E4261 v1

NATIONAL ENVIRONMENT MANAGEMENT COUNCIL
BARAZA LA TAIFA LA HIFADHI NA USIMAMIZI WA MAZINGIRA

INTEGRATED PEST MANAGEMENT PLAN (IPMP) FOR KIHANSI CATCHMENT

FINAL REPORT

June 2013

Contents

List of Tables

List of Figures

ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ASDP	Agricultural Sector Development Programme
ASSP	Agricultural Services Support Programme
CBD	Convention on Biological Diversity
CGS	Community Grant Schemes
DALDO	District Agriculture and Livestock Development Officer
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EMP	Environmental Management Plan
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organisation
HIV	Human Immunodeficiency Virus
IPM	Integrated Pest Management Plan
IPMP	Integrated Pest Management Plan
IWRMP	Integrated Water Resources Management Plan
KCCMP	Kihansi Catchment Conservation Management Project
KST	Kihansi Spray Toad
LD50	Lethal Dose
LKEMP	Lower Kihansi Environmental Management Project
LNIP	Lower Nzoia Irrigation Project
LWCP	Landscape Wide Conservation Plan
MAFS	Ministry of Agriculture and Food Security
NEMC	National Environment Management Council
PHS	Plant Health Services
PMP	Pesticides Management Plan
POP	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
RYMV	Rice Yellow Mottle Virus
SMS	Subject Matter Specialist
SUA	Sokoine University of Agriculture
URT	United Republic of Tanzania
TPRI	Tropical Pesticides Research Institute
UDSM	University of Dar es Salaam
ULV	Ultra Low Volume
VEO	Village Extension Officer
WHO	World Health Organization
WSDP	Water Sector Development Programme

1. INTRODUCTION

1.1 The Kihansi Catchment

Administratively, Kihansi catchment covers three key Districts of Kilolo, Mufindi and Kilombero. Kilolo and Mufindi Districts are upstream of Kihansi River while Kilombero is downstream. In this context, management aspects for pesticides and other key issues will mainly focus on the upstream districts and its surrounding villages. The Kihansi gorge is located in a remote part of the country on the eastern part of Udzungwa Mountains which form part of the thirteen blocks of the Eastern Arc Mountains that run from Southern Kenya to Southern Tanzania. The Kihansi Gorge is approximately 85 kilometers southeast of Iringa, in southeastern Tanzania at $35^0$52'E and $8^0$14'S. The Eastern Arc Mountains comprise a portion of one of the 34 global biodiversity hotspots which are sites that contain unusually high concentrations of endemic plant and animal species and have experienced at least 70% loss in historical vegetation. The Kihansi gorge is an important site for biodiversity within the Udzungwa Mountains because of the unusual habitats that are found there including spray wetlands and montane forest. Furthermore, the Gorge sustains some endemic species that are found within a very restricted geographical range such as the Kihansi Spray Toad.

The catchment is characterized by steep slopes in the eastern part (Uhafiwa and Udzungwa area) and gentle slope in the western part (Ilogombe, Mkalasi and Mapanda area). Though the population in the area is few the field visit indicated that much of the catchment is being turned into agricultural land particularly in the Western part of the catchment, and much of the forest except the forest reserves of Udzungwa (in the eastern part of the escarpment), Idaho and Ihanga are being turned to agricultural land.

Surface water, ground water and drainage are all important in the Kihansi catchment's hydrology. There are three main rivers and streams in the Kihansi catchment. These are the Kihansi, the Udagaji and the Mhalala. (LWCP, 2005). The Kihansi catchment refers to the upper watershed area above the dam and hydropower station and lies between 1,200m and 2,200m above sea level. The high-biodiversity Udzungwa forest reserve covers the land to the east, while the rest of the catchment is covered with forest, grassland and bush. The catchment is 584 km^2 and spreads over the Kilolo and Mufindi administrative districts (Figure 1). The area receives rainfall between 1,000mm in the western and northern parts to 3,200 mm in the eastern part of the catchment. There are no significant high flow seasonal changes within years responding to wet and dry seasons and moderate flows are sustained throughout the year. For example, the median daily flow of the catchment at the river outlet NC3 is 12.43m^3/s with 7.23 m^3/s of flow available 95% of the time from the catchment.

There are three main forests within the upstream catchment of the Kihansi River. These are Udzungwa Scarp, Ihangana and Idewa. These forests form important part of catchment in the area.

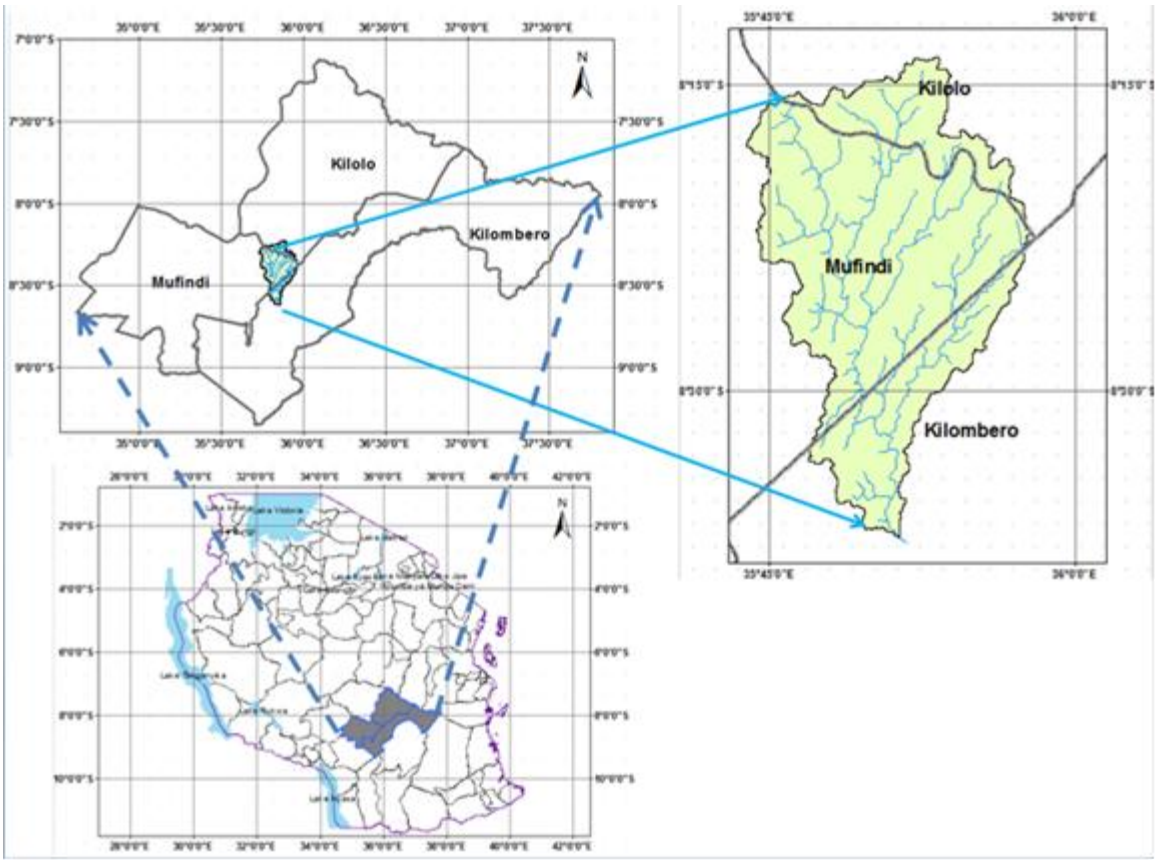

Figure 1. Districts that will be impacted by project activities within the catchment

(Source: Valimba, 2013)

1.2 Climate

The climate of the Kihansi catchment is dominated by the Indian Ocean monsoon. The rainy season starts in November and continues to May peaking in April. The catchment receives about 1,944 millimeters of rainfall annually. The lower part of the catchment is hotter and drier than the upper parts which are cooler. The highest temperature is experienced during January and February and lowest temperature during June and July (Environmental Management Plan, 2004). The volume of rain falling between November and March varies greatly, and there is a marked dry season from June to October. The mono-modal distribution of rainfall contrasts with the bi-modal pattern in the northern part of the Eastern Arc mountains – some parts of which are humid (i.e. receive at least 100 millimetres of rain in every month of the year). The long period without rain has implications for the vegetation, as the area becomes susceptible to fire during the dry season.

1.3 The Kihansi Catchment Conservation and Management Project

Due to its significance in terms of biodiversity conservation within the Eastern Arc, the construction of a hydropower plant in the mid-1990s led to the formulation of long term conservation measures and ecological monitoring of especially endangered and threatened species such as the Kihansi Spray Toad, endemic coffee and butterfly species. These conservation and monitoring measures were implemented through the Lower Kihansi Environmental Management Project. Recognising the importance of this catchment and the work that is currently on going to support catchment conservation activities under the ID funded Water Sector Support Programme, the Government of Tanzania has requested for additional support from the GEF to mainstream conservation activities in the catchment conservation activities. This support is through the World Bank implemented 'Kihansi Catchment Conservation and Management Project – KCCMP'.

'

The KCCMP is aligned under the CBD with five major Aichi Biodiversity Goals for 2011 – 2020: Strategic Goal A - Mainstreaming biodiversity across government and society; Strategic Goal B – Reduce direct pressures on biodiversity and promote sustainable use; Strategic Goal C – Improve the status of biodiversity by safeguarding ecosystems, species, and genetic diversity; Strategic Goal D - Enhance the benefits to all from biodiversity and ecosystem series; and Strategic Goal E – Enhance implementation through participatory planning, knowledge management, and capacity building.

