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THE UNITED REPUBLIC OF TANZANIA

PRIME MINISTER'S OFFICE

Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Investment Project

INTEGRATED PEST MANAGEMENT PLAN (IPMP)

MARCH 2014

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ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome
ASDP	Agricultural Sector Development Programme
ASDS	Agriculture Sector Development Strategy
ASP	Agriculture Services Providers
ASSP	Agricultural Services Support Programme
CF	Catalytic Fund
AVRDC	Asian Vegetable Research Development Centre
CBB	Coffee Berry Borer
CBD	Coffee Berry Disease
CBO	Community Based Organisation
CBSD	Cassava Brown Streak Disease
CLR	Coffee Leaf Rust
CMD	Cassava Mosaic Disease
CORMA	Client-Oriented Research and Development Management Approach
DADP	District Agriculture Development Plans
DGIC	Directorate General for International Cooperation
DPPO	District Plant Protection Officer
DRDP	District Rural Development Programme
ECGA	Eastern Cotton Growing Area
ESMF	Environmental Social Management Framework
ESMP	Environmental and Social Management Plan
EMP	Environmental Monitoring Plan
FFS	Farmers Field Schools
FM	Fund Manager
GLS	Grey Leaf Spot
GTZ	Gesellschaft fur Technische Zusammenarbeit
HPR	Host Plant Resistance
ICIPE	International Centre of Insect Physiology and Ecology
IDA	International Development Agency
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
IPN	Integrated Plant Nutrition
IPM	Integrated Pest Management
IPMP	Integrated Pest Management Plan
JICA	Japan International Cooperation Agency
KAEMP	Kagera Agricultural Environmental Management Project
LGA	Local government authority
LGB	Larger Grain Borer
LVEMP	Lake Victoria Environmental Management Project
LZARDI	Lake Zone Agricultural Research and Development Institute
M&E	Monitoring and Evaluation
MAFC	Ministry of Agriculture, Food Security and Cooperatives
MANREC	Ministry of Agriculture, Natural Resources, Environmental and Cooperatives
MARA-FIP	Mara Region—Farmers' Initiative Project
MGF	Matching Grant Fund
MOA	Memorandum Of Agreement
MSV	Maize Streak Virus
MWLD	Ministry of Water and Livestock Development
NAEP	National Agricultural Extension Programme
NALP	National Agricultural and Livestock Policy
NARS	National Agricultural Research Systems
NEMC	National Environment Management Council
NGO	Non Governmental Organizations
NPPAC	National Plant Protection Advisory Committee
NPV	Nucleopolyhedrovirus
OPEC	Organization of Petroleum Cooperation
PADEP	Participatory Agriculture Empowerment Project

PCS	Pest Control Services
PHS	Plant Health Services
PMD	Powder Mildew Disease
PMP	Pesticides Management Plan
POP	Persistent Organic Pollutants
PPD	Plant Protection Division
PRA	Participatory Rural Appraisals
RAS	Regional Administrative Secretary
RPF	Resettlement Policy Framework
RGZ	Revolutionary Government of Zanzibar
RYMV	Rice Yellow Mottle Virus
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SVCF	Social Venture Capital Fund
SGR	Strategic Grain Reserve
SIIC	Smallholder Irrigation Improvement Component
SMS	Subject Matter Specialist
SPFMV	Sweet potato feathery mottle virus
SPFS	Special Programme for Food Security
SPSVV	Sweet potato sunken vein virus
SPVD	Sweet Potato Virus Disease
SUA	Sokoine University of Agriculture
SRESA	Strategic Regional Environmental and Social Assessment
URT	United Republic of Tanzania
TIC	Tanzania Investment Centre
TPRI	Tropical Pesticides Research Institute
UDSM	University of Dar es Salaam
ULV	Ultra Low Volume
USD	United States Dollars
VEO	Village Extension Officer
WCGA	Western cotton growing areas
WFF	Ward Farmers Forum
WHO	World Health Organization
ZARDEF	Zonal Agricultural Research and Development Funds
ZARDI	Zonal Agriculture Research and Development Institutes
ZEC	Zonal Executive Committees

EXECUTIVE SUMMARY

This integrated pest management plan (IPMP) addresses the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Investment Project's (the Project) need to monitor and mitigate negative environmental impacts of the project by promoting biological and ecosystem based pest management. The overall SAGCOT Program is broadly identified as a public-private partnership intended to improve the incomes, employment opportunities and food security of smallholder farmers across the southern corridor of Tanzania. This will be done by linking them to internationally competitive supply chains and accelerating commercial agricultural development, in particular by using foreign direct investment attracted by the removal of policy and infrastructural constraints to competitiveness and by facilitated access to land. SAGCOT lies along an existing road, rail and power corridor running from Dar es Salaam west through Iringa to Mbeya and beyond. Initially investments will be focused on six areas with high potential for quick agricultural development ("clusters"), including the Kilombero Valley. Over the next 20 years the initiative aims to bring 350,000 ha of land into commercial production, increase annual farming revenues by US$1.2 billion, and lift some 450,000 farming households out of poverty.

The Project will promote intensive commercial agriculture in tropical and subtropical environments with significant pest and disease control challenges. Pesticide use and management will be guided by Tanzanian law, World Bank policy OP 4.09 (Pest Management), international best practice, and experience with Integrated Pest Management (IPM) in the agricultural sector in Tanzania. It specifically draws heavily from related work done to prepare for the Agricultural Sector Dvelopment Project (ASDP).

The management aspects of pests and diseases of the key major crops have been discussed in detail. These include food crops such as maize, sorgum, beans, banana, sweet potatoes, finger millet, rice; cash crops: coffe, cotton, cashem nutst, etc. horticultural crops: coconuts, managoes, citrus, pinapples, tomatoes, onions and brasiccas (cabbages and kale) and migratory and outbreak pests: rodents, birds (quelea quelea spp) and armeworms.

The Government of Tanzania (GoT) have taken deliberate measures for promotion of IPM in all crop production systems. In 1997, the GoT formulated and introduced the Agriculture and Livestock Policy and the National Environmental Policy. In line with these two policies, a Plant Protection Legislation was encacted in 1997 followed by its regulations of 1999. Umbrella framework legislation, the Environmental Management Act No. 20 of 2004 is in place. All these policies and legislation emphasise use of sustainable production approaches particularly IPM.

The IPMP for SAGCOT is based on the experiences gained during the implementation of IPM experience in Tanzania Mainland and information obtained through review of published materials and discussion with crop experts, researchers, farmers and extension workers. It provides a framework for the development of IPM programme for food, cash and horticultural crops in the SAGCOT Programme to identify, understand and manage pest problems in the components, reduce human and environmental health risks associated with pesticides use, and protect ecosystem by conserveing beneficial agents such as natural enemies of pests use, and protect ecosystems by conservering beneficial agents such as natural enemies of pests and pollinators to increase productiviey. The IPMP also provides guidelines for pest management purposes in accordance to the IPM approach. It augments the biological, chemical and cultural control aspects of the management of pests and diseases.

An outline of the specific pest management measures to be incorporated (including a "positive list" for procurement, rules for safe handling of pesticides, and promotion of IPM); and an implementable workplan outlining those specific measures (e.g. budget, timeline, institutional roles and responsibilities) are given in this IPMP.

1. BACKGROUND

1.1. INTRODUCTION

The overall SAGCOT Program is broadly identified as a public-private partnership intended to improve the incomes, employment opportunities and food security of smallholder farmers across the southern corridor of Tanzania. This will be done by linking them to internationally competitive supply chains and accelerating commercial agricultural development, in particular by using foreign direct investment attracted by the removal of policy and infrastructural constraints to competitiveness and by facilitated access to land. SAGCOT lies along an existing road, rail and power corridor running from Dar es Salaam west through Iringa to Mbeya and beyond. Initially investments will be focused on six areas with high potential for quick agricultural development ("clusters"), including the Kilombero Valley (*see **Appendix 5:** SAGCOT Corridor and Clusters*). Over the next 20 years the initiative aims to bring 350,000 ha of land into commercial production, increase annual farming revenues by US$1.2 billion, and lift some 450,000 farming households out of poverty.

The Government of Tanzania (GoT) has requested support from the International Development Agency (IDA, part of the World Bank) to assist in implementation of the SAGCOT concept. The proposed World Bank support ("the Project") will be in the form of a Specific Investment Loan (SIL).

The World Bank *Operational Policy 4.09 Pest Managetment* is triggered as the Project will promote intensive commercial agriculture in tropical and subtropical environments with significant pest and disease control challenges. Although the Catalytic Fund will not directly support purchase of any pesticides, in the field improvements envisioned under the MGF and SCVF could increase the use of inputs - particularly chemical fertilisers, improved seeds and irrigation facilities. This may lead to an increase in the use of synthetic pesticides, and associated potential human and environmental hazards, and hence the requirements for mitigation plan. Pesticides Management Plan (PMP) identifies and addresses changes in pest management practices and concerns that may arise out any increase in chemical pesticides use and propose mitigation in compliance with the World Bank Safeguard Policy on Pest Management (OP 4.09).

Pesticide use and management will be guided by Tanzanian law, World Bank policy (including OP 4.09), international best practice, and experience with IPM in the agricultural sector in Tanzania. It specifically draws heavily from related work done to prepare for the Agricultural Sector Dvelopment Project (ASDP). To support such efforts, SAGCOT will also apply the standards set under the *International Code of Conduct on the Distribution and Use of Pesticides* which encourages responsible and generally accepted trade practices and sets out the “conduct for public and private entities engaged or associated with the distribution and use of pesticides.” The Code is designed for use within the context of national legislation as a basis whereby government authorities, pesticide manufacturers, those engaged in trade and any citizens concerned may judge whether their proposed actions and the actions of others constitute acceptable practices. In addition, it describes the shared responsibility of many sectors of society to work together so that the benefits to be derived from the necessary and acceptable use of pesticides are achieved without significant adverse effects on human health or the environment.

The main purpose of preparing this Integrated Pest Management Plan (IPMP) is to: (i) assess the current and anticipate pest problems in the programme areas; (ii) review the country experiences on IPMP; (iii) develop a pest management plans (IPMPs) using recommended best-practices; (v) develop monitoring and evaluation systems for the various pest management practices of the IPMPs based on the government laws and the World Bank policy. It draws upon experience with other IPMPs in Tanzania, including that of the Agricultural Sector Development Project (ASDP).

1.2. METHODOLOGY

Preparation of this IPMP builds on the following approach and methods that were used to gather information from relevant stakeholders for ASDP IPMP:

(i) Participatory approach

The preparation of the IPM guidelines used a participatory process aimed at facilitating a broad based dialogue and transparency in identification of key pesticides problems and management issues. Moreover, the extensive consultations with farmers, district staff, communities, lead IPM researchers and practitioners, crop specialists, etc. in Tanzania Mainland and Zanzibar helped to solicit relevant information on pest management.

(ii) Review of literature and checklists of documentation

- Relevant SAGCOT program/ project documents;
- Policy and legal documents used in Tanzania pesticide industry, namely Plant Protection Act 1997, Pesticide Regulations 2002, Agriculture Policy 1997, National Environmental Policy 1996 and the Environmental Management Act No. 20 of 2004. In Zanzibar the following documents were consulted: Agriculture Policy of 2002, Environmental Management for Sustainable Development Act of 1996 and Plant protection Act of 1997; and
- World Bank Safeguard Policies in particular OP 4.09

(iii) Questionnaires and checklists for guiding consultative meetings with following stakeholders:

- ASSP preparation team
- The ASDP Secretariat
- Ministry of Agriculture and Food Security, namely Department of Research and Development, Departments of Crop Production, Plant Health Services, Agricultural Extension Services, Participatory Agriculture Empowerment Project (PADEP), Smallholder Irrigation Improvement Component (SIIC), etc.
- Ministry of Water and Livestock Development, namely Veterinary services
- Zonal Research and Development Institutes, namely Lake Zone, Northern Zone, Eastern Zone, Western Zone, Southern Highland Zone
- Ministry of Agriculture, Environment, Natural Resources and Cooperatives, Zanzibar and Zanzibar Agriculture Research Institute in Kizimbani
- Tanzania Pesticides Research Institute
- Sokoine University of Agriculture, namely Pest Management Research Centre
- Division of Environment, Vice-President Office
- National Environmental Management Council
- District Councils
- Farmers representatives
- NGOs
- IPM, bird control and armyworm projects

(iv) Questionnaires and checklists for guiding consultative meetings with following stakeholders:

- Ministry of Agriculture and Food Security, namely Department of Research and Development, Departments of Crop Production, Plant Health Services, Agricultural Extension Services, Participatory Agriculture Empowerment Project (PADEP), Smallholder Irrigation Improvement Component (SIIC), etc.
- Ministry of Water and Livestock Development, namely Veterinary services

- Zonal Research and Development Institutes, namely Lake Zone, Northern Zone, Eastern Zone, Western Zone, Southern Highland Zone
- Ministry of Agriculture, Environment, Natural Resources and Cooperatives, Zanzibar and Zanzibar Agriculture Research Institute in Kizimbani
- Tanzania Pesticides Research Institute
- Sokoine University of Agriculture, namely Pest Management Research Centre
- Division of Environment, Vice-President Office
- National Environmental Management Council
- District Councils
- Farmers representatives

2. DESCRIPTION OF PROPOSED PROJECT

2.1. INTRODUCTION

The proposed Project Development Objective (PDO) will be to: create and expand partnerships between smallholder farmers and agribusinesses in the Southern Corridor leading to adoption of new technologies and improved market access by smallholders.

2.2. PROJECT COMPONENTS

The SAGCOT Project comprises three components that will be implemented over a five year period:

- ***Component 1: Strengthening of SAGCOT Support Institutions (total USD15.99 million, IDA USD8.67 million).*** The objective of this component will be to strengthen the capacity of the main SAGCOT support institutions in order to pursue their functions of information and data provision, support of investment planning and guidance, government/private sector intermediation, business enabling environment and investment promotion. The component will support two institutions under the following sub-components:

    - SAGCOT Centre (total USD10.82 million, IDA USD3.50 million): under this sub-component the Project will jointly with other donors support the SAGCOT-Centre, which was established as a public private partnership entity in 2011 to: (i) Facilitate agri-business and partnership development; (ii) Ensure inclusive and sustainable investment and development; and (iii) Advocate for an improved enabling environment. The Project will support the Centre by providing financing for staff and operational costs, studies and consulting services to be contracted by the Centre.

    - Tanzanian Investment Centre (Government institution) (total USD5.17 million, IDA USD5.17 million): under this sub-component the Project will support the TIC which was established as a public sector entity in 1977 and designated as the first point of call and a "one-stop facilitation centre" for all potential investors coming into the country. The Project will support TIC to reform its processes with the aim to: (i) strengthen its capacity to leverage high quality, responsible, inclusive and sustainable commercial investments (ii) provide a competitive framework for tendering and (iii) monitor and evaluate investments. The Project will finance incremental equipment, technical assistance and consultancies.

- ***Component 2: Strengthening Smallholder Business Linkages (total USD77.68 million, IDA USD45.00 million):*** The objective of this component will be to link smallholder farmers to agricultural value chains. The component will (a) expand the number of smallholders linked to agribusinesses in successful commercial partnerships and (b) improve the revenues derived by smallholders and rural communities from these partnerships in the form of growth in agricultural productivity, income and employment. This component will comprise two sub-components:

    - Fund Management (total USD13.00 million, IDA USD6.50 million): under this sub-component the Project will jointly with other donors support a management structure responsible for the implementation of the Catalytic Trust Fund (including Board, Secretariat and Fund Manager). Project support will include fees and salaries, goods and equipment, office operational costs, meetings and workshops, communications and technical assistance.

    - Matching Grants (total USD64.68 million, IDA USD38.50 million): Matching Grants (MG) at a size of USD250,000 up to USD1.5 million with a matching contribution of 30 percent (national businesses) and 40 percent (international business operators) will be awarded to existing agribusiness operators with undisputed land rights following a defined process of application, evaluation and competitive selection. The grants can be used for operational cost

and capital costs directly related to expanding smallholder participation in competitive agricultural supply chains.

- ***Component 3: Project Management and Evaluation (total USD6.33 million, (of which USD3.00 million were provided as Project Preparation Advance) IDA USD6.33 million):*** The component will establish project management and M&E systems and provide financing for salaries, office equipment, transportation and technical assistance services. It will support the coordination between implementation agencies at all levels and with other government programs and institutions.

Pesticide issues are considered to be most relevant in the Matching Grants included in Component 2, as such grants will support expansion of outgrower activities that are likely to involve expanded use of pesticides. As such, the IPMP focuses on incorporating measures to ensure necessary capacity, tools (including safety equipment) and monitoring are in place for subprojects supported through the Matching Grants window.

2.3. PROJECT IMPLEMENTATION ARRANGEMENTS

The implementation of SAGCOT will take place through the use of existing government structures as well as the SAGCOT Centre, through their mandates to implement the SAGCOT programme. These institutions and their SAGCOT responsibilities are described below.

2.3.1 The Catalytic Fund

The Fund Manager(s) of the Catalytic Fund (CF) will identify, finance, and develop viable investments across the value chain in the Corridor. It will also assist in the process of raising third-party commercial finance once the opportunities are "investment ready". In the process, the Fund Manager(s) will ensure that projects are developed in ways that maximise a range of financial, economic, social and commercial developmental impacts.

The Fund Manager(s) shall have the mandate and function of: (a) raising additional Funds subject to the consent of the Board; (b) preparing the investment pricing policy of the Social Venture Capital Fund for approval by the Board; (c) marketing the Funds, (d) approval of applications and (e) operational management of the Funds.

The bulk of World Bank support will go to the Catalytic Fund via the Matching Grant Facility. Therefore, the CF must have in place a set of procedures that assure compliance with both GoT environmental regulations and World Bank safeguards, including those of World Bank OP 4.09 *Pest Management*.

2.3.2 The SAGCOT Centre

The SAGCOT Centre is the key coordinator of the SAGCOT programme with numerous cross-cutting roles. The SAGCOT Centre has been established to facilitate investment and manage the coordination of the partnership to ensure the successful achievement of its objectives. Its activities include:

(i). Managing and expanding the SAGCOT Partnership;

(ii). Information provision & Market intelligence;

(iii). Facilitating introductions;

(iv). Facilitating access to finance;

(v). Coordination of cluster and corridor development;

(vi). Identification of enabling environment obstructions and helping to address these; and

(vii). Monitoring and evaluating progress.

With this remit, the SAGCOT Centre will be instrumental in communicating the principals of sustainable investment across stakeholders in both the public and private sectors. To accomplish this mandate, the SAGCOT Centre will need to have the capacity to undertake the following;

(i). keep stakeholders updated on environmental and social issues surrounding development in the Corridor, including those associated with pest management;

(ii). communicate to potential investors, in collaboration with TIC, the sustainable and green investment principles which SAGCOT will promote;

(iii). be the first "stop" for all investments regarding transparent land transfer requirements;

(iv). provide preliminary information on clean technology and reduced carbon footprint opportunities for investors.

(v). Finally, the SAGCOT Centre will also be the focal point for annual reporting on safeguard progress across the implementing agencies and organizations to the World Bank.

2.3.3 Tanzania Investment Centre

The Tanzania Investment Centre (TIC) was established under the provisions of the Tanzania Investment Act, Cap 38 (Act No 26 of 1997). The Centre is designated to be a one-stop shop for investors and is mandated to co-ordinate, encourage, promote and facilitate investment in Tanzania and to advise the Government on investment policy and related matters. Within this remit, the TIC has the authority to:

(i). identify investment sites, estates or land together with associated facilities on these, for the purposes of investors and investments in general;

(ii). assist investors to obtain permits, licence approvals consents, authorisations, registrations and other matters required by law for a person to set up and investment; and

(iii). enable certificates issued by the Centre to have full effect.

TIC will assist in incorporation and registration of enterprises; promote both foreign and local investment activities, and grant certificates of incentives. As the first port of call, the TIC will need to develop a set of guidelines for potential investors that detail the principles of sound sustainable agriculture development in the Corridor, including those for resettlement.

These principles should cover the following topics:

(i). reliable information on land availability with maps (in a modern format (GIS));

(ii). information linking land suitability to potential crop production;

(iii). transparent methods for land transfer, registration and leasing arrangements;

(iv). land lease revenue options or equivalents;

(v). corporate social responsibility and community development funds, including those related to resettlement and livelihood restoration programmes;

(vi). the role of grievance mechanisms, tribunal or adjudication assurance for investors and villagers, and

(vii). potential "road blocks" and ways to navigate around these complex issues.

The guidelines will be developed using technical information from the Ministry of Lands, Housing and Human Settlements Development and also the Rufiji Basin Development Authority (RUBADA)[1].

[1] RUBADA is not receiving support under the World Bank Specific Investment Loan, but it is an institution that is relevant to implementation of SAGCOT

3. THE GENESIS OF AGRICULTURAL PEST MANAGEMENT PRACTICES

3.1. INTRODUCTION

The pest management practices have existed for quite long in the history of agricultural systems having a key drive on human population trends. Until half a century ago crop protection practices were integral parts of any cropping system. Growing world population required dramatic increases of agricultural production. From the 1940's to the 1970's, a spectacular increase in yield was obtained with the aid of an intensive development of technology, including the development of a variety of agro-pesticides. In many countries this advancement was coupled with the development of education of farmers and efficient extension services. In many development countries, however, this foreign technology was dumped without adequate support systems. Agro-pesticides were often used injudiciously. Misuse and over-use was stimulated by heavy subsidies on agro-chemicals.

Many developing countries adopted a system of technology transfer in which a research apparatus developed or adapted technology that was transferred to farmers by an extension unit. Crop protection measures were often reduced to easy-to-use pesticide application recipes, aimed at immediate and complete destruction of the causal organism. In places where the use of improved varieties was propagated, packages of high-yielding varieties with high inputs of agro-pesticides and fertilisers made farmers dependent on high external inputs.

Recently, it was realised that this conventional approach has its disadvantages. Conspicuous drawbacks are undesirable side-effects of pesticides which includes the following:

- human toxicity;
- poisoning and residue problems;
- destruction of natural enemies and other non-target organisms;
- development of resistance in target organisms; and
- environmental pollution and degradation.

Pesticides are expensive and good management of their use requires skills and knowledge. For various reasons the (Research-Extension–Farmers) transfer of technology often does not work well. The technology is frequently inadequate and not adapted to the specific local needs.

Based on above, it can be revealed that; relying on the use of pesticides in not sustainable as their unjudicial use is not human and environmental friendly. Thereby the need to improve the development and transfer of technology down to end users.

3.2. THE MEANING AND IMPORTANCE OF IPM

What is IPM?

Integrated Pest Management (IPM) could be defined *as a comprehensive approach to pest control that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment.*

In OP 4.09, the definition of IPM uses the same principles but emphasizes the following points:

1. The IPM approach must be ecologically-based (making use of the ecosystem 's ability to regulate pest populations);

2. Emphasis is on Pest Management as opposed to Pest Eradication; and

3. Reliance on multiple tactics as opposed to the "Silver bullet" approach (Chemical pesticides)

The definition is the policy allows for selecting and applying pesticides, in a way that minimizes adverse effects on beneficial organisms, humans, and the environment.

Why IPM?
The experience on drawbacks in the agricultural pest management systems, necesitated a crop protection approach that is centred on local farmer needs that are sustainable, appropriate, environmentally sound and economically viable. Such approach is called **Integrated Pest Management** (IPM). It should also be noted that when pesticides are applied in a given crop its only 1% hits direct the targed pest the rest 99% it becomes a burden to the environment and human health.

The IPM approach encourages; the use all available, suitable methods of prevention and control, including resistant varieties, cultural methods such as planting time, intercropping and crop rotation, biological control. Pesticides will only be used as a last resort when plant protection decisions are made based on the damage/economic thresholds. Thus the soft and selective pesticides are used to minimise detrimental effects on humans, natural enemies and other non-target organisms. The philosophy of IPM is layed on the; no total eradication of all noxious organisms, but keeping them at levels below injury and conservation of the ecosystem that stimulate the presence of natural enemies. The technology can widely be since it has to be developed by farmers in collaboration with researchers and extensionists.

Compliance: the integrated pest management approach is in line with the WB OP 4.09, whereby the policy supports safe, effective, and environmentally sound pest management aspects, such as the use of biological and environmental friendly control methods. As outlined in the Environmental Social Management Framework (ESMF) for SAGCOT. Since the IPM approach is location and crop specific, most sub-projects under the program may need a specific pest management plans for addressing the concerns on board. More importantly, the IPMP for the SAGCOT Project will serve as a guidance and reference document for the preparation of specific subprojects PMP.

3.3. FUNDAMENTALS OF IPM

- An understanding of the ecological interrelationships within a farming system; crop, plant, pests organisms and factors influencing their development;
- An understanding of economical factors within a production system; infestation: loss ratio, market potential and product prices;
- An understanding of socio-cultural decision-making behaviour of the farmers; traditional preferences, risk behaviour, etc;
- The involvement of the farmers in the analysis of the plant protection problems and in the elaboration of solutions; and
- The successive creation of a legislative and agricultural policy framework conducive to a sustainable IPM strategy; plant protection and pesticides legislation; pesticides registration and price policy.

3.4. KEY CHARACTERISTICS OF AN IPM APPROACH

- Use all available, suitable methods of prevention and control, including resistant varieties, cultural methods such as planting time, intercropping and crop rotation, biological control. Pesticides will only be used as a last resort, but preferably selective ones, or used in a selective way to prevent detrimental effects on natural enemies and other non-target organisms.
- Conservation of the ecosystem, stimulate the presence of natural enemies
- No total eradication of all noxious organisms, but keeping them at a low level
- Technology is developed by farmers in close co-operation with researchers and extensionists
- Farmers make their own decisions and carry them out.

3.5. THE PRINCIPLES OF AN IPM

- Grow a healthy crop;
- Recognise pests, diseases, and natural enemies;
- Carry out regular observations; and
- Make the right crop protection decisions, through discussion with fellow farmers.

4. EXISTING AND ANTICIPATED PEST PROBLEMS

The existing and anticipated pest problems in the SAGCOT Project Area are described in this chapter. A list on food, cash and horticultural crops and migratory and outbreak pests is presented and an analysis is made on existing and anticipated pest problems and their management practices.

4.1 FOOD CROPS

The major food crops shown in Table 4.1 which are grown in the target project areas are maize, rice, sorghum, millet, beans, cassava, and banana. The importance of each crop varies from one area to another and the priority list varies depending on the source of information. However, maize is the most popular staple of many Tanzanians, and is a major cash and food crop in many parts of the Southern Highlands. This is followed by rice, sorghum, millet, bananas, beans, cassava, sweet potato, wheat and legumes. Some of these crops such as rice, maize, beans, sorghum and millet are regarded as food and cash crops depending on the area.

Table 4.1: Summary of major food, cash and horticulture crops grown in the SAGCOT Project Area

Zone	Regions	Major crops		Horticultural crops
		Food	Cash	
Eastern	Morogoro Coast Tanga Dar es Salaam	Maize Rice Beans Cassava Round potatoes Sorghum Banana	Coffee Cotton Cashew Sugarcane Tea	Citrus fruits Pineapples Brassicas Tomatoes Mangoes Coconuts
Southern Highlands	Iringa Mbeya Ruvuma Rukwa	Maize Sorghum Fingermillet Rice Beans Cassava Sweet Found potatoes	Tea Tobacco Coffee Rice Cotton Sunflower Wheat Cashew Pyrethrum Palm oil	Bananas Tomatoes Mangoes Pineapples Potatoes Peas Brassicas

Maize

Maize is the major staple food crop and it is grown in all the agro-ecological zones. It can be grown over a wide range of altitude ranging from 0-2400m a.s.l. Maize requires an optimum rainfall of 1800 mm. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 1,564,000 ha and 2,810,490 ha were put under maize cultivation in 1995/6-2002/03 respectively with overall production of 1,831,200 and 3,415,600 tons. In terms of percentage contribution in 2002/03, the Southern Highlands produce 45%, followed by Lake Zone (20%), Northern Zone (11.0%), Western Zone (10%), Eastern Zone (8%), Central Zone (4%), and Southern Zone (2.5%). The southern highlands supplies 90% of the strategic grain reserve (SGR), thus making it the national grain basket.

The major insect pests of maize are: African maize stakeborer (*Bossuela fusca*), pink stalkborer (Sesamia calamistis), spotted stalkborer (chilo partellus), American bollworm (Helicoverpa armigera), cutworms-greasy cutworm (*Agrotis ipsilion*), and maize leafhopper (*Cecadulina mbila*).

The major diseases of maize are: leaf rusts (*Puccinia sorghi and P.polysora*), leaf blights (*Helminghtosporium turcicum* and *maydis*), Maydis leaf blight (*Helminthosparium maydis*), maize streak disease (maize streak virus), grey leaf spot (GLS) (*Cerospora zaea-maydis*), Gibberella Ear Rots, common sut.

