protection Convention
ISPMs	International Standard for Phytosanitary Measures
LF	Lymphatic *Filariasis*
LLINs	long-lasting insecticide-treated nets
MANR	Ministry of Agriculture and Natural Resources
MDA	Mass Drug Administration
NaFFSL	National Farmers Federation of Sierra Leone
NaFRA	National Fertilizer Regulatory Agency
NCD	Newcastle disease
NPMC	National Pesticide Management Committee
NPPO	National Plant Protection Organisation
NTDs	Neglected Tropical Diseases
Oncho	Onchocerciasis
PHCs	Plant Health Clinics
PMC	Pesticide Management Committee
PMP	Pest and Pesticide Management Action Plan
PPR	Peste des Petits Ruminants
PPRSD	Plant Protection and Regulatory Services Division
PRA	Pest Risk Analysis
SCH	Schistosomiasis
SLeSCA	Sierra Leone Seed Certification Agency
SLICASS	Sierra Leone Cassava Variety
SME	Small/Medium/Entrepreneur
SPAT	Safe Pesticide Application Techniques
ToT	Training of Trainers
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
UPoCA	Unleashing the Power of Cassava in Africa
WAAPP	West Africa Agricultural Productivity Project
WAATP	West Africa Agricultural Transformation Programme
WHO	World Health Organisation
WTO	World Trade Organisation
WTO-SPS	WTO-Sanitary and Phyto-Sanitary

1 Executive Summary

1. ECOWAS initiated the West and Central Africa Agricultural Transformation Program (WCAATP) with the financial support of the World Bank to boost the transformation of Agriculture in West and Central Africa. The WCAATP covers eight (08) countries (seven in the West: Côte d'Ivoire, Ghana, Guinea, Burkina Faso, The Gambia, Liberia and Sierra Leone, and one in Central Africa: Cameroon). The regional coordination of the program is ensured by CORAF on behalf of ECOWAS.
2. Sierra Leone is therefore required to develop the following safeguard instruments: (i) an Environmental and Social Management Framework (ESMF) that would include both "chance finds" procedures and provisions for both forest resources and natural habitats; (ii) a Pest and Pesticide Management Plan (PPMP); and (iii) a Resettlement Policy Framework (RPF).
3. In collaboration with CORAF and the World Bank, Sierra Leone is to develop an appropriate framework for effective implementation of the Pest and Pesticide Management Plan (PPMP) in conformity with World Bank Policy of Pest Management (OP 4.09) for improved agricultural productivity, human health and the environment.
4. Currently, Sierra Leone has no legal framework to regulate the importation, registration, distribution, sale and application of pesticides; and no laboratory facilities to monitor the level of pesticide residues in food, water and the environment.
5. Early 1980, FAO/UNDP had supported a project that established a Crop Protection Service (CPS) with two sub-units: the Crop Protection Extension with pest control teams stationed at all the 13 districts; the Phytosanitary Control Unit, as well as a plant pests diagnostic laboratory anchored at Magbosi in Mile 91, all aimed at fighting hunger and poverty by reducing crop losses due to pests damage. The Phytosanitary Control Unit is concerned with plant quarantine matters at official designated entry points to intercept the entry of transboundary pests associated with plant/plant products imports as part of Sierra Leone compliance to international agreements/conventions on the movement of plants in international trade. Between 1991 and 2001, those on-going programmes were disrupted; facilities and infrastructure were vandalized by rebel invasion that caused considerable loss of human lives and displacement of communities.
6. CPS has oversight responsibility for plant protection and phytosanitary activities. In spite of the recovery programme**,** CPS is still challenged by serious constraints, including, adequately trained personnel, infrastructure, facilities, mobility, and operational funds and revised legal and regulatory instruments for supporting plant protection activities. As a result, with support from CABI plant wise, a plant health system was introduced and plant health clinics established at some Agricultural Business Centres (ABCs) and extension agents trained as "Plant Doctors" to provide regular IPM advice and practical field training in integrated pest management practices to farmers. The idea of plant health clinic system was developed by CABI (UK) to help farmers

understand their pest problems. This approach combines different management strategies and practices to grow healthy crops and minimize the use of pesticides.

7. For the Crop Protection Service to function effectively there is need to re-structure, strengthen and adequately resource for continuous staff training at various levels to enable them function efficiently and effectively. Serious impediment in the management of pesticides in the country is due to lack of coordination and collaboration between government agencies and other stakeholders and the private sector, all as a result of the absence of a legal framework to regulate the importation, registration, distribution, use and application of pesticides in the country.
8. In 2014, WAAPP-1C supported the preparation of a draft Plant Protection policy for the establishment of a Plant Protection and Regulatory Services Division within CPS, and in 2016, WHO supported both MAFFS and MoHS for the drafting of a National Integrated Pesticides Management policy for both agricultural and public health pesticides management. These two now ready for presentation to Sierra Leone parliament for enactment into law. Both policy documents cover pesticides regulation in line with WHO, WTO and ECOWAS regulations on pests and pesticide management.
9. Consequently, both the ECOWAS pesticides regulation and the FAO/International Plant Protection Convention (IPPC) International Standards for Phytosanitary Measures (ISPMs) for pesticides management in the country's National Gazette No. 62, 20th November 2014; and enacted the Sierra Leone Seed Certification Agency (SLeSCA) and the National Fertilizer Regulatory Agency (NaFRA) in November 24, 2017. In the interim, MAFFS has put temporary mechanism in place for the importation and sale of agricultural pesticides. For the importation of pesticides, the importer needs to complete and submit an import application form. This has provided guidelines in reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques, such as non-chemical alternatives to pesticides. This has helped to minimise the indiscriminate use of pesticides by the farming population, recognising that some of those pesticides used by farmers without seeking advice could belong to WHO class 1a or 1b categories of hazardous pesticides.
10. In response to actual and potential pest threats in the need to intensify agriculture, MAFFS annually purchase and distribute pesticides to the Agricultural Business Centres (ABCs) and Plant Health Clinics in the districts through CPS within Crops Division. A number of private agro-dealer companies play vital roles in the supply of pesticide and pesticides spray equipment.
11. Currently there is no official data to define the importance of crop pests and diseases in Sierra Leone and this has retarded the progress of crop protection in every aspects especially in the implementation of agricultural projects. The establishment of plant health clinics system at Farmer-Based Organisations (FBOs) and the Agribusiness Centres (ABCs) in 2008 has helped to identify some of the prevalence pests associated with the main crops.

12. The most serious pests that have recently invaded Sierra Leone include the fruit fly species *Bactrocera invadens, Anastrepha* spp and the papaya mealybug *Paracoccus marginatus.* These pests attack a wide range of fruits extensively grown nation-wide (e.g. mango, guava, papaya, citrus spp, banana, cashew, apple, avocado, etc.) causing losses even to the local market. Production of crops used for human and animal consumptions are increasingly at high risk due to pests. On November 4, 2017, the fall armyworm *Spodoptera frugiperda* that attacks maize and several other crops including rice was officially confirmed in Sierra Leone by a team comprising FAO and National Experts.

13. In the area of public health concerns, a lot of pests are listed and these include: cockroaches, body, head, and crab lice, mosquitoes, ticks, bed bugs, various rats and mice and various microorganisms. Of these, malaria caused by mosquitos is by far the most important vector borne endemic disease found everywhere in the country, including the cities; and the most vulnerable groups include children under five years and pregnant women. However, malaria control has so far achieved significant progress especially in the areas of prevention.

14. Pesticide use, though not in large quantities is a big problem in the country, especially where pesticides are brought without due consideration to their effects to human health and the environment, and labels written in unknown languages, and pesticide operators and farmers as well have no foreknowledge of the various pesticides they use. To address this, a pilot Neem production factory supported by UNIDO has been established at the Levuma Beach under the supervision and operation of the National Farmers Federation of Sierra Leone (NaFFSL). Promoting this crop for botanical pesticide production will be great idea as no pest has ever been recorded to have built up resistance to a Neem based pesticides. Beneficiaries will include:

    - The resource poor farmers, small scale village level agribusiness enterprises
    - The women and the unemployed rural youth
    - Technical institutions such as Agricultural Universities, SLARI

15. This Pest Management Plan is designed to address the following priority areas necessary for effective implementation of the IPM within WAATP in collaboration with existing planned activities of CPS for effective functioning and sustainability of this PMP.

    a. Support to CPS to enact into Law the draft Plant Protection policy for the establishment of a Plant Protection and Regulatory Services Division;

    b. Support to ensure the operationalization of a national Pesticide Management Committee (PMC);

    c. Support CPS to review laws/regulations and strategies related to pesticides and fertilisers;

    d. Effective training of farmers groups in pesticide management practices;

e. Support CPS in collaboration with SLARI and Njala University to develop a comprehensive pest list associated with main economic crops, and their beneficial organisms;

f. Create public awareness on banned pesticides and approved pesticides and safe use methods;

g. Organise training for farmers and other beneficiaries on IPM methods;

h. Support the development of IPM training modules and guidelines, factsheets, posters, etc for farmers use;

i. Support the establishment of Neem plantations (Neem Agroforestry), and the production of Neem based pesticides (Neem production factory).

16. The PMP Action Plan must be anchored at CPS/MAFFS to provide training and advisory services to farmers and other community facilitators in the area of pest management.

17. Monitoring and evaluation plans for pesticides have already been put in place temporarily which are been implemented by the CPS which is the competent authority for agricultural pesticides for bulk purchase to implement effective monitoring.

18. Sustainable adoption of IPM by farmers will only occur if they get information about it along with the tools and technologies to implement it. To effect this, in collaboration with the CPS, WAATP should actively engage in farmer training and capacity building programs around the country, in partnership with the public sector. Within MAFFS, SLARI and Njala University, there are already master trainers on pests' management for training of farmers and plant health doctors. Special training for pesticide management should be made to complement previous master training programmes.

19. Effective implementation of the PMP will involve many actors. The Crop Protection Service Unit/Livestock and Veterinary Division in collaboration with other experts drawn from SLARI and Njala University will provide technical support to WAATP project by contributing field staff to be trained as IPM Trainers and who will subsequently train WAATP farmers in IPM practices.

20. WAATP will organize its members into farmer groups or FBOs for training and promotion of IPM practices. They will set up Community IPM Action Committees to coordinate IPM activities in their areas. The Ministry of Health and Sanitation will supervise surveillance activities around the small-scale irrigation sites on the incidence of disease vectors; use of treated bed-nets and re-treatment of bed-nets.

2 Introduction

This is a Pest Management Plan geared towards building on the capacities of existing pest management systems in Sierra Leone Sierra Leone is expected to prepare a Pest Management Plan for its implementation in conformity with World Bank Policy of pest management (OP4.09) for improved agricultural production, productivity, human health and the environment.

2.1 WAATP Background

ECOWAS initiated the West and Central Africa Agricultural Transformation Program (WCAATP) with the financial support of the World Bank to boost the transformation of Agriculture in West and Central Africa. The WCAATP covers eight (08) countries (seven in the West: Côte d'Ivoire, Ghana, Guinea, Burkina Faso, The Gambia, Liberia and Sierra Leone, and one in Central Africa: Cameroon). The regional coordination of the program is ensured by CORAF on behalf of ECOWAS.

It is within this framework that the Government of Sierra Leone, in collaboration with CORAF and the World Bank, has undertaken the preparation of the WAATP for Sierra Leone with World Bank funding.

Due to the nature, the characteristics and the scope of WCAATP proposed activities, the potential social and environmental risks and impacts are low in scale, minimal mostly site specific, easily manageable and typical characteristics of category B operations. Thus, the following four (04) safeguards policies are set to be triggered, namely: (i) OP/BP 4.01 "Environmental Assessment"; (ii) OP 4.09 "Pest Management"; (iii) OP/BP 4.12 "Involuntary Resettlement"; (iv) OP/BP 4.11 "Physical Cultural Resources".

In line with the above, Sierra Leone is required to develop the following safeguard instruments: (i) an Environmental and Social Management Framework (ESMF) that would include both "chance finds" procedures and provisions for both forest resources and natural habitats; (ii) a Pest Management Plan (PMP); and (iii) a Resettlement Policy Framework (RPF).

The aim is to develop an appropriate framework for effective implementation of the Pest Management Plan (PMP) that highlights the major pests and diseases associated with the project's priority commodities: rice, cassava and livestock (poultry and small ruminants) and propose an Integrated Pest Management (IPM) strategy to ensure effective pest management options, minimizing the use of pesticides for improved agricultural productivity and public health.

2.2 Background of Geographical Description of Sierra Leone

Sierra Leone is located on the west coast of Africa, between the 7^{th} and 10^{th} parallels north of the Equator, bordered by the Republic of Guinea to the North and Northeast, Liberia to the South and Southeast, and the Atlantic Ocean to the west. The country has a total area of 72,000 sq km of which 60, 650 sq km is upland and 11, 650 sq km lowlands spread over four distinct geographical regions: coastal Guinean mangroves, the wooded hill country, an upland plateau, and the eastern mountains. Along most of the coastal areas are mangrove swamps. The rest of the country is a plateau with

altitudes ranging from 300m and above. However, the countryside is characterized by hills and mountains, from which it derives the name of Sierra Leone (from Portuguese words Serra Leoa, meaning Lion Mountains). The main mountains are Wara Wara, Sula, Loma, Tingi, Kongotan Range, all in the eastern part of the country, and the Peninsula Mountains in the Southern part of the country. There are also several river systems in the country. The main rivers are the following: Moa, Mano, Rokel, Pampana, Great Scarcies, Little Scarcies' Sewa / Bagbe, Waanjie, Jong / Taia, Bankasoka, Mabole, and Gbangbaia. The river systems have hundreds of tributaries that form a network within the country. There are also numerous lakes, the majority of which are relatively small in size, such as Lakes Mapa, Mabesi, Popei, Gambia, Sonfon and Balama, most in the south of the country. Arable lands in the uplands are estimated at 43,000 sq km while about 90 percent of the lowland area is considered arable. The lowlands are differentiated in four ecosystems and comprise inland valley swamps (630,000 ha), mangrove swamps (200,000 ha), boli lands (120,000 ha) and riverine grasslands (110,000 ha).