The project will be implemented within the three key Components:

Component 1: *Develop operational guidelines for conducting Environmental Flow Assessment and a sustainable financing plan for the management of the Kihansi catchment*. The objective of this component is to incorporate biodiversity conservation at a planning level into Integrated Water Resource Development and Management Planning (IWRDMP) under the Water Sector Development Programme (WSDP). To fully operationalize biodiversity conservation in river basin planning in Tanzania, an operational framework and guidelines relevant to river basin planning and EIA, which integrates environmental flow assessment, are required.

Component 2: *Conserve endangered species in the Kihansi catchment*. This component focuses on operational level interventions in the Kihansi catchment to ensure the conservation of critically endangered plant and animal species and their habitat and sustainably managed over the long-term. The component has two subcomponents namely S*pecies and habitat conservation* and *Community conservation*.

Component 3: *Project Management and Coordination*. The National Environment Management Council (NEMC) will be responsible for project coordination at the national, regional, district and village levels. The component will provide support for office operating costs including annual audit costs.

1.4 Objectives of having the IPMP

The World Bank supports a strategy that promotes the use of biological or environmental control methods and reduces reliance on synthetic chemical pesticides", and "in appraising a project that will involve pest management, the World Bank assesses the capacity of the country's regulatory framework and institutions to promote and support safe, effective, and environmentally sound pest management. The World Bank and the borrower will hence incorporate in the project components to strengthen such a capacity. Due to this precondition, the purpose of preparing this Integrated Pest Management Plan (IPMP) for Kihansi catchment is to: (i) assess the current and anticipate pest problems in the programme areas; (ii) develop a pest management plan (PMP) by using the recommended best-practices; (v) develop monitoring and evaluation systems for the various pest management practices of the PMP based on the government laws and the World Bank policy.

3 METHODOLOGY

3.1 The Consultation process

This IPMP for Kihansi catchment was prepared after carrying out extensive reviews on the available documentation regarding the catchment during the operation of the Lower Kihansi Environmental Management Project (LKEMP), consultations with different stakeholders during the development of an Environmental Impact Assessment (EIA) for Kihansi catchment, and discussions with District Agricultural and Livestock Officers and District Natural Resources Officers specifically aimed at focusing on pesticides issues. Discussion was carried out in the three key Districts of Kilolo, Mufindi and Kilombero and was guided by a prepared checklist. Key crops, pests, diseases and weeds were identified during these discussions. However, only those crops or agricultural activities that will have an impact on the Kihansi river catchment and its existing biodiversity will be discussed in this report.

During the preparation of this report, the existing IPMP which was developed by the Ministry of Agriculture through the Agriculture Service Support Programme and specific reports on pesticides use in the catchment which were prepared as a result of two surveys that were carried out by the Tropical Pesticides Research Institute (LKEMP, 2005, 2010) have been used as key reference documents.

4. POLICY AND LEGAL FRAMEWORK FOR IMPLEMENTING THE IPMP

4.1 Key policies relevant to the implementation of the project

4.1.1 The National Environmental Policy (1997)

The Environmental Policy focuses on the satisfaction of basic needs for humans and protecting the environment in the cause of development. The policy also recognizes the need to ensure food security and eradication of rural poverty through the promotion of production systems, technologies and practices that are environmentally sound. 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. The IPMP as a planning tool shall be used to integrate environmental considerations in the decision making process in order to ensure sustainability. The plan will also address the following policy objectives with respect to environmental management in agriculture: i) to ensure sustainability, security, equitable and sustainable use of natural resources; ii) to prevent and control degradation of land, water, vegetation, and air; iii) to conserve biological diversity of the unique ecosystems the country; iv) to raise public awareness and understanding of the essential linkages between environment and development; and, v) to promote individual and community participation in environmental action.

4.1.2 The National Agricultural and Livestock Policy (1997)

The ultimate goal of having NAL 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 and livestock keepers. The policy's main objectives include: i) to ensure basic food security for the nation and to improve national standards of nutrition, by increasing output, quality and availability of food commodities; ii) to improve standards of living in the rural areas through increased income generation; iii) to increase foreign exchange earnings for the nation by encouraging production and increased exportation of agricultural and livestock products; iv) to promote integrated and sustainable use and management of natural resources such as land, soil, water and vegetation in order to conserve the environment; and, v) to provide support services to the agricultural sector, which cannot be provided efficiently by the private sector.

In relation to the *Plant Protection Services* measures have been taken to improve and strengthen the services in order to minimise crop losses resulting from pests and diseases. The Ministry strongly advocates using IPM approaches to be disseminated to farmers through the agricultural extension services, and has in place supervisory and regulatory instruments to register, license, monitor and supervise manufacturers, importers, distributors and users of agricultural inputs such as pesticides and herbicides.

4.1.3 The National Water Policy (2002)

Water resource is one of the major inputs for socio-economic activities. There are various socio-economic uses of water that compete for limited resources particularly during droughts and times of scarcity. Water allocation priorities have been defined in the NWP, but clear guidelines for both prioritization of water use at different times of year to address

the growing competition for water as well as for allocation of water for ecosystem uses are lacking, resulting into conflicts among users. The policy, however, states that priority use is the supply of water for domestic use followed by water needed to maintain ecosystem functions or minimum environmental flow.

4.1.4 Rural Development Policy (1996)

The Rural Development Policy augments the Development Vision for Tanzania and serves to lay down the parameters for a Rural Development Strategy. The policy focuses on four key issues; i) promotion of widely shared economic growth; ii) increasing opportunities and access to social and economic services; iii) reducing risks and vulnerability; and, iv) enhancing good governance. In the context of the proposed KCCMP the policy states that for the planning of special and protected areas, *"The government shall ensure sustainable and profitable utilisation of the natural resources for the benefit of rural people by involving local communities in management and utilisation of these resources".*

4.1.5 Agriculture Sector Development Programme (ASDP, 2003)

The ASDP identifies the need to streamline crosscutting issues and multi-sector activities. The programme identifies the following as important cross-cutting issues, mainly Environment, HIV and AIDS, gender, forestry, fisheries, education, health, water supply and rural infrastructure (e.g. rural roads). The ASDP (2003) underscores the importance of promoting environmental research through linkage with the Vice President's Office and the National Environment Management Council (NEMC). It recognizes the linkage between subsistence agriculture and poverty, hence the need for promoting agricultural productivity and farm income as well as household food security. This proposed project will emphasize on sustainable farming and operation practices.

4.1.6 National Strategy for Urgent Actions on Land Degradation and Water Catchments (2006)

The National Strategy for Urgent Actions on Land Degradation and Water Catchments is a recent effort by the Government to deal with the serious encroachment and degradation of land and water sources which has accelerated the severity of the impacts of drought. Poor management and weak control of water uses (particularly for irrigation) in the country is leading to inadequate inflows of water for hydropower generation. Power rationing as a result of inadequate water available for hydro-electric power production has become widespread and regular.

The strategy identifies 12 environmental challenges, cites example of areas seriously affected for each challenge and prescribes actions required in addressing each challenge in a given time-frame. One of the environmental challenges identified in the Strategy is environmental degradation resulting from agricultural activities in mountain slopes, basins and water sources. The activities of the proposed project will be carried out in such a way that environmental degradation such as destruction of water sources and pollution are minimized.

4.2 Legal Framework

4.2.1 The Environmental Management Act (2004)

The EMA Cap 191 has directed the establishment of environmental management units at each sector, with the responsibility of ensuring compliance on environmental matters. The sector environmental unit has, among others, the responsibilities of; i) advising and implementing policies of the government on the protection and management of environment; ii) coordinating activities related to the environment; iii) ensure that environmental concerns are integrated into the Sectors' development planning and project implementation in a way which protects the environment; iv) prepare and coordinate the implementation of environmental action plans at the national and local levels; v) refer to the Council any matter related to the enforcement; and, vi) 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.

Furthermore, the Minister has the powers to make regulations regarding the prevention and control of pollution. 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. The responsible Institution will give immediate notice of the discharge to NEMC and the 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 pesticides in agriculture.

4.2.2 The Plant Protection Act No. 13 (1997)

This Act has made provisions for consolidation of Plant Protection Act, 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.

As regards to this Act, the activities of Tanzania Pesticides Research Institute have been incorporated into the Plant Protection Act. In relation to IPM, importation of biological control agents is not allowed unless under the prescribed permit by the Ministry.

4.2.3 Tropical Pesticide Research Institute (TPRI) Act No. 18 (1997)

This is an Act to establish the Tropical Pesticide Research Institute, to provide for the research and pesticide control. The key functions of the Institute include; i) to carry out and to promote pesticides research and to evaluate and disseminate the findings on the fundamental aspects of pesticides application and behaviour in relation to the control of tropical pests; ii) to supervise and regulate the manufacture, importation, distribution, sale, and use of pesticides in the country; and iii) to administer regulations made under the provision of this Act.

The KCCMP will ensure that any chemicals used in this irrigated project are approved by TPRI and are applied as per TPRI guidelines.

4.2.4 The Water Resource Management Act (2009)

The Act provides for institutional and legal framework for sustainable management and development of water resources; outlines principles for water resources management; for prevention and control of water pollution; and provides for participation of stakeholders and general public in implementation of the National Water Policy. Its main objective is to ensure that the country's water resources are protected, used, developed, conserved, managed and controlled in ways that meet the basic human needs of present and future generations, prevent and control pollution of water resources and protect biological diversity especially the aquatic ecosystems.