Because the crop is grown under different agro-ecological zones, pest problems (pre and post harvest) associated with it and the recommended management options vary accordingly (Table 4.2).

Table 4.2: Major maize pest problems and recommended management practices

Zone	Pest			Recommended management practices
Southern Highlands	Insects	Pre-harvest	Stalk borers (*Busseola fusca*)	• Stalks are buried or burned to eliminate diapausing larvae • Early sowing reduces infestation • Intercropping with pulses (except rice) • Neem(arobani) powder (4-5 gm i.e. pinch of 3 fingers) per funnel • Neem ssed cake (4 gm/hole) during planting • Use the extract of *Neuratanenia mitis*, a botanical pesticide
			African armyworm (*Spodoptera exempta*)	• Scout the crop immediately the forecast warns of expected outbreak in the area • Apply recommended insecticide or botanical extract timely (Table 4.3)
			Seedling weevils *(Tanymecus* spp. & *Mesokeuvus* spp)	• Timely planting to escape damage • Scout the crop • Apply lambda cyhalothrin if necessary (Table 4.3)

Zone	Pest			Recommended management practices
		Post harvest	Larger grain borer (LGB) Weevils Moths	• Selection of tolerant varieties • Timely harvest • Dehusking and shelling • Proper drying • Sorting and cleaning of the produce • Cleaning & repair of the storage facilities • Use rodent guards in areas with rat problems • Use improved granaries • Use appropriate natural grain protectants e.g. where applicable or • Use recommended insecticides at recommended dosage (Table 4.3) and/or • Keep the grain in air tight containers and store these in a shady place, preferably in-doors • Carry out regular inspection of the store and produce. Timely detection of any damage to the grain and/or storage structure is essential to minimise potential loss or damage • Promote biological control of LGB using *Teretriosoma nigrescens (Tn)* to minimise infestation from wild sources. This is the task of the national plant protection services because the agents have to be reared and released in strategic sites. However, the farmers will benefit from this strategy.
	Diseases		Grey leaf spots (GLS)	• Crop rotation • Plant recommended resistant varieties e.g. H6302, UH6010, TMV-2 • Observe recommended time of planting • Removal of infected plant debris by deep ploughing
			Maize streak virus	• Early planting • Plant recommended resistant varieties e.g. TMV-1 in areas below 1500m above sea level, Kilima ST and Katumani ST and Staha
			Northern leaf blight	Rotation Deep plough of the crop residues Plant recommended resistant varieties e.g. H6302, UH6010, TMV-2, H614

Zone	Pest			Recommended management practices
	Weeds		All types See Table 3.4	• Hand pulling and hoe weeding • Intercropping • Use resistant/tolerant varieties • Improvement of soil fertility • Tillage • Proper land preparation • Timely weeding (at 2 and 5-6 weeks after planting) • Apply recommended herbicides
Eastern	Insects	Pre harvest	Stalk borers	• Follow recommended time of planting Proper disposal of crop residue
			Armyworms	• Scout the crop immediately the forecast warns of expected outbreak in the area • Apply recommended insecticide or botanical pesticide timely (Table 4.3)
		Post harvest	Larger grain borer (LGB), Weevils, Moths	As Northern
	Diseases		Maize streak virus	• Observe recommended planting dates • Plant recommended tolerant varieties e.g. Kito-ST, Staha-ST, Kilima-ST
	Weeds		All types	• Proper land preparation • Timely weeding (at 2 and 4 weeks after planting) • Use recommended herbicide (Table 4.3)

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru, 2000; Mbwaga et.al. 1993.

Table 4.3: List of pesticides recommended for use on maize

Chemical		Common name	Formulation	Application rate	Target pest	Comments
Insecticides	Post harvest	Cypermethrin	0.5% D	100gm/100kgs	LGB	
		Permethrin	0.5%D	100gm/100kgs	LGB	
		Pirimiphos methyl	2% D	200-500gm/100kgs	All storage insect pests for all grains	Not good enough against LGB
		Pirimiphos methyl + permethrin	1.6% + 0.3%D	100gm/100kgs	All storage insect pests for all grains	
Herbicides		Atrazine + metalochlor	50% FW	4l/ha	All types	Apply pre-emergence
		Atrazine	80% WP	2.5 to 3.0 l/ha	All types	Pre/post emergence

Notes:

1. All herbicides are applied using knapsack sprayers.

2. All the insecticides for storage pests are in dust form and therefore used as supplied without mixing with anything else.
3. The pre-harvest insecticides are used without mixing.
4. The list of pesticides can change as new products are recommended and/or some of the chemicals are withdrawn in the market. Therefore always consult the nearest plant protection extension worker if in doubt.

Rice

In Tanzania rice is considered to be cash and food crop. Almost half of the world population use rice as its staple food in Asia and Africa. Tanzania is the largest producer and consumer of rice in the East, Central and Southern African region after Madagascar (Banwo (2001). According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 439,300 ha and 626,300 ha were put under rice cultivation in 1996/97-2002/03 respectively with overall production of 549,700 and 1,283,700 tons. The major rice production areas are the coastal zone, western zone up to Lake Victoria, areas around the lakes and other area with enough water such as Kilombero valley and southern plains. The crop is grown under different agro-ecological areas (upland, lowland and irrigated environments) and therefore, the pest pressure varies accordingly (Table 4.5). Overall, upland rice contributes 80% while lowland rice is only 20% of the total production (Kanyeka, et.al.1995).

Locally, the economic value of rice depends largely on where it is grown. In Mwanza and Shinyanga regions, it is grown mostly for cash whereas in Morogoro, it is a cash-food crop (Table 4.1). Because it is grown in many parts of the country and under different management systems (rain-fed and under irrigation), the pest problems and management tactics also vary (Table 4.5). Unfortunately and until recently, issues related to pest management in rice production were given low priority (Banwo *et al.*2001), and therefore, available information on pest control options is scanty (Table 4.5).

The most devastating pest of rice in Tanzania is the rice yellow mottle virus (RYMV). Although indigenous to Africa, the disease was reported in Tanzania in 1980s and now has spread to all the major growing areas notably in Morogoro, Mbeya and Mwanza (Banwo, *et al.* 2001). The disease can cause up to 92% yield loss on "super", the most popular rice variety in Tanzania (Banwo, 2003).

The only viable control option for the disease is by planting resistant varieties). Unfortunately, only a few of the local varieties in the SSD-1, SSD-3, SSD-5, SSD-7, SSD-35 series have same level of resistance to the disease.

Table 4.5: Major pests of rice and recommended management practices

Pests		**Recommended management practices**
Insects	Stem borers (*Chilo partellus, C. orichalcociliellus, Maliarpha separatella, Sesamia calamistis*)	• Plant recommended early maturing varieties • Destruction of eggs in the seedbeds • Early planting • Proper fertilisation • Use recommended plant spacing • Observe simultaneous planting • Destruction of stubble after harvest • Clean weeding • Plough after harvest to expose the eggs to natural enemies
	Stalk-eyed fly (*Diopsis* spp)	
	African rice gall midge (*Orseolia oryzivora*) Small rice grasshoppers (Oxya spp.) (Senene)	
	African armyworm (*Spodoptera exempta*)	Resistance varieties Stalk management in dry season
	Flea beetles (*Chaetocnema varicornis*)	Suspected to be the key vector of RYMV (Banwo, *et al.* in press; Kibanda, 2001). No known control measures.
	Rice hispa (*Dicladispa* sp)	

Pests		Recommended management practices
Weeds	Cyperus rotandus, striga All types (see Table 4.5)	• Early clean weeding • Use recommended herbicides if necessary
Diseases	Rice yellow mottle virus	Field sanitation including buring of crop residues and removal of volunteer plants Use of resistant varieties
	Rice blast (*Pyricularia oryzae*)	Destruction of crop residues Clean seeds Avoid use of excessive nitrogen fertilizers Use of wide spacing to avoid overcrowding Use resistance varieties Appropriate crop rotation Timely planting Burying crop debris
	Brown leaf spot (*Helminthosporium* spp)	
	Sheath rot (*Acrocylindrium oryzae*)	
Vermines	Birds Wild pigs Hippopotamus Rats	Scaring Bush clearing Early weeding Early harvesting Spraying against Quelea Queleas

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru, 2000

Sorghum

Sorghum is an important subsistence food crop in Tanzania that is grown mainly in Morogoro, Lindi, Tabora, Dodoma, Singida, Mwanza, Shinyanga and Mara regions. Sorghum is a drought resistant crop. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 622,400 ha and 557,323 ha were put under sorghum cultivation in 1996/97-2002/03 respectively with overall production of 498,500 and 461,400 tons. Sorghum needs a minimum of 300-380 mm of rainfall during growth and has a wide range of pests (Table4.6). The recommended pest management strategies are summarised in Table 4.6.

Table 4.6: Sorghum major pests and recommended management practices

Pest			Recommended management practices
Insects	Pre harvest	Shootfly (*Atherigoma soccata)*	Observe recommended time of planting to avoid the pest Plant recommended varieties Destroy infected crop residues by burying Apply recommended insecticides if necessary e.g. endosulfan or fenitrothion
		Stalk borers (*Busseola fusca & Chilo partellus*)	• Stalks are buried or burned to eliminate diapausing larvae • Early sowing reduces infestation • Intercropping with pulses (except rice) • Neem(arobani) powder (4-5 gm i.e. pinch of 3 fingers) per funnel • Neem ssed cake (4 gm/hole) during planting • Use the extract of *Neuratanenia mitis*, a botanical pesticide

Pest			Recommended management practices
		African armyworm ((*Spodoptera exempta*) Cutworms (*agrotis ipsilon*)	• Plough a month before sowing • Rapid seedling growth • Weeding early • Use of plant treated seeds • Treat the seed bed with wood ash • Scout the crop immediately the forecast warns of expected outbreak in the area Apply recommended insecticide or botanical pesticide timely (Table 3.3)
	Post harvest	LGB, weevils and moths	Use of botanicals, e.g. Neem or pili-pili Bio-control (use of natural enemies)
Diseases		Grain moulds	• Plant recommended tolerant/resistant varieties e.g. IS 9470, IS23599, IS24995, cv. Framida and cv. Serena • Observe recommended time of planting • Field sanitation • Practice good crop rotation
		Grey leaf spot (*Cercospora sorghi*)	• Observe recommended time of planting • Field sanitation Practice good crop rotation Use clean planting material
		Anthracnose (*Colletotrichum graminiocola*)	Plant recommended tolerant varieties e.g. Tegemeo, Serena, Framida and Segaolane • Observe recommended time of planting Field sanitation
		Rust (*Puccinia purpurea*)	• Use disease free seeds and follow recommended spacing • Plough in crops immediately after harvesting • Crop rotation • Observe recommended time of planting • Field sanitation
		Leaf blight (*Exserohilum turcicum*)	• Plant recommended tolerant varieties e.g. Tegemeo and Serena • Observe recommended time of planting • Field sanitation
		Ladder leaf spot (*Cercospora fusimaculans*)	• Observe recommended time of planting • Field sanitation Practice good crop rotation • Use clean planting material
		Sooty stripe (*Ramulispora sorghi*)	
		Zonate leaf spot (*Gleocercospora sorghi*)	
Weeds		Witchweed (*Striga asiatica)*	As for maize in Kagera region

Pest			Recommended management practices
Vermines		*Quelea quelea* spp Warthog Hippopotamus	• Scaring • Bird trapping • Farmers to scout potential breeding sites and destroy nests • Monitoring and organised aerial spraying using fenthion 60%ULV at the rate of 2.0l/ha • Spot spraying, targeting roosting sites

Source: LZARDI-Ukiriguru 2000; Mbwaga, et.al. (1993) and MAFS: Plant Pests Field Book: A guide to management, 2002

Pearl millet

Pearl millet (burlush millet) is one of the indigenous subsistence food crops which grow well in areas with reliable rainfall such as those found in central Tanzania. The crop has many advantages over other cereal crops in that it is drought tolerant and therefore suitable for the semi-arid areas of the country (Mbwaga et.al. 1993). Pearl millet grows best on reasonably fertile soils but they have the ability to give satisfactory yields on infertile soils. It is one of the most import food crops in the dry semi-arid regions, mainly Dodoma and Singida. Significant quantities of pearly millet are also produced in Shinyanga, Mwanza and Tabora regions. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 353,360 ha and 242,100 ha were put under millet (bulrush and finger millet) cultivation in 1995/6-2002/03 respectively with overall production of 347,700 and 118,200 tons. There has been limited local research work on the crop and therefore available information on its major pest problems and management options is scanty (Table 4.7).

Table 4.7 The major pests of pearl millet and recommended management practices

Pest			Recommended management practices
Insects	Pre harvest	Shootfly (*Atherigoma soccata)*	Observe recommended time of planting to avoid the pest Plant recommended varieties Destroy infected crop residues by burying Apply recommended insecticides if necessary e.g. fenitrothion
		Stalk borers (*Busseola fusca & Chilo partellus*)	• Stalks are buried or burned to eliminate diapausing larvae • Early sowing reduces infestation • Intercropping with pulses (except rice) • Neem(arobani) powder (4-5 gm i.e. pinch of 3 fingers) per funnel • Neem ssed cake (4 gm/hole) during planting • Carbofuran and carbaryl are effective insecticides • Use the extract of *Neuratanenia mitis*, a botanical pesticide

Pest			Recommended management practices
		African armyworm ((*Spodoptera exempta*) Cutworms (*agrotis ipsilon*)	• Plough a month before sowing • Rapid seedling growth • Weeding early • Use of plant treated seeds • Treat the seed bed with wood ash • Scout the crop immediately the forecast warns of expected outbreak in the area Apply recommended insecticide or botanical pesticide timely (Table 3.3)
		Leaf spot	No recommendation
		Rust (Puccinia penniseti)	Observe recommended time of planting Field sanitation Plant recommended tolerant varieties if available
		Smut (Moesziomyce bullatus)	Plant resistant varieties e.g. ICMV 82132, ICMPS 900-9-3 & ICMPS 1500-7-3-2
		Downy mildew (Sclerospora graminicola)	Early sowing Use of disease free seed Transplanting the crop suffers less from the disease Roughing of infected plants to avoid secondary infection
Weeds		Witchweed (Striga spp)	Farm yard manure Weeding
Birds		*Quelea quelea* spp	• Scaring • Bird trapping • Farmers to scout potential breeding sites and destroy nests • Monitoring and organised aerial spraying using fenthion 60%ULV at the rate of 2.0l/ha • Spot spraying, targeting roosting sites

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru, 2000 Mbwaga et.al. 1993.

Banana

Banana is a major food crop for about 4.0 million people in Kilimanjaro, Arusha, Kagera, Mbeya and Kigoma (Table 4.1 and maps). The produce has various uses but it is mostly used as a fruit and/or vegetable. It is therefore eaten either cooked, or as desert when ripe. Bananas are of great importance to the rural population in the Chagga homegardening and to those living in the Pare and Usambara mountains. The crop provides households with both food and income, while its produce includes leaves for thatching houses and pseudostema to feed livestock (although of poor nutritional value). Bananas are growing in association with various other crops, such as coffee, beans, maize, cocoyams and fruit trees. Farmers apply no chemical control measures to protect the crop. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 241,400 ha and 390,200 ha were put under banana cultivation in 1996/7-2002/03 respectively with overall production of 604.100 and 1,898,800 tons.

The major disease to bananas is Panama wilt (Fusarium), while balck S igatoka or balck leaf streak disease is of lesser importance. Both diseases are caused by fungi and can destroy all susceptible varities within a large area. Panama disease are caused is soil borne and spreads through soil and infected planting materials. Black Sigatoka is soil borne and spreads by wind, water dripping or splashing, but also by infected planting materials. Farmers' control of both diseases is limited to removal of diseased plants, application of large

quantities of farmyard manure and avoidance of planting susceptible varieties. Options for their control by IPM include field sanitation (such as rotation), use of clean suckers and planting of resistant varieties. Application of farmyard manure reduces the damaging effect of the two diseases.

Two important pests causing great loss of harvest are banana weevils and nematodes. The latter cause toppling of the plants because the rooting system is seriously weakened. Weevils cause snapping at ground level of the bananas. Both pests may be present in planting materials and hence infect new fields. The extent of damage by weevils and nematodes is further enhanced by poor soil fertility management. Weevils can be trapped and removed by using split pseudo stems and corns, but application of botanicals, such as Tephrosia, tobacco and Mexican marigold can also be tried.

The key pests and their management options for the northern zone and Kagera regions are summarised in Tables 4.8. It has to be noted that, local agronomic practices and agro-ecological conditions influence the pest types and pressure. Therefore, farmers in other banana growing areas should be advised to select and experiment with the options developed for the northern zone where similar pest problems are experienced.

Table 4.8: Banana major pest problems and recommended management practices for Lake and Northern Zones

Pest		**Recommended management practices**
Insects	Banana weevil (Cosmopolites sordidus) (Temnoschoita delumbrata) Kiswahili name*: Funza ya migomba*	• Practice crop rotation • Intercropping with legume which reduce weevil movement • Sanitation/crop hygiene • Use healthy planting material (use a combination of corm paring and hot water (at 55^0C for 20 minutes or solarisation) treatment • Sequential planting to avoid nematode infested areas • Rational use of weevil trapping with using bate (split pseudostems or discs and corns) • Use of repellent botanicals, such as Tephrosia, tobacco, Mexican marigold, Neem and *Iboza multiflora* • Improved soil fertility management and crop husbandry • Mulching • Deep planting to discourage egg-laying • Application of high quantities of manure to improve soil fertility • Harvest hygiene
	Ants	• Trapping
Diseases	Panama disease or Fusarium wilt (Fusarium oxysporum f.sp. cubense) Kiswahili name: *Mnyauko panama*	• Grow banana cultivars with resistance to pest and disease like the East African Highland bananas (*Matoke*) • Fallow or rotation • Sanitation/crop hygiene • Planting of clean suckers • Establish new crop on disease free sites • Mulching • Application of high quantities of manure • Destroy debris of wilted plants by burning
	Black and yellow sigatoka (Mycosphaerella fijiensis) Kiswahili name: *Sigatoka*	• Resistant cultivars • Uproot and burn the affected parts

Pest		Recommended management practices
	nyeusi	• Use of large quantities of farmyard manure • Pland and field sanitation • Use disease free seeds • Prune, remove suckers and weed frequently • Avoid close spacing • Avoid transfer of seeds from affected areas to unaffected areas
Nematodes	Burrowing nematodes, e.g. Pratylenchus goodeyi, Radophilus similis, Meloidogyne spp. and Helichotylenchus multicintus	• Improved farm management, including sequential replanting and soil fertility • Practice crop rotation • Sanitation/crop hygiene • Farmer training in disease identification and control measures • Use healthy planting material • Establish new crop on disease free sites • Mulching to enhance beneficial soil organisms to suppress nematodes • Treatment of infested suckers with hot water • Application of high quantities of manure • Sterilise planting material through solarization and/or the hot water method as for weevil control
Vermines	Rodents	• Trapping by using local methods • Cleanliness of the farm

Source: MAFS: Plant Pests Field Book: A guide to management, 2003, IPM working group in the Northern Zone 2001; LZARDI-Ukiriguru 2000; Anania & Sayi (2001), Paul, et.al. (2000)

Cassava

Cassava is one of the major food crops in all areas except in the northern zone. Increased production is affected by pre-harvest and post harvest pest problems. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it is estimated that 1,426,000 ha and 2,503,500 ha were put under casava cultivation in 1996/7-2002/03 respectively with overall production of 2,149,100 and 2,833,200 tons.

Table 4.9: Cassava major pests and recommended management practices

Pest			Recommended management practices
Insects	Pre harvest	Cassava mealybugs (*Phenococcus manihot*)	Improve the soil fertility by manuring, mulching and intercropping Practice crop rotation Use clean planting material Resistant varieties Plant health stem cuttings Plant as the beginning of the wet season
		Cassava green mites (Mononychellus tanajaa)	Improve the soil fertility by manuring, mulching and intercropping Practice crop rotation Use clean planting material Resistant varieties Plant health stem cuttings Plant as the beginning of the wet season

Pest			Recommended management practices
		Cassava root scale (Stictococus vayssierra)	Plant health stem cuttings Plant as the beginning of the wet season
		Cassave white scale *(Aonidomytilus albus)*	Plant health stem cuttings Plant as the beginning of the wet season
		Variegated grasshopper (Zonocerus variegates)	Destructing the breeding sites Dig egg-laying sites of variegates grasshopper in the wet season to expose and destroy egg pod of the pest Biological control: use fungal pathogens, e.g. *Metarlizium spp*
		Spiralling whitefly (Aleurodicus dispersus)	Crop rotation Plant health stem cuttings Plant as the beginning of the wet season
		White fly *(Bemisia tabaci*)	Eliminate the sources of the virus Plant health stem cuttings Plant as the beginning of the wet season
	Post harvest	LGB, Weevils and Red flour beetle	Use of botanicals, e.g. Neem or pili-pili Bio-control (use of natural enemies)
Diseases		Cassava mosaic disease (CMD)	• Improve the soil by manuring, mulching and intercrops • Plant health stem cuttings • After harvesting destroy infected cassava stems • Use resistance varieties that tolerate CMD like Kibaha, Msitu Zanzibar, Aipin Valencia, Kigoma nyekundu and Mzungu • Manipulate sowing date and planting spacing to reduce incidence of the disease • Plan resistance varities against TMS 4(2)1425, TMS 81983, TMS 83/01762
		Cassava bacterial blight (Xanthomorias ampestris)	• Plant cuttings from health plants without leaf chlorosis • After harvesting destroy discarded infected cassava stems • Cleansing of farmers tools • Crop rotation • Avoid growing cassava consecutively on the same field • Check field regularly • Fallow practice • Use of resistant varieties • Rogue and destroy plants

Pest			Recommended management practices
		Cassava Anthracnose (*Colletotrichum graminiocola*)	• Plant cuttings from health plants without leaf chlorosis • After harvesting destroy discarded infected cassava stems • Cleansing of farmers tools • Crop rotation • Avoid growing cassava consecutively on the same field • Check field regularly • Rogue and destroy plants
		Cassava brown streak disease	• Plant cuttings from health plants without leaf chlorosis • After harvesting destroy discarded infected cassava stems • Cleansing of farmers tools • Crop rotation • Harvest early • Grow resistance varieties like Mzungu
		Cassava root rot disease (*Phytophtora, Pithium and Fusarium spp)*	• Harvest early • Plant cuttings from health plants without leaf chlorosis • After harvesting destroy discarded infected cassava stems • Cleansing of farmers tools
Weeds		Acanthospermum spp	• Cultural methods
Vermines		Baboons, Monkeys and rats (Lake Zone)	• Hunting farmer groups • Use of traps

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru 2000;

Pre-harvest

Cassava mealybugs (Phenococcus manihot)

The pest is widespread with frequent outbreaks in Ruvuma, Kigoma, Dodoma and Mara regions. Effective control is achieved through biological control using a wasp (*Apoanagrus lopezi*). This wasp has reduced the population significantly in most parts of Tanzania (Anon, 1999). However, in parts of Mara, Mwanza, Iringa and Kigoma, the pest is still devastating cassava. In these areas, another bio-control agent, (*Hyperapsis notata*), a predator, was released to compliment the wasp. Because of limited funding, the predator has been released in a few areas only (Anon, 1999).

Cassava Green mites (Mononychellus tanajoa)

This pest is also widespread but is more devastating in the Lake zone. The pest can cause 60% to 80% crop loss if left uncontrolled (Anon, 1999). Like the case of the mealybugs, effective control can be achieved through biological control. To affect this, an exotic predatory mite, *Tyhlodromallus aripo*, was imported and first released 1998 (Anon, 1999). The agent has spread too many areas including the southern zone, parts of Coast, Lake and S. Highlands. Where the agent has established, the pest population has been reduced considerably (Anon, 1999).

Cassava white mites

This is a major pest in the Lake zone. Currently, the only recommended management option is uprooting and burning of infected plants. However, some local selections are known to be tolerant to the pest. Such varieties should be identified, popularised, multiplied and distributed to farmers.

Cassava mosaic disease (East AfricaCMV, ACMV)

The disease is widespread but is more devastating in Mwanza, Mara, Kigoma and Coast regions where an incidence of 60% to 80% has been recorded (Dr. Rose Mohamed, personal communication). Farmers in affected areas are advised to uproot and burn infected plants and encouraged to plant resistant varieties. Currently, multiplication of resistant varieties (TMS 60142, TMS 30337, TMS 4(2) 1425, TMS 30572) is being done at Lake Zone Research and Development Institute in Maruku and Ukiriguru in collaboration with IITA. In addition, TMS 4(2) 1425 and TMS83/01762 (6) were multiplied in Mara region in collaboration with MARAFIP for distribution to farmers. An open quarantine site at Maruku, Bukoba was established in 1999 to further facilitate efforts to introduce resistant varieties from neighbouring countries (Anon, 2000).

Cassava mosaic disease Uganda variant (UgV)

The disease is devastating in the Lake zone, particularly in Shinyanga, Kagera, Geita district and Kigoma (R. Mohamed, personal communication). Use of resistant varieties is the only suitable management strategy. Such varieties are not available in the country. Through the East African cassava disease control programme, a resistant variety, Serere selection 4 (SS4), has been identified in Uganda. This material has been brought in the country for multiplication under the CMD East African programme.

Cassava brown streak disease

The problem is common along the coast (from 0-500m above sea level, from Tanga to Mtwara and around Lake Nyasa. The only viable management option is through planting of tolerant/resistant varieties. Some resistant varieties have already been identified in Kenya. These varieties will be imported through Mwele-Tanga open quarantine for multiplication and distribution to farmers. The work has not yet started due to lack of funds. It is estimated that the national programme will need about US$ 20,000 for two seasons to facilitate importation, multiplication and distribution of clean cuttings to affected areas.

Post harvest

The larger grain borer (LGB) is the most damaging pest of dried cassava. Loss of about 35% can occur in a period of 4-6 months if uncontrolled (Mallya, 1999).

Rodents, particularly the multi-mammate rat (*Mastomys natalensis*) attacks dried cassava chips and can cause high losses (quality and quantity) and therefore farmers should adopt and use recommended strategies to minimise potential attack.

The current integrated stored products guidelines (Nyakunga & Riwa, undated) if adopted, will go a long way in reducing potential losses due to LGB and rodents on dried cassava.

Common Beans (Phaseolus)

Common beans or phaseolus may be regarded as on e of the principal sources of protein as well as income to most farmers in Tanzania. According to Basic Data Agriculture Sector 2001/2002-2002/2003 (MAFS 2004), it is estimated that 732.200 ha and 651,000 ha were put under rice cultivation in 2001/2002-2002/03 respectively with overall production of 562,200 and 603,200 tons.

Beans are grown throughout the country with major production in the southern highlands, northern, eastern and some parts of Lake Zone Consequently, the pest pressure and type varies due to agro-ecological and management differences. Small-scale farmers grow beans mainly as intercrop with maize, while large-scale farmers grow them as monocrop. In contract to large-scale farmers, who apply a wide spectrum of chemicals, small scale farmers mainly apply cultural practices, and storage insecticides to control pests and disease in beans.

The most common diseases in beans are angular leaf spot disease, anthracnose, bean rust, and root rots. These are disease transmitted by fungi. One of the common causes of sever damage is the intensive cultivation of beans without sufficient rotation, the cultivation of resistant varieties and seed dressing are potential IPM control measures, but farmers have also to be trained in the proper diagnosis of the diseases.

Common pests in beans are stem maggots, brochids and foliage beetles. Maggots of the bean fly and foliate beetles cause damage to the beans while in the field. Brochids are storage insects that may cause severe loss of crop. Storage hygiene, improved storage structures and the application of ash, vegetable oil and botanicals, such as Neem and Tephrosia, are among the potential IPM control measures of bean bruchids. Maggots and foliage beetles may be controlled by seed dressing or spraying with botanicals, or by cultural practices, including rotation, post harvest tillage and earthing-up mulching.

Overall, some of the major diseases have been taken care of through breeding and selection for tolerance/resistance (Table 4.10). Farmers in different parts of the country already grow some of the disease tolerant/resistant varieties. The pest management options as summarised in Table 4.10 have been developed for the southern zone but can also be used by farmers in other areas. However, since this is not a blue print, farmers should be advised to select and try them out before full adoption.