There are two main seasons determining the agricultural cycle: the rainy season from May to November, and a dry season from December to May, which includes harmattan and temperature can be as low as 16°C (60.8°F) the night-time. The average temperature is 26°C (78.8°F), and rainfall at the Coast ranges between 3000–5000 mm per year. On average rainfall is 2000-2500 mm.

2.3 Overview of Agricultural Production and Productivity

Agriculture is a way of life for most people in Sierra Leone. The vast majority of cultivated land is used by small scale farmers for subsistence agriculture. Previous research has shown that returns to agricultural investment are high, but in practice many farmers do not take on profitable investments.

Following the end of the civil conflict, domestic food production has continued to increase. It is estimated that the share of households with adequate food consumption has increased from 56% in 2005 to 71% in 2007. With regards to production of specific crops, the level of rice self-sufficiency in the country increased from 57.4% to 71% between 2002 and 2007. It is therefore evident that economic growth and poverty reduction in Sierra Leone will only be sustained with developments in the agricultural sector.

MAFFS seeks to improve agricultural production and productivity in order to achieve food security, by providing an enabling environment for farmers, promoting appropriate research, extension, input delivery and market systems, thereby improving rural incomes, reducing poverty and maintaining the natural environment. To this end, MAFFS formulates and implements policies, and coordinates, designs and monitors programs for the development of the agricultural sector. It works with the following objectives:

- To increase agricultural productivity, output, rural incomes and employment, while ensuring adequate protection of the environment;
- To ensure balanced regional agricultural growth and equitable distribution of income;

- To increase diversified domestic production of food, with a view to achieving food security in the medium and long term; and
- To maximize foreign exchange earnings from the agricultural sector.

2.4 Patterns of Crop Production

Crop production continues to receiving the highest premium in the country's agricultural development processes. Crops are grown for the production of (a) food items for consumption by the people, and (b) non-food items for export for cash generation. Patterns of agricultural production are based on the various cultivable ecologies.

The Uplands which account for 80% of arable land is highly leached with low fertility status, suitable for a variety of food and cash crops. Shifting cultivation is the main farming practice for rice, and mixed cropping being the common cropping pattern although there are significant differences depending on the land type. Several crops (rice, cassava, maize, sweet potato, groundnut, soya bean, cocoa, coffee, oil palm, ginger, cashew and kolanut) are grown for local consumption as well as for the export in the Sub-region. Farmers are encouraged for the intensification and value addition of these crops.

2.5 Methodology

This assignment is implemented through a consultative participatory process consisting of the following elements:

- Consultation and working in close interaction with professionals in Crop Protection Service (CPS)Livestock and Veterinary Services Division/MAFFS and the MoHS;
- Discussion and close interaction with relevant officials in the MAFFS to assess the pests and pesticides management practices by farmers and the Plant Protection Unit;
- Consultation with relevant NGOs and the Private Sector involved in plant protection products and regulatory services;
- Discussion with colleagues on public health issues and remedial actions;
- Discussion with livestock specialists for getting information on prevalent livestock diseases in Sierra Leone;
- Consultations with the Agricultural Extension Division to identify gaps for effective use of agropesticides;
- Consultation with CPS authority for relevant phytosanitary standards and other related issues;
- Inventorization and compiling of pests and pesticides lists and other documentation;
- Getting information from pests management documents in pdf formats/ internet for new information on transboundary invasive pests of crops and livestock;

Consultation with CPS for preparing pests and pesticides management guidelines, action plan and budget.

3 Pesticide Management in Sierra Leone

Pest and pesticide management are very important factors for safe agricultural products for human consumption as well as in maintaining the natural environment. Although there is not much in the use of pesticides in food production, as it is expensive for the smallholder farmers, pesticides use in general is always of concern for human health, wildlife and the environment, whilst it is very useful for pest management for production of healthy crops. In Sierra Leone, effective management of both public health pesticides and agricultural pesticides remain in the hands of various actors; the Ministry of Agriculture, Forestry and Food Security (MAFFS) and the Ministry of Health and Sanitation (MoHS) manage their pesticides separately; and the Environmental Protection Agency (EPA-SL) also addresses pesticide issues alongside encouraging proper management of the environment. With the lack of legislative instruments, importation of pesticides is very much disorganized, and difficult to enforce. The private sector and pesticide operators lack basic knowledge in proper management of pesticides. This project is therefore designed to elucidate national and institutional challenges that impede effective pest and pesticide management system and to make recommendations for crop pest management with very little of pesticide use. As a result, details of the available systems and guiding principles for pests and pesticides management are provided as follow:

3.1 Legal Framework and Institutional Capacities

Currently, there is no legal framework to regulate the importation, registration, distribution, sale and application of pesticides in Sierra Leone; no public laboratory facility for the monitoring of pesticide residues in food, water and the environment.

In the 1980s FAO/UNDP supported a project in Sierra Leone to develop a Crop Protection Service with plant pests diagnostic laboratory established at Magbosi in Mile 91. This system functioned satisfactorily until the project terminated and successfully created the existing structure of the Crop Protection Service in Sierra Leone. The setup is consistent with FAOs strategic objective to fight hunger and poverty in Africa through improvements in national plant protection services to reduce crop losses.

The term *pest* is used in this document according to the FAO definition of pest which is "*any form of plant or animal life or any pathogenic organism that is injurious or potentially injurious to plants, plant products, livestock or people; pests include insects and other arthropods, nematodes, fungi, bacteria, viruses, vertebrates and weeds"*

The Crop Protection Extension Service Unit, incorporating the Pest Control section is responsible for crop protection extension services to farmers; these include pest surveillance, pest risk assessment and reporting, providing technical advice and crop pest control information to farmers, farmer education and training in pest management practices, mass spraying against economic pests. The Phytosanitary Control Unit is concerned with plant quarantine matters, including phytosanitary inspection of plant products, certification and ensuring compliance with the requirements of the IPPC and the WTO-SPS protocol. This unit maintains inspection posts at the International airport,

the Queen Elizabeth II Quay (Freetown), Kambia/Gbalamuya, Jendema/Bo Waterside, Buedu and Koindu in the Kailahun border posts. This unit was established through the Plant Phytosanitary (Import) Rules in the context of the Agricultural Act (Cap 185) No 66 of 1974.

Regrettably, Sierra Leone experienced a very severe and complex civil conflict which resulted in serious socio-economic challenges. On-going programmes were disrupted; facilities and infrastructure were vandalized and destroyed and there was considerable loss of human lives and displacement of communities. However, commendable efforts have been made during the recovery programme to revive the organizational structure of the Crop Protection Service.

3.2 Institutional Capacities

Activities of CPS are on-going especially at district and community levels; national, regional and international collaboration and linkages are being established and the potentials for developing an efficient plant protection Service are extremely high. Nonetheless, CPS is challenged by serious constraints, including, adequately trained personnel, infrastructure, facilities, mobility, operational funds and revised legal and regulatory instruments for supporting plant protection activities. Staff capacity at district levels are also very thin on the ground to handle any emergency problems. Basic diagnostic laboratory facilities and equipment, other than hand lenses for visual examination are non-existence.

In spite of these gaps, CPS has the full oversight responsibility for plant protection and phytosanitary activities in the country. Ongoing initiatives of CPS are designed to introduce integrated pest management (IPM) into the farming communities. With support from CABI plantwise, a series of plant health clinics have been established at all 13 districts and some Agricultural Business Centres (ABCs) where extension agents have been trained as "Plant Doctors" to provide regular IPM advice and practical field training in integrated pest management practices to farmers. Through technical and financial support provided by CABI Bioscience in collaboration with Rothamsted Research UK, these clinics were successfully developed in the districts. CPS and the plant doctors collaborate with and share information with the Global Plant Clinic in the UK.

The District Agriculture Officers (DAOs) are responsible for managing all agriculture related activities and supervise all Agricultural Extension Agents within their districts, including crop protection and other phytosanitary services. Although pesticides are solely managed by the National Plant Protection Organisation (NPPO), however, all pesticides supplies to districts are officially directed to the DAOs. Crop Protection Officers at district level who manage pesticides have been trained in pests and pesticide management practices. Plant doctors only recommend to farmers pesticides that have been purchased or accepted for use by MAFFS. This way, the use of pesticides is somehow being controlled for crop pests' management.

Notwithstanding, the Environmental Protection Agency (EPA-SL) whose mandate is principally to conduct an environmental impact assessment of all projects with a potential environmental impact and issues permits to all agricultural and infrastructure construction projects, coordinates and monitors actors involved in activities relating to environmental protection legislation, to ensure compliance with national environmental policies, regulates and monitors the processing of waste,

pollution and other environmental hazards, is also seen engaged in pesticide management. The Agency collaborates with the Forestry Division of MAFFS on a number of issues related to environmental regulation in forest concession areas, and most notably on matters related to carbon financing in the forestry sector.

Lack of coordination and collaboration between government agencies and other stakeholders, such as the private sector (e.g. pesticide importers, retailers, and pest control operators), the police, customs, civil society, academia and research institutions is a serious impediment in the management of pesticides in the country. Consequently, problems in pesticide management that could have been recognized and dealt with at an early stage are either overlooked or only addressed when issues arise.

3.3 Institutional Constraints

a) There is no plant protection policy to direct the delivery of crop protection services in the country.

b) Although some of the respondents are aware of the benefits of Integrated Pest Management (IPM), it is not operational as a national policy for crop protection in Sierra Leone.

c) The number of staff with the requisite expertise (three) in crop protection is low in relation to the challenges. At least thirteen University graduates are required to fill in the gaps at district level.

d) There is no pesticide laboratory nor are there equipment for testing of pesticides for their purity and efficacy.

e) Lack of corporation and support from other relevant government functionaries for compliance in pesticide management due to lack of enforcing mechanism.

The development of sustainable strategies for the effective control of major insect pests and diseases is a major challenge. For the Crop Protection Service to function effectively the Service needs to be re-structured, strengthened and adequately resourced. Continuous staff training should be a major focus to upgrade the skills of crop protection officers at various levels to enable them function efficiently and effectively.

3.4 Legislative and Regulatory Framework for Pesticide Management

The government of Sierra Leone has the autonomous right to regulate pesticides import to achieve the appropriate level of protection for cultivated, wild flora, human, livestock and the environment for food production and productivity, and in a way that is compatible with its international obligations. Currently, there is no legal framework to regulate the importation, registration, distribution, use and application of pesticides in Sierra Leone. The types and quantities of pesticides entering Sierra Leone needs to be known for their effectiveness and their safety for human, livestock

and the environment. Because of this, two policy documents for pesticides management have been drafted, viz: the Plant Protection Policy document (2014) funded by WAAPP-1C for the establishment of a Plant Protection and Regulatory Services Division (PPRSD), charged with Phytosanitary Inspection, Control and Certification; Policies, Regulations and Standards, and Diagnostics and Laboratory Services; and through funding by WHO, a draft National Integrated Pesticides Management Policy document are available awaiting parliamentary enactment into national law. The two draft documents strictly followed recommendations and suggestions by international conventions and agreements including the ECOWAS recommended regulation/REG.3/08/2008 for harmonising the rules governing the registration of pesticides in the ECOWAS region. The move towards a more harmonized and regulated sector is meant to provide farmers and agribusinesses with protective measures that will assure quality and safety when acquiring and using agro-pesticides. The country requires a legal and regulatory framework to encourage the private sector in agropesticides trade and promote compliance to international conventions and agreements in pesticide management. Consequently, the Government of Sierra Leone published the ECOWAS pesticides regulation and the FAO/IPPC International Standards for Phytosanitary Measures (ISPMs) for pesticides management in the country's National Gazette No.62 dated 20th November 2014; and the enactment of the Sierra Leone Seed Certification Agency (SLeSCA) and the National Fertilizer Regulatory Agency (NaFRA) in November 24, 2017. The objectives for the regulation are to:

- Protect the population and the environment from the potential dangers of pesticide use;
- Facilitate trade of pesticides through the application of regionally agreed principles and rules that minimize barriers to trade;
- Facilitate access to the best pesticides for farmers at the appropriate time and place;
- Ensure the rational and judicious use of pesticides;
- Contribute to the creation of an environment conducive to private investment in the pesticide industry;
- Promote public-private partnership in pesticide use and distribution

3.5 Institutional Framework for Pesticide Management

Farmers as well as agro-dealers bring in pesticides at will without reference to MAFFS due to lack of pesticide import regulation and enforcement instrument. Nonetheless, MAFFS has put temporary mechanism in place for the importation and sale of agricultural pesticides. For the importation of pesticides, the importer needs to complete and submit an import application form. Before an import permit is issued, a pest risk analysis (PRA) is first carried out at the EU Pesticides Database/EPA-USA Pesticides websites for sustainable use of pesticides. These provide guidelines in reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques, such as non-

chemical alternatives to pesticides. This has been particularly helpful where big investors (companies and industries) have been involved since they are interested in following proper and internationally acceptable procedures as well as recognising their international obligations. What is now lacking is the legal and regulatory framework for promoting plant health system, although there is already a draft plant protection policy with regulatory powers to deter the importation of pesticides and encourage pesticide registration based on ECOWAS regulation for pesticides import.