The Act stipulates that any owner or occupier of land whose activities or processes are likely to cause pollution of a water source, shall take all reasonable measures to prevent any such pollution from occurring, continuing or recurring. Failure to comply with such a directive, the Basin Water Board may take measures as it considers necessary to remedy the situation. In this context, the IPMP will strive to comply with the provisions of the Act.

4.3 World Bank Safeguard Policies

The World Bank Operational Policies (OP) and Bank Procedures (BP) Environmental Assessment – BP 4.01 and OP 4.01 require environmental assessment of projects that are considered to have potential adverse impacts upon the environment to help ensure that they are environmentally sound and sustainable.

Environmental Assessment is one of the 10 environmental, social, and legal Safeguard Policies of the World Bank, which aim at improving decision making, to ensure that project options under consideration are sound and sustainable, and that potentially affected people have been properly consulted.

In accordance with the Bank guidelines, KCCMP has been classified as category B. The following safeguards are triggered: Environmental Assessment (OP 4.01), Pest Management (OP 4.09), Forests (OP/BP 4.36) and Natural Habitats (OP/BP 4.04).

4.3.1 Pest Management (OP 4.09)

The policy supports safe, affective, and environmentally sound pest management. It promotes the use of biological and environmental control methods. A preferred solution is to

use Integrated Pest Management (IPM) techniques and encourage their use in the whole of the sectors concerned. The policy also aims at assisting proponents to manage pests that affect either agriculture or public health, supports a strategy that promotes the use of biological or environmental control methods and reduces reliance on synthetic chemical pesticides. For World Bank funded agriculture projects, pest populations are normally controlled through IPM approaches, such as biological control, cultural practices, and the development and use of crop varieties that are resistant or tolerant to the pest. The Bank may finance the purchase of pesticides when their use is justified under an IPM approach resort.

The policy calls for assessment of the nature and degree of associated risks, taking into account the proposed use and the intended users for procurement of any pesticide in Bank-financed projects. It is a requirement that any pesticides that will be used, will be manufactured, packaged, labelled, handled, stored, disposed of, and applied according to standards acceptable to the Bank.

This policy will be triggered by the project due to application of pesticides and herbicides in valley bottoms within the catchment and the potential topical treatment of selected individuals using fungicides in the reintroduced caged population in the spray wetlands in Kihansi Gorge.

4.3.2 Environmental Assessment (OP 4.01)

This policy requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus improve on decision making. The EA process takes into account the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and cultural property) and trans-boundary and global environmental aspects.

Operational Policy 4.01 further requires that the EA/ESMP report must be disclosed as a separate and stand-alone document by the Government of Tanzania and the World Bank as a condition for bank appraisal of this project. The World Bank system assigns a project to one of three project categories and the project has thus been screened and assigned an EA Category B. This category of projects are defined as projects likely to have potential adverse environmental impacts on human populations or environmentally important areas including wetlands, forests, grasslands, and other natural habitats and are less adverse than those of category A projects. These impacts are site specific, few if any of them are irreversible, and in most cases mitigation measures can be designed more readily than for Category A projects. The EA process for Category B projects such as the KCCMP examines the potential negative and positive environmental impacts and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance.

4.3.3 Natural Habitats (OP 4.04)

This policy aims at the conservation of natural habitats, like other measures that protect and enhance the environment. The policy is essential for long term sustainable development. The Bank therefore supports the protection, maintenance, and rehabilitation of natural habitats.

Natural Habitats are land and water areas where the ecosystems' biological communities are formed largely by native plant and animal species, and human activity has not essentially modified the areas primary ecological functions. The policy recognizes the important role of biological, social, economic, and existence value of natural habitats, including natural arid and semi-arid lands, mangrove swamps, coastal marshes, and other wetlands; estuaries, sea grass beds, coral reefs, freshwater lakes and rivers;

Therefore, the Natural Habitats policy may be triggered in certain cases because the investments proposed under the project may have potential impact within the catchment, where rivers and forests immensely contribute to the sustainability of critical ecosystems. The natural ecosystems of the wetlands, rivers and forests are known to support varying degrees of natural complexities of flora and fauna.

This policy requires that any activities that adversely impact these ecosystems are successfully mitigated so that the balance of the ecosystems are maintained or enhanced. Specific measures to enhance ecosystem functions must include provision for monitoring and evaluation to provide feedback on conservation outcomes and to provide guidance for developing or refining appropriate corrective actions.

4.3.4 Forests (OP 4.36)

This operational policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development. The policy recognizes the role forests play in poverty alleviation, economic development, and for providing local as well as global environmental services. Success in establishing sustainable forest conservation and management practices depends largely on changing the behaviour of all critical stakeholders and instituting partnership among the stakeholders to accomplish what an individual institution cannot achieve alone.

The forest strategy suggests three equally important and interdependent pillars to guide future Bank involvement with forests including harnessing the potential of forests to reduce poverty, integrating forests in sustainable economic development, and protecting vital local and global environmental services and forest values. This policy applies to the World Bank-financed investment projects that have or may have impacts on the health and quality of forests, projects that affect the rights and welfare of people and their level of dependence upon or interaction with forests and projects that aim to bring about changes in the management, protection, or utilization of natural forests or plantations, whether they are publicly, privately, or communally owned.

This safeguard will be triggered as some of the catchment management activities will involve planting of trees to stabilize slopes as well as reduce erosion rate and siltation to the river.

5. KEY INFORMATION ON THE CATCHMENT

5.1 The Existing Landscape and Land use Pattern

Kihansi catchment is characterised by undulating landscape, and hence most of the farming activities are carried out on the steep slopes or in river valleys to take advantage of the moisture throughout the year. The landscape of the Kihansi catchment is mainly characterized with six major units, comprising: (i) highlands with complex of flat to sloping terrain; ii) highlands with a complex of flat and gently sloping terrain; iii) sloping and moderate to very steep terrain; iv) hills with complex of flat and gently sloping terrain; v) hills with complex of flat and gently sloping terrain, sloping and moderate to very steep terrain; and, vi) low hills with complex of sloping and moderate to very steep terrain and lowlands with complex of sloping and moderate to very steep terrain (Figure 2; Table 1; LWCP, 2005).

Downstream is the Kilombero valley, which is a floodplain.

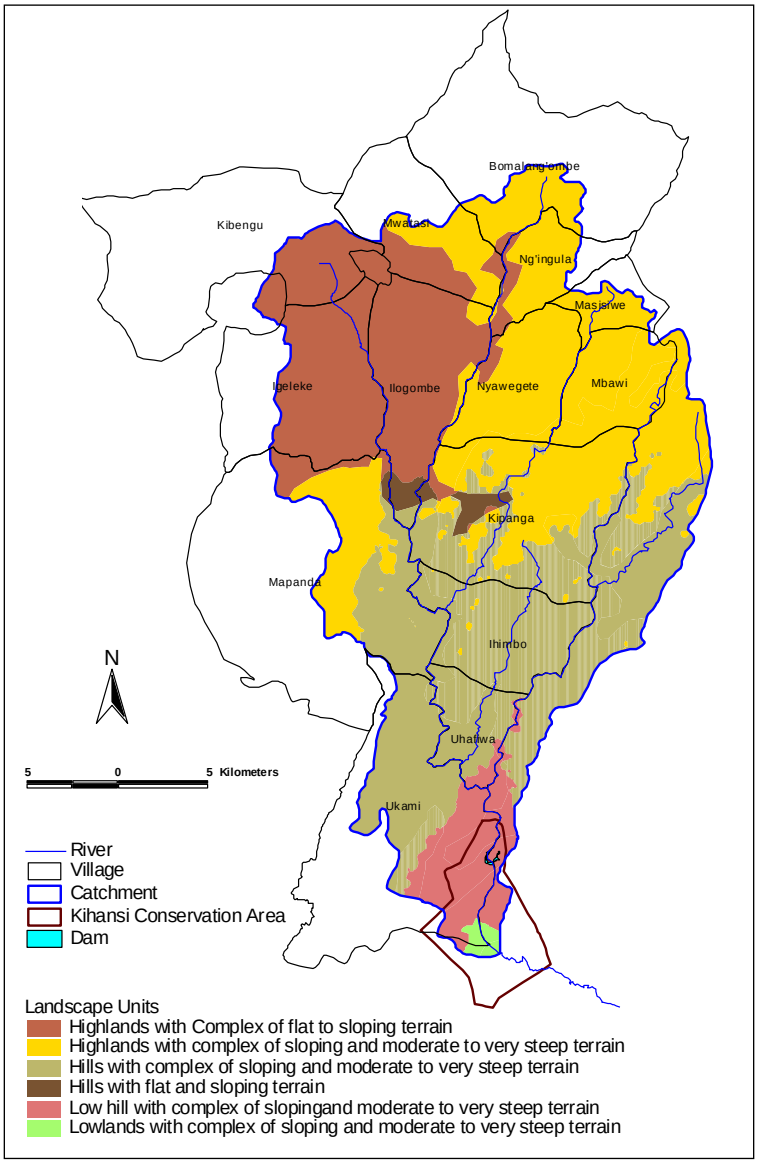

Figure 2. Existing landscape upstream

(Source: LWCP, 2005)

Table 1. Landscape units and their corresponding land uses.