Table 4.10: The major pest problems of beans and recommended management practices

Zone	Pest			Recommended management practices
Southern Highlands	Insects	Pre-harvest	Bean stem maggot (*Ophiomyia* spp)	• Seed dressing • Apply recommended insecticide or botanical extracts within five days after emergence • Plant tolerant/resistant varieties if available • Improvement of soil fertility through application of manure and/or fertilisers
			Bean aphids (*Aphis fabae*)	• Practice early planting • Apply recommended insecticides or botanical extracts if necessary
			Bean leaf beetle (*Ootheca benningseni*)	• Observe recommended time of planting • Practice good crop rotation • Post harvest ploughing where possible • Apply recommended insecticides
			Bean pod borer (*Helicoverpa armigera*)	• Apply recommended insecticides or botanical extracts

Zone	Pest			Recommended management practices
		Post harvest	Bean bruchids (*Acanthoscelides obtectus*)	• Ensure the beans are dry and well cleaned before storage • Apply recommended storage insecticide/ botanical extracts
	Diseases		Bean anthracnose	• Practice good crop rotation • Sanitation and crop hygiene • Use certified seed • Observe recommended time of planting • Plant tolerant/resistant varieties e.g. Uyole 98, Uyole 84 & Kabanima
			Angular leaf spot	As above
			Rust (*Uromyces appendiculatus*)	• Avoid planting beans in high altitude areas • Practice good crop rotation • Sanitation and crop hygiene • Plant tolerant/resistant varieties e.g. Ilomba, & Uyole 90 • Observe recommended time of planting • Spray with recommended fungicide when necessary
			Haloblight (*Pseudomonas* sp)	• Plant tolerant/resistant varieties e.g. Uyole 84 • Spray with recommended fungicide when necessary • Use certified seed
			Ascochyta (*Phoma* sp)	• Avoid planting beans in high altitude areas • Spray with recommended fungicide when necessary • Plant tolerant/resistant varieties e.g. Ilomba & Uyole 98 • Sanitation and crop hygiene
			Bean common mosaic virus (BCMV)	• Plant tolerant/resistant varieties if available • Effect good control of aphids

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru 2000; IPM working group in the Northern Zone 2001; Anania, et.al. (2001); Paul, et.al (2000), Madata, et.al. (2001).

Sweet Potato

The food crop is mainly grown in most small scale farming system. Cultivated areas under sweet potatoes in 2002/2003 were in Mbeya (69,000 ha), Kigoma (27,800 ha), Shinyanga (73,800 ha) and Mwanza (90,200 ha) regions. In 2002/2003 sweet potatoes production was as follows: Kigoma (233,400 tonnes), Shinyanga (164,100 tonnes), Mwanza (150,800 tonnes), Rukwa (87,900 tonnes), Kagera (69,000) and Mbeya (47,000 tonnes). According to Basic Data Agriculture Sector 1996/7/2002-2002/2003 (MAFS 2004), it is estimated that 287,000 ha and 470,600 ha were put under sweet potatoes cultivation in respectively with overall production of 477,700 and 957,500 tons. Sweet potatoes plan an important role during periods of food scarcity and are part of the survival strategies employed by rural households. The crop suffers from two major pests, which reduce significantly its yield: mole rats and may provoke other

pathogens to enter and cause rotting. Factors that contribute to the presence of these pests include monocropping, use of infested planting materials (weevils), drought and late harvesting. Table 4.11 presents pests and management practices.

Table 4.11: The major pests of sweet potato and recommended management practices

Pest			***Recommended management practices***
Insects		Sweet potato weevil (*Cylas brnneus)* Kiswahili name: *Fukuzi wa viazi* (adult) and *Funza wa viazi* (larva)	Sanitation Use of clean materials Crop rotation Plant varieties that form tubers at a greater depth Early harvesting of tubers; as soon as weevil damage is observed on tuber tips, harvesting should begin Keeping distance (at least 500m) between successive sweet potatoes plots Destroy infected crop residues by burying Planting of repellent species, such as Tephrosia, tobacco and Mexican Hilling up twice (at 4th and 8th week after planting) in the season to cover soil cracks and exposed to minimize eggs laying Traps with pheromones
		Rough sweet potato weevil (*Blosyrus sp*)	• Crop rotation • Sanitation • Planting of repellent species • Botanical pesticide
		Striped sweet potato weevil (*Alcidodes dentipes*)	• Sanitation • Use of clean materials • Crop rotation • Plant varieties that form tubers at a greater depth • Early harvesting of tubers; as soon as weevil damage is observed on tuber tips, harvesting should begin
Diseases		Sweet potato feathery mottle virus (SPFMV)	• Use of resistant varieties • Crop rotation • Sanitation
		Sweet potato sunken vein virus (SPSVV)	Avoid disease plants as a source of planting materials Use of resistant varieties
		Sweet potato virus disease (SPVD)	Sanitation Use of resistant varieties Crop rotation

Pest			*Recommended management practices*
Vermin's		Mole rats *(Tachyoryctes splendens*) Kiswahili name: *fuko*	• Planting of repellent species, such as Tephrosia, tobacco, onion, garlic and Mexican marigold in the field and its boundaries • Insert pars of repellent plant species into tunnels
		Monkeys, wild pigs	• Local scaring

Source: MAFS: Plant Pests Field Book: A guide to management, 2002; LZARDI-Ukiriguru, 2000

4.2 CASH CROPS

The major cash and export crops grown in the target project areas include coffee, cotton, cashew, tea, sisal and tobacco. Coffee, cotton, cashew and tobacco are largely small holder crops. The cash crops have special agro-ecological requirements and therefore are grown in specific zones and areas within the Corridor. Similarly, the pest pressure and management tactics recommended for the crop varies between zones.

Coffee

In Tanzania coffee is one of main export crops and leading foreign exchange earner. It accounts for about 20% of total domestic export. It is predominantly a small scale crop grown by about 420,000 farmers who produce over 90% of the crop and depend on it for their income and hence social welfare (Nyange 1999).

There are two major types of coffee grown in the country. Arabica coffee (*Coffee arabica*) is grown in all coffee zones (Northern, S. Highlands, Lake and Eastern) while the robusta coffee (*Coffee canefora*) is mainly grown in Kagera with small amounts in Tanga and Morogoro regions.). According to Basic Data Agriculture Sector 1996/97-2002/2003 MAFS 2004), it was estimated that overall production in the country was 52,220 and 53,220 in 1997 and 2003 tons respectively. Coffee production for mild, hard arabica and robusta was 29,835, 2,383 and 17,184 tonnes in 2002/2002. Moreover, the bulk of the crop is grown in the northern zone.

Coffee insects and other coffee pests are some of the major factors that undermine coffee productivity by direct reduction of crop yield and quality to coffee growers. There are about 850 species of insect pest known (Le Pelly 1973). In Tanzania there are more than 25 insect pests which attach coffee and pests of economic importance. Arabica coffee is much affected by pests, of which the most important species Antesia bug and white stem borer. Of less importance are leaf miner, coffee berry moth, scale insects, mealy bugs, coffee berry borer and rood-knot nematodes.

Table 4.12: Coffee pest problems and recommended management practices

Zone	**Pest**		**Recommended management practices**
Ruvuma sub-zone	Insects	Antestia bugs (*Antestiopsis* spp.)	• Pruning • Mbuni stripping • Apply recommended insecticides at recommended dosage if necessary

Zone	Pest		Recommended management practices
		White stem borer and yellow headed stem borer	• Sanitation and crop hygiene • Stem cleaning • Mechanical (hook the larvae out if possible)
		Mealybugs and scale insects	• Proper planting depth • Build the plant "skirt" soon after the first harvest to deter ants from climbing through branches to enhance build up of natural enemies
	Diseases	CBD & CLR	Management as for the northern zone
		Fusarium wilt	• Plant recommended tolerant varieties e.g. KP 423 (locally known as "nylon" • Field sanitation • Proper pruning
	Weeds	All types	• Clean hand weeding • Apply herbicide if necessary. Use recommended herbicides (Table 4.13)
Southern Highlands	Insects	As for Ruvuma sub-zone	As for Ruvuma sub-zone
	Diseases	CBD & CLR	As for northern zone
		Fusarium wilt	• Plant recommended varieties e.g. N36, which should be obtained from certified seed multiplication farms only. • Field sanitation • Maintain good drainage • Uproot and burn any diseased plants and avoid replanting in the same hole for 2 years

Source: MAFS: Plant Pests Field Book: A guide to management, 2003; LZARDI-Ukiriguru 2000; IPM working group in the Northern Zone 2001

Table 4.13: List of recommended pesticides for use in coffee

Chemical	Chemical common name	Formulation	Lts product/ha	Comments
Insecticides	Diazinon	600EW	1.0 -1.5	
	Deltamethrin	25%EC	0.5	
	Chlorpyrifos	4 EC	1.25-2.0	
	Carbofuran	5%G	60gm/plant	Spread the granules around the plant when the soil is wet and rake it into the soil

Chemical	Chemical common name	Formulation	Lts product/ha	Comments
	Fenitrothion	50%EC	1.0 -2.0	
	Profenophos	720EC	0.2 - 0.7	
	Endosulfan	35%EC	1.0 - 1.5	
Fungicides	Cyproconazole	100SL	1.0 - 2.0 kg	
	Hexaconazole	5% FL	25-100ml/100l of water	CLR
	Triadimefon	25%EC	1.0	CLR
	Propineb	25%EC	1.0kg	CLR
	chlorothalonil	50% FW	2.0 - 5.0	CBD & CLR
		W75	4.5	CBD & CLR
		54%FW	4.5	CLR
	Cupric hydroxide	50WP	7.0 - 8.0kg	CBD
	Cuprous oxide	50WP		CBD & CLR
	Copper oxychloride	50WP	7.0 - 8.0 kg	CDB & CLR
Herbicides	Gyphosate	36% SC	3-6l/ha	All types, post emergence
	Paraquat	20%EC	1-3l/ha	All types, post emergence

Notes:

1. All pesticides except carbofuran are applied with a knapsack sprayer.
2. The list of pesticides can change as new products are recommended and/or some of the chemicals are withdrawn. Therefore always consult the nearest plant protection extension worker if in doubt

Cotton

Cotton in Tanzania is purely a smallholder crop. The crop is grown in two major zones based on agro-ecological difference. The western cotton growing area (WCGA) include Mwanza, Shinyanga, Mara, Kigoma, Tabora, parts of Kagera, Singida and Kigoma regions, while the eastern cotton growing areas [ECGA] cover Morogoro, parts of Kilimanjaro, Coast and Iringa regions. According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it was estimated that overall production of cotton was 221,280 and 188,200 tons in 1997 and 2003 respectively.

Similar to coffee, the pest problems and the recommended management options vary depending on location (Tables 4.14, 4.15 & 4.16).

The recommended current cotton pest management strategies emphasises integration of several aspects of IPM (Tables 4.14 & 4.15). However not all farmers in all the cotton growing areas are aware and informed about the approaches.

A cotton quarantine established in 1946 (Cotton plant quarantine GN 265 of 1946: quarantine areas: Southern Province) is meant to prevent the entry of the red bollworm (*Diparopsis castanea*) from the neighbouring countries in the south (Malawi, Zambia & Mozambique) to the major traditional cotton area (the WCGA & ECGA). The quarantine has been effective in preventing the entry of the pest in the cotton area to date, and must therefore be maintained. Any attempt to grow cotton in the quarantine area should therefore be strongly discouraged. Should the pest enter the traditional cotton areas, the pest management strategies must be changed, and will probably lead to more use of pesticides, increased health and environmental problems in the traditional cotton growing areas.

Crop scouting (regular crop inspection) was recommended in the late 1980s as another IPM component to optimise insecticide cotton spraying in the WCGA. However, to date, only a few farmers in Shinyanga, Kagera and Mara regions practice it. Only the IPM farmer groups and their immediate neighbours practice crop scouting before spraying. It is important to recognise that scouting for a pest is a prerequisite for good crop pest management and judicious use of pesticides. There is therefore a need to mobilise farmers through appropriate training, to inform and enhance wider use of regular crop inspection as a means to optimise the benefits of pesticide use if they have to be used.

Crop scouting guidelines have not yet been developed for the ECGA but the approach developed for the WCGA could be tested and fine-tuned by farmers for adoption.

Traditionally, spraying against aphids in the WCGA was discouraged for two major reasons. First, it is not economically justified in most seasons. Secondly, aphids are usually controlled by a wide range of its indigenous natural enemies (predators and parasitoids) that builds up in the crop early in the season. In addition, the aphid populations are often washed away by the heavy rains in March/April. Occasionally, the population can build up to damaging levels (resulting to sooty mould, which can damage the quality of the crop). When this occurs, insecticides recommended for the bollworms can be used effectively.

The indigenous aphid natural enemies are polyphagous and will also feed on the eggs and larvae of *H. armigera,* the key pest of cotton in the area.

Insecticide mixtures e.g. profenophos + cypermethrin (Table 4.14) were discouraged to safeguard and promote the build up of the natural enemies to further extend integration of bio-control agents in the cotton systems.

Table 4.14: Cotton pest problems and recommended management practices in the WCGA

Pest		**Recommended management practices**
Insects	Jassids (Empoasca sp)	• Plant recommended UK varieties (resistant plant varieties) • Spray in case of a severe attack at seedling stage
	American bollworm *(Helicoverpa armigera)*	• The host plants should be inspected regularly • Souting • Encourage natural enemies • Use botanical pesticides like neem and Utupa • Plant recommended UK varieties (inditerminant varieties) • Early planting • Spray with recommended insecticides after scouting (Table 3.13)

Pest		Recommended management practices
	Aphids *(Aphis gossypii)*	• No spraying. • Encourage build up of natural enemies like birds • Populations often washed off by rain
	Spiny bollworm (*Earias insulana and E.biplaga*)	• The host plants should be inspected regularly • Scouting • Encourage natural enemies like birds • Use botanical pesticides like neem and Utupa • Early planting
	Lygus (Lygus vosseleri)	Spray with insecticides in case of an early season attack
	Cotton stainers (*Dysdercus* spp)	• Observe the close season • Early and frequent picking avoid build-up of stainers • Sanitation in and around cotton ginneries and buying posts • Apply 1 to 2 sprays of recommended insecticides if necessary (inspect the crop before spraying)
	Blue bugs *(Calidea dregii*)	• Observe the close season • Early and frequent picking avoid build-up of stainers • Sanitation in and around cotton ginneries and buying posts • Apply 1 to 2 sprays of recommended insecticides if necessary (inspect the crop before spraying)
Diseases	Bacterial blight (*Xanthomonas malvacearum)*	• Rotation • Plant recommended UK 82 varieties (resistant plant varieties) • Observe the close season • Crop sanitation
	Fusarium wilt (*Fusarium oxysporum* f.sp. *vasinfectum)*	• Rotation • Crop sanitation • Plant recommended UK 77 or 91 varieties (resistant plant varieties)
	Alternaria leafspot (*Alternaria macrospora)*	• Rotation • Field sanitation

Pest		Recommended management practices
Weeds	All types (See Table 3.4)	• Proper land preparation • Early clean weeding • Use recommended herbicides (Table 12)
Vermines	Field rats, monkeys and baboons	• Scaring • Trapping

Source: MAFS: Plant Pests Field Book: A guide to management, 2003; LZARDI-Ukiriguru 2000

Table 4.15: List of pesticides recommended for use on cotton in the WCGA

Chemical	Chemical common name	Formulation	Application rate g a.i./ha	Comments
Insecticides	Endosulfan	25% ULV	625	
	Cypermethrin	1.8% ULV	45	
	Fenvalerate	3% ULV	75	
	Flucythrinate	1.7% ULV	42.5	
	Lambda cyhalothrin	0.6% ULV	15	
	Esfenvalerate	0.5% ULV	12.5	
	Alpha cypermethrin	0.8% ULV	20	
	Biphenthrin	2%ULV	50	
	Betacyfluthrin	0.5%ULV	12.5	
	*Profenofos + cypermethrin	1% + 16% ULV	400+ 25	
	*Deltamethrin + dimethoate	0.3+ 12 % ULV	7.5 + 300	
	Flucythrinate	1.33% Me/ULV	33.25	
Fungicides	Bronopol	10% dust	5/100kg	
	Cuprous oxide	45% dust	5/100kg	
Herbicides	Diuron	80W	1000	For use on light soils only
	Fluometuron	500FW	2000	For use in light soils only
	Metalachlor + Dipropetrin	400EC	800+1200	For use in light soils only

Notes:

All the insecticides are applied using ULV pumps at the rate of 2.5l/ha at a swath width of 4.5 meters. The target pest is the American bollworm and farmers are advised to scout the crop starting from when the first buds are formed or 10 weeks after planting until first boll split before spraying.

Early season (before first flower) spraying is strongly discouraged, as this will interfere with the build up of indigenous natural enemies of aphids and the bollworms.

All herbicides should be applied pre-emergence.

The list of pesticides can change as new products are recommended and/or some of the chemicals are withdrawn. Therefore always consult the nearest plant protection extension worker if in doubt

*These pesticides are unnecessary for the WCGA as continued use will jeopardise conservation and use on natural bio-control in the cropping system.

Table 4.16: Cotton pest problems and recommended management practices in the ECGA

Pest		**Recommended management practices**
Insects	Jassids (Empoasca sp)	• Plant recommended IL varieties (resistant plant varieties) • Spray in case of a severe attack at seedling stage
	American bollworm *(Helicoverpa armigera)*	• Plant recommended IL varieties • Early planting
	Aphids (Aphis gossypii)	• Spray using recommended insecticides (Table 14)
	Cotton stainers (*Dysdercus* spp)	• Observe the close season (mid-September to early November) • Early frequent picking • Apply 1 to 2 sprays of recommended insecticides if necessary (inspect the crop before spraying) • Sanitation in and around cotton ginneries and buying posts
	Pink bollworm (*Pectinophora gossypiella*)	• Early planting and early picking • Close season
Diseases	Bacterial blight (*Xanthomonas malvacearum)*	• Plant recommended IL varieties (resistant varieties) • Observe close season
	Alternaria leafspot (*Alternaria macrospora)*	Plant dressed seed only (Table 14)
Weeds	All types see Table 3.4	• Cultural control • Good land preparation • Early hand weeding • Use recommended herbicides (Table 14)

Table 4.17: List of pesticides recommended for use on cotton in the ECGA

Chemical	Chemical common name	Formulation	Application rate g a.i./ha	Lts product/ha	Comments
Insecticides	Cypermethrin	1.8% ULV	45	2.5	
	Cypermethrin	10%EC	45	0.45	
	Fenvalerate	20% EC	75	0.375	
	Flucythrinate	10% EC	42.5	0.425	
	Lambda cyhalothrin	0.6% ULV	15	2.5	
		5% EC	20	0.4	
	Esfenvalerate	2.5% EC	20	0.8	
	Deltamethrin	0.3% ULV	7.5	2.5	
		0.5% ULV	12.5	2.5	
		2.5%EC	7.5	0.2	
	Fluvalinate	2%EC	100	0.2	
Fungicides	Bronopol	10% dust	5/100kg		
	Cuprous oxide	45% dust	5/100kg		
Herbicides	Fluometuron	500W	2500-3000 3500	5.0 - 6.0 7.0	Light and medium soils Heavy soils

Notes:
The herbicides should be applied pre-emergence only.
All ULV formulations are applied using the ULV pump at a swath width of 4.5 m. Spraying is done once a week beginning 8 weeks after planting and should continue until boll split.
All the EC formulations are applied by knapsack sprayers at the rate of 120l/ha
The list of pesticides can change as new products are recommended and/or some of the chemicals are withdrawn. Therefore always consult the nearest plant protection extension worker if in doubt

Cashewnuts

In the southern zone widespread planting of cashew was carried out after 1945 and in a relatively short period of time, it developed into an important cash crop for smallholders. It appears that expansion first started on the Western Makonde Plateau and then spread northwards into Lindi and Coast regions and eastwards into Ruvuma. Cashew is mostly grown on poor soils in the coastal districts and the south of the country; Mtwara, Lindi and Ruvuma produce about 70% of the crop. By 1960, the region gave 40,000 tonnes of nuts which were being exported and it had become Tanzania's fourth most valuable export. Production continued to increase and reached a peak of 145,000 tonnes in 1973/4. From the peak year there was a catastrophic decline in production to a low of 16,500 tonnes in 1986/7. Some of the reasons for such a dramatic fall in production were due to a complex of socio-economic and biological factors (Brown, et. al. 1984). The biological factors which are relevant in the context of this report:

- The onset of powdery mildew disease (Oidium anacardii Noack)
- Overcrowding of trees

According to Basic Data Agriculture Sector 1996/97-2002/2003 (MAFS 2004), it was estimated overall production of cashewnuts was 65,400 and 92,200 in 1997 and 2003 respectively.

Powder mildew disease (PMD) *Oldium anacardii*

The most serious biological constraint to cashew production in East and Southern Africa is powdery mildew disease, *Oldium anacardii.* In East Africa, PMD develops on young growing tissue, e.g. new shoots with tender leaves, panicles from the very young to the mature, apples and young nuts. The infected parts look as though they are covered in a white/grey powder. Severely infected young leaves change colour from green to brown, become deformed and eventually drop off prematurely. Mature, older leaves, with a well-developed cucile, are not attached. Prior to early 1970's, PMP was not a problem in East and Southern Africa. It was first officially reported in Tanzania and for that matter, Africa, in 1979 (Casuli 1979). PMD was one of the factors responsible for the catastrophic decline in cashew production with tool place in Tanzania from 1973 to 1986.

A range of different control measures against PMD were developed by research, to try and cater for different farmer types and address various environmental concerns. Very fine sulphur dust (usually 99% pure) has been used in Tanzania for more than 15 years to control PMD; the dust is blown on the trees using motorized blowers. However, only 22% of the dust is deposited on the tree and if dew is absent at the time of application, the percentage deposited on the tree drops off dramatically (Smith at.al1995). Most of sulphur ends up on the soil, where in the longer term, it has caused soil acidification in various parties on the Makonde plateau in Mtwara region (Ngatunga, 2001).

Other diseases but of less economic importance in Tanzania include anthracnose (Colletrotrichum gloeosporides Penz), dieback (Phomopsis anacardii Punith), cercospora leaf spot (Pseudocercospora anacardii Nova), pestalotia leaf spot (Pestalotia hetercornis Guba) and wilting syndrome which causes shedding of leaves and sometimes death, is a minor, sporadic problems (Sijaona 1997).

Sucking Pests (Helopeltis and Pseudotheraptus)

The sucking pests Helopeltis and Pseudotheraptus Miller (Hemiptera: Miridae), H. schoutedenii Reuter and Pseudotheraptus way (Hemiptra: Corediae) are the main insect pests of cashew in East Africa. Sucking pest damage can be very variable from year to year and place and place. In Tanzania, Helopetis populations tend to build up on cashew from May/June to September/Octover, coincind with the period of leaf flush and panicle development (Topper 1998). Sucking pest leaf damage can stake the form of black lesions on petioles or on the leaf midrib, or black angular spots on the leaf surface.

The presence of the weaver ant, Oecophyla longinoda (Hymenoptera: Fromicidae) has been shown to have a significant effect in reducing sucking pest damage. It is possible to assist these predators in colonising new trees and thereby enhance their capacity for control of sucking pests.

Other less important insect pests are trunk borer (Mecocorynus loripes, Coleoptera, Curculionidae) – the larvae of this large weevil bore through the sapwood of branches and trunks, which result in the death of the infected part of the whole tree.

This is the main cash crop of the southern zone and along the coast in the eastern zone. The pest problems and respective recommended management approaches are similar in all cashew-growing areas.

Although the current pest management options advocate use of IPM approaches (Table 3.14), there is evidence to show that there is an increase in insect pest pressure due to excessive use of sulphur to control powdery mildew (Anon, 2000). Alternative pesticides have been identified and registered since 1994 (Anon, 2000) but the new products have not yet been popularised among growers.

Education and mobilisation of farmers is needed to promote wide adoption and use of the recommended disease tolerant/resistant clones and cultural practices (Table 15) to reduce over reliance on chemical pesticides (Table 4.17) for the control of the major diseases.

Table 4.18: Major pests and recommended management practices in cashew

Pest		Recommended management practices
Insects	Coreid bugs (*Pseudotheraptus* wayi)	• Biological control using the African weaver ant (*Oecophilla longinoda*). T o enhance effectiveness of the bio-control agents, farmers are advised to do the following: 1- Apply Hydramethyl to control Brown house ants (*Pheidole megasephala*) when necessary 2- Interplant coconut with recommended suitable host trees of weaver ants 3- Construct artificial aerial bridges to facilitate mobility of weaver ants between trees 4- Plant weaver ant nests in areas where they do not occur naturally • Apply recommended insecticide at recommended dosage (Table 16) in case of severe outbreaks
	Holopetlis bugs *(Helopeltis* anacardi) Kiswahili name: *Mbu wa mikorosho*	• Biological control using the African weaver ant (*Oecophilla longinoda*). (Maji Moto) • Not intercropping pigeon pea with cashew • Apply recommended insecticide at recommended dosage (Table 16) in case of severe outbreaks
	Cashew mealybugs (*Pseudococcus longispinus*)	• Crop sanitation (removal & proper disposal of affected plant parts) • Biological control
	Thrips (*Selenothrips rubrocinctus*)	• Control should mainly target larvae stage during early stages of flowering
	Stem borers, Weevils, (*Mecocorynus loripes)*	• Adults should be collected and destroyed by hand • Mechanical, using a recommended hooks • If the tree is severely attacked, cut and dispose properly
Diseases	Powdery mildew (*Oidium anacardii*)	• Prune to provide good ventilation and aeration within trees making microclimate not conducive to the pathogen multiplication • Scouting • For established plantations, practice selective thinning • Remove off-season young shoots which can be sources of fresh innoculum during the season • Sanitation • Thin densely populated trees and leave them well spaced, to reduce or delay mildew epidemic due to changes in microclimate in the field • Plant recommended tolerant clones e.g. AC4, AC10/220, AZA2 and at recommended spacing • Apply recommended fungicides as appropriate (Table 16)
	Anthracnose (*Colletotrichum gloeosporioides*)	Remove and burning of all infected organs before the start of the cashew season. Plant recommended tolerant clones e.g. AC4, AC10/220, AZA2 and at recommended spacing Apply at recommended pesticide at correct rate and time (Table 16)
	Dieback *(Phonopsis anacardii)*	Remove and burning of all infected organs before the start of the cashew season.
	Wilt syndrome	Apply at recommended pesticide at correct rate and time (Table 16)

Source: MAFS: Plant Pests Field Book: A guide to management, 2003; Topper, et, al, 2003

Table 4.19: Pesticides recommended for use on cashew

Chemical	Chemical common name	Formulation	Application rate	Target pest	Comments
Insecticide	Fenitrothion	50% EC	17ml/tree	Thrips	
	Profenofos	48%EC		Cashew mealybugs	
	lambda cyhalothrin	5%EC	5ml in 1 l of water per tree	*Helopeltis* & Coreid bugs	
	Hydamethyl			Brown house ants (Table 11)	
Fungicides	Sulphur	D	250gm/tree	Powdery mildew	Apply with motorised blower
	Hexaconazole	5%FL	10-15 ml in 0.75 - 1.25 l of water, three sprays at 21 days interval		
	Penconazole	10%EC			
	Triadimenol	25%EC			
	Copper hydroxide	50%WP		Anthracnose	

Note:

1. All the pesticides except for sulphur, are applied using a knapsack sprayer or with a mist blower (Sijaona, & Anthony, 1998; Sijaona & Barbanas, 1998)
2. The list of pesticides can change as new products are recommended and/or some of the chemicals are withdrawn. Therefore always consult the nearest plant protection extension worker if in doubt.

4.3 HORTICULTURAL CROPS

A wide range of horticultural crops are grown in Tanzania (Table 4.1). However, the sub-sector is still under developed and poorly exploited for several main reasons. First, the resources allocated for research and development to the sub sector has always been inadequate. At the national level, the sub sector has been accorded only medium to low priority. IPM research on vegetable and fruit crops has a very low profile as reflected by the state of inadequate funding for research and development as well as lack of staff continuity in the sub sector. On-going research activities are patchy and uncoordinated. Consequently, local information on appropriate pest management tactics for the major horticultural crops is scanty except for coconut and tomatoes.

The coconut programme based at ARI Mikocheni has done commendable work by developing appropriate IPM approaches for coconut cropping systems that can be extended to farming communities in the coconut growing areas (Table 4.17).

Effort to improve tomato production through breeding and selection for tolerance and/or resistance to key pests, particularly diseases, in the country has been facilitated by the AVRDC Arusha station beginning in 1994.

For the majority of crops, e.g. mangoes, farmers are experimenting with borrowed ideas and fine-tuning them to solve pertinent pest problems. The cut flower industry, which is a domain of large-scale growers, operates independent of the national system, and therefore, each grower has in-house capacity and capability to address pest problems.

Coconuts

Coconut production is basically a smallholder crop largely confined to the coastal belt from Tanga to Mtwara, mostly in Eastern and Southern regions. The agro-ecological conditions and the management practices of the crop are similar in all the growing areas and therefore, the pest problems and recommended control options are the same (Table 4.17).