As the government functionary institution charged with agricultural pesticides, using the draft policies, MAFFS setup an adhoc Pesticide Management Committee (PMC) to look at those pesticides that importers intend to bring into the country. A committee of five comprising both Directors of Crops and Extension Divisions, two Assistants and the Head of Crop Protection was mandated to examine agro-pesticides applications for import certification. This committee continues to function until the draft national policies are enacted into law.

In response to actual and potential pest threats in the need to intensify agriculture, MAFFS annually purchase and distribute pesticides (through tender) to the ABCs and PHCs in the districts through CPS within Crops Division. A number of private agro-dealer companies play vital roles in the supply of pesticide and pesticides spray equipment. For example, MAFFS acts upon request of CPS which prepares the list of pesticides and spraying equipment and protective gears needed for farmers and plant health clinics which are distributed nationwide. No pesticides are formulated and packaged in Sierra Leone. However, pesticide companies normally work in consultation with the Crop Protection Service of MAFFS for advice and to provide a list of pesticides acceptable for use in Sierra Leone (Appendix II). CPS/MAFFS always performs crosschecks from country of origin to ascertain import requirements prior to approval.

4 Pest and Pesticide Management Approaches in Agriculture and Public Health

There is currently no official data to define the importance of crop pests and diseases in Sierra Leone and this has retarded the progress of crop protection in every aspects especially in the implementation of agricultural projects. However, with the introduction of a plant health clinics system at Farmer-Based Organisations (FBOs) and the Agribusiness Centres (ABCs) in 2008 as farmers' enquiry points to help identify and solve field crop pests' problems, the following pests (Table 1) have been recorded on specific crops by plant health doctors based upon reports by farmers.

Table 1: Common pests of some crops in Sierra Leone

Crop	Pest	Disease
Rice	i. African white stem borer (*Maliarpha separatella*) ii. Pink stem borer (*Sesamia calamistis*) iii. African striped stem borer (*Chilo* spp) iv. Stink bug (*Aspavia armigera)* v. Green stink bug *(Nezara viridula)* vi. Stalk–eyed fly (*Diopsis thoracica*) vii. Rice caseworm (*Nymphula depunctalis*) viii. African armyworm (*Spodoptera exempta*) ix. African rice gall midge (*Orseolia oryzivora*)	i. Blast (Pyricularia oryzae) ii. Brown leaf spot (Helminthosporum oryzae) iii. White tip (*Apphelenchoides besseyi*) iv. Seedling blight (*Entyloma oryzae*)
Cassava	i. Variegated grasshopper (*Zonocerus variegatus)* ii. Cassava mealybug (*Phenacoccus manihoti)* iii. Whiteflies (*Bemisia tabaci*) iv. Green mite (*Mononychellus tanajoa*)	i. *African cassava mosaic virus* ii. Brown leaf spot iii. Bacterial stem rot iv. Cassava brown streak virus disease
Maize	i. Fall armyworm (*Spodoptera frugiperda)* ii. Stem borer *Busseola fusca*) iii. Striped stem borer (*Chilo partellus*) iv. Aphids (several species)	
Legumes	i. Legume pod borer (*Maruca* spp) ii. Whiteflies (*Bemisia tabaci*) iii. Aphids (*Aphis cracivora)* iv. Thrips v. Bean flies	

Prepared by: IMO Shamie, MAFFS

4.1 Plant Health Clinic System

This programme was introduced and instituted into the agricultural extension system due to the fact that loses caused by pests on farmers' crops constituted major factors resulting to low yields and poor-quality produce. Farmers have been using several pesticides such as Malathion for controlling pests on their fields but those pesticides were ineffective and that farmers have not developed any alternate control measures. Many farmers also expressed that they stopped growing cassava specifically due to pest problems such as the variegated grasshopper infestation especially in the dry season when the second crop of cassava is planted. Secondly, other pests have also become serious, devastating tree crops and vegetable crops. The most serious pests that have recently invaded Sierra Leone include the fruit fly species *Bactrocera invadens, Anastrepha* spp and the papaya mealybug *Paracoccus marginatus.* These pests attack a wide range of fruits extensively grown nation-wide (e.g. mango, guava, papaya, citrus spp, banana, cashew, apple, avocado, etc.) causing losses even to the local market. Production of crops used for human and animal consumptions are increasingly at high risk due to pests, weeds and diseases of both crops and animals. The fall armyworm *Spodoptera frugiperda* has recently been confirmed in Sierra Leone that attacks maize and several other crops including rice.

The idea of plant health clinic system was developed by CABI (UK) to help farmers understand their pest problems. This approach combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. Plant Health Clinics are places where farmers are given information on the pests affecting their crops and how to control them. Farmers who attend plant clinics share information with others about problems affecting their crops. These clinics operate in places close to where farmers live and work or where farmers visit regularly in the course of their normal routine activities such as market places, ABCs, etc. WAAPP-1C had supported the training of plant doctors, purchased plant clinic equipment and established plant health clinics for their cassava/rice FBOs. One of the remits of the clinics is to provide pest surveillance data for the government of Sierra Leone on new plant health threats, in line with policy of the Ministry of Agriculture, Forestry and Food Security on production and commercialization programmes. The clinics are managed by "plant doctors" of the Crop Protection Services Unit of the MAFFS. When national experts need assistance, they refer their queries to the plant health diagnostic laboratory. This has helped to minimise the indiscriminate use of pesticides by the farming population, recognising that some of those pesticides used by farmers without seeking advice could belong to WHO class 1a or 1b categories. The strategy is fully promoted by FAO as the preferred approach to crop protection and regards it as a pillar of both sustainable intensification of crop production and pesticide risk reduction.

Pesticides also have a role to play in public health as part of sustainable integrated mosquito management options. Components of pesticide management include surveillance, source reduction or prevention, biological control, repellents, traps, and pesticide-resistance management.

4.1.1 Plant clinics operational objectives include:

- Awareness raising about plant health and its benefits towards food security, poverty reduction and environmental protection in order to strengthen national, regional and international plant health initiatives in improving the livelihood of farmers.
- Diagnose pest problems affecting crop production as the basis to develop a shared vision on priority needs and integrated pest management opportunities.
- Develop the capacity of the farming community to understand and manage pest problems through farmer-participatory learning approaches with research on feedback issues emanating from farmers field experiences.
- Introduce and promote microbial pesticides such as the Green Muscle and other and botanical pesticides as alternatives to harmful synthetic pesticide regimes thereby reducing environmental and personal health risk hazards in agriculture and the community.
- Teach farmers more about their crops including how plants are affected, symptoms, and management practices.
- To create better effective and efficient plant health system to the farming communities.

4.1.2 Pests found in agriculture, livestock (poultry and small ruminants) and public health

In both agriculture and public health, there are a lot of organisms causing damage by feeding on crops, parasitizing livestock, carrying protozoans within human habitat and causing diseases. Pests affecting agricultural crops include insects, nematodes, fungi, viruses, bacteria, mites, etc.

4.1.3 Some Crop Pests of Economic Importance

There are only two serious pests of crops of economic importance in the project operational area; the seasonal variegated grasshopper *Zonocerus variegatus* and the newly invasive transboundary pest of cereal crops the Fall Armyworm *Spodoptera frugiperda.*

I) The Variegated grasshopper (*Zonocerus variegatus*)

Farmers and small/medium/entrepreneur (SME) cassava factories are aware that the variegated grasshopper (*Zonocerus variegatus*, is a major biotic constraint to commercial production of cassava storage roots and stem planting materials and many other food security crops in Sierra Leone.

The pest hatch into nymphs by September/October (end of rainy season) each year. The nymphs and adults spread from hatching points to nearby vegetation and farm where they defoliate and demark crops from end of the rainy season to start of the next rainy season in April/May. The spread and intensity of the damage is heightened at peak dry season when the crops are also under water stress. Cassava, being the only annual crop with lush foliage in the dry season is particularly targeted by the grasshopper.

Defoliation causes loss of fresh leafy vegetables on the market; debarking cassava stems kills the buds and makes the stems unfit for planting. The loss in planting material undermines efforts by MAFFS partnerships with FBOs and SME factories to secure required volumes of planting materials

in April/June. Also, poor plant growth under grasshopper attack either kills the plant or causes poor root yield in cassava. In short, grasshopper infestations undermine agricultural production and productivity by causing significant loss of leaves (food), stems (planting material, especially of improved materials and storage root (food and industrial products). The damage causes significant short falls in availability of cassava planting materials of improved cassava varieties. The annual re-occurrence of food and economic losses caused by grasshoppers can be limited in its impact.

i) Management options

Over the years, farmers in Sierra Leone, under MAFFS guidance, relied heavily on cultural control and harmful pesticide regimes against grasshoppers. The cultural control interventions include handpicking, bush clearing around cassava farms; chemical control interventions include the use of synthetic pesticides (Malathion, Diazinon, Chlorpyrifos, etc). The results have been ineffective, as evidenced by increased grasshopper spread and damage severity each year. The over-reliance on inappropriate synthetic chemical insecticides contaminates the leaf harvest, farm and are hazardous to applicators, farmers, farm workers and farm families, livestock, fish, wild life and the environment. Therefore, grasshoppers control requires environmentally sustainable pest management solutions that also integrate well with commercial food production.

ii) Use of Bio-pesticides

The International Institute of Tropical Agriculture (IITA) has developed a fungus-based bio-pesticide, an ecologically sustainable option against the variegated grasshopper. The product is based on a fungal pathogen called *Metarhizium annisopliae* commonly known as Green Muscle which specifically kills grasshoppers with no harm to man, other living organisms and the general environment. The biological control product is mass produced on demand by IITA. The bio-pesticide has been field tested with excellent results in many countries in West Africa. In 2006, Care International Sierra Leone in collaboration with IITA and the Crop Protection Service of MAFFS field tested the bio-pesticide against the grasshoppers with excellent results.

In collaboration with IITA-UPoCA project, CPS/MAFFS had used this product to contain grasshoppers' seasonal populations. As a result, cassava cultivation has expanded in the last few years to support the several cassava possessing industries already constructed around the country by RPSDP, WAAPP-1C, UNIDO and IITA projects in collaboration with MAFFS. The increased national interest in cassava as a food and economic crop demands that cassava production requires sustainable plant protection solutions such as is provided by Green Muscle against the variegated grasshoppers.

II) The Fall Armyworm (*Spodoptera frugiperda*)

The Fall Armyworm (FAW) is an invasive transboundary insect pest that was not known to occur in Africa until early 2016. It is native to tropical and subtropical regions of the Americas, with the adult moth able to move over 100 km in a single night. It lays its eggs on plants, from which larvae hatch and begin feeding. FAW feeds on more than 80 plant species, causing damage to economically important cultivated cereals such as maize, rice, sorghum, and also to legumes as well as vegetable

crops and cotton, among others. High infestations can lead to significant yield loss.

FAW was first detected in Central and Western Africa in early 2016 (Sao Tome and Principe, Nigeria, Benin and Togo) and in late 2016 and 2017 in Angola, Botswana, Burundi, Cote d'Ivoire, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Namibia, Niger, Rwanda, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe. It has recently (Nov 2017) been confirmed in Sierra Leone, Liberia, and Cote d'Ivoire. Currently, about 30 countries have been infested on the African continent.

The presence of FAW in Sierra Leone was confirmed on 4th Nov 2017, during one of FAO backstopping missions. The authentication was based on specimens collected from fields visited and reports from the major maize growing areas across the country.

Subsequently, a quick nationwide rapid assessment was organized to ascertain the level of incidence of the pest to enable Sierra Leone undertake requisite mitigation and management actions. The FAW assessment was conducted by Staff of the Crop Protection and Extension Services of MAFFS, and the pest was found in all the 13 districts of Sierra Leone. The level of infestation as measured by the proportion of plants infested was more than 50% in the Western area, Bonthe, Bo, Moyamba, Pujehun, Kaliahun, and Tonkolili districts and could be described as the hot spots for FAW infestation. Since FAW could also feed on rice and other crops during the years to come, the pest could have a devastating impact on food and nutrition security in Sierra Leone. A robust investment in FAW management is therefore needed. Being the main technical partner in food production and productivity, FAO took immediate actions to support countries in responding to the threat of FAW in Africa. These engagements have strategically positioned FAO as the main hub to manage the FAW.

As it is now, the long-term impact of FAW on agricultural production and food security in Africa cannot be determined. However, as an aggressive transboundary/migratory pest with such wide host range, it has the potential to cause serious damage and yield losses to many food crops, especially its preferred cereal crops including rice that is the national staple of Sierra Leone. Thus, it can affect millions of livelihoods of various value chain operators on various commodities. FAW presence in Africa and for that matter Sierra Leone is irreversible. Large-scale eradication efforts are neither appropriate nor feasible. Large-scale eradication efforts are neither appropriate nor feasible. Small scale farmers in the Americas have learnt to manage the pest for many years, using methods that take environmental safety, animal and human health into consideration. To gather and analyze experiences and best practices from this region will help design a sustainable FAW management program, especially for smallholders.