S/N	Landscape unit type	Geomorphology	Land cover	Land use
1	Highlands with flat to sloping terrain. (Area of 14230 ha)	Highest areas in the catchment with flat to sloping terrain i.e. 0 – 7% at the of altitude of about 1700m a. s. l.	Forest, Grassland and bushland, farms, settlements	Protected district Forest Reserve, agricultural activities under different farming systems (scattered to intensive cultivation) and residential areas
2	Highlands with complex of flat and gently sloping terrain, and moderately steep to very steep terrain. (Area 21542 ha)	Highest areas in the catchment with complex of flat to gently sloping terrain, sloping (8 to 13%) to very steep terrain(> 14%) at an altitude of about 1700m a.s.l.	Forest, Grassland and bushland, farms, settlements	Protected National Forest Reserve, agricultural activities under different farming systems (scattered to intensive cultivation) and residential areas
3	Hills with flat and sloping terrain (800 ha)	Hilly areas of the catchment with 0% -7% slopes at an altitude of 1400 to 1700 m a. s. l.	Grassland, bushland and farms	Scattered agricultural activities.
4	Hills with complex of flat and gently sloping terrain, sloping and moderate to very steep terrain (Area 20969 ha)	Hilly areas of the catchment with complex of flat and gently sloping terrain, sloping terrain 8% - 13% and moderate to very steep terrain of more than 14% at an altitude of 1400 to 1700 m a. s. l.	Forest, Grassland and bushland, farms, settlements	Protected National Forest Reserve, agricultural activities under different farming systems (scattered to intensive cultivation) and residential areas
5	Low hill with complex of flat and gently sloping terrain, sloping and moderate to very steep terrain (Area 3785)	Hilly areas of the catchment with complex of flat and gently sloping terrain, sloping terrain 8% - 13% and moderate to very steep terrain of more than 14% at an altitude of 500 to 1400 m a. s. l.	Grassland and bushland, farms, settlements	Agricultural activities under different farming systems (scattered to intensive cultivation) and residential areas
6	Lowlands with complex of flat and gently sloping terrain, sloping and moderate to very steep terrain (Area 314)	Lowland areas of the catchment with complex of flat and gently sloping terrain, sloping terrain 8% - 13% and moderate to very steep terrain of more than 14% at an altitude of less than 500m a. s. l	Forest, Grassland and bushland	Mainly TANESCO area and villages downstream

Source: LWCP (2005)

According to the ecological monitoring study carried out in 2006, no substantial changes in land cover/use were observed between 1994 and 2002. The only notable change is the abandonment of cultivation in the conservation units around the dam site. The area has changed from cultivation to grassland, bush-land and bush-land with emergent trees (Mwansasu, 2007). However, of recent, changes have been observed in the conversion of grasslands into woodlots, especially in the areas of Mufindi (Mapanda village) as woodlots are more profitable and income earned from timber is much higher when compared with food crops.

5.2 Key economic activities

Within the catchment, the key economic activities are agriculture, livestock keeping, aquaculture, forestry-related (plantation, beekeeping) and other nonfarming activities (petty trading, etc, Khatibu *et al*, 2008). Table 2 below shows some of the income earning activities that are carried out in the catchment. It is therefore important to note that most economic related activities do not involve use of agrochemicals except in a few crops that are of commercial importance (maize, beans, cabbages and rice).

Table 2. Economic activities that are currently being undertaken in the catchment

District	Types activities	Crops that are applied with agrochemicals
Kilolo (upstream)	*Crops*: maize, wheat, beans, round potatoes, cabbage, carrot, sweet potatoes and sweet pepper	**Maize**, **beans** and **cabbages**
	Fruit crops: peaches, pears, avocado, passion	
	Livestock: Piggery and dairy cows	Not significant
	Forestry: tree planting (indigenous and woodlots), nursery establishment, beekeeping	None
	*SME**: small shops, milling machine, mobile sawmill	None
Mufindi (upstream)	*Crops*: maize, beans, wheat, beans, Chinese cabbage, figili?, sweet potatoes, round potatoes, sunflower, pyrethrum	**Maize, beans, cabbage, round potatoes**
	Fruit crops: peaches, avocado, pears	
	Livestock: dairy goats and cows, piggery and poultry	Not significant
	Forestry: tree planting (indigenous and woodlots), nursery establishment	None
	SME: carpentry, tailoring, small shops, animal draft	None
Kilombero (downstream)	*Crops*: rice, maize, sesame, cassava	**Rice, maize**
	Livestock: piggery, dairy cows, chicken	Not significant
	Aquaculture: establishment of fish ponds	None
	Forestry: nursery establishment, beekeeping	None
	SME: rice mills, energy saving stoves, shops, carpentry	None

Source: Khatibu *et al*. (2008), plus interviews with District Agricultural and Livestock Officers. *SME**: Small and Medium Enterprises.

Crop production is the dominant economic and major land use activity undertaken by most of the households in the Kihansi Catchment area. Households in all of the villages in the catchment depend almost entirely on small scale crop production as their main source of livelihood to provide food to the household as well as cash income. Most of the food crops are cultivated both in the uplands during the rainy season and in the valley bottoms (*vinyungu*) during the dry season. Cultivation in the valley bottom streams draining into the Kihansi River affect water flows and accelerate erosion and sedimentation downstream (LWCP, 2004).

Flat cultivation and use of ridges are the common cultivation practices in the KCCMP area. Use of ridges as a cultivation practice is associated with the type of crop cultivated in the catchment rather than a soil and water conservation practise. More than 70% of the households in the catchment practise flat cultivation in the production of maize, beans, finger millet and wheat, while all households practice ridge cultivation when they grow peas and sweet potatoes both in the upland and valley bottoms (LWCP, 2004).

Apart from crop production, livestock keeping (dairy cows and piggery), establishment of tree nurseries, beekeeping and petty trading are among the activities that are being actively taken by the communities. Aquaculture is more common in the Kilombero area (downstream) than upstream in the catchment.

6. EXISTING AND ANTICIPATED PEST AND DISEASE PROBLEMS

6.1 Introduction

There are two key categories of activities that will involve use of pesticides in the catchment and which will be the main focus of this document: i) agricultural for the control of pests, diseases, nematodes and weeds; and, ii) potential treatment of selected KST in enclosures in the spray wetlands using topical fungicides to control chytrid fungus. The major crops targeted under IPMP within the catchment are maize, beans, rice, sweet potatoes and cabbages, which involve the application of agrochemicals and inputs such as fertilisers, herbicides, insecticides, nematicides and fungicides. Activities related to livestock keeping do not involve use of pesticides such as acaricides as there were no dips identified in the area.

Another important activity relates to the potential application of topical fungicides to control chytridiomycosis in the KST housed in enclosures in the spray wetlands. Since only selected animals in the enclosure will be bathed in a small container containing an antifungal compound and the bathing solution will be transported out of the gorge after animals are treated the impact of fungicides on the environment in the gorge ecosystem will be negligible.

6.2 Food Crops

The following crop calendar provided an overview of the time when most applications of agrochemicals occur:

			Month											
	Crop	**Activity**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
1	Maize	*Land preparation*												
		Planting												
		Weeding												
		Harvesting												
2	Rice	*Land preparation*												
		Planting												
		Weeding												
		Harvesting												
3	Beans	*Land preparation*												
		Planting												
		Weeding												
		Harvesting												
4	Round potatoes	*Land preparation*												
		Planting												
		Weeding												
		Harvesting												
5	Cabbages		Grown throughout the year (except during heavy rains) in valley bottoms											

Figure 3. Cropping calendar showing timing of different activities for key crops in the Districts of Kilolo, Mufindi and Kilombero.

The cropping calendar indicates that rainfed crops such as maize, rice are grown in the period that coincide with the onset of rains in November/December – June/July), round potatoes in March/April, beans in April/May – July/August, tomatoes in June/July – September/October while vegetables are grown between June and October upstream and throughout the year (except during heavy rains) in valley bottoms. Fertilisers such as Minjingu (Phosphate), Di-Ammonium Phosphate (DAP), Urea, Calcium Ammonium Nitrate (CAN) and Sulphate of Ammonia (SA) are applied during planting and after weeding, consecutively. Most of the pesticide applications occur between February and April upstream, while application in valley bottom crops is done almost throughout the year.

6.2.1 Maize

Maize is the major staple food that is grown all over the country, over a wide range of altitudes, ranging from the sea level to 2400 meter a.s.l. Iringa region is among the high producers of maize and makes an important contribution to the national grain basket. The major insect pests of maize found in this zone and their recommended management practises are listed on Table 3.

Table 3. Common pests and diseases and their proposed management practises

Pest		**Recommended management practices**
Insects that occur between planting and harvesting	Stalk borers (*Busseola fusca*)	- Stalks are buried or burned to eliminate diapausing larvae - Early sowing reduces infestation - Intercropping with legumes (beans,…) - Neem powder (4-5 gm i.e. pinch of 3 fingers) per funnel - Neem seed 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
	Seedling weevils *(Tanymecus* spp. & *Mesokeuvus* spp)	- Timely planting to escape damage - Scout the crop - Apply recommended pesticide

Pest		Recommended management practices
Post-harvest insects	Larger grain borer (LGB) Weevils Moths and rodents	- Selection of tolerant varieties - Timely harvest - De-husking and shelling - Proper drying - Sorting and cleaning of the produce - Cleaning and repair of the storage facilities - Use rodent guards in areas with rat problems - Use improved granaries - Use appropriate natural grain protectants where applicable or - Use recommended insecticides - 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.
Weeds (pre and post emergence)	All types See Appendix 1	- 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

Table 4. Pesticides used to control pre and post-harvest pests occurring in maize

Chemical		Chemical common name	Formulation	Application rate	Target pest	Comments
Insecticides	Pre-harvest				Stalk borers & armyworm	Apply 3-4 weeks after emergence
		Carbofuran Chlorpyrifos	5G			
	Post harvest	Cypermethrin	0.5% D	100gm/100kgs	LGB	
		Fenitrothion + Deltamethrin				Controlling major storage pest of maize
		Pirimiphos methyl	2% D	200-500gm/ 100kgs	All storage insect pests	Not good enough against

		Pirimiphos methyl + permethrin	1.6% + 0.3%D	100gm/100kgs	for all grains	LGB
Fungicides	Pre-harvest	Imdaclopid Metalaxyl Thiram	10% 10% 10%		For soil born disease	Maize seed treatment
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

Source: IPMP (2004) – updated in 2013

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. Therefore always consult the nearest plant protection extension worker if in doubt

6.2.2 Rice

Rice is an important food and cash and crop in the country, the Kilombero valley (downstream) being among the highest producers in the country. It is grown as rainfed (once a year) or irrigated and faces a number of pests and disease problems. However, most of them do not need pesticide application, especially in rainfed areas. Table 5 shows the key pests and diseases of rice.