The research and development programme at ARI Mikocheni through support by the GTZ, has developed and formulated appropriate farmer friendly IPM approaches for the coconut cropping system. However, extension of the knowledge to farmers has been hampered by a lack of adequate funding.

Table 4.20: Major pests and recommended control practices for coconut

Pest		Recommended management practices
Insects	Coreid bugs (*Pseudotheraptus* wayi)	• Biological control using the African weaver ant (*Oecophilla longinoda*). To enhance the effectiveness of the weaver ants, farmers are advised to do the following: 1- Apply Hydramethyl to control brown house ants (*Pheidole megasephala*) when necessary 2- Interplant coconut with recommended suitable host trees of weaver ants 3- Construct artificial aerial bridges to facilitate mobility of weaver ants between trees 4- Plant weaver ant nests in areas where they do not occur naturally
	African rhinoceros beetle (*Orytes monoceros*)	• Cultural removal of breeding sites of the pest • Mechanical, using recommended hooks
	Coconut mites (*Aceria guerreronis*)	This is a new pest and therefore no control measures available
	Coconut termites (*Macrotermes* spp.)	• For species living above ground, the termitarium can be destroyed physically • Apply recommended insecticides at the recommended dosage rates
Diseases	Lethal Disease caused by phytoplasma	Plant recommended tolerant/resistant varieties. E.g. East African Tall sub populations Proper destruction of diseased plants Avoid movement of seedlings from infested to non infested areas Location specific replanting

Source: Source: MAFS: Plant Pests Field Book: A guide to management, 2003

The only pesticide recommended for use on coconut is hydramethyl for the control of the brown house ants, which interfere with the effectiveness of the weaver ants.

Mango

Mangoes are grown for the local and export market, mostly as a smallholder crop. Despite its popularity, there has been limited research on its major pest problems and producers develop pest control tactics on a need basis (Table 4.18). Therefore, much need to be done to improve the crop, and also to address the key pest problems as summarised below.

Table 4.21: Key pests of mangoes and current farmer practices to reduce losses

Pest		Farmer practices
Insects	Fruit flies (*Ceratitis* spp)	• Harvest as much fruit as possible; sort out the edible fruit and bury all those that are infested • Apply chlorpyrifos when necessary • Use toxic bait sprays e.g. yeast products mixed with malathion or fenthion around the tree base • Removal of infested fruits and proper disposal (collect and bury

Pest		Farmer practices
		at least 10 feet deep)
	Mango weevils (*Sternochetus mangifera*)	• Removal of infested fruits at least twice a week and proper disposal (collect and bury at least 10 feet deep) • Selected less sucsceptibe varieties , such as Ngowe, Kitovu or Boribo • Maintain field sanitation at the end of the season by clearing all seeds under the tree canopy
	Mango mealybug	Spray contact/systemic insecticides Control of attendant ants to reduce spread of the pest
Diseases	Mango anthracnose (*Colletratrichum gloesporiodes*)	• Apply available registered fungicides • Proper pruning to reduce excessive and minimise disease build-up • Use the recommended post-harvesting treatment
	Powdery mildew (*Oidium spp)*	Apply recommended fungicides

Source: MAFS: Plant Pests Field Book: A guide to management, 2002

Citrus

Like mangoes, citrus fruits are produced for the local and export markets but resources allocated for research and development are insufficient and therefore, the pest management strategies used by farmers to date have been borrowed from elsewhere and fine-tuned for local use on a need basis. Table 19 is a summary of the key pest problems and some of the available management options.

The biological control of the woolly whitefly, which is a new pest of citrus in Africa south of Sahara, is a recent good example. The programme, a collaborative initiative between PHS and GTZ-IPM, was embarked on after promising results were reported in Uganda and Kenya where successful initial releases were done.

The biological control of the citrus black flies is a spill-over from releases done on the Kenya coast in the 1970s. The efficacy of this bio-control agent has to be facilitated by controlling the attendant ants, which facilitate the spread of the pest and also interfere with the efficacy of the wasps (Dr. Z. Seguni, personal communication). Farmers in the coconut and cashew cropping systems can benefit from the technology already developed for the management of attendant ants on respective crops.

Overall, local information on sustainable management of citrus, particularly pest problems, are lacking (Table 4.22). Adequate resources must be allocated to enhance development and promotion of the crop.

Table 4.22: Major pest problems of citrus and recommended management practices

Pest		Recommended management practices
Insects	Scale insects	Normally ants protect aphids against natural enemies
	Mealybugs (Planococus citri-Risso)	Trees with dead brown leaves should be uprooted and replaced
	Aphids (Toxptera citricidus)	Normally ants protect aphids against natural enemies

Pest		Recommended management practices
	False codling moth (Cryptophlebia leucotrata)	Field sanitation (collect all fallen fruits and bury them at least 50 cm deep) Remove wild castor ("Mbarika") around the orchard
	Orange dog (Pappilio demodercus)	Regular scouting and hand picking of caterpillars Apply contact insecticides in case of a severe attack
	The wooly white fly (Aleurothrixus flocossus)	Biological control using imported parasitic wasps Management of attendant ants to reduce spread and facilitate the efficacy of natural bio-control agents
	Black flies (Aleurocanthus sp)	Management of attendant ants to reduce spread and facilitate the efficacy of natural bio-control agents
	Giant coreid bug (Anoplenemis curvipes)	New pest but farmers are encouraged to introduce and enhance the activity of weaver ants (refer to cashew & coconut approach)
	Citrus leafminer	Crop sanitation and mulching Apply recommended systemic insecticides when necessary
Diseases	Greening disease (Liberobacter africana)	• Propogation of disease free planting materials • Eliminate all infested trees • Strict quarantine measures • Natural enemies Hymenopterous chalcids such as Tetrastichus spp and Diaphorencytrus aligarhenses • Use clean planting material • Good plant nutrition
	Gummosis (Phytophthora spp)	• Budded at least 20cm from ground should be chosen • Cut infected trees • Affected orchards should not be excessively irrigated
	Tristeza (Virus localized in phlorm tissue)	• Use disease free budwood
	Green moulds (Pencillium italicum)	• Handle fruit carefully to reduce skin injury • Treat bruches, graders, etc • Use the recommended post harvesting treatment

Source: MAFS: Plant Pests Field Book: A guide to management, 2002

Pineapple

Pineapples are largely grown for the domestic market and have few known major pest problems in Tanzania. These include the pineapple mealybugs (*Dysmicoccus brevipes & D. neobrevipes* and pineapple wilt disease, which are transmitted by *Dysmicoccus brevipes.* The recommended pest management tactics therefore target the control of *Dysmicoccus brevipes*, the vector. The only viable approach is through effective management of attendant ants to reduce spread and build up of mealybugs in the crop.

Table 4.23: Major pest problems of pineapples and recommended management practices

Pest		Recommended management practices
	Mealybugs (Pseodococcus brevipes)	• Use clean planting materials • Trees with dead brown leaves should be uprooted and replaced
Diseases	Top and root rot (Phytophthora spp)	• Use well-drained soils from pineapple growing • Plant on raised beds at least 23 cm high after settling • Provide drainage system to get rid of excess water without causing soil erosion • Deep-trip down the slope before hilling if subsurface soil compaction is evident

Source: MAFS: Plant Pests Field Book: A guide to management, 2002

Tomato

Tomato is most important horticultural crop, grown by almost all small farmers in northern and southern Tanzania. There are two types of tomatoes grown in Tanzania. These are the tall or intermediate varieties e.g. Money maker and Maglobe, and the dwarf varieties e.g. Roma Vf and Tanya. Both types are grown across the country although consumer preference also influences local production.

Tomatoes are grown for cash and domestic use mostly by women and youths in Kilimanjaro, Arusha, Tanga, Iringa, Dodoma, Mbeya, Morogoro and Mwanza regions. It is also important for local processing, with processing plants in Iringa and Arusha. Some of the products from these plants are sold on the local market while the bulk is exported.

In some areas, e.g. in the northern zone, more resources are invested in tomato production than in coffee production because tomatoes gives better and fast returns (personal observation).

Farmers use fungicide or insecticide available at the rural markets and often do not respect proper timing and dosage instructions. Moreover, they do not wear protective gear when applying the chemicals and do not use the proper equipment (e.g. application by using naps in stead of sprayers).

Tomato production is seriously hampered by diseases, i.e. late blight, yellow leaf curl virus, powdery mildew and various wilts. The yellow leaf curl virus is transmitted by white flies, while late blight is caused by the *Phytophthora infestans* air borne fungus. Powdery mildew is a result of infestation by the obligate parasite *Oidium lycopersici.* Yellow leaf curl virus results in stunted plants with chlorotic leaves. Late blight causes leaf lesions and rotting of affected fruits. Powdery mildew causes discoloration of foliage that eventually dies. Year round cultivation of tomatoes without proper rotation is one of the major causes of the spread of these diseases. Later blight and bacterial spot develop under moist conditions, while dry weather conditions are favourable to yellow leaf curl virus and powdery mildew. Cultural practices, such as rotation and field hygiene, can be applied to reduce the effect of the diseases. Botanicals, such as Tephrosia, Neem and Mexican marigold, should be tested on their effect on white flies. New, tolerant tomato varieties may contribute to the IPM control of the diseases. Farmer Field Schools would be effective tools to improve farmers' knowledge about the diseases and their IPM control.

A specific category of diseases affecting tomato nurseries are damping of pathogens, such as *Pythium, Fusarium, Rhizoctonia, Phytophthora* and *Alternaria.* These pathogens cause damping off, wilting and rotting of the nursery plants. The spread of the rot fungi is enhanced by excessive moisture, continuous cultivation of tomatoes and the presence of volunteer plants. Seedbed hygiene (sterilization by fire or polythene sheets, removal of crop debris, rotation) is the best IPM control measure that should be promoted amongst tomato growers.

Various species of root-knot nematodes and red spider mites are among the major pests affecting tomato yield. Red spider mites are sucking insects that appear under dry weather conditions. Root-knot nematodes damage plants by devitalizing root tips and either stopping their growth or causing excessive root production and root are swelling. Major causes to both pests are lack of rotation or fallow and year round cultivation of tomatoes. Root-knot nematodes can be controlled by cultural practices, such as field sanitation, deep ploughing, and the use of clean planting materials and tolerant or resistant varieties. Red spider mites may also be controlled by botanicals, such as Mexican marigold, Tephrosia and Neem. However, the effect of these botanicals has to be confirmed. Farmers must be informed of the currently recommended control measures, including safe handling of chemicals.

Table 4.24: Major pests of tomatoes and recommended management practices for northern zone

Pest		Recommended management practices
Insects	American bollworm (Helicoverpa armigera)	• Destroy infected crop residues and fruit after harvesting • Encourage natural enemies (parasites, ants, Anghocorid-bugs and egg predators) • Use maize ads a trap crop (timing of crop stage; tasseling stage coincides with attack) • Inspect the crop regularly for new infestations • Use botanicals like Neem extract • Apply recommended insecticides at recommended dosage rate
	Cutworms (Agrotis spp)	Early ploughing to expose cutworms to predators Apply wood ash around plants Inspect the crop regularly soon after transplanting because this is the most susceptible stage of the crop Mechanical (hand collect and crush them) Use appropriate trapping methods. Crush the caterpillars or feed them to chicken Use repellent botanicals Spray with recommended insecticide if necessary (Table 21)
Nematodes	Root knot nematodes (*Meloidogyne*) Kiswahili: *Mnyauko nyanya*	Optima rotation and fallow Deep ploughing Avoid contaminated water Plant tolerant/resistant varieties Sterilise the seedbed before sowing Avoid planting a new crop on infested areas
Mites	Red spider mites *(Tetranychus spp)* Kiswahili name: *Utitiri wekundu*	• Rogue infected plants • Avoid dusty conditions during extreme dry season • Encourage moist microclimate by frequent irrigation • Hedge planting to reduce dust, invasion by mites blown by wind • Encourage natural enemies by mulching and hedging • Use neem as alternative sprays • Observe recommended time of planting • Application of irrigation • Plant tolerant/resistant varieties e.g. ARP 367-2 or Rossol • Sanitation and crop hygiene • Use healthy planting material • Frequent weeding • Inspect the crop regularly for new infestations • Use neem oil with cow urine (mfori) • Apply a recommended miticide if necessary (Table 21)

Pest		Recommended management practices
Diseases	Late blight (*Phytophthora infestants)* Kiswahili name*: Baka jani chelewa*	• Regular crop scouting to detect early attack • Field sanitation after harvest by removal of infected plant parts • Crop rotation • Avoid moist microclimate at shady places • Use wide spacing (wet season) • Observe recommended time of planting • Plant at correct spacing • Shade management • Decrease humidity through pruning, desuckering, staking and weeding • Avoiding the humid season and mulch to avoid rain splash causing infections
	Early blight (Alternaria solani)	• Remove infected plants staring from nursery • Weed out Solanacea plants • Try botanicals and other natural pesticides • Observe recommended time of planting • Regular crop scouting to detect early attack • Apply recommended fungicide if necessary
	Powdery mildew (*Oidium lycopersicum)*	• Sanitation , remove infested leaves and plants • Practice crop rotation • Use botanical and other natural pesticides • Regular crop scouting to detect early attack • Apply recommended fungicide if necessary (Table 21)
	Bacterial wilt (*Pseudomonas solanacearum*)	• Practice good crop rotation • Practice deep ploughing/post harvesting cultivation to expose soil to sun • Add organic matter to the soil (cow dung, mulch, green manure) • Rogue affected crops and weed-hosts, destroy or bury outside the field • Avoid transferring infested soil including soil on roots of plants • Do not irrigate with contaminated water from infested areas • Choose seedbed in clean uninfected area

Pest		Recommended management practices
	Fusarium wilt (*Fusarium oxysporum)* Kiswahili: *Mnyauko nyanya*	• Use resistant varieties (like Tengeru 97) are the best practical measure to manage the disease in the field. Tengeru 97 is resistant to both *fusarim* wilt races 1 and 2 • Practice good crop rotation • Sanitation and crop hygiene • Deep ploughing • Avoid transferring infested soil including soil on roots of plants • Do not irrigate with contaminated water from infested areas • Add organic matter to the soil (cow dung, mulch, green manure)
	Bactoria spot (*Xanthomonas compestris pv. Vesicatoria*) Kiswahili name: Madoa bakteria	• Use clean seed • Three year crop rotation • Avoid working in fields under wet conditions • Avoiding of injuries to fruits
	Tomato yellow leaf curl (TYLC)-virus transmitted by whitefly (*Bemisia tabaci*) Kiswahili names: *Rasta, Ngumi, Bondia*	• Use disease free planting materials • Time of planting • Scouting of the disease and removal of affected plants • Intercrop with onion. This also reduces aphids in tomatoes • Intercrop with eggplants as traps to draw whiteflies away from less tolant and virus prone crops like tomatoes • Use repellent botanicals, such as Tephrosia and Mexican marigold • Regular crop scouting to detect early attack • Good management of irrigation water • Remove and destroy crop residues immediately after the final harvest • Avoid planting Lantana camara near tomatoes • Encourage beneficial insects, such as Encasis • Spray if necessary but use recommended insecticides (Table 21)

Source: MAFS: Plant Pests Field Book: A guide to management, 2003, IPM working group in the Northern Zone 2001; LZARDI-Ukiriguru 2000

Table 4.25: List of pesticides recommended for use on tomatoes

Chemical	***Chemical common name***	***Formulation***	***Application rate***	***Target pest***	***Comments***
Insecticides	Pirimiphos methyl	50%EC		fruit worms	
	Profenofos	72%EC		Whitefly	
Miticide	Azocyclotin	25%WP		Red spider mites	Registered for use on greenhouse roses for spider mite control

Chemical	*Chemical common name*	*Formulation*	*Application rate*	*Target pest*	*Comments*
Fungicides	Metalaxyl + mancozeb	7.5% + 56%WP	3.0 to 3.5 kg/ha	Early & late blight	
	Mancozeb	80% WP	1.5 to 2.5 kg/ha		
	Chlorothalonil	50%FW	2.0 to 5.0 l/ha		
	Copper hydroxide	50%WP	4.0 to 5.0 kg/ha		

Source: Paul, Mwaiko & Mwangi, 2000

All pesticides on tomatoes are applied using a knapsack sprayer. The list of pesticides (Table 3.21) can change as new products are recommended and/or some of the chemicals are withdrawn. Therefore always consult the nearest plant protection extension worker if in doubt.

Onion

Onion cultivation takes place throughout the Northern Zone and the Central Zone, but most production is located in the cooler, higher altitude areas, such as the mountains of Mbulu, Lushoto, Pare and Usambara and the foot slopes of Mount Meru and Mount Kilimanjaro. Most onions are cultivated under irrigation during the dry season. The crop is often grown year after year on the same field without sufficient rotation, a practice that encourages the build-up of pest and disease epidemics.

Downy mildew and storage rots are among the most important diseases affecting onions. Downy mildew can be controlled by field sanitation, wide spacing and weed control, rotation and use of tolerant varieties. Storage rots, such as *Botrytis, Erwinia, Mucor and Fusarium* can be controlled by ventilation and storage of onions on racks, use of polypropylene or netted bamboo baskets, drying of onions before storage and removal of tops. These control measures are applicable by all categories of farmers and can be disseminated through leaflets and brochures.

Onion thrips are the most common insect pest affecting onion production. Development of thrips populations is encouraged by insufficient rotation and presence of crop debris. Cultural control measures include deep ploughing, field sanitation, crop rotation, timely planting, mulching and irrigation. Botanicals, such as Neem oil, and other control agents should be identified and tested on their effect on thrips.

Information on major pest problems in the central agro-ecological zone is scanty, and therefore Table 4.25 gives a summary of the major pests and respective management options for some parts of the northern zone only. However, these pest management options (Table 4.25) can also be refined and adopted by farmers in other areas.

Table 4.26: Major pest problems and recommended management practices

Pest		**Recommended management practices**
Insects	Onion thrips (*Thrips tabaci)* Kiswahili name: *Vithripi*	Sanitation Scouting Separate seed bed and field to reduce danger of carrying over thrips from one site to the other Crop rotation Mixed cropping of carrots and onions Observe recommended time of planting Field sanitation and crop hygiene Transplant clean seedlings Mulching reduces thrips infestation considerably Plough deep after the harvest to bury the pupae Irrigation/adequate watering Enhance beneficials (predatory mits, bugs, fungal pathogens like

Pest		Recommended management practices
		Metarhizium) Inspect the crop regularly Use botanical extract like Neem oil, Tephrosia, tobacco, etc.
Diseases	Downy mildew (*Peronospora destructor*) Kiswahili name: *Ubwiri unyoya*	• Use resistant varieties (red creole) and crop rotation for at least five years • Sanitation: remove crop remains after harvest, do no leave volunteer plants in the field and avoid over fertilization • Wide spacing and good drainage to decrease humidity in the plant stand • Apply mulch to avoid rain splash • Inspect the crop regularly
	Purple blotch (*Alternaria porri)*	• Sanitation: remove crop remains after harvest, do not leave volunteer plants in the field • Crop rotation • Mulching to avoid rain splash • Plant at recommended spacing • Inspect the crop regularly Apply recommended fungicide at correct dosage
	Storage rots (*Bortytis, Erwinia, Mucor, Fusarium)* Kiswahili name*: Uozo ghalani*	• Use of netted bamboo baskets • Avoid heaps exceeding 30 cm depth and use racks of 1m high • Ventilated stores • Minimize damage during handling • Drying of onions before storage • Remove tops • Avoid thick neck/split

Source: MAFS: Plant Pests Field Book: A guide to management, 2002, IPM working group in the Northern Zone 2001; LZARDI-Ukiriguru 2000

Brassicas (cabbages and kale)

Cabbages and kale are grown in the cool highlands. It is a valuable relish for urban dwellers where it is used as vegetable salad and as stew to accompany the starchy foods (rice, ugali, cassava etc.). To date, the crop has few major pest problems whenever it is grown in the country (Table 3.23). The crop is mainly grown for income generation. Like tomatoes, farmers apply available chemicals mainly to control insect pests.

The most common disease affecting cabbage is black rot. The disease can reduce yield by 90% during the rainy season. Black rot is caused by the *Xanthomonas campestris* bacteria which are spread by infested seed and through crop debris. Wet warm weather conditions encourage the development of bacteria populations. Cultural control measures, such as deep ploughing, crop rotation and field sanitation considerably reduce the damage by blank rot. Other potential IPM control techniques include seed dressing with *Bacillus* bacteria, seed treatment with hot water or antibiotics, and resistant varieties.

Diamond back moth and cabbage head worm (in lowland areas) are the most devastating insect pests affecting cabbages. The pests may yield by 60% if no control measures are taken. Dry and hot weather conditions and the presence of host plants encourage the insect populations to develop. Farmers apply insecticides or cow dung and urine to control the pests. Application of Neem oil has proven to be effective, while the effect of natural enemies and other botanicals, such as *Diadegma*, Tephrosia and Annona seeds

should be verified. An alternative control agent is *Bt-Bacillus thuringiensis*. Farmer Field Schools would be helpful instruments in training farmers in pest identification and evaluation of control measures.

Few pesticides are recommended for use in the production of cabbages, mainly for insect pest control. However, since cabbage and kale are grown in coffee cropping systems, farmers tend to use pesticides recommended for use on coffee to control brassica pests.

Table 4.27: Major pests of brassicas and recommended practices

Pest		Recommended management practices
Insects	Diamondback moth (*Plutella xylostella)* Kiswahili names: *Nondo mgono and Almasi*	Scouting Use botanical and other control agents Observe recommended time of planting Transplant healthy seedlings Inspect the crop regularly to detect early attacks Encourage natural enemies (predatory hoverfly larvae, coccinellids, parasitic wasps) by enhancing diversity Use botanicals (Neem oil, chillies, etc.)
	Aphids *(Brevicoryne brassicae)* Sawflies Cabbage webworms	
Diseases	Blackrot (*Xanthomonas compestris*) Kiswahili name: *Uozo mweusi*	Seed dressing with Bacillus bacteria Seed treatment with hot water Mulching Deep ploughing 3-year crop rotation Field and crop hygiene Transplant only healthy seedlings Plant certified seeds Plant tolerant/resistant varieties like Glory, Amigo FI Sterilise the seed bed before sowing Good drainage, and mulch to avoid infections from rain splash
	Downy mildew (*Peronospora destructor*) Kiswahili name: *Ubwiri unyoya*	• Practice good crop rotation • Observe recommended time of planting • Transplant only healthy seedlings • Plant at recommended spacing
	Alternaria leaf spot (Alternatira spp)	• Avoid overhead irrigation • Practice good crop rotation • Observe recommended time of planting • Transplant only healthy seedlings • Plant at recommended spacing
	Cabbage club rot (*Plasmodiaphora brassicae)*	• Crop rotation • Plant in well drained soils • Adjust soil pH to alkaline by adding hydrated lime

Pest		Recommended management practices
	Black rot (Xanthomonos compestris pv. Compestris)	• Crop rotation • Use of pathogen free seeds • Avoid overhead irrigation • Use of resistance cultivars (Glory FA, Amigo F1) • Sanitation: remove crop residues – plough under, compost or feed to animals • Good drainage, and mulch to avoid infections from rain splash
	Cauliflower mosaic virus (CaMV)	• Remove brassica weeds • Rogue young plants showing disease symptoms and immediately burns them
	Dumpting off (*Fusarium Spp, Rhizoctonia spp. Pytium spp and Phytophotra spp)*	• Provide good soil structure and drainage • Avoid overwatering • Apply wood ash in seedbed • Sterilise seedbed • Use treated beds • Pricking excessive seedlings (thinning)
	Bacterial soft rot *(Erwinia carotovora var. carotovora, Pseudomonas spp)*	• Avoid harvesting when the whether is wet • Handle produce carefully and store in cool, well-ventilated areas • Plough in crops immediately after harvesting • Practice crop rotation and provide good drainage • Timely planting to coincide with dry season

Source: MAFS: Plant Pests Field Book: A guide to management, 2002, IPM working group in the Northern Zone 2001; LZARDI-Ukiriguru 2000

Deltamethrin 25%EC, diazinon 60% EC and profenopos 72%EC are recommended for use on cabbage and kales but the pesticides are also recommended for use on coffee.

4.4 MIGRATORY AND OUTBREAK PESTS

The key migratory and outbreak pests of economic significance in Tanzania are armyworm (*Spodoptera exempta*), birds, notably the Quelea (*Quelea quelea* spp), the red locust, rodents (particularly the field rats) and the elegant grasshopper (*Zenocerus elagans*).

With an exception of the elegant grasshopper, the management of the rest of the pests under this heading is co-ordinated by the Plant Health Service of the Ministry of Agriculture and Food Security.

Rodents

Rodents, particularly the multi-mammate shamba rat, (*Mastomys natalensis*), are major pests of food crops. The most affected crops are maize, millets, paddy and cassava. Virtually all regions are affected with more frequent outbreaks in Lindi, Mtwara, Coast, Tanga, Rukwa (Lake Rukwa valley) and in the cotton areas of Shinyanga regions.

Maize is the most susceptible of all the crops. At the pre-harvest stage, maize is attacked at planting (the rodents retrieve sown seeds from the soil causing spatial germination). In some cases, as much as 100% of the seeds are destroyed, this forcing farmers to replant (Anon, 1999). Losses of cereals are usually quite high and are in average about 15%. This loss of cereals could provide enough food for 2.3 of population for a whole year. Annual control costs for rodents are approximately 217 million Tanzanians Shillings (MAFS 2004).

Farmers in outbreak areas are strongly advised to do the following (Mwanjabe & Leirs, 1997; Bell, undated) to reduce potential damage to crops and the environment:

1. Regular surveillance. The earlier the presence of rodents is observed, the cheaper and simpler any subsequent action will be and losses will remain negligible
2. Sanitation. It is much easier to notice the presence of rodents if the store is clean and tidy
3. Proofing i.e. making the store rat-proof in order to discourage rodents from entering
4. Trapping. Place the traps in strategic positions
5. Use recommended rodenticide. However, bait poisons should be used only if rats are present. In stores or buildings, use single-dose anticoagulant poisons, preferably as ready-made baits.
6. Encourage team approach for effectiveness. The larger the area managed or controlled with poison, the more effective the impact
7. Predation. Keep cats in stores and homesteads.

In the cotton growing areas of Shinyanga, rats are a serious problem in cotton at planting and harvesting. At planting, the rodents pick out the seeds after planting, this leading to uneven germination and poor establishment. At harvesting, the rats feed on the seeds, leaving the farmer with lint only. Through feeding the rats not only reduce the value of the crop but also affect its quality by contamination by faeces and urine.

To reduce rat damage on cotton during harvesting, farmers are advised to pick the crop frequently and to sale it immediately after picking.

Birds (Quelea quelea spp)

Birds are serious migratory pests of cereal crops, namely wheat, rice, sorghum and millet across the country. The quelea birds, which in Tanzania occur are swarms ranging from thousands to a few millions, have been responsible for famines of varying proportions in some areas. In 2001, total loss (100%) in 700 ha of wheat was experienced in Basuto wheat farms, Hanang District (MAFS 2001). Similarly, about 25% loss of rice was experienced on 1125 has in the Lower Moshi Irrigation Rice Project in 1997/8 due to quelea birds (MAFS 1998). Table 3.25 shows quelea invaded regions in 2003.

Table 4.29**:** Quelea Quelea invaded regions year 2003

Year	**Invaded regions**	**Sprayed**		
		Coverage (Ha)	**Queleatox (l)**	**Number of birds killed**
January 2003 to December 2003	Arusha Kilimanjaro Dodoma, Mbeya, Singida, Shinyanga, Manyara	2,123.50	7,654	191.8 million

Source: MAFS (2004): Basic data agriculture sector 1995/96-2002/2003

Table 4.30: Quelea quelea outbreaks and cereal damage in some regions of Tanzania, 1998-2002

Region	**Number of hectares destroyed per year**				
	1998	1999	2000	2001	2002
Manyara	320.5	167	0	0	288
Dodoma	145	600	430	186	230
Mbeya	170	522	573	342	190
Mwanza	24	370	110	80	0
Shinyanga	56	0	350	48	357
Singida	150	0	41	194	123
Kilimanjaro	0	102	0	0	0
Mara	0	500	125	0	73
Morogoro	0	254.5	36	202.5	191
Tabora	0	215	663	0	127
Total hectares	**865.5**	**2730.5**	**2328**	**1052.5**	**1579**

Source: Ministry of Agriculture and Food Security Report, 1998-2002

Bird pest problems in agriculture have proved difficult to resolve due in large part to the behavioural versatility associated with flocking. The array of food choices available to birds is also complex, hence forth; necessary information is needed for successful control strategies. The total damaged per bird per day, if the bird is exclusively feeding on cereal crops, has been estimated at 8 g (Winkfield, 1989) and 10 g (Elloitt, 1989).