CPS/MAFFS in collaboration with FAO, has set up a special FAW Task Force team at national and district level for the conduct of the assessment survey. The National Task Force responsibilities include:

i. Work with research Institutions and Universities to identify available biopesticides and natural enemies to guide biological control process;

ii. Identify MAFFS staff per district for the control of FAW;

iii. Conduct training sessions for staff and for farmers;

iv. Develop and print posters on A2 sized and distribute in the districts to be pasted at strategic places to raise rapid awareness of the population

v. Set up farmer to farmer programme aimed at educating beneficiaries on measures to take after detecting FAW invasion followed by mounting massive awareness raising campaigns over the local media in different languages

vi. Revise the farmer field school curriculum to capture FAW identification, control and preventive.

Two standard methods, indicated in the FAO Guidance Notes for FAW are to be used for monitoring FAW populations:

a) Pheromone traps:

Trapping male adult moths with synthetic sex pheromone gives a proxy indication of the presence of FAW in an area. Pheromone traps need to be procured and used intensively for surveillance to detect when the first FAW arrives within maize, rice, and other potential host crops during the 2018 planting season. The pheromone traps must be put in place before the planting season starts. FAO has already pre-qualified reliable pheromone and trap vendors in order to streamline the procurement process and ensure high quality products.

b) Field scouting:

Plants are inspected in detail to record the presence of egg, larva, damage and natural enemies.

5 Pests of Poultry and Small Ruminants

5.1 Poultry Diseases

Common Poultry diseases are one of the major challenges facing the poultry production in Sierra Leone. There have been many cases where farmers lost large investments worth several thousand dollars due to sudden poultry disease outbreak. Poultry diseases are commonly caused by bacteria, viruses, parasites and fungi (Table 2). Apart from these, improper poultry farm management skills, feeding of unhealthy feeds and unclean poultry environment can also lead to poultry disease outbreak. Some of the most important and deadly poultry diseases are: Newcastle disease (NCD), Fowl Pox, ticks, lice and fleas.

(a) Newcastle Disease (NCD)

Newcastle disease is one of the major important poultry diseases. The disease is transmissible and notifiable disease that has the potential of being rapid and wide spread. NCD disease is caused by a virus and is highly contagious, which means that it can spread rapidly among chickens. It has a high death rate and can affect any kind of poultry farm, from backyard to large commercial poultry farms. The NCD virus infects respiratory, digestive and nervous system and in severe cases may cause high economic losses.

Management of Newcastle disease

Intensive management of poultry where large numbers of chickens are housed together as well as the transportation of chickens over long distances promote the spread of the disease. The virus causing the disease is present in the droppings of sick as well as healthy chickens that carry the virus. Healthy chickens are infected when they eat food or drink water contaminated by the droppings; chickens are also infected by breathing in small airborne droplets that originate from sick chickens and from healthy chickens that carry the virus. The virus can live for some time outside chickens, and the disease can be spread by the movement of poultry, people, equipment and poultry products (the virus may be present on the clothing of people, equipment, at markets, etc). Vaccination and isolation of healthy birds from sick ones and proper disposal of dead birds can prevent diseases.

(b) Fowl Pox

Fowl pox is the worldwide disease of poultry caused by viruses of the family Poxviridae. Fowl pox is a slow-spreading viral infection of chickens and many other birds and is characterized by proliferative lesions in the skin that progress to thick scabs (cutaneous form) and by lesions in the and respiratory tracts (diphtheritic form).

Management of Fowl Pox

There is no cure for **fowl pox**, but there are comfort measures that can be provided for affected chickens as well as preventative measures to avoid secondary bacterial infections caused by the lesions. Unaffected birds can be vaccinated during an outbreak. Regular triple-antibiotic ointment can be used even in the corners of the eyes and mouth as long as the ointment does not contain pain-killers.

Table 2: (a) Poultry Diseases

Diseases	Sign	Treatment/management	Prevention
1. Newcastle disease	• Greenish diarrhoea • Ocular and nasal discharge • Neck twisted • Paralysis and collapse	None	• Quarantine new birds for 5 days; • Isolate and kill all sick birds • Vaccination **Broilers** Apply Hitchner B1 as follow: • 1-4 days • 12 -14 days • 35-42 days **Layers** • 1-42 days as above with HB1, • 10 Week- Lasota • 16 - Pox
2. Fowl pox	• Nodules on head, around eyes and mouth	• Clear pus from eyes and mouth apply iodine or glycerine	• Quarantine new chickens • Isolate stick birds • Disinfection of poultry house 2 times a year

Source: Dr. J.E.D. Terry, Livestock, MAFFS

Table 2: (b) External Parasites on poultry

Parasite	Sign/Symptoms	Treatment/management	Prevention
1. Ticks 2. Lice 3. Fleas	• Irritation • Itching • Loss of appetite • Drop in production • Weight loss	• Dust chickens with insecticide/ acaricide powder	• Cleaning and regular disinfection

Source: Dr. J.E.D. Terry, Livestock, MAFFS

Table 2: (c) Internal Parasites in poultry

• Flat or Round Worms	• Loss of appetite • Diarrhoea • Anaemia • Drop in production • Slow growth rate	Piperazine citrate	• Clear and disinfect after every batch of chickens leave poultry house for 21 days before restocking • Vaccinate Layer at 18 weeks old.
• Coccidiosis	• Bloody diarrhoea • Sudden death • High mortality in 10 days • Loss of appetite • Pale looking comb.	• Coccidiostat (Amprolicin) • Sulphono- mides	• Regular cleaning and disinfection
• Fowl Cholera	• Inflammation of the joint foot pack crest or comb • Diarrhoea • Loss of appetite • Respiration problem • High mortality	Tetracycline	• Vaccinate chicken about 6 weeks old observe hygiene rules • Avoid stress

Source: Dr. J.E.D. Terry, Livestock, MAFFS

5.2 Pests of Small Ruminants (PPR)

Pest of small ruminants also known as Peste des Petits Ruminants (PPR) is a highly contagious, non-zoonotic viral disease of sheep and goats. The disease is recognized in the field by a sudden onset of diarrhoea and fever, discharges from the eyes, nose, and mouth, sores with or without scabs or nodules around the mouth, pneumonia, and significant animal deaths. The disease is more prevalence in West Africa. For other pests of ruminants see Table 3 a,b,c.

Management of PPR

Since PPR is none transmissible to human, its control activities could be attractive and cost-effective when integrated with other diseases, such as goat pox, sheep pox, brucellosis (*Brucella melitensis*), and foot-and-mouth disease (FMD).

Table 3: (a) Diseases of Small Ruminants

Disease	Signs	Treatment	Prevention/Control
1. Pest of small Ruminants	• Loss of appetite • discharge from eyes • inflammation of the mouth and nose • Bloody diarrhoea • Dehydration • Death	None	• Vaccination of animals from 4 months old
2. Haemorrhagic septicaemia	• Swelling of the throat • Loss of appetite • Increased respiration • Salivation • Depression	• Tetracycline • Sulphur dimidine	• Vaccinate 1-2 month before the start of the raining season
3. Foot Rot	• Laineness • increase in temperature • loss of appetite	• cooper sulphate 0.5 solution • weight loss • inflammation of the interdigital space	• Good sanitation • Dry standing
4. Diarrhoea	• worms • old • infection • sudden change in feed	• watery feaces • high temperature	• Oral rehydrating salt • Deworm with albendezole • Give oxytetracycline
5. Rumen impaction	• 1. feeding on husk rice	• increase respiration • left flank swollen • collapse if not treated animals will die	• Epson salt • Castor oil • Plenty of water

Source: Dr. J.E.D. Terry, Livestock, MAFFS

Table 3: (b) External Parasites of Small Ruminants

Parasites	Signs/ Symptoms	Treatment	Prophylaxis
1. Mange Mites	• Itching • Loss of hair • Thickening of the epidermis • Anaemia	• Acaricidal wash every 7 days • Invention injection	○ Clear and disinfect pens regularly ○ Wash animals with acaricide once a mouth
2. Ticks	• Skin damage • Itching • Weight loss • Inflammation or sores • Anaemia	As above in	As above
3. Flies	• Cause worries • transmit diseases • Infected wounds		• Dispose manure properly; • Disinfect surrounding of pens regularly

Source: Dr. J.E.D. Terry, Livestock, MAFFS

Table 3: (c) Internal Parasites of Small Ruminants

Parasites	Sign/Symptoms	Treatment	Prophylaxis
1. Flat worm (Cestodes)	○ Loss of appetite ○ Anaemia ○ Diarrhoea ○ Rough coat ○ Emaciation	○ Levimisole ○ Tetramizole	○ Deworm every 3 months
2. Nematodes	Signs are as above	As above	Treat as above

Source: Dr. J.E.D. Terry, Livestock, MAFFS

5.3 Pests of Public Health Importance

There are a lot of pests listed in Sierra Leone of public health importance; they include: cockroaches, body, head, and crab lice, mosquitoes, ticks, bed bugs, various rats and mice various microorganisms, including bacteria, viruses, and protozoans.

The predominant vector borne diseases in Sierra Leone, namely Malaria, *Schistosomiasis* (SCH), *Onchocerciasis* (Oncho) and Lymphatic *Filariasis* (LF), account for the bulk of its disease burden. Some vector borne diseases are endemic in the whole country, while others are localized in certain parts where they contribute to the disease burden in the local communities.

Malaria caused by mosquitos is by far the most important vector borne disease which is endemic in the whole country, including the cities. The most vulnerable groups include children under five years and pregnant women. Malaria control has so far achieved significant progress especially in the areas of prevention. In November 2010, Sierra Leone conducted a one-week National Integrated Maternal and Child Health Campaign to provide health interventions, which included distribution of over 3.2 million long-lasting insecticide-treated nets (LLINs) to all households in the country and was aimed at achieving 100 percent household possession of LLINs. In addition to the distribution of LLINs the NMCP also launched the Indoor Residual Spraying Programme in four pilot districts in December 2010.

Regarding the NTDs, in 2006 the MoHS produced a national plan of action for integrated control of Oncho, SCH, STH and LF. The plan aims to eliminate LF by 2015 and to reduce morbidity due to Oncho, SCH and STHs to levels where the diseases are no longer of public health significance. The main strategy is mass drug administration (MDA) through community directed treatment (CDT) and or school-based approach. However, the strategies targeting vectors of LF, Oncho, and SCH were not incorporated in the Plan of Action. MDA alone is unlikely to interrupt disease transmission for some of the NTDs (e.g. SCH) or will take a very long time to do so (e.g. Oncho).

Schistosomiasis, Onchocerciasis and lymphatic Filariasis are among the major neglected tropical diseases (NTDs) that are widespread in the country. Schistosomiasis **s**tudies conducted in all 13 Health districts of the country in 2008 showed that 7 districts (Kono, Kailahun, Kenema, Bo, Koinadugu, Tonkolili and Bombali) have prevalence of *Schistosoma haematobium* and *Schistosoma mansoni* high enough to be targeted for mass drug administration (MDA) of Praziquantel to be conducted at school and community levels.

Onchocerciasis**,** the 4th leading cause of blindness after cataract, trachoma and glaucoma, is endemic in the 12 provincial Health districts. The Forest type of the disease is distributed in Eastern parts of the country, while the Savanna type is found in the North. A mixture of the two types is found in the Southern region. According to data the national prevalence of Oncho is around 46%. MDA is conducted for Oncho except in the Western Area (the only district where the disease is not endemic).

Lymphatic Filariasis is also highly endemic in Sierra Leone. According to a survey conducted for mapping of the disease in all districts of the country in 2005 using immuno-chromatographic test cards, the national average prevalence was 21% and all 13 health districts of Sierra Leone are

endemic for LF. Oncho and LF are co-endemic in 12 out of the 13 health districts and preventive chemotherapy with Ivermectin and Albendazole are justified annually in all 13 districts of Sierra Leone including urban areas such as Freetown and district headquarter towns.

Trypanosomiasis has not been considered a disease of importance in Sierra Leone as there have been no cases reported for many years. However, the recent reported resurgence of the disease in neighbouring countries calls for systematic surveillance, particularly in border areas, to be able to control transmission through the appropriate vector control interventions, should the disease reappear.

In spite of such a heavy burden of malaria and neglected tropical diseases (NTDs), control of vector borne diseases in Sierra Leone is focusing mainly on case management and mass drug administration (MDA). More efforts should therefore be made to reduce and interrupt disease transmission.

5.4 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) uses environmentally sound ways to keep pests from invading and damaging crops. A successful IPM combines several methods to prevent and manage pest problems without harming human, wild life or the environment. Integrated Pest Management is a combination of common sense and scientific principles. IPM is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides as well as minimizing risks to human health, livestock and the environment.

IPM is the best combination of cultural, biological and chemical measures to manage diseases, insects, weeds and other pests. It takes into account all relevant control tactics and methods that are locally available, evaluating their potential cost-effectiveness; makes good use of local resources and the latest research, technology, knowledge and experience. In practice, IPM is a site-specific strategy for managing pests in the most cost-effective, environmentally sound and socially acceptable way, and implementation principally lies with farmers, who adopt the practices they view as practical and valuable to their activities. These management methods could be applied to major crops grown in Sierra Leone (Rice, Cassava, Maize, and Vegetables) depending on when the crops are in the field and the target pests as discussed below.