Table 5. Major pests and diseases 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 - Use recommended plant spacing - Minimise simultaneous planting as this provides food continuously for the pest - 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.)	
	African armyworm (*Spodoptera exempta*)	- Resistance varieties - Stalk management in dry season
	Flea beetles (*Chaetocnema varicornis*)	- Suspected to be the key vector of RYMV. No known control measures.

Pests		Recommended management practices
	Rice hispa (*Dicladispa* sp)	- Found mostly in irrigated fields. Avoid stagnant water in the fields
Weeds	Cyperus rotandus, striga All types	- Early clean weeding - Use recommended herbicides if necessary
Diseases	Rice yellow mottle virus	- Field sanitation including burning 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 resistance varieties - Appropriate crop rotation - Timely planting - Burying crop debris
	Brown leaf spot (*Helminthosporium* spp)	
	Sheath rot (*Acrocylindrium oryzae*)	
Vermins	Birds Rats	- Scaring - Bush clearing - Early harvesting - Spraying against Quelea quelea

Source: IPMP, 2004

6.2.3 Beans (Phaseolus)

Common beans or phaseolus may be regarded as one of the principal sources of protein as well as income to most farmers in Tanzania. 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 contrast to large-scale farmers, who apply a wide spectrum of chemicals, small scale farmers mainly apply cultural practices 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 severe 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.

The 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.

Through breeding, a number of disease resistant and tolerant varieties are available to farmers. The following Table 6 shows general pest management options for beans, with a specific focus for Southern highlands (of which Iringa falls in this zone) and Northern zone.

Table 6. Major pest problems of beans and recommended management practices

Pest			**Recommended management practices**
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
	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
		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 -

Pest			Recommended management practices
		Bean common mosaic virus (BCMV)	- Plant tolerant/resistant varieties if available - Effect good control of aphids -

6.2.4 Sweet Potatoes

Sweet potatoes play an important role during periods of food scarcity and are part of the survival strategies employed by rural households. The crop suffers from a number of major pests including mole rats and insects which may provoke other pathogens to enter and cause rotting and sweet potato weevils. Factors that contribute to the presence of these pests include monocropping, use of infested planting materials (weevils), drought and late harvesting. Table 7 presents pests and management practices.

Table 7. Major pests of sweet potato and recommended management practices

Pest		Recommended management practices
Insects	Sweet potato weevil (*Cylas brnneus)*	- 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

Pest		Recommended management practices
	Sweet potato virus disease (SPVD)	- Sanitation - Use of resistant varieties - Crop rotation
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 parts of repellent plant species into tunnels
	Monkeys, wild pigs	- Local scaring

Source: IPMP (2004)

6.2.5 Round potatotes

Round potatoes are commonly grown in Mufindi district. Not much information is available on the management aspect, but since it within the Solanaceae family, management practises for the crops of similar family (eg tomatoes) will apply. Table 8 shows most important pests and diseases for the crop, while Table 9 shows the types of pesticides that are used to control pests and diseases in round potatoes. Information on the management practises is based on tomatoes.

Table 8. Major pests of round potatoes and their control measures

Pest		Recommended management practices
Insects		-
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
Diseases	Late blight (*Phytophthora infestants)*	- 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, de-suckering, 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
	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 - Choose seedbed in clean uninfected area
	Bacteria spot (*Xanthomonas campestris pv. Vesicatoria*)	- Use clean seed - Three year crop rotation - Avoid working in fields under wet conditions - Avoiding of injuries to fruits

Table 9. Pesticides used in round potatoes

Chemical	Chemical common name	Formulation	Application rate	Target pest
Insecticides	Pirimiphos methyl	50%EC		fruit worms
	Carbaryl	85%WP	12-24gms/10l water	
	Profenofos	72%EC		Whitefly
Nematicide	Dacomet Carbofuran	 5G		Nematodes
Fungicides	Metalaxyl + Mancozeb	7.5% + 56%WP	3.0 to 3.5 kg/ha	Early and 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	

6.2.6 Horticultural crops

Iringa region is well known for growing several horticultural crops such as tomatoes, cabbages, carrots, beans and sweet pepper. However, within the catchment tomatoes (which use heavy applications of agrochemicals) are not grown on a commercial scale, similar with carrots and sweet pepper. For the purpose of this report only management practises associated with cabbages will be discussed.

Cabbages are mainly grown for income generation and farmers apply available chemicals mainly to control insect pests. The most common disease affecting cabbage is black rot which is caused by bacteria *Xanthomonas campestris* and spreads through infected crop debris and seed. 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 black rot. Other potential IPM control techniques include seed dressing with *Bacillus* bacteria, seed treatment with hot water or antibiotics, and resistant varieties.

Diamond black moth and cabbage head worm (in lowland areas) are the most devastating insect pests affecting cabbages (Table 10). 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*.

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.

Table 10. Major pests of brassicas and recommended practices

Pest	**Recommended management practices**
Pests: Diamondback moth (*Plutella xylostella)* Aphids *(Brevicoryne brassicae)*	- 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 - Application of fermented cow urine (10-14 days fermentation) - Use botanicals (Neem oil, chillies, etc.)
Diseases: Black rot (*Xanthomonas compestris*)	- 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
Cabbage club rot (*Plasmodiaphora brassicae)*	- Crop rotation - Plant in well drained soils - Adjust soil pH to alkaline by adding hydrated lime
Dumping off (*Fusarium Spp, Rhizoctonia spp. Pythium spp and Phytophthora spp)*	- Provide good soil structure and drainage - Avoid overwatering - Apply wood ash in seedbed - Sterilise seedbed - Use treated beds

Pest	Recommended management practices
	- Pricking excessive seedlings (thinning)
Bacterial soft rot *(Erwinia carotovora var. carotovora, Pseudomonas spp)*	- Avoid harvesting when the weather 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: IPMP (2004)

6.2.7 Migratory and outbreak pests

The key migratory and outbreak pests of economic significance especially downstream of the catchment are armyworm (*Spodoptera exempta*), birds, notably the Quelea (*Quelea quelea* spp) and rodents (particularly the field rats). Management of such pests is co-ordinated by the Plant Health Service of the Ministry of Agriculture and Food Security as in some cases it involves aerial spraying or control measures to be taken on large areas.

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. In the maize and paddy fields, 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. If an outbreak occurs farmers are advised to do the following:

i. Regular surveillance so that any management option is taken as soon as possible.
ii. Keep the store clean so that presence of any rodents is noticed early.
iii. Make the store rat-proof in order to discourage rodents from entering.
iv. Place the traps in strategic positions.
v. Use recommended rodenticide such as anticoagulant poisons, preferably as ready-made baits.
vi. Encourage team approach for effectiveness. The larger the area managed or controlled with poison, the more effective the impact

Birds (Quelea quelea). 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. Bird pest problems in agriculture have proved difficult to resolve due in large to the behavioural versatility associated with flocking. 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 varieties and alternative cultural practices have been evaluated. All the methods have minimal value in situations where bird pressure is high. The aerial spraying of chemical (parathion and later fenthion) on nesting and roosting sites is the most widely used technique to date. Currently, only fenthion 60%ULV aerial formulation is being used. 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 led 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 which carry out organic matter cycling, predators and parasitoids of crop pests, while others like bees assure pollination of crops and wild plants and produce honey.

The risk to 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. The Food and Agriculture Organisation (FAO) has been encouraging the use of IPM approaches to the problem of bird attacks on cereal crops to minimise the use of pesticides.

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 90% are recorded. Armyworm outbreaks vary from year to year and outbreaks are predetermined by weather conditions.

Armyworm 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 traps that are distributed throughout the country to assist in forecasting potential outbreaks in the area. The traps are placed at district offices, research stations and in large-scale farms. Farmers are advised to inspect their fields for signs of infestation. If the crop is attacked, farmers should spray with the recommended pesticide. Both ULV and knapsack sprayers can be used depending on available formulation in the outbreak areas.

A new natural control for armyworm is being developed by using a naturally occurring virus known as nucleopolyhedrovirus as biological control measure in place of toxic insecticides. This disease kills armyworm caterpillars and can reduce infestation of up to 90%.

6.3 Amphibian diseases

The disease of major concern to amphibians in the catchment is known as cutaneous chytridiomcycosis, which is caused by a pathogenic fungus *Batrachochytrium*

dendrobatidis. The fungus mostly causes death in post-metamorphic frogs and infects the keratinized mouthparts of tadpoles. Mortalities in affected amphibians result from the disruption of normal epidermal functioning that leads to osmotic imbalance through loss of electrolytes. Chytridiomycosis has been identified as the causal agent of amphibian population decline and extinction worldwide.