The control of migrant pests such as Quelea is a major concern to most farmers and the Ministry of Agriculture and Food Security. Several techniques have been tried to reduce bird populations to levels where crop damage is minimal. Traditional methods, slings, bird scares, and scarecrows, are still being used in many parts. Modern techniques of frightening devices, chemical repellents, less preferred crop varities and alternative cultural practices have been evaluated.

All the methods have minimal value in situations where bird pressure is high and where habitation is likely to develop through repetitive repellent use and other methods, which may alleviate damage in small plots or in large fields for a short time.

The aerial spraying of chemical (fenthion) on nesting and roosting sites, the most widely used technique to date. Currently, only fenthion 60%ULV aerial formulation is being used. Fenthion is registered under restricted use category such that the pesticide is recommended to be used at the rate of 2.0l/ha.

The concerns over possible human health problems and environmental damage resulting from the large-scale application of chemical pesticide for quelea control have let to a proposal for alternative non-lethal control strategy. Chemical pesticide applied for quelea control represent a risk for human, terrestrial, non-target fauna and aquatic ecosystems. The chemical pose risk by directly poisoning or by food contamination/depletion. Among the terrestrial non-target invertebrates, there are beneficial species. Some are responsible for organic matter cycling; others are predators, and parasitoids of crop pests. Some assure pollination of crops and wild plants, while others again produce honey and silk. The fact that non-target

birds and, occasionally, other vertebrates may be killed by quelea control operations is well-established (Keita, et.al. 1994; van der Walt et.al. 1998; Verdoorn, 1998)

The risk of human health problems and environmental damage can be mitigated considerably by development of integrated environmentally sound control strategies including Net-Catching. These methods will educate farmers become custodians of the environment. A new emphasis is the possibility of harvesting quelea for food. Since quelea is a good source of protein and preferred by many people. This method offers more rapid prospects for implementation which enable farmers to continue making their own decisions important for the control of quelea in their area. While present indications are that harvesting is probably not an option as a crop protection technique, it offers the possibility of providing income to rural populations in compensation for crop losses. (T. N. Mtobesya, pers.comm). A sustainable and environmentally sound control strategy for quelea in Tanzania undated research document by B.Mtobesya).

In respect of quelea birds, FAO is currently encouraging the use of IPM approaches to the problem of bird attacks on cereal crops. This means working with farmers in examing all aspects of farming practice in relation to quelea damage, and seeking to minimise external inputs, especially pesticides. In includes modifying crop husbandry, planting time, week reduction, crop substitution, bird scaring, exclusion neeting, etc. and only using lethal control for birds directly threatening crops when the other methods have failed. It is also important for farmers to be aware of the costs of control using pesticides, and in the case of commericial farmers, for them to bear some or all of the costs. A major likely benefit of IPM is reduced environmental side-effects resulting from decreased pesticide use. Although some elements of IPM have been tried in bird pest management, a major effort has yet to be made, for quelea, to focus on farmers in all aspects of the problem (Elloit, 2000).

Locust

Locusts live and breed in numerous grassland plains, the best ecologically favourable ones are known as outbreak areas. During periods with favourable weather, locust multiply rapidly and form large swarms which escape and may result into a plagau. There are eight known red locusts outbreak in East and Central Africa, four of these are found in Tanzania. The include the Rukewa Valley and Iku/Katavi plains in the Southern West, the Malagarasi River basin in the West and Wembere Plains in the Centre. They cover a total of 8000 km2. The strategy for red locust control combines regular monitoring of breeding sites followed by aerial application of fenitrothion 96.8% ULV to eliminate potential threatening hopper populations. Table 4.30 shows invaded area and treatment used for red locust.

Table 4.31: Invaded area and treatment used

Year	**Type**	**Investigated areas**	**Invaded area**	**Treatment**		
				Area coverage (Ha)	Type of chemical used	Remarks
January 2003 to December 2003	Red locust	Wembere Plains (Tabora) Malagarasi Basin (Kigoma) Iku/Katasi Plains (Rukwa)	1. Iku/Kutanvi Plains (Rukwa) 2. Wembere Plains (Tabora)	2,600 600 4500	Metarhizium anisopline Fenitrothion technical Fenitrothion technical	Observation, shows Metarhizium anisophiae as a more effective chemical in controllong the spread of Red Locusts

Source: MAFS (2004): Basic data agriculture sector 1995/96-2002/2003

Recently, the red locust regional programme has started to investigate the viability *Metarhizium anisopliae*, a biopesticide, for locust control. This is a collaborative initiative funded by DFID between NRI-UK, Tanzania and Zambia Governments. If viable, the agent can also be used as an option in the management of the elegant grasshopper and the edible grasshopper (locally known as *nsenene*).

The edible grasshopper (*Ruspolia nitidula*, Scopoli) has become increasingly damaging on cereal crops (maize, wheat sorghum, rice and millets) in parts of the country, notably northern, eastern and lake zones in recent years (PHS, pers.comm.). There being no research done on the management of the pest, farmers have been forced to use any recommended insecticide as in the interim.

Armyworm

The African armyworm (Spodoptera exempta) is a major threat to basic food production in a number of east and southern African countries Armyworm is a major pest of cereal crops (maize, rice, sorghum and millets) as well as pasture (grass family) and therefore a threat to food security and livestock. Overall losses of 30% for crops have been estimated though in major outbreak years losses in maize of up to 92% are recorded. Armyworm outbreaks vary from year to year but serious outbreaks occur frequentely as depicted in Table 4.31.

Table 4.32: Armywork outbreaks in Tanzania

Seasonal Year	**Area Invesed (Hactres)**
1989/90	28,768
1990/91	15,214
1991/92	517,233
1992/3	34,844
1993/94	45,504
1994/95	4,798
1995/96	3,187
1996/97	577
1997/8	35,174
1998/9	311,560
1999/2000	50
2001/2002	157,942

Table 4.33: Damage of various croups by armyworms during the 2001/2002 cropping seasons in some region of Tanzania

Region	**District**	**Crops damaged**	**Hectares infested**
Arusha	Hanang	Maize, sorghum, millet, pasture	25,910
	Kiteto	Maize, millet, pasture	15,570
	Karatu	Maize, sorghum, millet	2,500
	Monduli	Maize	100
	Babati	Maize	3,090
	Arumeru	Maize, pasture	2,500
	Simanjiro	Maize, pasture	2,230
Dodoma	Dodoma Rural	Maize, sorghum, millet, pasture	21,300

Region	District	Crops damaged	Hectares infested
	Dodoma Urban	Maize, sorghum, millet	6,613
	Mpwapwa	Maize, sorghum, millet, pasture	5,906
	Kondoa	Maize, sorghum, millet, pasture	17,268
	Kongwa	Maize, sorghum, millet, pasture	21,328
Kilimanjaro	Hai	Maize, paddy, pasture	3,500
	Rombo	Maize	110
	Mwanga	Maize, pasture	281
	Same	Maize, paddy, pasture	251
	Moshi	Maize, paddy, pasture	15,000
Tanga	Korogwe	Maize, paddy, pasture	1,050
	Handeni	Maize, pasture	6,445
Morogoro	Morogoro Rural	Maize, paddy, sugarcane	5,483
Iringa	Kilosa	Maize, paddy	617
	Kilombero	Maize, paddy, sugarcane	747
	Iringa Rural	Maize	9
	Ludewa	Maize	113
Mbeya	Mbozi	Maize	22
		Total hectares infested	157,943

Source: Ministry of Agriculture and Food Security Report, 2001-2002

Due to its economic significance, management and control is centrally co-ordinated by PHS. Its control combines monitoring in identified breeding areas, forecasting and early warning of potential outbreaks. The national armyworm control programme based at Tengeru-Arusha, runs a network of 100 traps distributed throughout the country (Anon, 1999). The traps are placed at district offices, research stations and in large-scale farms. Weekly returns from these traps are used in forecasting potential outbreaks for the following week (Anon, 1999). The information about potential outbreaks is passed to the regions and districts from where it is further passed to farming communities through the extension system. Farmers are advised to inspect their fields for signs of infestation. If the crop is attacked, farmers should spray with diazinon, fenitrothion or chlorpyrifos, whichever is available at the nearest pesticide store. Both ULV and knapsack sprayers can be used depending on available formulation in the outbreak areas.

This service could be improved through a better monitoring and reporting system that empowers farmers to be partners in a co-ordinated network. This will require the following activities:

- Development of community based monitoring and early warning approaches
- Formulating and implementing appropriate training for district plant protection officers (DPPOs), village extension officers (VEOs) and farmers to impart simple reliable monitoring skills
- Formulating and implementing a reliable community based early warning network

This approach is likely to have a number of benefits. One, less pesticides will be used because farmers will be able to identify and apply control measures on the most vulnerable stage of the pest, which is not possible in the current set-up. Secondly, farmers can use less toxic and environmentally friendly proven alternatives to pesticides e.g. botanical extracts and/or biopesticides at relatively low cost with minimum environmental hazards. Thirdly, if well co-ordinated, the information generated by farming communities can be integrated in the nation monitoring and early warning system to improve the quality of the information at national and international level.

A new natural control for armyworm is being developed by using a natural disease of the armyworm as biological control in place of toxic chemeak insecticides (W. Mushobozi, pers.comm.). This disease of armyworm is caused by specific agent, the Spodoptera exempta nucleopolyhedrovirus (or NPV). It has been observed since the early 1960s the late in the season many armmworm outbreaks collapse due to the occurrence of a disease that killed up to 98% of caterpillars.

NPV can be sprayed like chemicals onto pest outbreaks causing epidemics of NPV desease that kill off the pests, effectively acting as a natural insecticide. What is more, the killed insects produce more NPV

spreading the disease further. The NPV produced by dying insects can infect later generations of armyworms so that the effect is longer lasting than chemical insecticdes (Mushobozi, et.al. undated).

5. POLICY, REGULATORY AND INSTITUTIONAL FRAMEWORK

5.1 INTRODUCTION

Tanzania's legislation on plant protection and pesticides dates back to 1997. Accordingly, though the review of previous legislation was primarily based on IPM applications, these laws have not taken into account the New Revised Text of the 1997 International Plant Protection Convention (IPPC), which is cited by the World Trade Organization (WTO) Sanitary and Phytosanitary Agreement (SPS Agreement) as the authoritative standard setting body for plant protection. One of the purposes of the legal component is to ensure the compliance of Tanzanian legislation with these standards.

As a member of the WTO, Tanzania is required to comply with the international standards within the WTO framework. Phytosanitary measures include all relevant laws, decrees, regulations, requirements and procedures taken by a state in order to protect plant health and prevent the spread of diseases and pests. However, in order to prevent such measures becoming disguised restrictions on trade, the WTO SPS Agreement requires harmonizing such measures at international level. Conversely, such standards can be argued to be an important way of ensuring market access for Tanzania's international exports. Also Maximum Residue Levels (MRL) set by large target export markets such as the EU, US and Japan require that agricultural products do not have pesticides residues that exceed established quantities. Pesticides control is also a considerable concern nationally, with unacceptable MRLs on some agricultural crops for the domestic market. Greater regulation through strengthened legislation will contribute to the judicious application and safe use of pesticides.

5.2 POLICIES AND STRATEGIES

National Environmental Management Policy (1997)

The National Environmental Management Policy (NEM) is set to achieve the following in terms of environmental management: "Integrated multisectoral approaches necessary in addressing the totality of the environment; Fostering government-wide commitment to the integration of environmental concerns in the sectoral policies, strategies and investment decisions; Creating the context for planning and coordination at a multisectoral level, to ensure a more systematic approach, focus and consistency, for the ever-increasing variety of players and intensity of environmental activities".

The policy has identified six key major environmental issues in the country. These are land degradation, water pollution, air pollution, loss of wildlife habitats, deterioration of aquatic systems and deforestation. Hence the policy has the following objectives with respect to environmental management in agriculture:

- ensure sustainability, security and equitable and sustainable use of natural resources;
- prevent and control degradation of land, water, vegetation, and air;
- conserve biological diversity of the unique ecosystems the country;
- raise public awareness and understanding of the essential linkages between environment and development, and to promote individual and community participation in environmental action.

National Agricultural and Livestock Policy (1997)

The ultimate goal of having this Policy is to improve the well being of the population whose principal occupation is based on agriculture. The focus of the policy is to commercialise agriculture so as to increase the livelihood of the smallholder farmers/livestock keepers. The policy's main objectives include:

- ensure basic food security for the nation and to improve national standards of nutrition, by increasing output, quality and availability of food commodities;
- improve standards of living in the rural areas through increased income generation from agricultural and livestock production;
- increase foreign exchange earnings for the nation by encouraging production and increased exportation of agricultural and livestock products;

- promote integrated and sustainable use and management of natural resources such as land, soil, water and vegetation in order to conserve the environment;
- provide support services to the agricultural sector, which cannot be provided efficiently by the private sector.

Plant Protection Act No. 13 (1997)
This Act has made provisions for consolidation of plant protection to prevent introduction and spread of harmful organisms, to ensure sustainable plant and environmental protection, to control the importation and use of plant protection substances, to regulate export and imports of plant and plant products and ensure fulfilment of international commitments, and to entrust all plant protection regulatory functions to the government and for matters incidental thereto or connected therewith. The activities of Tanzania Pesticides Research Institute (TPRI) are incorporated into the Act. In relation to IPM, importation of biological control agents is not allowed unless under the prescribed permit by the Ministry.

Environmental Management Act of 2004

This Act requires establishment of sector environmental management Units at each Ministry, with the responsibility of ensuring compliance on environmental matters. The sector environmental Units have, among others, the responsibilities of

- Advising and implementing policies of the government on the protection and management of environment
- Coordinating activities related to the environment of all persons within the Ministry
- Ensure that environmental concerns are integrated into the Ministry development planning and project implementation in a way which protects the environment
- To prepare and coordinate the implementation of environmental action plans at the national and local levels as required under this Act
- To refer to the council any matter related to the enforcement of the purposes of this Act
- To ensure that sectoral environmental standards are environmentally sound

In relation to the Management of dangerous materials and processes, of which agricultural chemicals may fall, the Minister shall have the power to make regulations pertaining to persistent organic pollutants (POP) and pesticides issues, to ensure that they are in compliance with the Stockholm Convention on POP of 2001 and Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade of 1998.

The Minister shall also have the powers to make regulations regarding the prevention and control of pollution. However, this mainly relates to the discharge of hazardous substances such as chemicals or mixtures containing oil in water or any other segment of the environment, except in accordance with guidelines prescribed under this Act or any other written law. It is an offence punishable by law to discharge such chemicals, and in this regard there is payment on the costs of removal, and those incurred during the restoration of environment.

The Institution/organisation is expected to give immediate notice of the discharge to the Council or relevant sector Ministry, and commence clean up operations using the best available clean-up methods, and comply with such directions as the Council may prescribe. In this context, services that relate to the regulation of agricultural chemicals in the Ministry of Agriculture and Food Security shall be at the forefront to ensure the judicial use of agropesticides.

In relation to *Plant Health Services* the Ministry has taken measures to improve and strengthen Plant health services in order to minimise crop losses resulting from pests and diseases. Hence the Ministry strongly advocates using IPM approaches to be disseminated to farmers through the agricultural extension services. On the aspects of migratory pests and diseases, the Ministry cooperates fully with the neighbouring countries (through regional initiatives on outbreak pest control) in the collective effort to control the damage of such pests. The Ministry also has in place supervisory and regulatory instruments to register, license, monitor and supervise manufacturers, importers, distributors and users of agricultural inputs such as pesticides, fertilizers and herbicides.

5.3 PROGRAMMES AND STRATEGIES

5.3.1 Africa Stockpiles Programme (ASP)

Although the Africa Stockpiles Programme (ASP) focused on obsolete pesticides and their associated waste, the Prevention component carried out legislative review under this project for the United Republic of Tanzania (URT) including plant protection matters for both mainland Tanzania legislation and Zanzibar. Through consultative meetings with the pesticide industry stakeholders, International trade requirements and harmonisation of the sanitary and phytosanitary systems. The Plant protection Act 1997 was split into two legislations: The Pesticide Management Act 2013 (Draft) and The Plant Protection Act 2013 (Draft). The programme also addressed the major issues in prevention of accumulation of obsolete pesticides and its associated wastes by putting in place an empty pesticides container maintenance strategy and the ASP sustainability Roadmap.

The Plant Protection Act 2013 (Draft)

The main objective of this Act is to prevent the introduction or spread of plant disease or pests; provide for phytosanitary control measures; facilitate trade in plants and plant products and to regulate other matters connected thereto. The Act is meant to establish a National Plant Protection Organization (NPPO). The NPPO core function will serve as a national contact point for the IPPC and shall develop mechanisms for consultation between responsible authorities for enforcement of the phytosanitary legislation for Tanzania and Promotion of integrated pest management and control.

A cabinet paper for this Act has been presented to the cabinet first sitting, issues raised from this seating has been addressed ready for the second sitting later this year (2014) before the Act is tabled by the Attorney general - Chief Draftsmen to the Parliament.

The Pesticide Management Act 2013 (Draft)

An Act to provide for the life-cycle management of pesticides, regulating the manufacture, formulation, importation into and exportation from the country, transport, storage, distribution, sale, use and disposal of pesticides and to regulate other matters connected thereto. This Act will establish the Tanzania Pesticides Control Authority (TPCA) responsible for monitoring the trade and use of pesticides, and collecting statistical and other information concerning the import, export, manufacture, distribution, sale and use of pesticides, about pesticide residues and safe use. The act prohibits the importation, manufacturing, formulating, transportation, distribution, exportation or sell of banned, obsolete pesticides under: PIC and POPs and any other pesticide banned or severely restricted in the country of origin under any circumstances within the country or any pesticide for which is not in the category/group currently under use.

In relation to IPM the authority suggests development and availability of safer alternatives to existing pesticides as per latest global research and development without compromising the importation of biological control agents as allowed in the Biological control agents protocol developed within the Plant Protection Act of 1997.

Like "*The Plant Protection Act 2013 (Draft)", a* cabinet paper for "*The Pesticide Management Act 2013 (Draft)"* has been presented to the cabinet first sitting, issues raised from this seating has been addressed ready for the second sitting later this year (2014) before the Act is tabled by the Attorney general - Chief Draftsmen to the Parliament.

5.3.2 Empty Pesticides Container Management Strategy

Pesticide use by small scale farmers has been on the increase in the recent years. This has been attributed by availability of affordable convenient packaging. The bulk of the pesticides distributed in Tanzania are in small packs resulting to increased number of empty pesticide containers. This has resulted in the accumulation of empty pesticide containers in the farming environment. The greatest challenge facing the use of pesticides is recovery and disposal of empty pesticide containers. Currently there is no legal framework mechanism to guide on the disposal of the containers. Also the absence of organized disposal

system has rendered farmers and other users of pesticides dispose containers by throwing them away or putting them in the solid waste system in urban areas. In addition, the absence of information to rural communities on the risks pertaining to reuse of empty containers has created a major challenge.

The strategy identifies the mechanism of dealing with empty pesticide containers and provided the framework of up-scaling the process through the stakeholder partnership and cost sharing initiatives. If not streamlined in the Good Agricultural Practices, the export market of agricultural produce will give a negative impact internationally.
The strategy addressed the following critical issues:

(i) increase awareness amongst pesticide users on the best practice of handling pest containers;
(ii) sensitize the communities on risks of reusing empty pesticide containers for other purposes;
(iii) provision of training and support of local agricultural authorities to promote safer use of pesticides;
(iv) The quantification of the build-up of empty pesticide containers in the government stores and the farming communities; and
(v) establishment of the recycling facilities of the pesticide packaging for which sustainable disposal/recycling options is needed.

The stakeholders and target beneficiaries of the strategy are: (i) farmers who benefit from the disposal of containers (ii) rural communities who benefit from tighter controls on pesticide container disposal mechanisms (iii) policy makers at several government departments and agencies with regard to improved pesticide use and management; and (iv) recycling industry benefit from availability of raw materials.

6. PEST CONTROL AND MANAGEMENT OPTIONS

6.1 INTRODUCTION

Insect control techniques for IPM have been known and are in use for along time. Some of the most effective non-chemical techniques such as biological control, host plant resistance, crop rotation, etc were widely used before the synthetic insecticides appear in scene.

Recent problems of insecticide resistance in insect pests, other side effects and increasing cost of the insecticides have renewed interest in the non-chemical techniques. The techniques can be conveniently categorized in order of preference in IPM as biological control, the use of attractant, pheremones, repellents, genetic manipulation, insect growth regulators and the use of plant extracts. In this section biological control, cultural control, chemical control, quarantine and physical or mechanical control, chemical control and botanical control are presented.

Biological control should not confused with natural control which is collective action of environmental factors that maintain the population of pests within certain upper and lower limits over a period of time (van den Bosch, 1982).

6.2 BIOLOGICAL CONTROL

Every living organism has its natural enemies and diseases which kept its population at equilibrium. The natural enemies include predators, parasitoids, nematodes, fungi, bacteria, viruses etc. The use of predators, parasitoids, nematodes, fungi, bacteria and viruses for to maintain the population density of pests at a lowest level than would occur in their absence is called biological control (bio-control). Tanzania has some experience based on the successful control of the cassava mealy bug, the cassava green mite and the water hyacinth (Anon, 1999). The National Plant Protection Policy is also conducive to the promotion and use of bio-control as a strong IPM component. However, at national level, the capacity and capability to implement an effective nation-wide programme is limited.

Approaches to biological control
There are three approaches are used in biological control. These include conservation/enhancement, augmentation and introduction.

Conservation/enhancement
This refers to optimization of the impact of living agents that already exist in the ecosystem

Augmentation
This refers to as an artificially increasing the numbers of natural enemies in the agroecosystem

Introduction
This refers as importing new natural enemies' species in the system where they were not found before.

Host Plant Resistance
The IPM concept stresses the need to use multiple tactics to maintain pest populations and damage below levels of economic significance. Thus a major advantage of the use of pest resistance crop varieties is its compatibility with other methods of direct control. Pest resistant cultivars allow a synergy of the effects of cultural, biological and even chemical pest control tactics. Host plant resistance (HPR) is of particular importance in developing countries where farmers lack the resources for other control measures. There are many examples of resistant varieties significantly increases crops productivity.

However, farmers continue to grow varieties which are susceptible because resistant varieties can reduce the burden of pest control by using chemicals. Resistance to pests is the rule rather than the exception the plant kingdom. In the co-evolution of pests and host, plants have evolved defense mechanism. Such mechanism may be either physical (waxy surface, hairly leaves etc) or chemical (production of secondary metabolites) in nature. Pest-resistant crop varieties either suppress pest abundance or elevate the damage

tolerance level of the plant. In other words, genetic resistance alters the relationship between pest and host. The functional of the pest to the resistance may be non preference or antibiosis (early death, abnormal development). Also genetic transformation of the plant (expression of the *bacillus thuringiensis* toxins, protease inhibitors).

The development of transgenic plants that are resistance plants that are resistant to viruses and insects has been more successful than for resistance to bacteria and fungi, but this gap is readily closing. Resistance genes for fungal and bacterial genes have now been cloned and there is a greater molecular understanding of plant pathogen interactions.

The inherent genetically based resistance of a plant can protect it against pests or diseases without resource to pesticides. Moreover to use it the farmer has no need to buy extra equipment or learn new techniques.

For example on farm in some parts of Kenya, up to 80% of plants exhibit symptoms of diseases in banana fields, but the use of plant resistance in bananas is the most effective approach to management of fusarium wilt and is the most economic and practical long term option for small scale farmers in Africa. Different Institutions in Nigeria and Uganda have developed banana cultivars with resistance to pests and diseases.

Another example of varieties which are resistance to pest attack are maize varieties (TMVI, Staha, Kilima) which are either resistant or tolerant to maize streak the viral disease that cause significant yield loss to late planted maize. Other examples of resistant varieties are coffee clones (MS1, MS2, MS3 and MS6) against coffee leaf rust, banana varieties FHIAs which are resistant to Nematodes, Panama and Black Sigatoka.

In cotton, host plant has been of the importance especially for small scale farmers who has low income. Great losses have been observed in cotton production due to insects like bollworm, aphids, leaf miner, jassids and diseases like fusarium wilt and bacterial blight. For pests like jassids though there is a means of spraying but it seems to be expensive because of high prices in buying chemicals and low farmers income to buy the chemicals. Thus all of varieties produced at Ukiriguru had resistance to jassids since they have hairs to interfere sucking insect pests. Also in the control of bollworm up to now still is a problem but in other countries the genetic transformation is used to transfer *Bacillus thuringiensis* to cottone plants in order to improve insect resistance in cotton cultivars. Cotton cultivars produced already showed success and had good response from farmers. The disease like fusarium wilt and bacterial blight, have the ability to reduce cotton yield to a high percentage. The effort to combat this situation is done on producing cultivars with resistance to these diseases. All Ukiriguru cotton varieties are resistant to bacterial blight and UK91 and UK77 varieties are resistant to fusarium wilt.

In other crops like sweet potato to avoid the weevils' infestation, other varieties are producing their tubers far away from the soil surface. Also sorghum to avoid bird attack some varieties have gooseneck that the bird can't reach grains easily. For rice some varieties have awns to prevent themselves from bird attack.

With host plant, the rate of spread and the rate of symptom development can be very slow. Also this tends to reduce the cost of pests and disease controls through buying chemicals also time consuming in bird scaring. Since pests and diseases reduce the quality of the produce thus the use of the host resistance materials assures the good quality for home consumption as well as for marketing where you are able to fetch a lot of income. All these efforts are made to reduce the costs involved in pests and disease control as well as to safe guide the environment.

Pest resistance genes are predominantly found in wild species within the same genus or family as the crop plant. Because such plants are in dynamic equilibrium with the pests, the resistance genes are present in a high frequency to be readily found. Unfortunately resistance genes from wild species are often combined in linkages with undesirable genes and many recombination and selection steps are require incorporating them into useful cultivars. Another source of resistance genes is primitive cultivars or landraces, although this is much smaller reservoir diversity than wild species. For example, in potato, high levels of resistance to the green peach (*Myzus persicae*) has been identified in about 6% of examined accessions of wild *Solunum species* (Flanders, et al. 1992). Wild crop relatives have yielded pathogen resistance in, amongst

others, rice, wheat, barley, cassava, sweet potato, tomato, sunflower, grapes, tobacco, cacao, sugarcane and Musa.

Host plant resistance (HPR) is also recognised in the new Plant Protection Policy as an invaluable component in IPM. Breeding and selecting for resistance to serious pest problems is an issue mandated to the National Agricultural Research programmes. These programmes have produced substantial results in terms of releasing varieties with necessary qualities and tolerance/resistance to a wide range of otherwise devastating pests of cotton, maize, sorghum, beans and cassava. Therefore, the Directorate of Research and Development in MAFS has the capacity and infrastructure to contribute HPR materials to farmers given the necessary logistical support.

Considering the scope of the proposed programme, it will be appropriate for the project to provide logistical support for the multiplication, popularisation and distribution of crop varieties already proven to posses acceptable levels of tolerance/resistance to pests of economic importance. The issue of the grey leaf spot disease of maize, cassava mosaic diseases and rice yellow mottle virus must be given priority to ensure household and national food security.

Rapid multiplication and distribution of cassava varieties with proven tolerance/resistance to cassava mosaic diseases and cassava streak diseases is equally important. Programme should allocate adequate funding to facilitate this activity.

In addition, logistical support to facilitate the multiplication and distribution of the earmarked coffee varieties with resistance to CBD and CLR will be required as soon as Tanzania Coffee Research Institute releases them. Fast multiplication and distribution of the material is essential to speed up reduced use of copper-based fungicides in the coffee cropping systems in the northern zone.

6.3 CULTURAL AND CROP SANITATION PRACTICES

This is one of the IPM components, which is used by farmers in controlling/reducing pests and diseases in crops. The cultural practices modify/destruct the environmental of crop pests and diseases by depressing their breeding/growing areas. The cultural practices are the same/different in single/groups. These practices are:

Crop rotation: This practice is used to depress weeds and/insect pests and diseases in some crops. Example: A weed Striga in sorghum and millet can be controlled/reduced by planting a trap crop like groundnuts, cotton

Intercropping: The field is used to grow two or more crops at the same time.

Relay cropping: Example: Banana relayed with mucuna to reduce the infestation of weevils.

Fallow: The field is not cultivated for some years in order to control various parasitic weeds.

Cover crops: These are leguminous crops, which are grown to suppress weeds in the field. They can be intercropped or not and they prostrate and cover the field e.g pumpkins, canavallia etc.

Trap crops: These induce the germination of a pest. The trap crop can be intercropped or rotated with a susceptible host (e.g groundnuts, bambaranuts, cotton etc).