5.5 Integrated Pest Management Methods

IPM methods involve a systematic decision-making process that aims to prevent pests from becoming problems and to determine what actions to take if pest problems occur. These processes include:

a) Prevention

Many aspects of crop management are designed to prevent initial outbreaks of insects, diseases or weeds. Practical strategies (outlined below) can be combined and optimized for an IPM program for specific crops. The overall goal is to prevent pest populations from building up to economically damaging levels. For example, the variegated grasshopper *Zonocerus variegatus* attacks cassava and many other crops from the end of the rainy season October/December and throughout the dry season April/May each year. This reoccurrence of this pest can be prevented by i) locating, dig out egg pods at egg-laying sites and destroy; ii) clearing of bush about 2 meters around cassava fields, and iii) killing of young nymphs at hatching sites before flying into cassava fields. Pests of rice such as the CMVD can be prevented by obtaining seed from CMVD resistant or tolerant varieties.

b) Crop Location

Growing crops in locations where they are best suited to climate, soil and topography provides them with optimal conditions from the start. Appropriate land preparation builds on these conditions. There are specific areas within the country best suited for cassava cultivation for maximum yields. For example, cassava must not be grown in areas with high termite populations; otherwise, destructions of termite colonies is recommended prior to planting. WAAPP already knows the cassava growing belt within the country. This knowledge can be tapped upon by WAATP for high quality cassava production.

c) Variety Selection

The cornerstone of IPM lies in choosing beneficial crop varieties, such as those with disease and pest resistance characteristics. Such varieties can be derived from traditional cross-breeding or modern biotechnology practices, pest-resistant and herbicide-tolerant varieties, may reduce the need for other crop protection measures. Selection of fast cassava growing cultivars such as SLICASS 6 or SLICASS 7 can outgrow weeds, resistant to cassava mosaic virus disease (CMVD). Various NERICA varieties are available in country and most are performing very well even under farmer traditional crop management system. Short duration maize varieties are also very prominent for high yielding. However, a new transboundary pest the fall armyworm (FAW) has been identified as a primary pest of the crop. Knowledge of the lifecycle of the pest could help in selection of maize variety.

d) Crop Rotation

Planting similar crops alongside each other such as maize field alongside rice field can substantially increase pests, this should be avoided. Planting different crops in alternate rows or under-sow a crop like maize with a legume such as cowpea will help improve soil fertility and reduce weeds and other pests associated with the previous crop. Growing different crops in rotation also helps reduce the build-up of pests, especially those in the soil such as root-feeding insects and fungi. Crop rotation can reduce weed problems too. Nonetheless, it is not advisable to rotate rice with maize as most of the pests attack and damage both crops.

e) Soil Management

Mechanical, physical and cultural crop protection methods prevent or minimize pests as well as reduce their build-up and carryover from one crop to another. For example, traditional ploughing turns the soil and buries crop residue and weeds before the seedbed is prepared for the next crop. However, tillage can lead to increased erosion as well as loss of soil moisture and organic material. For WAATP target crops, soil management is very important for quality production and productivity as well as reducing the cost of production.

f) Water Management

Supplying water to crops is essential to plant health but it can also greatly influence pest incidence and impact. Irrigation may be required, especially in dry areas or with crops that require a lot of moisture, e.g. swamp rice varieties. Irrigating lowland rice fields can control weeds but can adversely affect beneficial soil organisms and provide breeding space for mosquitoes. Drip irrigation or growing crops on ridges or raised beds may help combat these risks and conserve water. Rice gall midge *Orseolia oryzivora* invaded Sierra Leone from Kambia/Guinea border swamps, but recent studies have shown that the pest is all over the country specifically on swamp rice. Effective water control can reduce the incidence of gall midge infestation.

g) Monitoring

Management of any crop requires routine inspections to assess how well the plants are growing and what actions need to be taken from seeding to harvest. Walking through a field involves scouting for pests and distinguishing them from non-pests and beneficial insects. This is particularly very important for the new invasive transboundary pest (FAW) on maize, rice, legumes, and many vegetable crops. Pheromone traps, light traps, diagnostics and forecasting systems can assist with monitoring in a timely and accurate way.

A successful IPM requires collaborative decisions to provide effective control of pests. Some of these decisions need to be taken by national governments/institutions as the case may be in relation to quarantine regulations and legislation, provision and training of advisory services and strategies for control of highly mobile pests like the variegated grasshoppers or transboundary pests such as

the fall armyworm, larger grain borer *Prostephanus truncates*, fruit flies *Bactrocera invadens*, papaya mealybug *Paracoccus marginatus*, mango mealybug, *Rastrococcus invadens,* etc.

h) Cultural Control

Cultural practices are things one can do to discourage pest invasion such as good sanitation, removing debris and infested plant material, proper watering and fertilizing, growing competitive plants, or using pest resistant plants. Practices such as hand weeding or disease control by removing infected plant debris, should be assessed for their impact on plant roots and yields as well as their requirements for labour. The possibility of integrating cultural techniques with the careful use of pesticides should be explored. For example, instead of replacing manual weeding entirely with herbicides, hoeing may be used in conjunction with them. On cassava, hand weeding has been very effective, and the weed used as manure. Hand picking of grasshoppers have however, not been effective in the control of the pest

i) Biological Control

Biological control is a method of using other living organisms to control pests such as insects, mites, weeds and plant diseases. Biological control relies on introduction of beneficial organisms for predation, parasitism, herbivory, or other natural mechanisms, but typically also involves an active human management role for technical expertise such as formulation preparation, field application and resistance management. The use of beneficial insects to control pests has worked well in previous introductions such as for the control of the cassava mealybug *Phenacoccus manihoti* in Sierra Leone by the parasitic wasp *Apoanagyrus lopezi, Rastrococcus invadens* by the parasitoid *Anagyrus mangicola*. However, biological control programmes work best when crops are grown in controlled environments like greenhouses and plastic tunnels.

Bacteria, fungi, nematodes or viruses have also been mass produced and used to control some pests. The most common and successful is *Bacillus thuringiensis* (*Bt*), a naturally occurring bacterium, which has been used to control several important pests (e.g. caterpillar pests in vegetables and cotton). Reports have also confirmed that *Bt* is also effective in the control of FAW. The development and availability of insect sex pheromones and other behaviour-modifying chemicals offer farmers the possibility of:

- Selective trapping techniques to monitor the movement of pests or changes in their populations during the season.
- "Lure and kill" strategies to attract the pest to insecticide deposits and reduce the need for overall crop spraying.
- Mating disruption that slows population build-up to delay or reduce the need for control treatments.

j) Chemical Control

Chemical crop protection products (pesticides) are biologically active chemicals that control a range of insect and vertebrate pests, diseases and weeds. They are often the most cost-effective way of controlling infestations as part of an IPM strategy. Before crop protection products are released in the market, they are thoroughly tested for their safety, usefulness and effectiveness. When sold, they are labelled with explicit use instructions. To get the most out of these products, they must be applied correctly. Responsible use and good handling practices limit potential pesticide residues in crops and the environment as well as help avoid pest resurgence and resistance. Improved application techniques and equipment, such as reduced drift nozzles and spot spraying, help farmers protect natural habitats for wildlife and beneficial organisms. The timing of treatment (season and time of day) as well as the types of products used are also critical factors for their efficiency and efficacy.

6 Pesticide Management Methods and Usage

Generally, pesticide is the name used to describe a range of substances or mixtures used to kill, reduce, repel or manage many types of pests. They are one of many tools available to farmers for effective protection of crops from weeds, insect infestation and diseases infection. Pesticides are named according to the type of the pest they can control, such as; insecticides used against insects; herbicides for the management of weeds; fungicides used against fungi and mould diseases; rodenticides used against rodents; molluscicides used against mollusks and snails; Nematicides for the control of nematodes, etc.

Because of this and for a better understanding and management of pesticides, there is a need to have foreknowledge on their groupings based on their chemical or biological properties, their various mode of actions and effects. This could guide on what pesticide to use for specific crops and their associated pests.

6.1 Chemical Pesticides

Chemical pesticides are generally prepared from synthetic materials that directly kill or inactive target pests. Some examples of chemically-related pesticide groups include the following, some of which have been added to WHO list of "Extremely hazardous" and "Highly hazardous" class of pesticides (Appendix I).

6.1.1 Organophosphates (OP)

Most of these pesticides are insecticides and their effects on insects are similar to their effects on humans, livestock and some are very poisonous and highly toxic. However, they are usually not persistent in the environment. Some examples are Fenthion, Dichlorvos, Malathion, Parathion, Diazinon, Dichlorofenthion, Chlorpyrifos, Chlorpyriphos-Methyl, Dicrotophos, Fenitrothion, Methamidophos, Mevinphos, Monocrotophos, Phorate, Pirimiphos-Methyl, Profenofos, Terbufos, Tetrachlorvinphos, etc.

6.1.2 Carbamates

These insecticides are made from carbamic acid and used to kill or control insects similar to organophosphates. There are many forms of Carbamates, each different in the way they work and in their poisonous effects. Carbamates break down in the environment within weeks or months. They are used as sprays or baits to kill insects by affecting their brains and nervous systems. They are used on crops to kill ants, crickets, aphids, scale insects, and lace bugs. Some Carbamates have been found in groundwater at levels high enough to cause concern. Examples include Aldicarb (Temik), Carbofuran (Furadan), Carbaryl (Sevin), Ethienocarb, Fenobucarb, Oxamyl, and Methomyl; most of these have been classified in WHO class 1a and 1b group of pesticides.

6.1.3 Chlorinated Hydrocarbons

These are a group of chemicals composed of carbon, chlorine and hydrogen. As pesticides, they are also referred to by several other names, including chlorinated organics, chlorinated insecticides and chlorinated synthetics. Most of the chlorinated hydrocarbons, e.g. DDT, Aldrin, Dieldrin, Heptachlor, Lindane, Mirex, Endrin, Methoxychlor, Chlordecone, Chlorobenzilate, and Chlordane

have been banned for use in most countries, although DDT is still in use in some developing countries for combating insect vectors of human diseases. Their persistence is attributed to their long life in the soil.

6.1.4 Pyrethroids

Pyrethroids are synthetic version of the naturally occurring pesticide pyrethrin, modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system. Examples are Cypermethrin, Cyfluthrin, Deltamethrin, Permethrin, Phenothrin, Tetramethrin, Tralomethrin**,** etc.

6.1.5 Biopesticides

Biopesticides are certain types of pesticides derived from natural materials such as animals, plants, bacteria, fungi and certain minerals. For example, canola oil and baking soda have pesticidal actions and are considered biopesticides. By the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products worldwide. Biopesticides fall into three major groups:

6.1.6 Microbial biopesticides

These consist of microorganisms (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest. An example is the IITA developed fungus based biopesticide *Metarhizium annisopliae* commonly called Green Muscle, an ecologically sustainable option for the control of the variegated grasshopper *Zonocerus variegatus* throughout in West Africa. In Sierra Leone, Green Muscle was field tested with excellent results in 2006 with support from Care International Sierra Leone in collaboration with IITA and the Crop Protection Service of MAFFS. The product is prepared for field application as follow: 25grams GM in 300ml vegetable oil and 700ml kerosene to spray one hectare.

6.1.7 Biochemical pesticides

These are naturally occurring substances that control pests by non-toxic mechanisms. Biochemical pesticides include substances, such as insect sex pheromones that interfere with mating as well as various scented plant extracts that attract insect pests to traps (e.g. Methyl Eugenol for catching male Fruit flies *Bactrocera invadens*). Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, the Environmental Protection Agency Sierra Leone (EPA-SL) has established a special committee to make such decisions.

6.1.8 Botanicals

Neem *Azadirachta indica* pesticides play a vital role in pest management and hence have been widely used in agriculture. The tree has anti-bacterial; anti-parasitic, anti-fungal, anti-inflammatory and analgesic properties. Neem is recognized today as a natural product which has much to offer in solving global agricultural, environmental and public health problems. It is considered as a valuable instrument for sustainable development. Neem pesticides are being manufactured and exported to various countries as a lot of research has been conducted to test the

safety and efficacy of neem for use as a pesticide. Using Neem is very beneficial for proper crop and pest management. It also helps to nourish and condition the soil, environmental friendly, non-toxic and it can be used in combination with other pesticide and oil for more effectiveness.

Neem pesticides are generally water soluble and help in the growth of the plants. It acts as pest repellent and pest reproduction controller. Anti-feedant properties found in neem compounds helps to protect the plants. Pests generally do not develop a resistance to neem-based pesticides. Neem oil and seed extracts are known to possess germicidal and anti-bacterial properties which are useful to protect the plants from different kinds of pests. One of the most important advantages of neem-based pesticides and neem insecticides is that they do not leave any residue on the plants. The active ingredient Azadirachtin found in neem tree, acts as an insect repellent and insect feeding inhibitor, thereby protecting the plants. Neem insecticides are used to protect both food as well as cash crops like rice, legumes, cotton, other oils seeds, etc.