Control measures include use of fungicides such as Itraconazole especially in captivity, and application of biological control agents (bacteria) that inhibit the growth of chytrid fungus on the skin. Initial studies have shown promising results as the bacteria that is closely related to *Janthinobacterium lividum* has been identified to have antichytrid fungi activity by producing a metabolite which contains the active antifungal molecule 'vilacein'. Studies are ongoing to confirm such a behaviour in the identified bacteria (Misinzo, 2011).

Precautional treatment of KST with antifungal drugs prior to re-introduction in the wild (Kihansi Gorge) may not result in negative impacts to the gorge environment because no chemicals are going to be used to treat the environment prior to the release of the KST. Rather selected KST which are housed in enclosures may be bathed in an antifungal solution. The antifungal solution will be transported out of the gorge. Thus the only contact between antifungal chemicals and the environment is via the skins of the KST.

7. ENVIRONMENTAL AND SOCIAL IMPACTS OF PEST MANAGEMENT ACTIVITIES

7.1 Pest Management Approaches

Management of key crop pests, diseases and weeds within the catchment will involve using the recommended cultural practises, biological control methods and use of recommended agrochemicals.

7.1.1 Cultural control

This method includes weeding and all those recommended husbandry practises that are beneficial to the crop such as mulching to conserve water, crop pruning and thinning, trap crops, timely weeding and resistant varieties that can withstand pest infestation and diseases. Resistance can be achieved through the conventional breeding methods or genetic modification.

Crop sanitation practises improve the health of the crop and hence its ability to withstand pest and disease infestation. Intercropping between crops of different families (eg maize and beans) greatly reduces pest build up in the area.

Weeding is an important cultural control measure. Weeds compete with planted crops for light, nutrients and space. They occur whenever crops are grown and usually can survive in a wide agro-ecological range. Common weeds found in most of the areas under agriculture are listed Appendix 1.

Weeds can be removed by pulling, shallow cultivation, burning, planting of cover crop to minimise their emergence and solarisation (covering weed infested land with black polythene and leaving it for days under sunshine). Herbicides can also be applied prior to planting (pre emergence) or after planting (post emergence).

7.1.2 Physical and mechanical control

These are measures used to kill the insect pests by disrupting the physiology or environment that sustains them. Examples include hand picking, hot water treatment of planting materials to control nematodes, sun drying of stored grains to reduce humidity and use of insect traps to attract insect pests such as armyworms.

Physical control of chytrid fungus at the gorge involves dipping the shoes (disinfection) to prevent inadvertent transfer of pathogens such as the chytrid fungus.

There is also the possibility of using indigenous plants to prepare botanical extracts that are used to control pre and post-harvest pests as shown on Table 11.

Table 11. 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
Mstafeli	Sour soap	*Annona muricata*
Mtopetope	Bull-ox heart	*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*
Mbangi mwitu	Mexican marigold	*Tagetes* spp
Alizeti mwitu	Wild sunflower	*Tithonia diversifolia*

Source: IPMP (2004)

7.1.3 Biological control

Biological control involves the use of biological agents and predators to control pests and diseases. This has been practised and found successful in crops like cassava and water hyacinth (IPMP, 2004). It involves conservation or optimisation of the impact of living agents that already exist in the ecosystem, artificially increasing the number of natural enemies in the agro-ecosystem, introducing the new natural enemies' species where they were none before.

The Bt (*Bacillus thuringiensis*) bacteria and wasps have been widely used to control pests in crops such as cabbage.

Another potential strategy for controlling chytrid fungus in the KST population is to isolate bacteria on the skin of the KST which inhibits chytrid fungus and inoculating released animals with this bacteria. Since the bacteria species is host specific, the impact on the environment and other anuran species will be negligible.

7.1.4 Chemical control

Chemical control involves the use of herbicides, insecticides and fungicides to manage weeds, pests and diseases. They can be applied as liquid spray, in the form of granules, powder or fumigation in stores.

Under the Pesticides Control Regulations GN 401 of 1999), the TPRI is responsible for registration of pesticides, which are hence recommended as part of IPM components in all production/cropping systems as indicated in the previous sections of this report. Those

pesticides in WHO class Ib, namely, chlorpyrifos, quinalphos, carbofuran, and isazophos, some of which are WHO class I and II are still featuring on the list of registered pesticides, although most of them are in the phase out list. A list of different categories of pesticides is found in the IPMP.

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.

Of the three approaches, chemical control is found to be easy and produces quick results, especially in high value and improved crops such as maize and tomatoes. In places where the use of improved varieties has been propagated, packages of high-yielding varieties with high inputs of agro-pesticides and fertilisers made farmers dependent on high external inputs.

7.2 Pesticides as a control agent

In the context of this report, a pesticide is any agent used to kill or control any pest. Pests can be insects, rodents or birds, unwanted plants (weeds), fungi, nematodes, bacteria and viruses. Pesticides are by their nature poisons, and their use entails a degree of risk to humans, birds, fish, bees, and other living things, as well as to the environment. Excessive use of agrochemicals can cause harm to humans, flora and fauna within the environment.

i. Environmental risks that may arise include contamination of surface and underground water, which may occur during application or transportation of pesticides from one location to another within the catchment. As previously discussed, farmers cultivate in the valley bottom (vinyungu) and do spray their crops with chemicals, especially maize and vegetables. The pesticide containers and sprayers are washed in the streams which enter into the Kihansi River. Containers are also disposed haphazardly, which may hence lead to groundwater contamination through accidental spills, burying and leaching. This water is used for human related activities (drinking, washing), as well as flora and fauna within the catchment.

   Application on field crops may also cause risk of contamination of existing non-target flora and fauna, of which most are beneficial to the environment.

ii. Exposure to humans through contaminated water or during spraying. Almost all farmers in the area do not wear protective gear when applying these pesticides or use proper equipment such as the knapsack sprayers. Apart from farmers, even stockists and transporters have the possibility of being affected by these pesticides as safety measures are not being followed.

   The process of mixing the pesticide can lead to exposure via inhalation, dermal contact, and incidental ingestion, mostly from releases of pesticide vapours, and solutions. Vapour releases can occur when liquid concentrated emulsions are diluted. Workers can inhale the vapours or the particulates or be exposed through dermal contact. Spills could

also pose significant risk, especially for children who ingest the resulting residues that are left on surfaces such as floors.

iii. Residues on produced food may have an impact even outside the catchment.

iv. Pesticides are by their nature bio-poisons and whereas they are beneficial against pests (targets) their use may inadvertently harm other organisms (non-targets) leading to significant biodiversity losses. Loss of biodiversity makes ecosystems more vulnerable to changes in the environment, with lower genetic diversity and fewer species to support fundamental ecosystem functions such as breaking down pollination. All but the biologically based pesticides being recommended are broad spectrum in effect, thus will have negative impacts on beneficial arthropods in the case of insect and mite pests.

- Fungicides directed at plant diseases will reduce densities of beneficial pathogens that kill insects and mites as well as weeds. Insecticides can also kill herbivorous arthropods feeding on weeds.
- A number of crops are pollinated by bees that are not only sensitive when flying but also can carry contaminated pollen and nectar to the hive potentially killing off the whole colony.
- Rodenticide baits are highly toxic to humans and can also be eaten by domestic and wild animals with serious repercussions as they affect all mammals.
- Treated seeds can also be eaten by birds.
- Residues have also been found in fish species within the catchment.
- Specific studies that were carried out in relation to upstream pesticides use detected the presence of compounds such as p,p'-DDT and Organochlorines such as Heptachlor and Endosulfan in fish, sediment and soil samples (TPRI, 2005, 2010). These pesticides have serious toxicological impacts on aquatic organisms, since their accumulation can cause significant harm to the ecology of the Kihansi gorge, which contain unique and endemic species only found at the gorge.

7.3 Recommended classes of pesticides to be used within the catchment

Pesticides that are recommended for use within the catchment fall within the WHO classes III and IV which pose less danger when compared with Classes I and II. These are Pyrethroids, Carbamates and Organophosphates (Figure 3). Organochlorines such as Endosulfan are not recommended as they have been found to be toxic to amphibians (TPRI, 2010).

a) *Pyrethroids*: All pyrethroids are highly toxic to bees and highly toxic to fish and other aquatic organisms, except Deltamethrin which has low toxicity to other aquatic organisms. All other pyrethroids have very low toxicity to birds but highly toxic to mammals. In terms of persistency in the environment, only bifenthrin is persistent, the rest of the pyrethroids have low to medium persistency. Although Bifenthrin does not accumulate in the environment, there is potential for bioaccumulation in aquatic organisms for other pyrethroids.

b) *Carbamates*: Carbamates are highly toxic to bees, some aquatic organisms, mammals and birds. On the other hand, this insecticide has very low toxic properties on fish. In general, carbamates have low to medium indications for persistency in the environment and bioaccumulation in organisms.

c) *Organophosphates*: Organophosphates have different characteristics and impacts on different organisms depending on the type of insecticide. For example, Fenitrothion has low toxicity on mammals and fish and is not persistent in the environment, but it is highly toxic to bees, birds and other aquatic organisms, like crustaceans and aquatic insects and has a medium toxicity to aquatic worms. It has moderate to medium potential to bio accumulate in organisms. Malathion is highly toxic to bees, but it has very low impacts on fish and other aquatic organism and has very low potential to persist in the environment or bio-accumulate in organisms. It shows low to medium toxicity on mammals and birds. Pirimiphos-methyl is highly toxic to fish and other aquatic organisms and has a high potential to persist in the environment. It has low to medium toxic effects on mammals and bees. It does not bio-accumulate in organisms.