Mulching: This is covering of crop fields by dry grasses to control weeds and conserve soil moisture (e.g in coffee, banana, tomato field etc).

Hand pulling and hoes weeding: These practices are the most common and being used by small-scale farmers.

Burning: Land clearing and destroying infected plants/crops.

Fertilizer/manure application: The application of nutrients in the form of either inorganic fertilizer or farm-yard manure reduces both the infestation of fields by weeds (e.g Striga) and losses in crop yield.
Use of disease free planting material e.g: cassava cuttings, sweet potato vines etc.

Pruning: Done in coffee, tea orange tree etc. to reduce insect pests and diseases that might infest the crop.

Thinning: Done to reduce plant population in the field (e.g in maize, sorghum and millet, cotton etc).

Other cultural methods include spacing, desuckering, which is done in bananas; use of local tolerant varieties, sun drying to reduce moisture content of the material to be stored; and use of traditional storage method e.g 'Vihenge', banana sheaths, botanicals, clay soils etc.

6.4 PHYSICAL AND MECHANICAL CONTROL

Physical and mechanical controls are the measures kill the insect pest, disrupt its physiological or adversely the environment of the insect pest. These differ from cultural control in that the devices or actions are directed against the insect pest instead of modifying agricultural practices. For examples, hand picking of cotton stainers from cotton plants, banana weevils from banana pseudostems, tailed caterpillars from coffee, killing stem borers in coffee or American bollworm from tomato plants are the forms of physical control while use of a fly swatter against annoying flies is a form of mechanical control.

Common physical and mechanical control methods include the utilization of high and low temperature for instant hot water treatment of banana planting materials for control of nematodes, sun drying of stored grains, cool storage of maize grain, reducing humidity, utilizing insect attraction to light traps (lepidopteran insect pests viz. Armyworm and cotton bollworm).

6.5 CHEMICAL CONTROL

It is important to recognise that, all the registered pesticides (Table 5.1 below) are recommended as part of IPM components in all production/cropping systems as indicated in the previous sections of this report.

All the pesticides included on the list above are registered by TPRI Act, 1979 and Pesticides Control Regulations GN 193 of 1984) [Anon, 2001b], and this is why some pesticides e.g. paraquat, one of the 'dirty dozen', is still officially registered and allowed to be used in Tanzania. It is therefore strongly recommended that, the pesticide registrar ban all further importation and subsequent use of paraquat in Tanzania and others in the same category, with immediate effect.

Those pesticides in WHO class Ib, namely endosulfan, chlorpyrifos, quinalphos, carbofuran, and isazophos, should be deregistered with immediate effect and phased out by year three of the programme and encourage use of less toxic and more IPM friendly pesticides.

Both WHO class I and II are still featuring on the list of registered pesticides mostly because, the WHO class III, which are new generation pesticides known to be less toxic and therefore more environmentally and IPM friendly, are relatively more expensive and therefore beyond the means of most smallholder agricultural producers in Tanzania. In addition, the majority of such pesticides are not locally available. Therefore, judicious use of through integrated use of other pest management options is recommended to ensure reduction of potential health and environmental hazards.

It is evident, albeit from Table 5.1, that, the current list of registered pesticides is outdated and also not in line with international standards. It is therefore strongly recommended that, the registrar of pesticides must review the current list of registered pesticides in line with the WHO guidelines immediately.

The current list of pesticides registered in Tanzania indicates trade name, registration number, common name, registrant and usage. This is not informative enough given the wide range of its users. It is therefore recommended that, the proposed revised list should include the WHO class, oral LD50, active ingredient, and application rate.

Table 8.1 List of recommended and TPRI registered pesticides for crop production in Tanzania: Oral LD_{50} and WHO classification

Chemical	***Common name***	****Oral LD50/kg***	***WHO class***	***Comments***
Insecticides	Betacyfluthrin	500-800	II	
	Biphenthrin			
	Carbaryl	850	II	
	Chlorpyrifos	135-163	Ib	Deregister & Phaseout
	Cypemethrin	251-4125	III	
	Cypermethrin + Dimethoate	251-4125 + 2350	III	
	Deltamethrin	153-5000	III	
	Dealtamethrin + Dimethoate	153-5000+2350	III	
	Diazinon	220	II	
	Dimethoate	2350	III	
	Endosulfan	55-110	Ib	Deregister & Phaseout
	Esfenvalerate	451	II	
	Fenitrothion	800	II	
	Fenvalerate	451	II	
	Fenvalerate + Fenitrothion	451+ 800	II	
	Flucythrinate			
	Hydrmethyl			
	Lambda cyhalothrin	243	II	
	Permethrin	430-4000	III	
	Pirimiphos methyl	2050	III	
	Pirimiphos methyl + permethrin	2050 + 430-4000	III	
	Profenophos	358	II	
	Profenophos + cypermethrin	358 + 251-4123	II	
	Quinalphos	62-137	Ib	Deregister & Phaseout
Nematicides	Carbofuran	8-14	Ib	
	Dazomet	520	II	
	Isazophos	40-60	Ib	Deregister & Phaseout
Herbicides	Atrazine			
	Diuron			
	Fluometuron			
	Glyphosate			
	Metolachlor + Atrazine			
	Metalachlor + Dipropetrin			
	Paraquat			Dirty Dozen: should be banned with immediate effect
Chemical	***Common name***	****Oral LD50/kg***	***WHO class***	***Comments***
Avicides	Fenthion			
	Cyanophos			
Rodenticides	Bromodiolone			
	Coumatetralyl			

Chemical	*Common name*	**Oral LD50/kg*	*WHO class*	*Comments*
	Diphacinone			
Fungicides	Bronopol			
	Chlorothalonil	10,000+	III	
	Copper hydroxide	1,000	II	
	Copper oxychloride	70-800	II	
	Cupric hydroxide	1,000	II	
	Cuprous oxide			
	Cyproconazole	1,000	II	
	Hexaconazole	2189	III	
	Mancozeb	5000+	III	
	Metalaxyl + Mancozeb	633 + 5000+	III	
	Penconazole			
	Propineb	1,000	II	
	Triadimefon	1,000	II	
	Sulfur			

Sources: TPRI: List of Pesticides Registered in Tanzania, May 2004 and Nyambo 2002

It may be noticed that Tanzania has ratified the Convention on Persistent Organic Pollutants (POPs) in April 2004 (pers.comm. A.Madate, Division of Environment and National POPs Project Coordinator), but has not yet banned the highly harardous pesticides (WHO classes Ia, Ib, II). However, projects involving use of chemical pesticides under WHO Class Ia, Ib and Class II will not be financed under the proposed SAGCOT Investment Project. Appendix 4 provides WHO classification of chemical pesticides.

6.6 BOTANICAL PESTICIDES

Assessment of botanical pesticides for pre and post harvest is being done by a number of institutions in the country and some of the potential ones have been recommended for use in crop production (Paul et al. 2001). In beans, extracts of *Tephrosia vogelii* and *Neuratanenia mitis* have been recommended and farmers are using them because they are easily available and less costly. Where these do not occur naturally, farmers have also established the plants in their home gardens to ensure availability when needed.

The GTZ-IPM project in Arusha in collaboration with IPM farmer groups and the extension staff has compiled a list of useful botanical pesticides (Table 5.2) that could be used on a wide range of vegetables and other food crops. The information is useful but has to be used with caution. Most of the botanical extracts are already in use by small-scale farmers as crude in-house preparations. However, they should be used with caution.

It has to be remembered that ***not all*** botanical extracts are safe.

Tobacco extract is one of the deadly substances and should therefore not be promoted for use on vegetable production. *Tephrosia* spp extract and leaves are toxic to fish (local fishermen use the leaves for fishing) and therefore should be used with caution.

None of the suggested botanical extracts (Table 5.2) are registered in Tanzania because they have not been researched enough. In particular, information on dosage rate, mammalian toxicity (LD50), side effects on non-target organisms especially potential bio-control agents, biodegradation and reduce analysis data, is not available. However, 3 neem-based and 2 pyrethrum-based commercial formulations are being processed for registration. These two botanicals have been researched and registered in Kenya and elsewhere.

Table 8.2 List of potential plants that can be used to prepare botanical extracts for pre and post harvest pest control

Kiswahili name	***English name***	***Scientific name***
Mustafeli	Soursoap	Annona muricata
Mtopetope	Bull-oxheart	*A. reticulata*.
Mtopetope mdogo	Custard apple	*A. squamosa*
Vitunguu saumu	Garlic	*Allium sativa*
Mwarobaini	Neem	*Azadirachta indica*
Kishonanguo	Black Jack	*Bidens pilosa*
Pilipili kali	Chili	*Capsicum frutenscens*
Mpapai	Pawpaw	*Carica papaya*
Mnanaa	Thorn apple	*Datura stramonium*
Mnyaa/utupa	Milk bush	*Euphorbia tirucalii*
Mchunga kaburi	Barbados nut	*Jatropha curcas*
Mwingajini	Wild sage	*Lantana camara*
Tumbaku	Tobacco	*Nicotiana* spp
Kivumbasi	Mosquito bush	*Ocimum suave*
Mbagi mwitu	Mexican marigold	*Tagetes* spp
Alizeti mwitu	Wild sunflower	*Tithonia diversifolia*
Utupa	Tephrosia	*Tephosia vogelii*

Source: Paul (2000) and Madata (2001).

7. EXPERIENCES ON IPM IN TANZANIA

7.1 INTRODUCTION

During her study Nyambo (2002) gave a comprehensive analysis of the Tanzania Mainland experience on participatory IPM. Information from the analysis and visit to key stakeholders, namely the Minsitry of Agriculture and Food Security's Plant Health Services, Zonal Agriculture Research and Development Institutes (ZARDI), Sokoin University of Agriculture, districts and farmers are summarized in this section. The national research institutions have developed IPM approaches for a wide range of key pests of the major crops mentioned earlier. Some of the information is locality specific e.g. in cotton, maize, coffee and beans. Unfortunately, a lot of the information has not reached target farmers. The information that has filtered through to farmers is not user friendly and/or not appropriately formulated and therefore farmers are unable to optimise the benefits of such options (Nyambo, Masaba & Hakiza, 1996). This is a result of the "top-down" syndrome, which dominates the national research and extension systems. A change in attitude in the national research and extension system is needed to pave way for participatory knowledge development and transfer. Researchers, extension workers, farmers and other stakeholders must work as partners to achieve effective and sustainable technology development and transfer. Farmers must be active participants in the process of problem identification, development and formulation of appropriate solutions to identified pest problems in the context of other production constraints.

In recognition of the shortcomings of the traditional top down extension system in promoting sustainable IPM approaches and to prepare a foundation to facilitate and enhance grass-root based system of extension, the Ministry of Agriculture and Food Security, in collaboration with GTZ, FAO and IFAD, had implemented IPM pilot projects to promote farmer participatory integrated pest management approaches in different parts of the country and cropping systems. The lessons from the above projects will be integrated in the IPMP to support decision making in the dissemination and promotion of appropriate IPM options in different cropping systems under SAGCOT.

7.2 GTZ/PHS-IPM

The IPM project was initatied in 1992 by the Ministry of Agriculture and Food Security, namely Plant Health Services (PHS) and the German Agency for Technical Cooperation (GTZ). The IPM pilot area was the western growing zone (Shinynanga). This was the area using a lot of pesticides to redcue losses emanating from pests. The IPM project was resource intensive with the GTZ granting Tshs 500 million which is 90% of the budget allocated for IPM implementation annually and the counterpar funding by MAFS was Tshs 50 million per annum. The project operated for 11 years under the following phases:

- Baseline and diagnostic surveys, training of counterpart staff, introducing IPM concept at farmers' level, etc. Phase I (1992-1994)
- Developmemnt, testing and dissemination of the IPM technical packages on priority crops in the pilot area of the western zone
- Dissemination and extension of IPM technical packages to other regions in the western and northern zones respectively: Tabora, Kigoma, Kagera, Mara, Mwanza, Arusha, Kilimanjaro, Tanga. Phase II (1997-2002)
- Handing over and consolidating the achievements. The project came to end in September 2003.

IPM recommendations accomplished by the project indlcude:

- 6 recommendations in cereals (maize and sorghum)
- 4 recommendations in cassava
- 12 recommendations in beans
- 8 recommendations in onions
- 3 recommendations in cotton
- 2 recommendations in sweet potato
- 5 recommendations in vegitables and fruits
- 2 recommendations on weed management

The project was also instrumental to the production of the Plant Protection Act 1997, which was operationalized in July 2001. The knowledge base and capacity of the project is centred in PHS HQ and its plant health services zonal offices in the country.

Approach and Organizational structure:
The project used a modified farming systems approach for planning, development and field evaluation of IPM options. This is a mixture of participatory and exploratory methods, as deemed appropriate depending on the level of training of the extension workers and the problem to be addressed. The key elements in the approach include socio-economic baseline (knowledge, attitude & practices) and diagnostic technical plant protection surveys done by experts. These surveys generated a wide range of background information and a basis for M&E. This was followed by participatory technology development and transfer through farmer groups, referred to as *IPM Working Groups*, in different agro-ecological areas in respective regions. The baseline information was later used in the extrapolation of data and options to other areas in the project areas. In this approach, the *IPM Working Groups* are equivalent to the Farmers Research Groups used in the farming systems approach.

Group formation: The *IPM Working Groups* (self formed groups) were initiated by the project with assistance from VEOs and local community development officers for purposes of training and promoting IPM. However, if there were already existing self-formed farmer groups in the village, these were also considered for collaboration.

After clarification of the expectations and roles of the partners, the groups were recruited.

Group management and promotion of IPM: The project technical staff visited the *IPM Working Groups* frequently (several times a week at the beginning of the project) to establish rapport with the group members, to set-up on-farm trials and demonstrations, test extension materials as well as plan and evaluate group activities.

The project provides technical information on IPM options, training and group facilitation (moderation).

The role of the groups is testing and fine-tuning of IPM options and other extension recommendations. Once the IPM Working Groups have approved a technology, the group results are disseminated to other farmers in other similar agro-ecological areas.

After several seasons of training, the *IPM Working Group* is transformed to an IPM Farmer Training Group and a new *IPM Working Group* is initiated in another village and the process continues.

Participatory Group Training approach: The *IPM Working Group* in collaboration with the project technical staff identified key limiting pest problems and other production constraints for each crop in the area. The project technical staff provides a range of recommended relevant solutions for testing by farmer groups. For selected crops, individual members in the group tested the options in demonstration plots, one crop per farmer. The members make joint visits and analysis of the demonstration plots throughout the growing period until harvest.

During the training sessions, farmers are facilitated to recognise the major pest problems, potential damage, management options, insect pest's natural enemies and good post harvest practices with emphasis on IPM.

Essentially, group training involved four stages that are summarised as follows:

1. Capacity building to impart knowledge on IPM and participatory methods of technology transfer, group formation and management to selected project technical staff.
2. Demonstration within groups whereby the technology or information is tested for the first time by a farmer within the group under close supervision by the project technical staff. All group members make continuous visits and observations and participate in the analysis of the results.
3. Adaptations in farmer own plots by group members. Farmers are encouraged to keep field records, share the information with group members and carry out joint analysis of the results.
4. Village cycle spill-over whereby the technology is applied by non-IPM farmer groups in the same village.

5. The technology was finally approved for dissemination to other areas with similar crops/pests and agro-ecological similarities.

Participatory evaluation of results and practices: At the end of each crop season, the project technical staff guides the group members to evaluate the trial results using simple PRA tools. To motivate the groups, a meeting of representatives from all *IPM Working Groups* was convened once a year for joint evaluation of results.

Internal M & E: The project has an established continuous internal M & E to assess project impact and spill-over. The project was using an evaluation form, which was supported by regular field visits for verification.

Spill-over and role model effects: KAEMP and MARAFIP have copied the project approach.

Capacity Building: The project has trained 999 VEOs/DPPOs in IPM within the project area, i.e. 697 in the Western and 302 in the Northern Zones. The IPM project and the District Councils through their respective support programmes, i.e. MARA-FIP, KAEMP, Care, Farmafrica, DRDPs, Faida, Ecotrust, World Vision, LVEMP, etc. have jointly financed the training. The VEO have in turn trained 484,825 farmers in IPM, i.e. 421,487 in the Western and 63,338 in the Northern Zones.

The VEOs were also facilitated formation of 44 IPM working groups, each with an average of 15 farmers (14 IPM groups in the Western and 30 IPM groups in the Northern Zones). These groups play a role model for IPM development, testing of recommendations, validating, implementing and disseminating.

Impacts: The extent of impact achievement with regard to the benefits of IPM such as environmental conservation, restoration of beneficial organisms, etc. has not been evaluated. The following impacts have observed (Nyakunga 2003):

The use of conventional pesticides in cotton in Shinyanga has been reduced from 6 calender sprays to maximum 3 sprays without negatively affecting production. The evidence of this is the increased cotton production in the Western Zone from 38,000 tons in 1994/95 to 69,900 tons in 2000/01

Safety of users against conventional pesticides: The National Plant Protection Advisory Committee has been instituted in line with the Plant Protection Act of 1997 and is actively guiding and monitoring implementation of plant protection activities in Tanzania. A cost recovery system for the services rendered under the PPA of 1997 is in place with the PHS is able to strengthening the phytosanitary and quarantine measures at the major entry points. The IPM has also been integrated in the Agriculture and Livestock Policy as a national policy on plant protectin and the ASDP has provided that IPM should be disseminated country wide.

The success of the GTZ/PHS-IPM initiative was a result of team approach, institutional collaboration (NGOs, national research and extension institutions, and international institutions) harmonisation of technical information between collaborators, adequate flow of funds, good organisational and supervisory skills and staff continuity.

7.3 KAGERA AGRICULTURAL AND ENVIRONMENTAL MANAGEMENT PROGRAMME (KAEMP)

KAEMP was a multi-sectoral initiative of the Kagera region (Lake Zone) jointly funded by IFAD, BSF/JP and OPEC with contributions from the beneficiaries. The project was implemented by RAS Kagera and managed by the local government machinery. Its main focus was on improvement of food security and poverty elevation, and therefore, has a holistic approach (addresses agriculture, health, livestock, environment management, rural access roads and marketing) to rural development. In this setup, IPM has been embraced as the key pest management in all crops.

To support gradual and sustainable adaptation of IPM and integrated plant nutrition (IPN) by resource poor farmers, the project promoted validated and recommended technologies from national and international agricultural research institution. Selected technologies must be applicable, economically viable and environmentally friendly.

The major crops grown in the region are cotton, coffee, banana, cassava and beans.

As mentioned above, KAEMP borrowed the IPM approach (baseline studies, group formation and training, internal M & E etc.) from the GTZ/PHS-IPM Shinyanga project. In addition, the linkage between the two projects was strong. GTZ/PHS-IPM technical staff were used as resource persons by KAEMP while Kagera farmers visits the IPM Farmer Training Groups in Shinyanga for learning purposes.

However, due to the nature of the KAEMP set-up, some modifications of the Shinyanga approach were deemed necessary in order to accommodate the overall goals of the project. In crop production, declining crop yields, soils fertility and increased pest pressure were identified as major constraints. To address the issues, the project farmer groups were known as *IPM/IPN* groups (integrated pests management/integrated plant nutrition groups).

Capacity building: Since the project is an integral part of the regional development plan, all extension staff (from the district to the village level) were given training in IPM, IPN, and participatory methods of technology transfer with emphasis on group approaches. In this approach, the district extension officer was the foci for new extension messages. It was the responsibility of each district extension officer to ensure proper technology transfer to end-users and hence the need for them to be well informed about participatory methods of extension. In summary, capacity building in KAEMP was implemented in several stages

1. District technology transfer manager (master trainer) was trained in IPM/IPN concepts and approaches including participatory methods of technology transfer through farmer groups;
2. The master trainer trains the VEOs; and
3. The VEOs train farmer groups.

To enhance the learning process between groups, the project facilitated farmer-farmer learning through group exchange visits between groups within and between villages and districts. A few farmer representatives visited the Shinyanga IPM farmer training groups. To promote spillover, KAEMP organised and facilitated field days.

The IPM/IPN farmer groups were also used for the transfer of other development messages e.g health, water, environmental management etc. and therefore were foci for all extension messages.

The KAEMP initiative started in September 1999. By May 2001, the adoption of IPM/IPN within groups was 60% whereas the spillover (diffusion) after 20 months of operation was 1:3, which is quite impressive (J. B. Anania, E. A. M. Anyosisye, personal communication). KAEMP owes much of its success to the GTZ/PHS-IPM Shinyanga experience. The entire stakeholders at regional, district, village and farm level has received the approach with enthusiasm.

Successes:The achievements of the project was a result of good political support at regional level, team spirit, sufficient funding, effective capacity building, institutional collaboration, good organisational abilities and focused selection of appropriate technology for transfer to target clients.

7.4 MARA REGION FARMER INITIAITIVE PROJECT (MARAFIP)

MARFIP was an initiative of Mara region whose main objective was poverty alleviation through strengthening of capacity of the local institutions to respond to farmer's felt needs related to food, agriculture and livestock. The project was organised and implemented by RAS and funded by IFAD.

As mentioned above, MARAFIP was another offspring of the GTZ/PHS-IPM project (S. O. Y. Sassi, personal communication) and therefore, has many common features. However, MARAFIP used the FAO IPM-FFS approach of group training and technology transfer.

Capacity building: All district plant protection officers and VEOs were given training in IPM concepts to raise awareness about IPM to facilitate their supervisory role. Five VEOs (project staff) of selected villages

for FFS pilot groups were given one-month split course in IPM, group management and participatory technology transfer methods to provide them the capacity to organise and conduct IPM-FFS.

There were 5 IPM-FFS groups in the region, one per district. The main focus crops were cassava, cotton, maize, sorghum, legumes (cowpeas, field beans) and sweet potato. The IPM messages/technologies introduced to the FFS groups were borrowed from the Shinyanga IPM project without further refinement. In one case, the "broken telephone message syndrome" was noted with concern.

At farmer level, the approach has been received with enthusiasm and adoption of some messages among group members was estimated to be about 25% (one year after IPM training).

The IPM-FFS groups were also used as entry points for other extension messages e.g. soil and water management, livestock management and community health, which is in line with the regional objectives. However, funding to facilitate technical support to farmer groups was a constraint, and scheduled activities have been shelved.

7.5 MBEYA: SOUTHERN HIGHLANDS EXTENSION & RURAL FINANCIAL SERVICES PROJECT/IFAD

This initiative started with organised extension farmer groups in 1996/97 using a modified T&V extension method to enhance technology transfer at farm level. Essentially, the approach was still strongly based on the traditional "top-down" extension method (E.D. Y. Kiranga and A. H. Urio, personal communication).

In 1998/99 the project introduced IPM-FFS pilots in Mbeya (focused on tomatoes, cabbage, round potatoes and wheat) and Ruvuma (focused on coffee and maize) regions. The IPM-FFS and extension groups ran parallel in the same villages.

IPM-FFS capacity building (IFAD/FAO initiative): Two VEOs (master trainers) attended a 3 months course in Zimbabawe under the sponsorship of FAO. The project supervisors visited IPM-FFS groups in Kenya for two weeks to gain some basic experience on how to organise and conduct IPM-FFS. This was followed by 2-weeks residential training course in IPM and farmer participatory methods of technology transfer for 25 VEOs in Mbeya and Mbinga districts. The graduates reported back to their duty stations to organise and conduct IPM-FFS in their respective villages.

Similar to the GTZ/PHS-IPM project, farmer-farmer learning through exchange visits between farmer groups and within group members was facilitated. Like in the other initiatives, organised field days and exchange visits were used to encourage spillover to non-group members. Institutional collaboration was also emphasised during the project implementation phase. The IPM-FFS approach was highly appreciated by farmers and the VEOs because it was participatory and learning by doing.

7.6 MOROGORO SPECIAL PROGRAMME FOR FOOD SECURITY (SPFS) /FAO PROJECT

This was an initiative of the Ministry of Agriculture and Food Security in collaboration with FAO that targets Morogoro and Kilombero districts, with a focus on maize and rice (the major crops in the area) and promotion of small livestock (poultry, milk goats and chicken).

The project started in 1996 and ended in1998. The initiative promoted farmer participatory group approaches of technology transfer. Because this capacity was not within the project staff, training in participatory approaches was organised and provided by the Co-operative College Moshi for the project core staff (E. Shayo, personal communication).

Baseline surveys and group formation was the same as for the GTZ/PHS-IPM project detailed above. Although the project benefited from the southern highlands initiative, there was limited integration of the IPM-FFS approaches in the Morogoro farmer groups. At the time of the visit, seleceted VEOs were being given a course in IPM-FFS.

Capacity building

1. Master trainers were trained by Co-operative College Moshi to impart participatory methods of technology transfer to selected extension workers.
2. Selected VEOs and farmers from targeted farmer groups were given whole season training at one training site on selected crop and extension messages that included aspects of plant protection. The graduates were used for field demonstrations of identified and proven extension messages in target groups in their villages. This stage has some attributes of IPM-FFS.
3. The demonstration farmers in collaboration with the VEO trained group members. Once the technology is approved by the group, it is ready for dispersion to the whole village. This approach has many attributes of the GTZ/PHS-IPM and KAEMP approaches.

As in the other projects, the training groups in SPFS/FAO project were also used as entry points to transfer other extension information e.g. water control and management, exploitation of groundwater in crop production, marketing (input supply), credit system, record keeping, diversification of farm enterprises, shallow wells etc.

In the first year, the project provided free inputs to the demonstration farmers as motivation. In the second year, inputs were provided on credit with 50% advance payment to wean them off.

There was some adoption by group members and spillover particularly of those technologies that directly addressed farmer felt needs. Farmers, village leadership, VEOs, district and regional leadership also appreciated participatory group training as a means to effect quick and efficient technology transfer. However, due to a lack of logistical support, new training groups have not been formed.

7.7 LESSONS AND GENERAL DISCUSSION

7.7.1 Approach

All the projects discussed in the previous sections above were actively promoting participatory technology transfer to increase food security and cash income at farm level through self formed farmer groups. Some of these groups are now officially registered. All the initiatives emphasised IPM in their farmer groups. The groups were used as entry points for other innovations on a felt need basis irrespective of the original purpose. The IPM farmer groups were used as foci for the extension of a wide range relevant and appropriate technology and knowledge, this enhancing group cohesion and overall development.

The participatory group approach to technology transfer was received with enthusiasm by all the farmers and VEOs in all the visited projects. This is because it involved *hands-on-learning*, an observation made by all the farmers visited.

7.7.2 Capacity Building

These model projects have a lot in common. Capacity building with emphasis on participatory methods of technology transfer, group formation and management were deemed necessary and essential for the project technical staff before training farmer groups.

Collaboration and sharing of experiences between projects was key to the success of new initiatives in different parts of the country. The GTZ/PHS-IPM project played a major role in the set up and organisation of KAEMP and MARAFIP, whereas the Morogoro region initiative benefited from the experiences of the southern highlands project.

7.7.3 Institutional Collaboration

This was observed as key input in the success of the entire visited pilot projects. Institutional collaboration (as indicated in the GTZ/PHS-IPM initiative) ensured harmonisation of technical information, optimisation of scarce resources and ensured farmers of the best remedies to priority problems. As indicated above, collaboration between projects within the country was a healthy avenue for sharing experiences that facilitated speedy setup of new initiatives.

7.7.4 Funding and Logistical Support

This is very crucial in all the projects. Adequate and timely release of funds determined the progress of the projects.

Currently, and in particular where donor funding has been phased out, project activities have been constrained by a lack of continuous flow of funds, this resulting to infrequent visit and training of established farmer groups. Scheduled activities have been affected in most areas and technical input in existing farmer groups have been curtailed.

Fund flow from district councils to support extension services, particularly the farmer groups, after decentralisation is minimal and/or non-existence.

The lack of logistical support from the district councils is purported to be largely due to lack of awareness among district decision makers on the significance of promoting participatory group approaches in extension.

7.7.5 Political support

Local political support is also crucial in the implementation and sustainability of group approach to IPM promotion. KAEMP is the only initiative that seems to have stronger support. This is most likely a result of the project set-up and its holistic approach that addresses the broader needs of the region.

8. IMPLEMENTATION STRATEGY

8.1 INTRODUCTION

Implementation of PMP in the project area of SAGCOT is highly recommended. This PMP will address the project needs to monitor and mitigate negative impact of any increase in the use of agrochemicals, particularly chemical pesticides by promoting ecological and biological control of pest management. The PMP shall provide an information basis for stakeholder groups to establish functional mechanism enabling selected farmers to identify, understand and manage pest problems in the further development of community and farmer groups agriculture, reduce personal and environmental health risks associated with pesticide use, and protect beneficial biodiversity such as natural enemies of pests in the farmers' efforts to increase productivity. The PMP also raises the need of stakeholders to understand and respond to the situations where introduction of alien invasive species necessitates quarantine and stringent minimum pesticide residue levels. The PMP also proposes collaboration with national and international IPM institutions (plant protection organisations -research-extension- private partners) strengthening policy and institional framework and building capacity.