Azadirachta indica is native to the arid regions of the Indian sub-continent. It was introduced in Sierra Leone at the then Njala University College herbarium in 1949. FAO officially launched the Neem in Sierra Leone as a crop in 2010 and supported the establishment of 10,000 seedlings in the Kaffu Bullom chiefdom, Port Loko district. Currently, with support from UNIDO, a large number of trees are now being planted all over the country, and Njala University has done some research on the plant. Farmers are aware of the benefits of neem and the adverse effects of chemical pesticides. Farmers are keen to adopt neem based-pesticides in their plant protection schedules. Neem is now established in many districts nationwide, with 2 acres as Integrated Agroforestry at Njala University, 10 acres in Yakemo Kpukumu Krim chiefdom in Pujehun district and several acres in Bombali district.

A pilot neem production factory supported by UNIDO has been established at the Levuma Beach under the supervision and operation of the National Farmers Federation of Sierra Leone (NaFFSL). Promoting this crop will be great idea as no pest has ever been recorded to have built up resistance to neem-based pesticides. The main beneficiaries would be

a) The resource poor farmers, small scale village level agribusiness enterprises and micro-industries. Farmers would get access to less expensive and abundantly available pesticides improving their self-reliance, and small-scale village entrepreneurs could avail of the opportunity to use the simple technology to set up micro industries manufacturing the pesticides

b) Women and the unemployed rural youth would be particularly benefited as they would be involved in the agri-business of seed collection and processing of neem kernel for the manufacture of the neem-based pesticides, and this would generate employment for them.

c) Technical institutions such as Agricultural Universities e.g. Njala University would benefit from the technology transfer and institutional linkages as well as capacity enhancement through participating in the bio-efficacy studies.

d) Through reduction in use of polluting chemical fertilizers, health hazards from handling chemicals, and soil, water and food contamination would reduce.

e) Benefit to the environment through reduction in the persistent organic pollutants (POPs).

6.2 Impacts of the Use of Chemical Pesticides

6.2.1 Consequences in the improper use of pesticides

- health hazard to applicators,
- destruction of natural enemies of pests,
- development of resistant species of pests,
- pest resurgence,
- toxic chemical residues in food,
- soil and water bodies, and
- environmental pollution

6.2.2 Negative impacts of uncontrolled use of pesticides

Pesticides if used judiciously can provide immense benefit in agriculture as well as in the public health sector. They are used to control insect pests, disease causing pathogens, weeds, etc to increase yields and improve crop quality.

However, when pesticides are not regulated, these could have serious health implications to human, wildlife and the environment. There is now overwhelming evidence that some of these pesticides do pose a potential risk, and no segment of the population is completely protected against exposure to pesticides and the potentially serious health effects. High risk groups exposed to pesticides include production workers, formulators, spraying operators, mixers, loaders and agricultural farm workers.

6.2.3 Impact through food commodities

Uncontrolled pesticide use could have severe adverse effects on food commodities for local consumption as well as regional or international trade. In the European Union, a Monitoring of Pesticide Residues in Products of Plant Origin in the European Union' had been established since the 1990s. During such routine monitoring, pesticides such as acephate, chlopyriphos, Chlorpyriphos-methyl were analysed in apples, tomatoes, lettuce, strawberries and grapes. Currently, the European Union uses the EUROPHYT NOTICIFICATION SYSTEM to inform countries of any interception of consignment in which organisms or pesticides residues are found in export food commodities.

6.2.4 Impact on the environment

Pesticides can contaminate soil, water, and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-

target plants. Insecticides are generally the most acutely toxic class of pesticides, although herbicides can also pose risks to non-target organisms.

6.2.5 Surface water contamination

Pesticides can reach surface water through runoff from treated plants and soil. Contamination of water by pesticides is widespread. Cleaning of spray equipment in water sources can contaminate water for other users of the water source downstream.

6.2.6 Ground water contamination

Groundwater pollution due to pesticides is a worldwide problem. According to the USGS, at least 143 different pesticides and 21 transformation products have been found in ground water, including pesticides from every major chemical class.

6.2.7 Effect on soil fertility (beneficial soil microorganisms)

Heavy treatment of soil with pesticides can cause populations of beneficial soil microorganisms to decline; e.g. the soil will degrade if both bacteria and fungi are lost. Overuse of chemical fertilizers and pesticides have effects on the soil organisms that are similar to human overuse of antibiotics.

6.2.8 Contamination of air, soil, and non-target vegetation

Pesticide sprays can directly hit non-target vegetation or can drift or volatilize from the treated area and contaminate air, soil, and non-target plants. Some pesticide drift occurs during every application, even from backpack spray equipment. Drift can account for a loss of 2 to 25% of the chemical being applied, which can spread over a distance of a few yards to several hundred miles. As much as 80–90% of an applied pesticide can be volatilised within a few days of application

6.2.9 Non-target organisms

Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. Once there, they can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds, and other wildlife. Chlorpyrifos is highly toxic to fish, and has caused fish, kills in waterways near treated fields or buildings. Herbicides can also be toxic to fish.

6.2.10 Application time

Beneficial organisms are normally always in crop fields but unnoticed. Conserving natural enemies of pests is an important part of IPM and helps to prevent pest resurgence. The effect of a pesticide product or other interventions on both pests and their natural enemies needs to be considered. Timing pesticide application to match periods when natural beneficial organisms are not active, for example, may help protect them. Populations of beneficial species can recover quite quickly, even when broad-spectrum pesticides are used and particularly if they are easily degradable.

6.3 Assessment of Knowledge and Practices in Pesticide Management

Generally, the use of pesticides in Sierra Leone is very low with less than 1% of farmers applying pesticides for pest and disease control. Notwithstanding the rather insignificant use of pesticides to control pests and diseases, pesticide contamination of food and water bodies is a problem in Sierra

Leone. There are reported cases of pesticide-related accidents in Sierra Leone including the following:

- Death of humans and wild life
- Death of aquatic live especially fish
- General illness
- Skin and eye irritations

Until the invasion of the African Armyworm *Spodoptera Exempta* in 1979 and 1982, the use and application of pesticides was not a common practice in pest management. Large quantities of insecticides were imported amass to combat the pest in rice and maize fields. Within that period, the then Ministry of Agriculture and Natural Resources (MANR) with UNDP technical support and through Act of Parliament, established the Pest Control Unit (PCU) for pest management within the country. The MANR opened regional pest control offices and set up pest control teams at district levels to manage pests and pesticides and pest control activities. The presence of those teams made it possible for effective management of pesticides. Farmers were carefully guided on the use and application of pesticides and related precautionary measures.

However, over the years, with the invasion of other crop pests such as the cassava mealybug *P. manihoti*, mango mealybug *Rastrococcus invadens*, fruit flies *Bactrocera invadens*, with the introduction of biological control agents (parasitoids) and biochemical (pheromone traps), and the establishment of plant health clinic system, pesticide use has been minimized. Prior to PHC system, some of the practices instituted for the management of those pesticides include the following:

6.3.1 Selecting the Right Pesticides

In developing an IPM program with pesticides, it is essential to review product characteristics, applications and costs, then select the ones that provide the most cost-effective treatment with minimal undesirable effects. Note that some products have a broad spectrum of activity, while others only target a few types of pest species. Selective pesticide substances are less likely to affect natural enemies and other non-target organisms. When these are available, it is important to determine if a limited number of applications are more cost-effective than a cheaper one, or broad-spectrum product that requires more applications.

Seed treatments, which protect seedlings from early pests, are also beneficial and may prevent the need for pesticide applications later on. Most pesticides have a broad spectrum of activity and it is important to distinguish between their intrinsic toxicity and bioavailability. Every pesticide should be used according to manufacturer recommendations. Guidelines on the appropriate storage, transport and disposal of unused pesticides and empty containers should also be strictly followed.

6.3.2 Timely application

Targeted and timely application of any pesticide is key to effective and efficient pest management system. This requires the use of appropriate and well-maintained equipment as well as knowledge of the pest and pesticide.

6.3.3 Use of Public Health Pesticides

While the use of insecticides, for instance as aerosols, is widely practised in Sierra Leone, so far there is no documentation of the extent of their use by individuals at household level nor is there any official information of their use at commercial levels. There is a need for government of Sierra Leone to institute measures to determine the availability and use of public health insecticides and regulate their importation into the country in line with the relevant regulatory system.

The current PMP implemented by CPS/MAFFS is based on recommendations outlined in the draft Plant Protection, and the National Integrated Pesticide Management policies and the introduction of Plant Health Clinics at FBOs and the ABCs. The policies recommend that all agricultural pesticide imports must be approved by CPS/MAFFS. This is to ensure that importers abide by the recommended pesticides for use in Sierra Leone and that such pesticides are NOT on World Health Organisation (WHO) danger list. In collaboration with CABIplantwise, CPS prepared two pesticide usage guides (Appendix II). These in conjunction with the plant health clinics have been effective and helpful somehow in pest and pesticides management in the following ways:

i) Pesticides dealers have most of the time collaborated with CPS for any pesticide import;

ii) Samples of new pesticides are provided by importers for field trial and evaluation;

iii) Importers have regularly attended pesticides management meetings and workshops to assure compliance;

iv) Farmers associated with the ABCs have ceased from buying pesticides from street vendors;

v) The frequency of pesticide use by farmers has reduced drastically;

vi) Accidental pesticide poisoning has reduced;

vii) The use of bio-pesticide has widely been accepted and farmers are now requesting for Green Muscle (a bio-pesticide) for grasshopper control in cassava fields; Methyl Eugenol traps for fruit fly control;

viii) Farmers now report pests' incidences as are observed for the first time.

7 Action Plan for Pest and Pesticide Management

This Pest and Pesticide Management Action Plan (PMP) addresses some of the priority areas necessary for effective implementation of the IPM within WAATP in collaboration with existing planned activities of CPS/MAFFS, other institutions and government policies and regulations as identified for effective functioning and sustainability of this PMP. This PMP should be streamlined into the major components of the WAATP project in line with the requirements for compliance with the World Bank's safeguard Policies, OP 4.09 and BP 4.01 (Annex C). The PMP also proposes collaboration with other similar agricultural projects or NGOs in agriculture to assist CPS/MAFFS in the development of an IPM policy to encourage pesticide dealers and importers to comply with international conventions, agreements and guidelines on pesticide trade and distribution. Some of the priority areas for WAATP intervention to effect pesticide management are summarised in Table 4.

Table 4: Priority issues and actions required

Major issues	**Actions required**	**Responsible Institution/ Stakeholders**
Lack of documented regulatory system on pest and pesticide management	Support CPS to enact into Law the draft Plant Protection Policy for the establishment of a Plant Protection and Regulatory Services Division and its enforcement mechanism to ensure the operationalization of the national pest and pesticide management board/committee	MAFFS
Increased use and reliance on chemical pesticides	• Promote IPM through farmer's education and training. • Monitor use of pesticide among farmers • Monitor adoption of IPM practices. • Ensure strict adherence to existing policy on use of new chemical pesticide in project environment. • Create public awareness on banned and approved chemical pesticide and safe use methods. • Monitoring of pesticide poisoning in the farming and beneficiary communities. • Investigate remedial effect of pesticide misuse on agricultural products.	MAFFS, EPA
Introduction of new pest	• Monitor crops/livestock for alien or transboundary invasive species.	MAFFS
More focus on IPM and other non-chemical practices	• Develop IPM training modules. • Organize training of trainers and beneficiaries on IPM. • Produce and disseminate IPM information materials (posters, factsheets, etc). • Support participatory research in non-chemical pest control measures. • Strengthen extension support to IPM practices.	MAFFS, SLARI

Major issues	Actions required	Responsible Institution/ Stakeholders
	• Undertake periodic monitoring of pest management practice in use during project implementation. • Support necessary pest management practices. • Increase IPM awareness for communities & policy makers.	
Increase in vector population and vector-borne diseases	▪ Raise awareness on vector population and vector-borne diseases • Support health campaigns in the project areas in collaboration with MoHS. • Conduct regular vector surveillance surveys • Establish linkage between WAATP and national health programmes.	MAFFS, SLARI, MoHS

7.1 Strategy for Intervention and Pesticide Management Action Plan

Successful implementation of this PMP lies with the responsible of MAFFS. In the light of this, WAATP should support and encourage MAFFS administration to forge ahead with enactment processes of the draft Plant Protection Policy for the establishment of the PPRSD, and the National Integrated Pesticide Management policy for setting up of a National Pesticide Management Committee. This will foster initial pesticide registration and licensing scheme, take inventory of all available pesticides in country and sustainability of the scheme at the end of project life. Information dissemination to the farming communities, the general public and pesticide dealers about the dangers of pesticides will be enhanced, hence provisions are made in the legislation for effective monitoring with enforcement mechanism.

The PMP implementation programme must be located at CPS/MAFFS level with field action by farmer groups who will receive training and advisory services from CPS, and community facilitators who would have graduated from the Training of Trainers (ToT) sessions. Training at all levels will be based on participatory learning modules for capacity building in IPM information delivery. Specialized IPM needs, such as the development of crop associated pests list, and beneficial species list, should be addressed by relevant research institutes such as SLARI and Njala University with proven expertise in the respective problem areas. The PMP implementation process will promote environmentally sustainable pest management options and assesses the economic, environmental and social impact of each the interventions.

7.2 Monitoring and Evaluation Plan

Effective monitoring of pesticide in Sierra Leone must be a concerted effort involving many players; from policy makers, law enforcement government functionaries, dealers, MAFFS, and the farming community. This arrangement has already been spelt out in both the draft Plant Protection policy and the National Integrated Pesticides Management policy documents; all relating to pesticide registration as described below.