Pesticide	**Mammals**	**Birds**	**Fish**	**other aquatic organisms**	**Bees**	**Persistence**	**Bioaccumulate[1]**
Pyrethroids							
Carbamates							
Organophosphates							

[1]Bioaccumulation in the environment, not in mammalian bodies (mammalian detoxification produces different results).

Key to colours:

High Toxicity

Medium to High Toxicity

Medium Toxicity

Low to Medium Toxicity

Low Toxicity

Data Not Found

Figure 4. Level of toxicity to different types of pesticides

Source: Lower Nzoia Irrigation Project IPMP (2013)

8 MITIGATION AGAINST CHEMICAL CONTROL MEASURES

The following measures are proposed to mitigate the potential adverse impacts likely to occur as a result of pesticide use in the catchment. The primary mitigation measures include training in safe and judicious pesticide use and management; delivery of a mix of Information Education and Communication approaches targeting farmers, pesticide operators and teams; provision of Personal Protective Equipment (PPE); training to farmers, and thorough and consistent supervision and monitoring. It is also important to have appropriate pesticide storage facilities and training and equipping health facilities with adequate exposure treatment drugs.

Table 12 shows the proposed mitigation measures for various impacts that may arise due to application of pesticides in the catchment.

8.1 Training of pesticide applicators

At least two selected farmers per village will receive detailed training on the emergency steps to take if accidental exposure of the chemical occurs through ingestion, eye or dermal contact with the chemical. This training will be conducted in collaboration with the TPRI and PHS of the Ministry of Agriculture. It will include of drills to test knowledge of the operators. The following are basic first aid procedures that will be included in the training program as part of handling pesticide poisoning.

- Follow the first aid instructions on the pesticide label. Take the pesticide can or label to the doctor or medical practitioner if seeking medical assistance.
- For poison on skin: remove contaminated clothing and drench skin with water, cleanse skin and hair thoroughly with detergent and water, and dry victim and wrap in blanket.
- For chemical burns: remove contaminated clothing, wash with large quantities of running water, cover burned area immediately with loose, clean soft cloth (Do NOT apply ointments, greases, powders or other medications to burn).
- Poison in Eye: wash eye quickly but gently, hold eyelid open and wash with gentle stream of clean running water for 15 minutes or more (Do NOT use chemicals or medicines in the water; they may worsen the injury)
- Inhaled Poison: carry victim to fresh air immediately, open all windows and doors, loosen tight clothing and apply artificial respiration if the victim is not breathing or victim's skin is grey or blue. If the victim is in an enclosed area, do not enter without proper protective clothing and equipment
- Poison in mouth or swallowed: rinse mouth with plenty of water, give victim large amounts (up to 1 liter) of milk or water to drink, induce vomiting only if the pesticide label instructs you to do so.

Table 12. Mitigation measures to be employed by using various control methods at the catchment

Control method	Impacts (+ve or –ve)	Mitigation measure
Cultural:		
- Crop sanitation, mulching, pruning, thinning	- Improves the health of the crop and its ability to fight pests and diseases - Improves soil condition and helps to minimize weed infestation	- No mitigation measure required
- Weeding	- Pulling of weeds have minimum impacts to the environment	- No mitigation measure required
	- Use of herbicides will have an impact on environment	- Use measures proposed under chemical control
- Use of resistant varieties and tissue culture	- Use of pesticides is minimized and hence beneficial to environment	- No mitigation measure required
Mechanical:		
- Use of weeders and tillage equipment	- Minimizes use of herbicides - Health and safety may be impacted if operators are not skilled	- Use skilled manpower to operate the equipment - In case of accidents use proper procedures for treatment
- Insect traps (light, pheromones)	- Early detection of pests results in early application of pesticides before the situation becomes critical	- No mitigation measure required
- Manual weeding	- Involves no use of pesticides, hence friendly to environment - High labor costs - May impose danger to laborers (snake bites, etc)	- If any accident occurs, rush the affected to hospital or nearby dispensary for treatment
Biological:		
- Application of biological control agents such as Bt (*Bacillus thuringiensis*), wasps - Isolation of bacteria on the KST which inhibits chytrid fungus	- Cost effective - Involves no use of pesticides hence no environmental or health risks - Applied selectively against one or two pests - Takes long to generate results, hence cannot be used in emergency situations - Possibility of acquiring a new host if the old host is completely eliminated	- If the situation of acquiring new host arises, try to establish the minimum population required for survival
- Botanical extracts (neem, tephrosia)	- Friendly to the environment - Application rates are based on estimates. Usually preparation of extracts need a lot of material (such as leaves) for one application	- Try to establish an effective application rate

Control method	Impacts (+ve or –ve)	Mitigation measure
Chemical: - Lack of knowledge on the toxicity of pesticides to transporters and those involved in application	- Exposure to humans through inhalation, ingestion or dermal contact	- Train store keepers, transporters and all those involved with handling of pesticides. Training should be in the aspects of toxicity, steps to be taken in case of accidents or emergency, combustibility and handling of vehicle contamination - Female farmers who will be handling pesticides must be warned of the possibility of foetal exposure - Use of drugs recommended for treatment of exposure[1] (
-	- High costs of PPEs which makes farmers reluctant to purchase them	- Provide Personal Protective Equipment (helmet, respirators, overalls, gloves and rubber boots) or protective clothing (long legged trousers, long sleeved shirts, boots and wide brimmed hat) - Train on how to use and the benefits of using such gear
- Indiscriminate disposal of pesticide containers	- Risks of containers being used by other persons and children	- Containers should never be used to carry anything else apart from the intended formulation - Containers not to be used in households - Follow container disposal procedures provided by PHS or TPRI if available
- Water contamination	- Health risks to humans - Impacts on biodiversity (birds, bees, fish) - Impacts on amphibians at the gorge - Reduced densities of beneficial species	- Train farmers on health risks associated with improper use of chemicals - Regular monitoring of water quality. Check the presence of Organochlorines and other pesticides to determine if a lethal dose has been reached

[1] Drugs recommended for treatment: Promethazine (Promethazine Hydrochlorides), Panadol (Paracetamol), Diazepam (Benzodiazapine/Diazapam), Lorazepam (Lorazepam), Calamine cream (Calamine, zinc oxide, glycerol, phenol, purified water, sodium citrate, betonite), Vitamin E (Tocopherol, fragrance, mineral oil, deionized water, sodium hydroxide, stearic acid), Hydrocortisone cream (1% Hydrocortisone), Salbutamol (Sulbutamol 100 mcg suspended inert aerosol, Salbutamol tablets (Salbutamol Sulphate 4 mg) Activated Charcoal . Source: LNIP IPMP (2013).

Control method	Impacts (+ve or –ve)	Mitigation measure
- Contamination of pesticides to other amphibians	- Precautional treatment of KST with antifungal drugs prior to re-introduction in the wild (Kihansi Gorge) may not result in negative impacts to the gorge environment because no chemicals are going to be used to treat the environment prior to the release of the KST. Rather selected KST which are housed in enclosures may be bathed in an antifungal solution. The antifungal solution will be transported out of the gorge. Thus the only contact between antifungal chemicals and the environment is via the skins of the KST. -	- Application will only be carried out in the captive breeding facilities when need arises

8.2 Measures to be taken when storing pesticides

In order to mitigate risks associated with pesticide storage at the farm level, the following key points will serve as key mitigation steps:

- All primary pesticide storage facilities will be double-padlocked and guarded.
- All the storage facilities will be located away from nearby water courses, domestic wells, markets, schools, hospitals etc.
- Soap and clean water will be available at all times in all the facilities.
- A trained storekeeper will be hired to manage each facility.
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed.
- All the warehouses will have at least two exit access routes in case of fire outbreak.
- A fire extinguisher will be available in the storage facilities and all workers will be trained on how to use this device.
- Warning notices will be placed outside of the store in the local language(s) with a skull and crossbones sign to caution against unauthorized entry.
- All pesticides will be used and any remnants will be stored under lock and key until the next round of application.
- Application of First In/First Out approach in pesticide distribution will be practiced to avoid accumulation of expired pesticide

8.3 Avoiding the accumulation of obsolete pesticides

A number of preventive steps will be undertaken to avoid the difficult problems and costly solutions of pesticide waste disposal. These include the judicious purchase, collection, transport, storage and use of pesticides. Recently NEMC, through the Africa Stockpile Programme (funded by FAO) has completed the transportation of obsolete pesticides which had accumulated at various locations throughout the country. This has been an expensive venture as all obsolete pesticides had to be transported out of the country for their disposal. It is important to take key steps to avoid further accumulation of such pesticides.

- When purchasing pesticides calculate the amount needed and try to avoid being left with a surplus.
- Do not buy a large container if only a small portion of its contents is likely to be used by the end of the season.
- Buy the pesticide that is needed for application (eg against stalk borers or armyworm).

8.4 Challenges faced during the implementation of mitigation measures

Although several mitigation measures have been proposed, the implementation of these will face several challenges, some of which are highlighted below:

a) Farmers in the catchment are not used to wearing protective clothes when spraying pesticides. Mixing of chemicals is done without using gloves or goggles to prevent their eyes.
b) Pesticides are stored in the house together with other products.
c) The type of pesticide to use or application dosage depends upon the recommendations from ‘peers’ or fellow farmers. In some cases information on labels is not readable due to poor storage conditions, hence the application rate is an estimate.
d) There are no proper storage facilities as indicated under Section 8.2.
e) No container disposal plan is in place, in the catchment or in the Region as a whole.