The main objectives of the PMP is to enable SAGCOT to oversee in holistic the implementation of the IPM as a tool for pest management including monitoring of pests and disease vectors and mitigate negative environmental impacts associated with pest control in the project area and promote agro-ecosystem management. The plan provides decision-makers, key stakeholders and investors under SAGCOT with clearer guidelines on IPM approaches and options to reduce crop and livestock losses while protecting human and environmental risks.

For all sub-projects which triggers OP 4.09 the MGF recipient must adhere to the provisions and recommendations of this IPMP. It is also recommended that the requirements indicated in the IPMP be incorporated by binding references in the project legal agreement. Further to this the SAGCOT Investment Project's Operational Manual should include the list of pesticide products authorised for procurement under the sub-project (table 8.1 and 8.2) as well as the WHO pesticides classification lists which dictates pesticides that are not permissible in the Project (Appendix 4).

8.2 INSTITUTIONAL ROLES AND RESPONSIBILILTIES

Various stakeholders will be critical for the implementation of the IPMP. The roles and responsibilities of these stakeholders are described below.

8.2.1 MGF Applicant/ Recipient

As part of the MGF application the MGF Applicant should include basic information on current use of pesticides, potential impacts from the proposed sub-project on pesticides use, any existing pest management systems used by the Applicant, and the Applicant's proposed approach to address potential impacts. Appendix 3 contains an IPM checklist to guide the planning and implementation of pest controls on crops. For category A and B sub-projects the MGF Applicant is responsible for preparing an Environmental and Social Management Plan (ESMP). The ESMP will outline Environmental & Social actions to be implemented by the MGF Applicant against a proposed timeframe, and this will be reviewed by the FM and discussed with the Applicant to ensure the adequacy of the ESAP. The ESMP should consolidate actions from all required safeguard studies which must be prepared and submitted along with the grant application (e.g. PMP if applicable).

If the sub-project intends to introduce new pest management practices or expand the use of pesticides or other agrochemicals, and a Pest Management Plan is required (as determined by screening, scoping and/or the EIA), the MGF applicant will have to include in the grant application (in the text or in an annex) a list of pesticide products authorised for procurement under the sub-project[2], or an indication of when and how

[2] The World Bank does not finance formulated products that fall in WHO classes IA and IB, or formulations of products in Class II, if (a) the country lacks restrictions on their distribution and use; (b) they are likely to be used by, or be accessible to, lay personnel,

this list will be developed and agreed on. This authorised list will also be referenced in the ESAP. In the case where a proposed sub-project has been approved the implementation of the PMP will be the responsibility of the MGF Applicant (now the project implementing entity). The project implementing entity shall also cover all costs associated with the implementation of the PMP including training and awareness activities and submit regular status report on the E&S performance (including pest management performance and pest use) to the FM.

8.2.2 Catalytic Fund

The Fund Manager (FM) will undertake a preliminary screening of proposed sub-projects based on the inherent environmental and social risks associated with the sub-project type and requirements (location, size, etc.), using the Screening form in Annex 8 of the ESMF. The results of the preliminary screening form exercise will be used to determine (i) the eligibility of the sub-project for further processing, (ii) the environmental category of the proposed sub-project, and (iii) the environmental and social due diligence work required in order to prepare a detailed application (including preparation of safeguard instruments such as a PMP). If the sub-project intends to introduce or expand the use of pesticides or other agrochemicals the FM will trigger OP 4.09 and require the MGF Applicant to prepare a PMP which will be reviewed and approved by the FM. OP 4.09 should also be triggered if sub-projects plans introduce new cropping methods or diversify into new crops, particularly those that require intensive pest control.

The FM will be responsible for carrying out compliance monitoring by visiting selected sub-projects on a regular basis and reviewing the effectiveness of implementation of the activities specified in the sub-project ESAP including mitigation measures related to pest management.

8.2.3 Ministry of Health and Social Welfare

Health facilities (hospitals, health centres and dispensaries) in the SAGCOT area should set up databases on incidence of data on poisining, effect of pesticides on human health and environmental contamination. This data will then be used to measure and validate the ameliorating effects of IPM adoption and pilot PMP implementation that is expected to reduce risks to pesticides exposure.
Considering the number of Class II pesticides that might be used and Rodent control products (Ia), it would be wise to strenghthen the poison centers or units of the hospital and equipe them with key antidotes (vitamin K in case Rodenticide poisoning and Atropine for Organophosphate poisoning.

8.2.4 Ministry of Agriculture, Food Security and Cooperatives

The Ministry of Agriculture, Food Security and Cooperatives (MAFC) is key stakeholder responsible for ensuring that promotion of IPM as standard practice for SAGCOT investors and associated smallholder/outgrower operations.

8.3 PROMOTION OF IPM UNDER SAGCOT

8.3.1 Specific PMP for Sub-Projects

As mentioned, all sub-projects which triggeres OP. 4.09 are required to prepare a detailed PMP. The PMP should address those aspects of a chemical pesticide's life cycle that are part of project activities, from pesticide production to distribution, handling, transport, storage, and application, to its final disposal. The plan should also include provisions to supply necessary safety equipment and training for their use. For all PMP activities detailed budget lines must be specified and included in the overall budget for the sub-project.

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farmers, or others without training, equipment, and facilities to handle, store, and apply these products properly. Therefore, in compliance with this requirement, under SAGCOT, sub-projects involving use of chemical pesticides under WHO Class IA, IB and Class II will not be financed.

In cases where MGF recipients during project implementation wish to procure or use pesticides which are not included in the list of pesticide products authorised for procurement the pesticide product is subject to a screening and approval done by the FM. The criteria for the selection and use of pesticides specifically require that: "(i) They must have negligible adverse human health effects; (ii) They must be shown to be effective against the target species; (iii) They must have minimal effect on non-target species and the natural environment. The methods, timing, and frequency of pesticide application are aimed to minimize damage to natural enemies. Pesticides used in public health programs must be demonstrated to be safe for inhabitants and domestic animals in the treated areas, as well as for personnel applying them; and (iv) Their use must take into account the need to prevent the development of resistance in pests.

8.3.2 IPM to be Part of Environmental and Social Management Plan

Each of the subprojects to be financed through the SAGCOT Investment Project will be subject to environmental and social screening, assessment, and approval process as required by SAGCOT's Environmental and Social Management Framework (ESMF). The process complies with both the World Bank's safeguard policies and Tanzanian EIA regulations and related guidelines. It is also consistent with the Investment Policies and Operating Guidelines for the Matching Grants Facility and Social Venture Capital Fund outlined in the Trust Deed of the SAGCOT Catalytic Trust Fund (which includes Environmental and Social Review Procedures). For category A subprojects a site specific Environmental and Social Impact Assessment (ESIA) will be conducted. For both category A and B sub-projects grant applications must include an Environmental and Social Action Plan (ESMP).

The ESMP include activities, impacts, mitigation and enhancement measures, time schedule, costs, responsibilities and commitments proposed. Subsequently, the ESMP will inform the environmental management system (EMS) of the project through:

(a) Ensuring that its activities are in line with applicable environmental laws and regulations;
(b) Determining priorities and set objectives and targets to be met by the EMS. A reporting mechanism shall also be established so as to determine whether the targets are met or not, and for record purposes;
(c) Identify training needs vis-à-vis the environmental and social objectives and targets, and put a plan for capacity building among staff in place; and
(d) Establish environmental and social management programs to be undertaken within given time frames and by particular persons to take corrective measures. As such, roles and responsibilities shall be defined, documented and communicated for effective environmental and social management.

In essence, where the use of pesticides is considered necessary, ESIA studies will dwell around the following information which must be obtainedas minimum:-

- Pest and beneficial populations in the field crop;
- Assessment of economic pest damage;
- Target crops and possibly growth stages;
- Recommended pesticides for the crop and its problem, their price and where obtainable;
- Pests and beneficials spectrum covered, including growth stages of the target organisms;
- Dose rates, dilution, timing and frequency of application;
- Waiting period (particularly for vegetables and stored produce);
- Method of application and equipment;
- Costs of application;
- Precautions to be taken (safety gears and measures); and
- Storage conditions and shelf life.

8.3.3 The IPM Strategies for Promoting its Adoption

The main strategy to promote IPM in the project area could be embedded as: *"Sensitize-Capacitate-Adapt and Scale Out"*. All key stakeholders are sensitized on the benefits of IPM, and the necessary capacity provided at different levels. This is mainly; training, provision of resources and logistic support.

Technological options are then tested in collaboration with Research Extension and farmers and those proven to work are adopted and spread by farmers among themselves. As the process becomes dynamic and self-propelling, the technical team continues into new areas and the extension agents continue to backstop. Participatory approaches and tools (IPM working groups, Farmer Field Schools (FFS) etc) are the hub of the strategy, and where necessary, the strategy avoids duplication of efforts by consolidating outputs and experiences from the previous pilot IPM Tanzania/GTZ project and other IPM/ FFS projects.

Since the IPM strategy has not been widely adopted, the SAGCOT could adequately mainstream the IPM policy directives, organize and coordinate IPM platform nationally and or regionally. The strategy could bring on board other non-government IPM initiatives (Private Sector, NGOs and Development projects) whose approaches and strategies are not integrated into the national strategy. For some reasons of lack of adequate and sustainable resource allocation, popularization of IPM strategy outside the former pilot area has been limited, and therefore use of technologies and experiences from previous projects has not been fully exploited. SAGCOT could therefore make use of this experience where applicable. However, SAGCOT project initiatives and operational procedures on IPM could be the fundamental process through which IPM can be popularized. The strategies and operational procedures could also be complemented by strategies from elsewhere in Africa.

8.3.4 SAGCOT to Advice Investors on IPM Practices

As a rule of thumb, Farmers practicing IPM are regularly advised by the agricultural extensionists who could receive training on IPM from projects and elsewhere. This is part of their day-to-day activities but due to problems of transport and other logistic support, advice to farmers throughout the cropping cycle cannot be guaranteed. SAGCOT could harmonize with the local government authorities to organize field days for IPM farmer groups where many farmers are advised at a time. Moreover, SAGCOT could fund the preparation and printing of extension material and be provided to the extension services. Other avenues for disseminating information could include the use of mass media, particularly the radios, TVs and annual agricultural shows at district and regional levels.

8.3.5 SAGCOT to Support IPM Training in Research and Training Institutions

Currently, in the curriculum of MAFC agricultural colleges, IPM is a subtopic under a major topic of Insect Pest Control Methods, and it is the last on the list of these subtopics. Other topics include methods of controlling field and storage pests, physical and mechanical control, biological control, legislative control, cultural control, host plant resistance and chemical control. Students are only made aware of IPM but nothing detailed. The learning objective in the curriculum states that students should be able to explain the importance of IPM in conserving biodiversity. Sokoine University of Agriculture has a pest management centre. The centre provides tailor made training on IPM on request. In the faculty of agriculture, IPM is a subject in pathology, entomology and weed science. At master's degree, IPM is one of the optional research subjects (personal communication). Generally, there is not a common understanding of IPM among training institutes at different levels due to misconceptions reflected in some of the curricula. Lack of policy direction with regard to IPM research and training is a limitation in integrating IPM training in academic and research institutions. However, the aforementioned inclusion of IPM in the curricula at different levels of training and research institutions is an opportunity to capitalize on in capacity building and mainstreaming of IPM training.

8.3.6 SAGCOT to Support IPM Training and National Policy

Since Farmer Field Schools have been embraced within the extension service as participatory approach of choice, in support of this, MAFC has designated four farmer training centres in the country (Mkindo–Morogoro; Bihawana- Dodoma; Inyala- Mbeya, and Ichenga- Iringa). The SAGCOT project could support by putting efforts to facilitate development of sustainable capacity to research and disseminate different options for testing/validation and adoption by farmers in the different agro ecological settings. In the FFS, farmers are very enthusiastic on the concept of biological control. They are good at scouting to identify the beneficial organisms but they may not tell why they are beneficial nor which pests the natural organisms

can control unless are given adequate trainings. In part this interest in biological control stems from their experience of various national biological control programs. The notable one is the classical biological control of cassava mealybug (*Phenacoccus manihoti)* by use of a wasp (*Apoanagrus lopezi*), an experience known by almost every Tanzania cassava farmer. Others include control of water hyacinth (*Eichhorniae crassipes)* using *Neochetina bruchi* and *N. Eichhorniae* and citrus woolly white fly using *Encarsia haipiaensis.*

8.4 SPECIFIC PEST MANAGEMENT MEASURES

8.4.1 Rules for Safe Handling of Pesticides

All pesticides are poisonous and thus rules have to be observed to avoid human health impairment and environmental pollution. In addition to material safety data sheet (MSDS) accompanied with any given pesticide, the following general rules will have to be observed:

- Keep only closed original containers with labels.
- Keep pesticides under lock and key in a cool, dry and ventilated place away from fire, food, feed, water and out of reach of children. In the same room also the spraying equipment can be stored.
- Pesticides should be shelved and the floor be of cement to be able to detect leakage and clean it early enough where applicable.
- Equipment for weighing and mixing pesticides should only be used for this purpose and be locked in the store.
- Protective clothing should be used only for spraying purposes.
- Absorb spillage immediately with sawdust or earth; sweep up, burn or bury. Have cement floor for better cleaning.
- Do not re-use empty containers. Empty containers should be burnt if possible or crushed and bury in a sanitary landfill.
- Use a well aerated store and sales room.
- Instruct your personnel on safety precautions before (!) it is too late.
- Make contacts to a qualified physician for emergencies.

In view of the above, the use of protective equipment and capacity building on pesticide management aspects, which would be the responsibility of the Matching Grant applicant/ recipient, will be critical.

8.4.2 Recommended Pesticides in Tanzania

Table 8.1 List of recommended and TPRI registered pesticides for crop production in Tanzania[3]

Chemical	***Common name***	****Oral LD50/kg***	***WHO class***	***Comments***
Insecticides	Betacyfluthrin	500-800	II	
	Biphenthrin			
	Chlorpyrifos	135-163	Ib	Deregister & Phaseout
	Cypemethrin	251-4125	III	
	Cypermethrin + Dimethoate	251-4125 + 2350	III	

[3] This table has been slightly updated. Important notice is that an extraordinary meeting of the National Plant Protection Advisory Committee (NPPAC), a body responsible for review of the pesticide list, took place in February 2014; the new list has been approved and the Pesticide Registrar's Office is expected to publish the list before June 2014.

Chemical	*Common name*	**Oral LD50/kg*	*WHO class*	*Comments*
	Deltamethrin	153-5000	III	
	Dealtamethrin + Dimethoate	153-5000+2350	III	
	Diazinon	220	II	
	Dimethoate	2350	III	
	Esfenvalerate	451	II	
	Fenitrothion	800	II	
	Fenvalerate	451	II	
	Fenvalerate + Fenitrothion	451+ 800	II	
	Flucythrinate			
	Hydrmethyl			
	Lambda cyhalothrin	243	II	
	Permethrin	430-4000	III	
	Pirimiphos methyl	2050	III	
	Pirimiphos methyl + permethrin	2050 + 430-4000	III	
	Profenophos	358	II	
	Profenophos + cypermethrin	358 + 251-4123	II	
	Quinalphos	62-137	Ib	Deregister & Phaseout
Nematicides	Dazomet	520	II	
	Isazophos	40-60	Obsolete	Deregister & Phaseout
Herbicides	Atrazine			
	Diuron			
	Fluometuron			
	Glyphosate			
	Metolachlor + Atrazine			
	Metalachlor + Dipropetrin			
	Paraquat			Dirty Dozen: should be banned with immediate effect
Chemical	*Common name*	**Oral LD50/kg*	*WHO class*	*Comments*
Avicides	Fenthion		II	
	Cyanophos		II	
Rodenticides	Bromodiolone		Ia	
	Coumatetralyl		Ia	
	Diphacinone		Ia	
Fungicides	Bronopol			
	Chlorothalonil	10,000+	III	
	Copper hydroxide	1,000	II	
	Copper oxychloride	70-800	II	
	Cupric hydroxide	1,000	II	
	Cuprous oxide			
	Cyproconazole	1,000	II	
	Hexaconazole	2189	III	
	Mancozeb	5000+	III	
	Metalaxyl + Mancozeb	633 + 5000+	III	

Chemical	*Common name*	**Oral LD50/kg*	*WHO class*	*Comments*
	Penconazole			
	Propineb	1,000	II	
	Triadimefon	1,000	II	
	Sulfur			

As expressed in the footnote 3 above, the above list is subject to review by relevant authorities in Tanzania. SAGCOT Investment Project will adhere to reviewed list(s) that will be released by such authorities any time during the implementation of the project. As part of monitoring and evaluation (Section 8.5), the project will also inform the authorities of pesticides required to be phased out for reported health concerns.

8.4.3 Pesticides Banned in Tanzania

The following pesticides considered as persistent organic polluntants (POPs) are banned in Tanzania and will therefore not recommended for use by any investor under SAGCOT: Aldrin, Camphechlor; Chlordane; Ddt; Dibenzofurans (Chlorinated); Dieldrin; Endrin; Heptachlor; Hexachlorobenzene; Mirex; Polychlorinated Biphenyls; and Polychlorinated Dibenzo-P-Dioxins.

On the other hand, the importation and use of chemicals indicated in the table below are Subject to the Prior Informed Consent (PIC) procedure in Tanzania.

Table 8.2 List of pesticides whose use are subject to the Prior Informed Consent (PIC) procedure in Tanzania

Chemical	**Category**	**Registration Status in Tanzania**	**Import Decision**
2,4,5-T and its salts and esters	Pesticide	Not registered	No consent
Aldrin	Pesticide	Restricted registration for use in soil against termites	Consent
Binapacryl	Pesticide	Not registered	No consent
Captafol	Pesticide	Banned since 1986	No consent
Chlordane	Pesticide	Restricted registration for use in soil against grubs, termites, ants and crickets	Consent
Chlordimeform	Pesticide	Not registered	No consent
Chlorobenzilate	Pesticide	Not registered	No consent
DDT	Pesticide	Banned for agricultural use, restricted for public health	Consent for public health
Dieldrin	Pesticide	Restricted registration for emergency cases in limited amount	consent
Dinitro-*ortho*-cresol (DNOC) and its salts (such as ammonium salt, potassium salt and sodium salt)	Pesticide	Not registered	No consent
Dinoseb and its salts and esters	Pesticide	Not registered	No consent
1,2-dibromoethane(EDB)	Pesticide	Restricted registration for fumigation application on soil	consent
Ethylene dichloride	Pesticide	Not registered	No consent
Ethylene oxide	Pesticide	Not registered	No consent
Fluoroacetamide	Pesticide	Not registered	No consent
HCH (mixed isomers)	Pesticide	Not registered	No consent
Chemical	**Category**	**Registration Status in Tanzania**	**Import Decision**
Heptachlor	Pesticide	Registered for use in various crops against termites and other soil pests	consent
Hexachlorobenzene	Pesticide	Not Registered	No consent
Lindane	Pesticide	Registered hides and skins	Consent
Mercury compounds, including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds	Pesticide	Not Registered	No consent
Monocrotophos	Pesticide	Not registered	No consent

Chemical	Category	Registration Status in Tanzania	Import Decision
Parathion	Pesticide	Banned in 1986	No consent
Pentachlorophenol and its salts and esters	Pesticide	Not registered	No consent
Toxaphene	Pesticide	Banned in 1986	No consent
Dustable powder formulations containing a combination of: - Benomyl at or above 7 per cent, - Carbofuran at or above 10 per cent,& - Thiram at or above 15 per cent	Severely hazardous pesticide formulation	Not registered	No consent
Monocrotophos (Soluble liquid formulations of the substance that exceed 600 g active ingredient/l)	Severely hazardous pesticide	Not registered	No consent
Methamidophos (Soluble liquid formulations of the substance that exceed 600 g active ingredient/l)	Severely hazardous pesticide	Not registered	No consent
Phosphamidon (Soluble liquid formulations of the substance that exceed 1000 g active ingredient/l)	Severely hazardous pesticide	Not registered	No consent
Methyl-parathion (emulsifiable concentrates (EC) at or above 19.5% active ingredient and dusts at or above 1.5% active ingredient)	Severely hazardous pesticide	Banned in 1986	No consent
Parathion (all formulations – aero-sols, dustable powder (DP), emulsifiable concentrate (EC), granules (GR) and wettable powders (WP) - of this substance are included, except capsule suspensions (CS))	Severely hazardous pesticide formulation	Not registered	No consent

Source: Designated National Authority - Prio Informed Consent Procedure (DNA PIC)

8.5 MONITORING AND EVALUATION ARRANGEMENT

Successful implementation of IPMP will require regular monitoring and evaluaton of activities undertaken by individual SAGCOT investors. It is also crucial to evaluate the prevailing trends in the benefits of reducing pesticide distribution, application and misues as well as the progress in national policy reform regarding IPM implementation and regulatory control on handling and use of pesticides. New situations on pesticides risks that arise during project implementation should also be monitored. The indicators that require regular monitoring and evaluation during the programme implementation include the following:

- The IPM capacity building SAGCOT investors;
- Numbers of investors who have adopted IPM practices as crop protection strategy in their crop production efforts; evaluate the rate of IPM adoption;
- How many investors have adopted IPM and improved the production derived from adopting IPM;
- Economic benefits: increase in crop productivity due to adoption of IPM practices; increase in revenue resulting from adoption of IPM practices, compared with conventional practices;
- Numbers of IPM networks operational and types of activities undertaken;
- Extent to which pesticides are used for crop production;
- Effeciency of pesticide use and handling and reduction in pesticide poisoning and environmental contamination;
- Levels of reduction of pesticide use and handling and reduction in pesticide poisoning and environmental contamination;
- Number of IPM participatory research project completed;
- Pesticide residues in groundwater or in surface water downstream from irrigation schemes;
- Pesticide residues in food (e.g.: crops, drinking water, fodder, livestock);
- Impact on non-target organisms (e.g.: beneficial insects, fish and other aquatic life, wildlife, non-target crops and plants through herbicide drift).

- Influence of the results of IPM participatory research on implementation of IPM and crop production; and
- Overall assessment of activities that are on-going according to plans; activities that need improvement; and remedial actions required.

The above indicators will have to be appropriately made part of Environmental and Social Management Plan (ESMP) and Environmental Monitoring Plan (EMP) for any individual category A or B subproject. The ESMP include monitoring measures, parameters to be measured, sampling methods to be used, sampling locations, analytical techniques to be used, frequency of measurements, recording of data, data analysis, and dissemination of information collected and decision reached. The ESMP and EMP will define thresholds that will signal the need for corrective actions.

8.6 WORKPLAN AND BUDGET

The SAGCOT Centre will be responsible in the implementation of this IPMP and estimated costs for the various activities under this program will be build in the budget. Most funds would be provided by the Matching Grants applicants as part of their co-financing. The core activities will include capacity building, advisory services, environmental management, and project management. Annual workplan will be developed by SAGCOT Catalytic Fund in collaboration with SAGCOT Centre in consultation with all key stakeholders. Approximately **USD 1,375,000.00** will be required to effectively implement the IPMP over a five-year period (Table 8.3 below).

Table 8.3: Workplan and Budget for IPM implantation

	Line item	Year 1	Year 2	Year 3	Year 4	Year 5	Total (USD)
	1. Capacity Building						
1.1	IPM orientation workshop for MGF recipients/ beneficieries	50,000	0	0	0	0	**50,000**
1.2	Annual workshops on progress and reviews are held by SAGCOT Catalytic Fund in collaboration with SAGCOT Centre	0	30,000	30,000	30,000	30,000	**120,000**
1.3	Hiring of Project IPM Advisor responsible for capacity building, coordinanation, monitoring and evaluation	25,000	25,000	25,000	25,000	25,000	**125,000**
	Sub-total	**75,000**	**55,000**	**55,000**	**55,000**	**55,000**	**295,000**
	2. Advisory Services						
2.1	IPM diagnostic baseline surveys are undertaken at the beginning of the Project	50,000	0	0	0	0	50,000
2.2	IPM technologies are developed (field guides/IPM materials) and made available for MGF applicants and recepients	10,000	10,000	10,000	10,000	10,000	50,000
2.3	Create and promote public awareness programes and advocacy	15,000	10,000	5,000	5,000	5,000	40,000
2.4	Undertaking regular pest/ vector surveillance	0	30,000	30,000	30,000	30,000	120,000
	Sub-total	**75,000**	**50,000**	**45,000**	**45,000**	**45,000**	**260,000**
	3. Environmental Management						
3.1	Pesticides risk reduction through IPM implementation are integrated and streamlined into ESMPs and EMP of SAGCOT's specific invetments	70,000	50,000	0	0	0	120,000
3.2	Support to IPM research and development in the project area	100,000	0	100,000	0	100,000	300,000
	Sub-total	**170,000**	**50,000**	**100,000**	**0**	**100,000**	**420,000**
	4. Project Management						
4.1	IPMP implementation coordination	30,000	30,000	30,000	30,000	30,000	150,000
4.2	Monitoring and evaluation of IPMP implementation	50,000	50,000	50,000	50,000	50,000	250,000
	Sub-total	**80,000**	**80,000**	**80,000**	**80,000**	**80,000**	**400,000**
	Grand Total	**400,000**	**235,000**	**280,000**	**180,000**	**280,000**	**1,375,000**

Workplan Notes

	1. Capacity Building	Notes
1.1	IPM orientation workshop for MGF recipients/ beneficieries	This workshop is recommended to be done in the first year of project implementation. It could as well be scheduled to be done alongside all other safeguard tools (SRESA, ESMF and RPF) to all MGF recipients and other key stakeholders.
1.2	Annual workshops on progress and reviews are held by SAGCOT Catalytic Fund in collaboration with SAGCOT Centre	These will be workshops for disseminating progress made and challenges encountered in the implementation of IPM requirements.
1.3	Hiring of Project IPM Advisor responsible for capacity building, coordinanation, monitoring and evaluation	Given the nature and the size of the project, and the expected magnitude of pesticide use in the entire project area, a local national IPM advisor is being proposed to coordinate all matters related to IPM. It should be noted that it could be appropriate to get an advisor who can cover for SRESA, ESMF and RPF but IPM needs an expert with specialized knowledge and skills.
	2. Advisory Services	
2.1	IPM diagnostic baseline surveys are undertaken at the beginning of the Project	These surveys would give current baseline data in specific project areas which could also be included in EIA studies.
2.2	IPM technologies are developed (field guides/IPM materials) and made available for MGF applicants and recepients	Field guides could be needed for some specific pesticides
2.3	Create and promote public awareness programs and advocacy	The programs could be in form of TV and radio jingles, posters, and sensitization workshops.
2.4	Undertaking regular pest/ vector surveillance	Field assessment and sample collection as monitoring/ control studies.
	3. Environmental Management	
3.1	Pesticides risk reduction through IPM implementation are integrated and streamlined into ESMPs and EMP of SAGCOT's specific invetments	Refer to activity 2.1 above
3.2	Support to IPM research and development in the project area	SAGCOT centre could work with relevant research institutions such as Tanzania Pesticide Reserach Institute (TPRI) and Sokoine University of Agriculture (SUA) to undertake adaptation research and development in SAGCOT project area.
	4. Project Management	
4.1	IPMP implementation coordination	Supervison and general coordination responsibilities.
4.2	Monitoring and evaluation of IPMP implementation	For routine and ad hoc vfield visits for monitoring and evaluation missions.

9. RECOMMENDAITONS

In order for the SAGCOT to ensure compliance with OP 4.09 and adopt ecologically-based IPM as the standard approach to pest management, the following are recommended:

(i). Promote IPM by following the ways presented in this document;
(ii). Establish ecologically-based IPM as a guiding principle for development at SAGCOT and realign relevant activities and strategies to support rather than undermine IPM and OP 4.09;
(iii). Discourage conflicts of interest by screening out inappropriate SAGCOT partnerships that threaten to undermine IPM;
(iv). Encourage effective collaboration across IPM projects, sectors and departments to support the integration of IPM and sustainable agriculture into SAGCOT;
(v). Make better use of locally and regionally available knowledge and expertise in IPM and improve collaboration with farmers groups, NGOs, national and international institutions with expertise in participatory and environmentally sustainable approaches to agriculture; and
(vi). A new/ reviewed list of approved pesticides is expected to be published before June 2014. This will have to be observed by the SAGCOT Invetsment Project management for adoption.