7.2.1 Recommended Actions

- Collaborate with CPS institute a system of registration so that all importers of pesticides apply for registration for approval by the PMC. Information on whether the pesticide meets the requirements on effectiveness, toxicity level and environmental effects, must be provided. This information should be supported with documents either from the country where the manufacturer is based or through records of trials under similar conditions other than Sierra Leone.
- When an application meets all importation requirements, an approval letter valid for a stipulated period will be issued to the applicant. Within that period, the company or individual will be allowed to import the quantities approved on the application form for a registered pesticide. An import license valid for the applied quantity in one or more shipments will then be issued. For a renewal of the registration after the expiration of the stipulated period, information gained from experiences in the previous licensing period can be used.
- The relevant Pesticide Control Authority will keep a register of all pesticides permitted for import which should be published at least once per year in the government gazette. Imported pesticides, which do not meet the quality requirements and regulations and certain minimal product labelling requirements should be refused entry into Sierra Leone.
- For internal monitoring, CPS/MAFFS will use pesticides import records, distribution areas, and PHCs records to assess where pesticides were used. CPS/MAFFS will use regulation procedures in relation to unused expired pesticides. Phytosanitary control personnel at the borders will intercept any illegal pesticide import at the various customs/security border posts.

7.3 Training Plan of Actors Involved in PMP

Long-term and sustainable adoption of IPM by farmers will only occur if they get information about it along with the tools and technologies to implement it. To effect this, in collaboration with the CPS/MAFFS, the project would actively engage in training of farmers, frontline extension staff, CPS staff (Plant doctors) and Agro-dealers and capacity building programs around the country, in partnership with the public sector. Within MAFFS/SLARI/Njala University, there are already master trainers on pests' management for training of farmers and plant health doctors. The capacity of these could be upgraded on the area of pesticide management.

Key components include:

- Training technical staff as Master Trainers, who may teach advisory and sales staff about IPM.
- Training MAFFS field staff, private extension staff as well as pesticides dealers and seed distributors and retailers.

- Developing education and training programs for farmers.
- Practical ways of reaching farmers may include Farmer Field Schools, community radios and social media, newsletters, direct mail, videos, factsheets and posters.

A major goal of the training is to maximize product benefits and minimize their risks. Such training covers all aspects of handling and storing pesticides, as well as when to use and when not to use them, including how to:

- Identify pests and beneficial insects
- Assess risk of pest populations and potential crop damage
- Manage pests according to IPM principles
- Apply crop products safely and effectively if required
- Avoid unacceptable risks to people and the environment
- Minimize product residues on crops and monitor for pest resistance

7.3.1 Training of Trainers (ToT)

Six to ten days intensive courses should be conducted for 20-30 men and women extension agents. The course will consist of participatory learning modules (PLM) developed in line with identified farmers' training needs. Participants will be trained in:

a) Purchase, transport and storage of pesticides
b) Personal protective equipment
c) Mixing and preparing pesticides
d) Disposal of empty containers
e) Portable application equipment
f) Good spraying practices
g) Record keeping
h) Pesticides and pesticide safety
i) Reporting

7.3.2 Farmers' Group Training

Farmer training will focus on group learning (FFS) for informed decision making on IPM issues. Group learning will be experiential through farmer-led field trials and discussions on practical aspects of crop production, plant protection and indigenous knowledge. Farmer group learning will be facilitated by a pair of Master Trainers (both men and women extension agents). Several training visits must be organized. Group decision making will be achieved through Agro-ecological system by comparing IPM practices with normal farmer practices. At each Agro-ecological system, the Extension staff and farmers will observe, record and monitor changes in soil, crop/livestock and trophic relationships affecting crop/livestock growth. Group learning helps to increase scientific literacy, ownership of biological and ecological information and knowledge, and informed decisions making habits in the communities.

7.3.3 Information and Awareness Raising

Generally, there is not much awareness in the risk in the use of pesticides despite farmers tend to use pesticides to control their pests. In disseminating pesticide information particularly to the farming community, MAFFS through its international partner CABIplantwise in pests' management, the establishment of plant health clinics have been very useful. Awareness raising has been effected at the ABCs and PHCs by plant doctors and extension staff at block level as well as at agricultural trade fairs. For effective information dissemination, WAATP must support the development and production of the following media packages to reach a wider audience:

- Develop, produce and distribute pest factsheets for each WAATP target crops;
- Develop, produce and distribute pesticide management factsheets (Insecticide, Herbicide, Botanicals),
- Develop posters on Safe Pesticide Application Techniques;
- Develop Extension messages for Radio discussion on pest and pesticide management at community levels;
- Develop Radio and TV discussion messages for phytosanitary procedures for pesticide import;

7.3.4 Coordination and Monitoring of the PMP

It must be noted that CPS/MAFFS have been buying and supplying pesticides at district level for farmers use. Large quantities of those unused pesticides are still in MAFFS stores. The status of those pesticides needs to be known and to be used as benchmark for future monitoring of this current plan. Coordination and support are wholly WAATP responsibility in collaboration with CPS/MAFFS to see that the following are implemented.

Activities for Coordination

a) Conduct a baseline survey to assess what pesticides are in the field;

b) Needs assessment to be carried out across the project area to effect a standardised training for the implementation of the PMP;

c) Identify farmers' training needs areas in pest and pesticide management;

d) Consult with CPS/MAFFS and SLARI to Identify and select suitable local training resource persons within their institutions and outside as well;

e) Develop training modules for various levels for farmer groups and frontline extension staff;

f) Identify and organize farmers groups for training;

g) Training implementation needs to be planned in consultation with farmer groups so that participants could be identified in advance;

h) Technical support needed in the preparation and delivering of specific training materials as well as evaluating resource materials;

i) Involve local expert in the preparation and supervising training implementation;

j) Monitor performance of farmer trainers and post-training assignments;

k) Support local expert for the preparation of training progress reports;

7.3.5 Monitoring the Implementation of the PMP

The following factors will determine effective implementation of the PMP

a) Types and number of training Modules delivered;

b) Number of extension agents and farmers trained in each Module;

c) PMP techniques frequently demanded by extension agents as well as farmers;

d) Types of management practices preferred by crop farmers;

e) Types of management practices preferred by livestock farmers;

f) Management practices adopted most by farmers**:**

g) Number of other farmers trained by WAATP project trained farmers;

h) Number of farmers who have correctly applied the skills they had learned;

i) Assess the level of pest damage and crop losses;

j) Assess the rate of adoption by WAATP farmers of IPM practices and impact on production and productivity;

k) Compare increase in crop production by adopting IPM practices with farmer normal practices;

l) Compare the two practices with increase in farm revenue;

m) Assess the level of reduction in pesticide purchase and use;

n) Assess the number of WAATP farm families using malaria prevention practices they learned.

8 Institutional Arrangements for the Implementation and Monitoring of Pesticide Management Plan (PMP)

Effective implementation of the PMP will involve many actors. However, WAATP will play a pivotal role in the implementation of the PMP, whilst other institutions will provide technical support for implementation of the plan.

The major actors will be:

a) Ministry of Agriculture, Forestry and Food Security (MAFFS) – The Crop Protection Service Unit/Livestock and Veterinary Division in collaboration with other experts drawn from SLARI and Njala University will provide technical support to WAATP project by contributing field staff to be trained as IPM Trainers and who will subsequently train WAATP farmers in IPM practices. MAFFS will provide policy guidance/oversight for implementation of the PMP and undertake the monitoring, supervision and coordination of the IPM activities.

b) WAATP Farmers – as the principal beneficiaries, WAATP will organize its members into farmer groups or FBOs for training and promotion of IPM practices. They will set up Community IPM Action Committees to coordinate IPM activities in their areas. WAATP Farmer groups will act as the body to discuss general pest/vector problems and make decisions about IPM programmes with local experts.

c) The Ministry of Health and Sanitation will supervise surveillance activities around the small-scale irrigation sites on the incidence of disease vectors; use of treated bed-nets and re-treatment of bed-nets.

8.1 Pesticide Regulation Units

Both MAFFS and MoHS have statutory mandates to regulate Agricultural, Public Health, household, and all other related pesticides. With WAATP support, the relevant Units in each Ministry will:

- Review applications for registration of pesticides;
- Conduct science-based health, environmental and efficacy assessments;
- Develop and implement policies and guidelines related to pesticide management;
- Promote sustainable development;
- Enforce compliance with the legislation and disseminate information on pesticide management issues.

8.2 Inter-departmental Cooperation

The draft Integrated Pesticide Management (IPM) policy recognizes that effective and efficient management of pesticides must be a concerted effort that requires inter-departmental coordination

from a range of team players. Then the responsibility for the enforcement of pesticide regulation will be shared among various ministries and agencies with MAFFS and MoHS having the statutory responsibility.

Recognizing that these departments will have complementary responsibilities, MAFFS and MoHS and the various government ministries and agencies need to develop inter-departmental Memorandum of Agreement (MoA) in relation to pesticide management issues. These MoAs are intended to foster a strong working relationship between the parties by delineating their respective responsibilities and identifying areas of mutual interest for effective monitoring.

8.3 Monitoring and Research

Many pesticides are known to accumulate in the environment and to have detrimental effects on human health and the environment. Long-term monitoring programmes and targeted research are essential in order to evaluate these impacts. Without adequate and reliable data, it would be impossible for the government to assure Sierra Leoneans that pesticides in current use are not posing such a risk to human, wildlife and the environment.

Research and monitoring will help to identify changes on crops as a result of pesticide sprays. WAATP support to SLARI and Njala University laboratories can diagnose symptoms of pesticide residual effects on crops, particularly insecticides; for their effectiveness such as the Neem based pesticide. Some pesticides, such as herbicides may be field tested prior to full application on crops, CPS could carry out field trials of some herbicides without relying solely on manufacturers recommendations by applying the basic principles of IPM (Appendix III).

Farmer-educational activities will be central to an exit strategy which will feature increased roles and responsibilities of national institutions to take primary responsibilities in the development of action plans and expertise exchange for IPM development and promotion. Committed national partners will take primary responsibilities for influencing the development of national policies that fully recognize and promote IPM as important integral component of agricultural production and productivity.

8.4 Work Plan and Budget

An annual work plan will be developed in consultation with the CPS/MAFFS in line with the various priority issues. Approximately US$ 727,380 will be required to effectively implement this PMP over a five-year period (Table 5).

Table 5: PMP Implementation Budget

Line item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
1. Capacity building						
Developing training modules	15,000	0	15,000	0	0	**30,000**
ToT trainings	20,000	0	15,000	15,000	0	**50,000**
Training of Neem factory Operators	15,000	15,000	0	0	0	**30,000**
Support to Neem production	20,000	10,000	5,000	5,000	5,000	**45,000**
Support Implementation of draft policies	15,000	15,000	0	0	0	**30,000**
Sub-total	**85,000**	**40,000**	**35,000**	**20,000**	**5000**	**185,000**
2. Advisory services						
IPM baseline survey	10,000	0	0	0	0	**10,000**
Factsheets	9,000	0	5,000	5,000	0	**19,000**
Poster	0	15,000	0	15,000	0	**30,000**
Mobility (pickup vans, motorbikes)	102,000	0	0	0	0	**102,000**
Field guides/IPM materials	5,000	5,000	5,000	0	0	**15,000**
Public awareness/sensitization campaigns	10,000	10,000	10,000	5,000	5,000	**40,000**
Pest/vector surveillance	10,000	5,000	5,000	5,000	5,000	**30,000**
Sub-total	**146,000**	**35,000**	**25,000**	**30,000**	**10,000**	**246,000**
3. PMP Management						
Equipment (Desktop, laptops, Typewriters, printers)	9,400	0	0	0	0	**9,400**
Field guides/IPM materials	5,000	5,000	5,000	0	0	**15,000**
Field equipment (GPS, cameras, sample collection kits, magnifying lenses	2,600	0	2,000	0	0	**4,600**
Lab equipment (microscope, dissecting kits	880	0	500	500	0	**1,880**
Poultry treatment (NCD vaccine, HB1, Lasota, pox vaccine, Multivite powder)	5,000	3,000	3,000	3,000	3,000	**17,000**
Small Ruminant Treatment	6,500	5,000	5,000	5,000	5,000	**26,500**
Vector surveillance	18,000	0	15,000	0	10,000	**43,000**
Treated bed nets	10,000	5,000	0	5,000	0	**20,000**
Equipment; bed nets; chemicals, neem	5,000	10,000	5,000	5,000	0	**25000**
Support to IPM research and development	10,000	15,000	10,000	5,000	2,000	**44,000**
Sub-total	**72,380**	**43000**	**45500**	**23500**	**20000**	**206,380**
4. Coordination						
Monitoring and evaluation	10,000	6,000	10,000	10,000	0	**36,000**
PMP coordination	6,000	2,000	2,000	2,000	2,000	**14,000**
IPM Research and development	10,000	0	10,000	10,000	0	**30,000**
Training Reporting	2,000	2,000	2,000	2,000	2,000	**10,000**
Sub-total	28,000	10,000	24,000	24,000	4,000	**90,000**
Grand total						**727,380**