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APPENDICES

Appendix 1: Names of Experts Involved in Preparing This IPMP for SAGCOT

Expert 1: Team Leader	Expert 2	Expert 3
Kayonko Juma Kayonko, Registered Environmental Expert, (NEMC/EIA/0162 and NEMC /EA/0034), 10th FL, Mawasiliano Towers, 20 Sam Nujoma Road, P. O. Box 30, Dar es Salaam, Tanzania Mobile: (+255) 0787/ 0754 616 700 Email: kayonkoj@gmail.com Skype: juma.kayonko	Gasana Damian Rwabufigiri. Officer In Charge PQPS Dar es salaam Port Field officer Outbreak pest control. Ministry of Agriculture Food Security and Cooperatives. Plant Health Services P. O. Box 9071, Dar es Salaam, Tanzania Mobile:+255784410184. +255762787336 E-mail gasanadamian@yahoo.com, damiangasana512@gmail.com	Lazaro W. Kitandu, National IPM Coordinator, Ministry of Agriculture, Food Security and Cooperatives, Plant Health Services, P. O. Box 54802, Dar Es Salaam Phone: +255 22 286 5641/2 Cell: +255 754 673 154 Email: lazkitandu@hotmail.com Skype: lazaro.kitandu

Appendix 2: Persons Consulted During the Preparation of IPMP for ASDP

Ministry of Agriculture and Food Security Dr. George Sempeho, DED Mr. Chacha Nyakomari, ASDP Mr. Muro, PADEP Mr. Masija, SIIP Mr. Maro, FAO/Food Security Mr. S. Semgelewe, Planning Dr. L. Ngatunga, DED	**Ministry of Water and Livestock Development** Mr. D. Shirima Principal Economics Planner Policy and Planning Division Dr. H. Mjengera Director Water Laboratories Unit Mr. J. Mihayo Director Water Resources Division Dr.. R. Mngodo Head Hydrology and Geographic Information Systems (GIS) Unit Water Resources Division
Division of Environmental, Vice President Office Ms. Angelina Madate Assistant Director, Pollution Control Mr. Muungi Assistant Director, EIA	**National Environmental Management Council** Ms. E.Kerario Director, EIA Mr. P. Kijazi Pollution Control Officer
Agricultural Research Institute Ukiriguru Mr. Peter Kapingu ZDRD – Lake Mr. Robert Kileo Zonal Research Coordinator Ms. Epihania Temu Zonal Information Liaison Officer	**Musingwe District Council** Mr. Michael Fundo District Agriculture and Livestock Officer Mr. Gerald Krange SMS Mechanization Mr. Kachrima Manager, Participatory Irrigation Development Project

Kwimba District Council Mr. Stephen M. Solo District Extension Officer Mr. John Enock Extension Officer	**Agricultural Research Institute Selian** Director of Zonal Research NP Massawa - Zonal Research Coordinator A.K.Kissiwa - Zonal Extension Liaison Officer Roma Ngatoluwa - Head of Special Program Hussein Mansoor - Scientist Special Programme F.Ngulu - Phytopathologist S.Sluma - Entomologist Kitgenge - Breeder Matovo - Agronomist Mbaga - Entomologist Peter Xavery - Socio-economist/database management Phillemon Mushi - Computer Manager and NZARDI Website Manager Horti-Tengeru Research Institute Mr. Safamali Tengeru – Division of Plant Health Services Mwangi Jubilant - IPM – Technical Adviser (Northern Zone) M.S. Marawit - Plant Health Service Inspector K.K Mngara Post-Harvesting Management Coordinator Steven Mirau - Bird Control Unit Wilferd Mushobzi - Arm worms – National Control Center Coordinator
Tanzania Pesticides Research Institute Charles J. Mkangirwa Director of Research Jonathan Ak'habuhaya Registrar of Pesticides	**Arusha Municipal Council** Joseph Y. Mkwizu Coordinator- SCAPA
Aremeru District Council District Planning Officer Mwihayo SMS - Irrigation	**Tanzania Coffee Research Institute** Grace Chipangohelo Prinicipal Research Officer Msonjo Humphrey Temu Extension Agronomist
Muheza District Council Manpower officer Planning officer Isipor Mweumpya DALDO Mzirya Agriculture Extension Officer	**Agriculture Research Institute Mlingano** Dr. Adolf Nyaki Depute Director – Eastern Zone Ms. Catherine Senkoro Information Liaison Officer Joseph D.J. Mbogoni GIS Unit Shabani Hamisi Coordinator for Sisal Research Mrs Lady Swai Plant Pathologist

Agriculture Research Institute Ilonga Joseph Asenga – Breeder	**Sokoine University of Agriculture** Professor Ludovick Kinabo - Project Coordinator TARP II – SUA Project Professor A.J.P Tarimo - Extension services and linkage specialist Professor LLL Lulandala - Agroforestery researcher Profesor Vicent Nsoloma - Coordinator – Mushroom research Dr. A. Massawe - Pest Management Centre Dr. L.S Mulungu - Pest Management Centre Professor K.P Sibuga - Project Coordinator - ICE Dr. Gaspar Ashimogo - Entrepreneurship and Agribusiness Manager – The Focal Programme
Tabora **District LGA** Ms. R Elipenda - District Executive Director Uyui District Council Mr. F. Kashiridye - District Livestock Devt Office Uyui District Council Mr. M. Ndunguru - Plant Protection Office Uyui District Council Mr. T. Toziri - Livestock Ward Extension Officer Magiri Uyui District Council Mr. H. Ikandilo - Ward Executive Office Magiri Uyui District Council	

ZARDI Western Zone
Dr.B. Mbaga
Zonal Director – Tumbi

Mr B. Gama
Zonal Research Liason Coordinator

Mr. R. Shenkalwa
Head, Crop Sciences

Mr. J. Chiligati
Head Research Extension Officer

Mr. M. Kusekwa
Head Livestock Research Program

Dr. D. Byamungu
Ag. Head, Crop Research Program

District staff

Mr. L. Muliahela
Ag. District Executive Director and
District Agricultural & Livestock officer
Mbeya (Rural)

Mr. M. Mwandiga
Ag. District Planning Offier
Mbeya (Rural)

Mr. M. Matambi
IPM Specialist
District Agr & Livestock Devt
Mbeya (Rural)

Mr. G. Lihemula
Land use Planner
District Agr. & Livestock Office

Mr. C. Mtono
District Agr. & Livestock Office
Mbeya (Rural)

Ms. S. Msemwa
District Agr. & Livestock Extension Office
Mbeya (Rural)

Southern Highlands Zone staff
Dr. M Msabaha
Zonal Director – Uyole

Dr. R. Mbwile
Ag. Zonal Research Coordinator and
Head, Livestock Research Programme

Dr. Z. Malley
Head, Special Research Programme

Mr. E. Kiranga
Zonal Research Extension & Liason Officer

Mr. C. Madata
Head, Crop Research Program

Ms. C. Kabungo
Ag. Head, Socio-economic Unit

Appendix 3: An IPM Checklist for Planning and Implementing Pest Control on Crops

I. Is Pest Control Necessary?
A pest is an unwanted organism - animal, plant, bacteria, fungus or virus.

What pest problem do you have?

What collections are affected?
_____

II. Will Your Pest Control Be Effective?
What chemical or non-chemical treatment are you using?
_____

Is the problem persisting?
_____

Does the pest return? How often?
_____

Where is the pest problem?
_____

What is the original source of the pest?
_____

What does it like to eat?
_____

What is the pest's life cycle?
_____

What does it need to survive? (food, light, temperature, humidity, habitat)
_____

Integrated pest management uses biological and non-chemical methods to reduce and eliminate pest problems in the following steps:

1. Inspection
(a) *Pre-harvesting*. Does the crop invite pests into the farm via the soil, other crops, wind, bad sanitation, etc.

(b) *Post-harvesting*. Do storage facilities attract pests, or make the storage a better place for the pests to live?

2. Diagnosis & Reporting
(a) Catch pest examples (do not squish); use sticky baited and/or unbaited traps. Lures might include pheromones or black (UV) lights.

Note: Some insects will not be attracted to baits or traps.

(b) Collect examples of pest damage and waste.

(c) Have an entomologist identify the pest.

(d) Learn the pest's preferred diet, life cycle and habitat.

(e) Record the location and date pests were found to determine what areas of the collection are infested.

3. Planning Integrated Pest Management
Match the pest control treatment to the particular pest: to where it lives and what it eats, to the crop..

(a) Mechanical and physical control. These constitute the physical collection and subsequent destruction of pests.

(b) Cultural control. These constitute sanitation and farm hygiene, selection of planting sites and selection of planting dates (avoids pest attack) and intercropping/strip cropping/ crop rotation, trapping/pseudostem and mulching/solarization (suppress pest population)

(c) Use of pest resistant plants. This is genetically inherited ability of plant species to withstand or tolerate pests or diseases. Have you used pest resistant plants?

(d) Biological control. These use natural occurring organisms to regulate pest population to acceptable levels. Will another organism solve the problem or combines with other control measures?

(e) Chemical control. This is the use of pesticides to control pests. Try to avoid use of pesticides or try local treatment, specific to the habits of the pest.

4. Implementing Pest Management Plan
(a) Inform everyone in the village, ward and districts why changes must be made and how they can change their habits.

(b) Record what you have done, the date it was done, and where it was done.

(c) Investigate any IPM method you plan to use: or pesticides use is it legal and the least invasive or least toxic method available?

(d) Apply biological pest control methods properly.

(e) Know what dosage (concentration) to use and in what form of botanic pesticides.

(f) Know how long a treatment lasts at the temperature and relative humidity of your climate

(g) Be certain that a pesticide will not affect vegetation or groundwater. Know how safe it is for humans.

5. Evaluate the Results
(a) Monitor with sticky traps, baits, pheromone traps, or black light traps; document numbers, location,

and date. Check traps on a regular basis (every week or every month).

(b) Survey a sample of the susceptible collection. For example, look in a different part of your farm every month to inspect different pests.

III. How Toxic is a Pesticide to You?
Toxic means poisonous.

Types of toxicity include:

(1) Acute poisoning is measured as LD50, meaning the lethal dosage for 50 percent of the animals tested. Sometimes it is measured as LC50 meaning the lethal dosage in the air for 50 percent of the animals tested. The lower the LD50 or the LC50, the more poisonous the pesticide.

(2) Chronic poisoning affects an animal or human over a long period of time after small, repeated doses. There is no widely recognized measure of chronic toxicity.

Poisons enter the body in three, measurable, ways:

(1) Dermal toxicity refers to poison absorbed through the skin. Some areas of the body are more susceptible than others.

(2) Oral toxicity refers to poison that is ingested. Pesticides on hands can be ingested while eating, drinking or smoking.

(3) Inhalation refers to poisons breathed through your nose. Breathing the vapor of the pesticide can cause harm.

A pesticide is a chemical or other agent that will destroy a pest or protect something from a pest. There are two types:

(1) A residual pesticide destroys pests and keeps them from causing damage for long periods of time after it is applied.

(2) A short-term pesticide breaks down almost immediately after application into nontoxic by-products. For example, a fumigant is a poisonous gas that kills when absorbed or inhaled. Most are highly toxic but have no residual effects.

IV. Will Farmer Field School approach to IPM be useful?
This approach should be promoted by ASSP and IPM Farmer Groups play key role in dissemination of ecological based pest management. Is IPM integrated into the Programme activities of each component and is it in compliance with OP 4.12?

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Appendix 4: Pesticide Classification List – WHO

Table1: Extremely hazardous (Class 1a) technical grade active ingredients of pesticides (common name) – not permissible in the SAGCOT Investment Project

Aldicarb	Difethialone	Parathion – methyl 1
Brodifacoum	Diphacinone	Phenylmercury acetate
Bromadiolone	Disulfoton	Phorate
Bromethalin	Ethoprophos	Phosphamidon
Calcium cyanide	Flocoumafen	Sodium fluoroacetate
Captafol	Fonofos	Sulfotep
Chlorethoxyfos	Hexachlorobenzene	Tebupirimfos
Chlormephos	Mercuric chloride	Terbufos
Chlorophacinone	Meviphos	
Difenacoum	Parathion	

Table 2: Highly hazardous (Class 1b) technical grade active ingredients of pesticides (common name) – not permissible in the SAGCOT Investment Project

Acrolein	Ethionfencarb	Omethoate
Ally alcohol	Famphur	Oxamyl
Azinphos – methyl	Fenamiphos	Oxydemeton-methyl
Azinphos- methyl	Flucythrinate	Paris green (C)
Blasticidin – S	Fluoroacetamide	Pentachlorophenol
Butocarboxim	Forrmetanate	Pindone
Butoxycarboxim	Furathiocarb	Pirimiphos-ethyl
Cadusafos	Heptenophos	Propaphos
Calcium arsenate	Isazofos	Propetamphos
Carbofuran	Isofenphos	Sodium arsenate
Chlorfenvinphos	Isoxathion	Sodium cyanide
3-chloro-1,2-propanediol	Lead arsenate	Strychnine
Coumaphos	Mecarban	Tefluthrin
Coumatetralyl	Mercuric oxide	Thallium sulfate
Zeta-cypermethrin	Methamidophos	Thiometon
Demeton-S-methyl	Methidathion	Thiometon
Dichlorvos	Methidocarb	Triazophos
Dicrotophos	Methomyl	Vamidothion
Dinoterb	Monocrotophos	Warfarin
Edinofenphos	Nicotine	Zinc phosphide

Table 3: Moderately hazardous (Class II technical grade active ingredients of pesticides (common name) – not permissible in the SAGCOT Investment Project

Alanycarb	Endosulfan	Paraguat
Anilofos	Endothal-sodium	Pebulate
Azaconazole	Esfenvalerate	Permethrin
Azocyclotin	Ethion	Phenthoate
Bendiocarb	Etrimfos	Phosalone
Bensulide	Fenitrothion	Phoxin
Bifenthrin	Fenobucarb	Piperophos
Bilanafos	Fepropidin	Pirimicarb
Bioallethrin	Fenpropathrin	Prallethrin
Bromoxynil	Fenthion	Profenofos
Brobuconazole	Fentin acetate	Propiconazole

Bronopol	Fentin hydroxide	Propoxur
Butamifos	Fenvalerate	Prosulfocarb
Butymine	Fipronil	Prothiofos
Carbaryl	Fluxofenim	Pyraclofos
Carbosulfan	Formothion	Pyrazophos
Cartap		Pyrethrnis
Fuberidazole		
Chloralose	Gamma-HCH	Pyroquilon
Cholordane	Guazatine	Quinalphos
Chlofenapyr	Haloxyfop	Quizalofop-p-tefuryl
Chlorphonium chloride	Heptachlor	Rotenone
Chlorpyrifos	Imazalil	Sodium fluoride
Clomazone	Imidacloprid	Sodium hexafluorosilicate
Copper sulfate	Iminoctadine	Spriroxamine
Cuprous oxide	Ioxynil	Sulprofos
Cyanazine	Ioxynil octanoate	Terbumeton
Cyanophos	Isoprocarb	Tetraconazole
Cyfluthrin	Lambda-cynalothrin	Thiacloprid
Beta-cyfluthrin	Merchurous chloride	Thiobencarb
Cynalothrn	Metaldehyde	Thiocylam
Cypermethrin	Metam-sodium	Thiodicarb
Alpha-cypermethrin	Methacrifos	Triazamate
Cyphermethrin	Methasulfocarb	Trichlorfon
Deltamethrin	Methyl isothiocyanate	Tricyclazole
Diazinon	Metolcarb	Tridemorph
Difenzoquat	Metribuzin	Vernlate
Dimethoate	Molinate	Xylylcarb
Dinobuton	Naban	
Diquat	Naled	

Table 4: Slightly hazardous (Class III) technical grade active ingredients of pesticides (common name) – Permissible in the SAGCOT Investment Project under IPM

Acephate	Chlormequat (chloride)	Dichlorbenzene
Acetochlor	Chloracetic acid	Dichlorophen
Acifluorfen	Chlorthiamid	Dichlorprop
Alachlor	Copper hydroxide	Diclofop
Allethrin	Copper oxychloride	Dienochlor
Ametryn	Cucloate	Diethyltoluamide
Amitryn	Cyhexatin	Difenoconazole
Azamethiphos	Cymoxanil	Dimepiperate
Bensultap	Cyproconazole	Dimetethachlor
Bentazone	Dazomet	Dimethamethryn
Bromofenoxim	Desmethryn	Dimethipin
Butroxydim	Dicamba	Dimethylarsinic acid
Chinomethionat	Dichlormid	Diniconazole

Table 5: Technical grade active ingredients of pesticides unlikely to present acute hazard in normal use (Common name) – Permissible in the SAGCOT Investment Project

Acephate	Mecoprop	Bentazone
Acetochlor	Mecoprop-P	Bromofenoxim
Acifluorfen	Mefluidide	Butroxydim
Alachlor	Mepiquat	Chinomethionat
Allthrin	Metalaxyl	Chlormequat (chloride)
Dinocap	Metamitron	Chloracetic acid
Diphenamid	Metconazole	Chloracetiamid
Dithianon	Methylarsonic acid	Copper hydroxide
Dodine	Metolachlor	Copper oxychloride
Emphenthrin	Myclobutanil	Nuarimole
Esrocarb	2-Napthyloxyacetic acid	Octhilinone
Etridiazole	Nitrapyrin	N-octylbicycloheptene
Fenothiocarb	Ametryn	Dicarboximide
Ferimzone	Amitraz	Oxadixyl
Fluazifop-p-butyl	Azamethiphos	Paclobutrazol
Fluchloralin	Bensultap	Pendimethalin
Flufenacet	Mecoprop	Pimaricin
Fluoroglycofen	Mecoprop-P	Pirimiphos-methyl
Flurprimidol	Mefluidide	Prochloraz
Flusilazole	Mepiquat	Propachlor
Flutriafol	Metalaxyl	Propanil
Fomesafen	Metamitron	Propargite
Furalaxyl	Metchnazole	Pyrazoxyfen
Glufosinate	Methylarsonic acid	Pyridaben
Hexazinone	Metolachlor	Pyridaphenthion
Hydramethylnon	Myclobutanil	Pyridate
Iprobenfos	2-Napthyloxyacetic acid	Pyrifenox
Isoprothiolane	Nitrapyrin	Quinoclamine
Isoproturon	Ametryn	Quizalofop
Isouron	Amitraz	Resmthrin
Malathion	Azamethiphos	Sethoxydim
MCPA – thioethyl	Bensultap	Simetryn
Sodium	Dithianon	Nuarimole
	Dodine	Octhilinone
Sulfluramid		
	Empenthrin	N-octylbicycloheptene
Tebuconazole		
Tebufenpyrad	Esrocarb	Dicarboximide
Tebuthiuron	Etridiazole	Oxadixyl
Thiram	Fenothocarb	Paclobutrazol
Tralkoxydim	Ferimzone	Pendimethalin
Triadimefon	Fluazifop-p-butyl	Pimaricin
Triadimenol	Fluchloralin	Pirimiphos-methyl
Tri-allate	Flufenacet	Prochloraz
Triclopyr	Fluoroglycofen	Propachlor
Triflumizole	Flurprimidol	Propanil
Undecan-2-one	Flusilazole	Propargite
Uniconazole	Flutriafol	Pyrazonxyfen
Ziram	Fomesafen	Pyridaben
	Furalaxyl	Pyridaphenthion
Cycloate	Glufosinate	Pyridate

Cyhexatin	Hexazinone	Pyrifenox
Cyproconazole	Hydramethylnon	Quinoclamine
Cymoxanil	Iprobenfos	Quizalofop
Dazomet	Isoprothiolane	Resmethrin
Desmetryn	Isoproturon	Sethoxydim
Dichlormid	Isouron	Simetryn
Dichlorbenzene	Malathion	Sodium chlorate
Dichlorophen	MCPA-thioethyl	Sulfluramid
Dichlorprop	Mecoprop	
		Tebuconazole
Diclofop	Mecoprop-P	Tebufenpyrad
Dienochlor	Mefluidide	Tebuthiuron
Diethyltoluamide	Mepiquat	Thiram
Difenoconazole	Metalaxyl	Tralkoxydim
Dimepiperate	Metamitron	Triadimefon
Dimethachlor	Metconazole	Triadimenol
Dimethamethryn	Methylarsonic acid	Tri-allate
Dimethipin	Metolachlor	Triclopyr
Dimethylarsinic acid	Myclobutanil	Triflumizole
Diniconazole	2-Napthyloxyacetic acid	Undecan-2-one
Dinocap	Nitrapyrin	Uniconazole
Diphenamid		Ziram

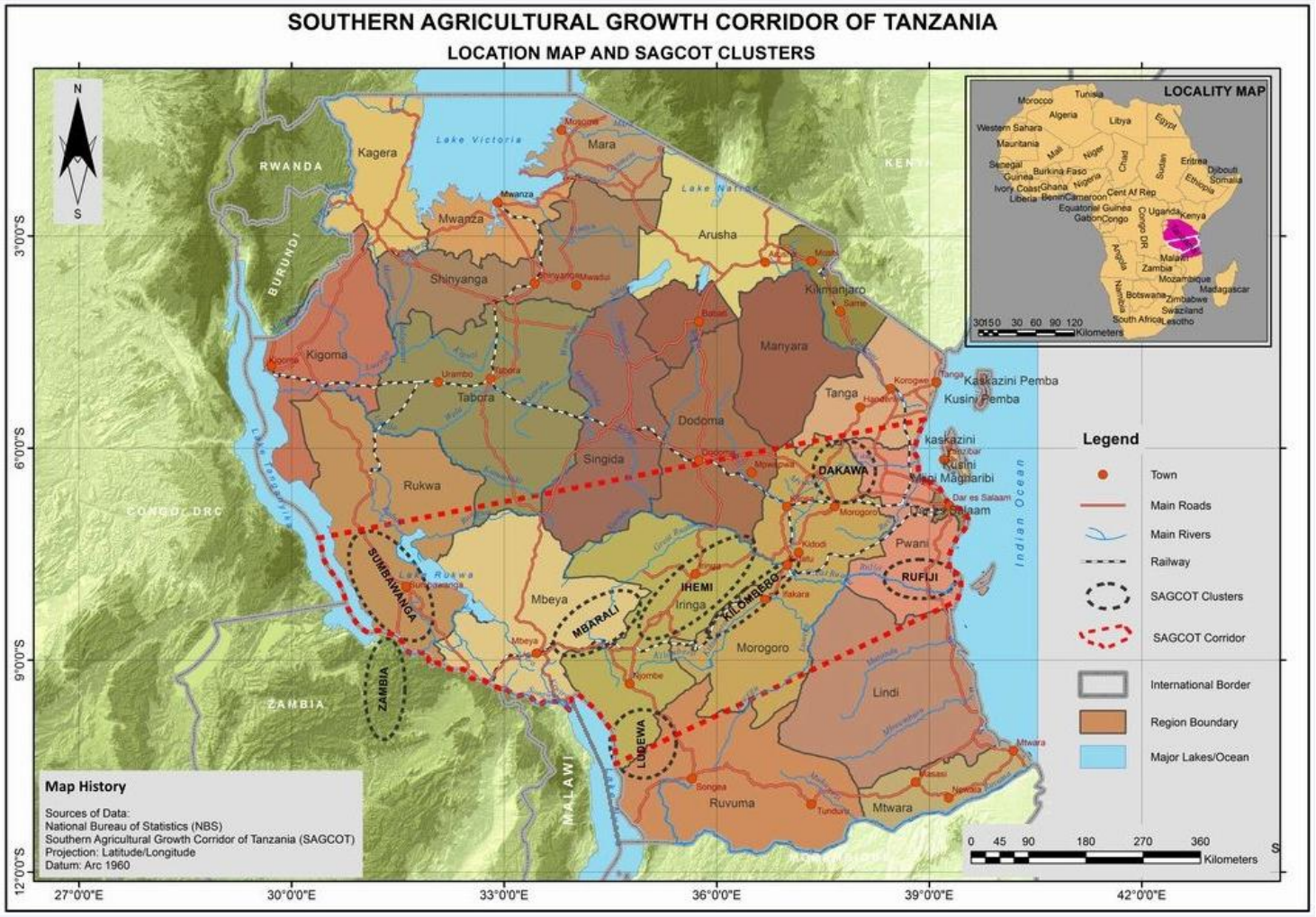
Table 6: Technical grade ingredients of pesticides unlikely to present acute hazard in normal use (common name) – Permissible in the SAGCOT Investment Project

Aclonifen	Chlorthal-dimethyl	Fenhexamid
Acrinathrin	Chlozolinate	Fenoxycarb
Alloxydin	Cinmethylin	Fenpiclonil
Amitrole	Cinosulfuron	Fenpropimorph
Ammonium sulfamate	Clofentezine	Fenuron
Ancymidol	Clomeprop	Fenuron-TCA
Anthraquinone	Clopyralid	Ferbam
Asulam	Cloxyfonac	Flamprop
Atrazine	Cryolite (c)	Flucarbazone-sodium
Azimsulfuron	Cycloprothrin	Flucycloxuron
Azoxystrobine	Cyclosulfamuron	Flufenoxuron
Benalaxyl	Cycloxydim	Flumetralin
Benafluralin	Cyhalofop	Flumetsulam
Benfuresate	Cyromazine	Fluometuron
Benomyl	Daimuron	Flupropanate
Benoxacor	Dalapon	Flupyrsulfuron
Benuslfuron-methyl	Daminozide	Flurenol
Bifenox	Desmedipham	Fluridone
Bioresmethrin	Diafenthiuron	Flurochloridone
Biphenyl	Dichlobenil	Fluroxypyr
Bispyribac	Dichlofluanid	Fluthiacet
Bitertanol	Diclomezine	Flutolanil
Borax	Dicloran	Tau-fluvalinate

Bromacil	Diclosulam	Folpet
Bromobutide	Diethofencarb	Fosamine
Bromopropylate	Diflubenzuron	Fosetyl
Bupirimate	Diflufenican	Gibberellic acid
Buprofezin	Dikeculac	Glyphosate
Butachlor	Dimefuron	Hexaconazole
Butralin	Dimethirimol	Hexaflumuron
Butylate	Dimethomorph	Hexythiazox
Captan	Dimethyl phtalate	Hydroprene
Carbendazim	Dinitramine	Hymexazol
Carbetamid	Dipropil isocinchomerate	Imazamethabenzmethyl
Carboxin	Dithiopyr	Imazapyr
Carpropamid	Diuron	Imazaquin
Chlomethoxyfen	Dodemorph	Imazethapyr
Chloramben	Ethalfluralin	Imebenconazole
Chloransulam methyl	Ethefon	Inabenfide
Chlorbromuron	Ethirimol	Iprodione
Chlorfluazuron	Ethofumesate	Iprovalicarb
Chloridazon	Etofenprox	Isoxaben
Chlorimuron	Famoxadone	Kasugamycin
Chlorothalonil	Fenarimol	Lenacil
Chlorotoluron	Fenbutatin oxide	Linuron
Chlorpropham	Fenchlorazole	Maleic hydrazide
Chlorpyrifos methyl	Fenchlorim	Mancozeb
Chlorsulfuron	Fenfuram	Maneb
Mefenacet	Pentanochlor	Rimsulfuron
Mepanipyrim	Phenmedipham	Siduron
Mepronil	Phenothrin	Simazine
Metazachlor	Phnylphenol	Spinosad
Methabenzthiazuron	Phosphorus acid	Sulfometuron
Methoprene	Phtalide	Sulphur
Methoxychlor	Picloram	Tebutam
Methyldymron	Piperonyl butoxide	Tecnazene
Metiram	Pretilachlor	Teflubenzuron
Metobromuron	Promisulfuron	Temphos
Metosulam	Probenazole	Terbacil
Metoxuron	Procymidone	Terbuthylazine
Metsulfuron methyl	Prodiamine	Terbutryn
Monolinuron	Prometon	Tetrachlorvinphos
2-(1-Naphthyl) acetamide	Prometryn	Tetradifon
1-naphthylacetic acid	Propamocarb	Tetramethrin
Napropamide	Propaquizafop	Thiabendazole
Naptalam	Propazine	Thidiazuron
Neburon	Propham	Thifensulfuron-methyl
Niclosamide	Propineb	Thiophanate-methyl
Nicosulfuron	Propyzamide	Thiocarbazil
Nitrothal-isopropyl	Pyrazolynate	Tolclofos-methyl
Norfluzaron	Pyrazosulfuron	Tolyfluanid
Ofurace	Pyrimethanil	Transfluthrin

Oryzalin	Pyriminobac	Triasulfuron
Oxadiazon	Pyripoxyfen	Tribenuron
Oxine-copper	Pyrithiobac sodium	Trietazine
Oxycarboxyn	Quinclorac	Triflumuron
Oxyfluorfen	Quinmerac	Trifluralin
Penconazole	Quinoxyfen	Trifulusulfuron-methyl
Pencycuron	Quintozene	Triforine
		Triticonazole
		Validamycin
		Vinclozolin
		Zine

Appendix 5: SAGCOT Corridor and Clusters



Note: International border shown for Lake Malawi is the median boundary: this is not accepted by all riparian states.