8.4.1 Budget notes

1. IPM Diagnosis: Conduct baseline survey to assessment of IPM problems in the three regions (North, South and East) = $10,000
2. Training Modules: Cost of developing and producing two training modules (for ToT and farmers) at $5,000 per module = $10,000
3. Training of Trainers: 1 ToT course in each of 3 regions (North, South and East) at $15,000 per course lasting 1-week for 30 participants per course (i.e. 90 trained extension agents at $500 per participant).
4. Field guides: Cost of preparing and producing 2000 copies of a field guide at $2.5 per copy =$5000.
5. Office equipment: Cost of five Desktop Computers at $830 each, Five Printers at $850 each, five Typewriters at $200 each) = $9,400
6. Field equipment: cost of five GPS at $150 each, five digital cameras at $150 each, magnifying lenses $500, sample collection kit $600) = $2,600
7. Laboratory equipment (Five Microscope at $500 each, five dissecting pins set at $130, $250 for forceps, dissecting knives) = $880
8. Factsheets: Cost of preparing and producing 3000 copies of pests factsheets at $3.0 per copy = $9,000
9. Posters: Cost of preparing and producing 1500 Information posters at $10 per copy = $15,000
10. Mobility: Cost of two pickup vans at $45,000 each, Four Motorcycles at $3,000 each = $102,000
11. Public awareness and sensitization campaigns: cost of TV and radio jingles, posters, and sensitization workshops.
12. Poultry treatment: Cost of NCD Vaccine, HB1, Lasota, Pox vaccine, dewormers (Piperazine) Multivite powder, acaricide powder = $5,000
13. Small Ruminant Treatment: PPR vaccine, dewormers (Levamisole drench), Ivomectin injection, vitamin ADE injection, Acaridae powder/liquid, antibiotic injection = $6,500
14. Equipment, bed nets, chemicals and botanicals: Purchase and distribution of materials.
15. Support to IPM research and development (Field trials at regional level on pesticide efficacy) at $10,000 per region = $30,000
16. Botanicals: Support to Neem pesticide production at $8,000
17. Coordination: $2,000 for supervision visits to FBOs for post training assignment in three regions =$2,000 x 3 = $6,000 per year
18. Monitoring and evaluation (field work by 10 persons per region at $40 per person per day for 3 days) = $400 x 3 days = $1200 per region. Total cost $1200 x 30 = $36,000
19. Training Report: Support local expert to assist in the preparation of training reports = $2,000 per training

9 Conclusion

Pest management issues in agriculture (crops and livestock) and public health are rarely put in the forefront of most development projects, primarily due lack of legislative instruments for guidance and implementation. The general structure of CPS/MAFFS consists of major components in pest and pesticide management in line with ECOWAS pest and pesticide management guidelines/protocols. We therefore strongly recommend that this project strengthens the capacity of the CPS, so it is able to manage invasive transboundary pests and emergency outbreaks and support the upgrading of the legal and regulatory frameworks governing the establishment of a Plant Protection and Regulatory Services Division within MAFFS to align with similar NPPOs within the ECOWAS region.

10 Appendices

Appendix I: List of banned pesticides in Sierra Leone

1) WHO Class 1a: "Extremely Hazardous" Pesticides

Acrolein, Aldicarb, Arsenous, Brodifacoum, Bromadiolone, Bromethalin, Calcium, Captafol, Chlorfenvinphos, Chlormephos, Chlorophacinone, Chlorthiophos, Coumaphos, Crimidine, Cycloheximide, Demephion-o, Demephion-s, Demeton-o, Demeton-s, Dibromochloropropane, Difenacoum, Difethialone, Dimefox, Diphacinone, Disulfoton, EPN, Ethoprophos, Fenamiphos, Fensulfothion, Flocoumafen, Fonofos, Fosthietan, Hexachlorobenzene, Leptophos, Mephosfolan, Mercuric, Mevinphos, Parathion, Parathion, Phenyl mercury, Phorate, Phosfolan, Phosphamidon, Prothoate, Schradan, Scilliroside, Sodium, Sulfotep, Tepp, Terbufos, Thionazin, Trichloranat.

2) WHO Class 1 b: "Highly Hazardous" Pesticides

Aldoxycarb, Aldrin, Allyl Alcohol, Aminocarb, Antu, Azinphos Ethyl, Azinphos Methyl, Benfuracarb, Blasticidin-s, Bromphos Ethyl, Butocarboxim, Butoxycarboxim, Cadusafos, Calcium Arsenate, Carbofuran, Carbophenothion, Cloethocarb, Coumachlor, Coumatetralyl, Crotoxyphos, Demeton-s Methyl, Demeton-s Methylsulphon, Dichlorvos, Dicrotophos, Dieldrin, Dimetilan, Dinoseb, Dinoseb Acetate, Dinoterb, Dioxathion, Dnoc, Edifenphos, Endrin, Esp, Famphur, Fenthion, Flucythrinate, Flouroacetamide, Formetanate, Fosmethilan, Furathiocarb, Heptenophos, Isazophos, Isofenphos, Isoxathion, Lead Arsenate, Mecarbam, Mercuric Oxide, Methamidophos, Methidathion, Methomyl, Monocrotophos, Nicotine, Nitralicarb, Omethoate, Oxamyl, Oxydemeton Methyl, Paris Green, Pentachlorophenol, Phenyl mercury Nitrate, Pirimiphos Ethyl, Propaphos, Propetamphos, Sodium Arsenite, Sodium Cyanide, Strychnine, Tefluthrin, Thallium Sulfate, Thiofanox, Thiometon, Triamiphos, Triazophos, Tributyltin Oxide, Vamidothion, Warfarin, Zeta Cypermethrin, Zinc Phosphide.

Appendix II: Pesticides Recommended by the Ministry of Agriculture, Forestry and Food Security (MAFFS) for use in Sierra Leone

Active Ingredient	Substance Group	Target pests	Mode of Action	Toxicity to Mammals	Toxicity to Birds	Toxicity to Bees
INSECTICIDES						
Imidacloprid	Neonicitinoid	Sucking and soil	Systemic, with contact and stomach action	Moderate	High	High
Alpha-Cypermethrin (Alphamethrin)	Pyrethroid	Sucking and soil insects	Non-systemic, with contact and stomach action	Moderate	High	High
Cypermethrin	Pyrethroid	Many different insects	Non-systemic, with contact and stomach action	Moderate	High	High
Deltamethrin	Pyrethroid	Many different insects	Non-systemic, with contact and stomach action	Moderate	High	High
Chlorpyrifos	Organophosphate	Soil and foiage insects, mites and nematodes	Non-systemic, with contact and stomach action	Moderate	High	High
Diazinon	Organophosphate	Chewing and sucking insects	Non-systemic, with contact and stomach action	Moderate	High	High
FUNGICIDES						
Captan	Phthalimide	Many fungi	Non-systemic, with preventive and curative action	Low	Moderate	Moderate
Mancozeb	Dithiocarbamate	Many fungi	Non-systemic, with preventive and curative action	Low	Moderate	Low
Propineb	Dithiocarbamate	Mildew, leaf spots, scab, black rots, grey moulds	Non-systemic, with contact action	Low	Low	Moderate
Difenoconazole	Triazole	Many fungi	Systemic, with preventive and curative action	Moderate	Low	Moderate
Propiconazole	Triazole	Many fungi	Systemic, with preventive and curative action	Moderate	Low	Moderate
Tebuconazole	Triazole	Smuts, bunts	Systemic, with curative, preventive and eradicant action	Moderate	Moderate	Moderate
Cupric oxide (Copper II Oxide)	……	Many fungi and bacteria	Protective, inhibits spores and prevents pathogens from entering host	Moderate	Moderate	Low
HERBICIDES						
Ethofumesate	Benzofuran	Grasses and broad-leaved weeds	Systemic, absorbed through roots and shoots	Low	Moderate	Moderate
Glyphosate	Phosphonoglycine	Grasses and broad	Systemic, with contact action	Low	Moderate	Moderate
Metamitron	Triazinone	Grasses and broad	Systemic, absorbed through roots	Moderate	Moderate	Moderate
FUMIGANTS						
Zinc Phosphide	……	Vertebrates	Nerve toxin, with respiratory action	High	High	……
Aluminium phosphide	……	Vertebrates, insects	Nerve toxin, with respiratory action	……	High	High

Appendix III: Recommended Improved Management Practices and Pesticide Management Measures

Pesticides are one of many tools available for effective protection of crops from pests (insects and diseases) and weeds. However, pesticides require special care and handling before, during and after application. The following are some vital recommended practices for pesticide use and handling that can help protect human, the environment, livestock, wildlife and water resources.

- Eliminate or minimize exposure to pesticides during mixing, loading, cleaning and applying. Always read the pesticide label for information on required personal protection equipment.
- Know what to do in case of accidental pesticide exposure. Emergency wash area must be prepared ahead of spraying operations for personnel exposed to pesticides.
- Follow all national regulations regarding the transport of pesticides.
- Wash affected areas after possible exposure to skin and remove personal protective equipment prior to eating, drinking or smoking. Shower at the end of the day or after completion of application.
- Wash and inspect personal protective equipment after each use. Wash clothes exposed to pesticides separately from other laundry.
- Know what to do in case of pesticide poisoning. Have a pesticide first aid kit readily available. Check the product label for instructions in the event a pesticide is swallowed, or in the event of a serious dermal or inhalation exposure.
- Follow label use, storage and disposal instructions.
- Store pesticides only in the original labelled container, separated from other products such as food, feed and seed, and in a locked building with appropriate warning signs.
- Rinse containers immediately after emptying.
- Dispose of empty paper bags, plastic bags and other types of containers.
- Do not burn any pesticide container in an open fire, such as in the field, in trash barrels or on burn piles.
- Do not reuse pesticide containers unless they are dedicated for reuse or unless they have been cleaned according to the pesticide manufacturer's protocol and are intended to be refilled with pesticides.
- Purchase only the amount of pesticide needed for the job.
- Dispose of unusable or unwanted pesticides properly. The EPA-SL provides opportunities for the disposal of unusable and unwanted pesticides.
- Always read and follow all product label directions and precautions appearing on or included with pesticide containers.

- Develop an incident response plan for dealing with pesticide incidents quickly and effectively. A plan describes the pesticide storage, handling, disposal, and incident response practices at a given location. Incident response plans are required for locations involved in commercial pesticide application, non-commercial pesticide application, structural pest control, and locations which have bulk storage of pesticides and fertilizers.
- Mix and load pesticides and clean pesticide equipment to capture and contain spills, leaks, and wash water.
- Never mix, load pesticides, or clean application equipment near water wells. Follow product label requirements for safe isolation distances between pesticide use activities and water sources.
- Spraying operators must know the exact location of the area to be treated, as well as the potential hazard of spray drift or subsequent pesticide movement to surrounding areas.
- Calibrate spraying equipment properly before mixing and loading pesticides.
- Apply post-emergence herbicides when weeds are at their most vulnerable growth stage.
- Apply pesticides uniformly across the target.
- Use the lowest appropriate rate to minimize pesticide loss to the environment.

Appendix IV: Basic Principles of Integrated Pest Management

1. Identify pests, their hosts and beneficial organisms before taking action

The cause of the problem and associated plant or animal species must be correctly identified. For many plant problems, If the pest is not easily found, consider other causes, including abiotic (non-living) disorders, such as sunscald, wind or cold damage, inadequate moisture, etc. If the pest is found, an Entomologist can help identify insects. Once the pest is identified, determine the pest's life cycle, growth cycle and reproductive habits.

2. Establish monitoring guidelines for each pest species

Routine monitoring of both pests and natural enemies, is an important part of IPM. Methods of monitoring include visual inspection, pheromone and sticky traps, and sweep nets. Document and track both pest and beneficial organism population numbers. The ratio of natural enemies (usually insects) to pests should be taken into account before a pesticide is applied.

3. Establish an action threshold for the pest

A fundamental concept of IPM is that a certain number of individual pests can and should be tolerated. Farmers start by determining whether the pest will cause unacceptable damage to the value of their crop. What will happen if no action is taken? The action threshold in

crop production is generally based on economics. The economic threshold is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density, or population level, at which management should occur.

4. **Evaluate and implement control tactics**

   Select tactics that will be most effective, economical and have least impact on non-target species and the environment. Select methods that will impact beneficial organisms as little as possible while suppressing the pest. If a pesticide is one of the selected management tools, beneficial enemies will likely also be killed.

5. **Monitor, evaluate and document the results**

   Use routine monitoring to determine the success of any management strategies. This allows to make adjustments to improve the effectiveness of future pest management strategies. Keep records to help determine what worked well, and what to change the following year.

Appendix V: Persons met

a. Dr. Amadu T. Jalloh, Deputy Director, Animal Health, Livestock and Veterinary Services Division, MAFFS, Youyi Building
b. Dr. Amara Leno, Veterinary Officer, Livestock and Veterinary Services Division, MAFFS, Youyi Building
c. Dr. Braima D. James, Founder and CEO, Home Foods and Drinks, 14 Sumaila town, Freetown, Sierra Leone
d. Dr. J. E. D. Terry, Veterinary Consultant, 4 Mansaray Drive, Benguema, Waterloo Rural District
e. Foday M. Koroma, Plant Protection Officer (Retired), Allen Town, Freetown
f. Mr. Sorie Mohamed Kamara, Director, Livestock and Veterinary Services Division, MAFFS, Youyi Building
g. Ms Raymonda A. B. Johnson, Assistant Director/Head of Crop Protection, MAFFS, Freetown, Sierra Leone
h. Mohamed Ajuba Sheriff, Planning Evaluation Monitoring and Survey Division/MAFFS

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