9. PESTICIDE MONITORING PLAN (PMP)

9.1 Objectives of having a PMP

The main objectives of the PMP will be to monitor pests and diseases vectors and mitigate negative environmental impacts associated with pest control in the three key districts within the catchment. The plan provides decision-makers, community and farmer groups with clearer guidelines on IPM approaches and options to reduce crop and livestock losses with minimal personal and environmental health risks. Overall, the PMP will empower farmer groups to contribute significantly to householde and national economies. The specific objectives of the PMP are to:

a) Design and delivery of training programme for crop specialists, programme stakeholders and farmers to assist users in planning and implementing IPM activities specific for Kihansi catchment.

b) Promote biological and ecological approaches for farmers to learn, test, select and implement IPM options for reducing pest losses while promoting biodiversity, monitoring to serve as early warning systems on pest status, alien invasive species, benefical species, and migratory pests.

c) Establish linkages with the Plant Protection Act (1997) and the TPRI Act (1979) so as to be in compliance with international conventions and guidelines on pesticide use.

d) Monitor and evaluate the benefits of IPM including its impact of food security, the environment and health

9.2 Key Implementation Strategy

IPM is a knowledge intensive and interactive methodology. The need to accurately identify and diagnose pests and pest problems and understand ecosystem interactions will enable farmers with biological and ecological control opportunities to make pragmatic pest control decisions. Thus the success of IPM depends on developing and sustaining institutional and human capacity to facilitate learning for making informed decisions in integrating scientific and indigenous knowledge to solve specific problems for the benefit of biodiversity that will be conserved.

Capacity building will be achieved through farmer-based collaborative management mechanisms where all key stakeholders shall be regarded as equal partners whose role will be to facilitate the process and provide technical direction and any other support necessary for the implementation of PMP. The pilot PMP should be designed to build on, and to some extent strengthen existing national capacities for the promotion and implementation of IPM.

The major actors and partners will include the following:

a) Farmers who will be organized into Farmer Groups for training and adoption of IPM practices. The farmers will be facilitated to set up Community IPM Action Committees to coordinate IPM activities in their areas.

b) The Ministry of Agriculture and Food Security's Plant Health Services have the key mandate to ensure proper implementation of crop protection and pest management activities. The District Councils within the pilot PMP will provide staff like DPPOs, SMS and VEOs for training and collaborate with NGOs/CBOs in the public awareness campaign, production of extension materials, radio and television programmes in the respective districts. They should also monitor the prevalence of inputs supply by the dealers.

c) National Environmental Management Council (NEMC) will collaborate with the District Councils and MAFS to train beneficiary Farmer Groups in environmental management.

d) Agriculture Service Providers and NGOs will be trained to provide services to farmers and on proper storage of agricultural inputs to support the field implementation of IPM and other pilot PMP.

NEMC in collaboration with MAFS-PHS and District Councils (DALDOs) will prepare a comprehensive training manual on pesticide use and management, targeting different actors within the program, ranging from extension service providers, actual farmers, loaders, mixers, transporters, government staff among others. The training manual or guides to be developed for use must be simplified and easy to understand and participatory in nature with in-built and demonstration/ practical sessions as much as possible.

Extensive training programs for farmers, farmer leaders, extension workers, and stockists will be organized accordingly. Such trainings will be crop based with farmers being organized into groups led by a farmer leader. The method for training farmers and farmer leaders is based on on-farm demonstration where farmer groups are led, step by step in growing the crop during the season from planting to harvest and increasingly into post-harvest activities and even marketing.

9.3 Institutional Arrangements

Effective supervision and monitoring of implementation of the pilot district PMP will be done through the Project's management team (NEMC, District Councils-DALDOs, and MAFS). NEMC will be the major coordinating and will be responsible for the preparation/approval of the annual workplans from the Districts within the catchment.

Farmers IPM Action Committees will be formed with facilitation by the programme, to act as the body to discuss general pest problems, make decisions about IPM programs and facilitate IPM networks within and between Farmer Groups. Subject Matter Specialists (SMS) will develop IPM packages in collaboration with the IPM specialists who will provide technical support to Farmer Groups for all IPM

activities, including identifying crop protection issues, IPM training, study tours, community IPM networking, field visits to other beneficiary Farmer Groups.

9.4 Monitoring and Evaluation Arrangements

Successful implementation of the pilot district PMP will require regular monitoring and evaluation of activities undertaken by the Farmer Groups. The focus of monitoring and evaluation will be to assess the build-up of IPM capacity in the Farmer Groups and the extent to which IPM techniques are being adopted in crop production, and the economic benefits that farmers derive by adopting IPM. It is also crucial to evaluate the prevailing trends in the benefits of reducing pesticide distribution, application and misuse.

9.4.1 Monitoring indicators

Indicators that require regular monitoring and evaluation during the programme implementation include the following:

a) Number of farmers who have successfully received IPM training;
b) Numbers of Farmer Organizations that nominated members for IPM training*;*
c) Numbers of farmers who have adopted IPM practices as crop protection strategy in their crop production efforts.
d) Number of crop production systems that have adopted IPM;
e) Rate of adoption of IPM practises by farmers;
f) Economic benefits: increase in crop productivity (and overall income) due to adoption of IPM practices;
g) Numbers of operations IPM networks and types of activities undertaken;
h) Extent to which pesticides are used for crop production before and after the onset of the project;
i) Pesticide application rate per farmer.
j) Number of farmers using pesticides (when compared with the baseline value);
k) Overall assessment of: activities that are going according to plans; activities that need improvements; and remedial actions required

Monitoring of pesticide use will also be vital in order to detect health and environmental impacts that may arise, and to provide advice on reducing risks associated with the impacts. Depending on the circumstances, this may include monitoring of:

a) Appropriate use of protective gear
b) Incidence of poisoning
c) Pesticide residues in food crops and drinking water
d) Contamination of surface water and ground water
e) Environmental impact (key focus will be KST at the gorge)

9.4.2 Participatory Impact Monitoring

Participatory Monitoring and Evaluation Framework will follow a feedback principle in which results or impacts of any interventions can be traced to the activities/inputs.

Either by using conventional pest management method or IPM, the feedback will allow for evaluation of the methods used followed by corrective action (incorporation of additional control methods, plan adjustments, strategy changes. The results of the activities will form the basis of the factsheets to be used in monitoring.

The steps involved in participatory Monitoring and Evaluation should include:

a) Stakeholder Analysis and identification of Monitoring and Evaluation team;
b) Setting up objectives and expectations for monitoring;
c) Selection of Impacts to be monitored (Variables/Indicators);
d) Develop Indicator sheets;
e) Develop and test the tools to be used in data collection (Usually Participatory Rural Appraisal tools are used);
f) Collect the data from as many sources of stakeholders as possible.

The following indicators will be incorporated into a participatory monitoring and evaluation plan:

a) Types and number of participatory learning methods (PLM) delivered;
b) Category and number of extension agents and farmers trained;
c) Practical skills/techniques most frequently demanded by districts and farmers;
d) Category and number of farmers who correctly apply the skills they had learnt;
e) New management practices adopted by most farmers;
f) Level of pest damage and losses;
g) Rate of adoption of IPM practices;
h) Impact of the adoption of IPM on production performance of farmers
i) Assessment of the data and discussion for a arranged on regular basis

NEMC as an Implementing Agency will undertake the following monitoring role:

a) Ensure that IPMP monitoring systems are set up accordingly.
b) Facilitate the recruitment of an independent Consultant to undertake external monitoring of the IPMP implementation.
c) Refine monitoring indicators as per the circumstances.

10. WORKPLAN AND BUDGET

The programme management team of KCCMP will be responsible in the implementation of this PMP and estimated costs for the various activities under this program will be built in the budget. The core activities will be as follows:

a) Coordination
b) Development of IPM packages for the pilot districts PMP
c) IPM orientation workshops
d) Training of trainers and Farmer groups training
e) Public awareness and promoting the adoption of IPM practices
f) Field guides/training materials for production, purchase and distribution
g) Farmers field days
h) Field visits and study tours
i) Crop pest surveillance and updating pest/disease database at PHS
j) Annual workshops on progress and lesson learnt
k) Participatory IPM research and development
l) Monitoring and evaluation

A tentative cost estimate of budgetary requirements is given in Table ?? below:

Table 13. Tentative costs for capacity building and implementation of IPM activities in the 3 Districts of Kilolo, Mufindi and Kilombero

Line item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
1. Capacity building						
IPM orientation	5,000	5,000	5,000	5,000		**20,000**
Training of Trainers	20,000	20,000	20,000			**60,000**
Farmer Group training (baseline)	15,000	15,000	15,000	15,000	10,000	**70,000**
Preparation of IPM material (6 crops - Maize, beans, irish potatoes, cabbages, rice, sweet potatoes)	31,000					**31,000**
Field preparation for training	20,000	20,000	20,000	20,000		**80,000**
Surveillance (monthly: 3 districts x 6 months x 3 persons x 3 days)	15,000	15,000	15,000	15,000	15,000	**75,000**
Training on proper use of agrochemicals	20,000	20,000	20,000	20,000		**80,000**
Workshop	6,000	6,000	6,000	6,000		**24,000**
Total	**132,000**	**101,000**	**101,000**	**81,000**	**25,000**	**440,000**
Implementation of pilot community conservation investments						**-**
Purchase of initial material for training	60,000	60,000	60,000	60,000	57,000	**297,000**
Field days	10,000	10,000	10,000	10,000	10,000	**50,000**
Public awareness (tvs, documentaries, field visits)	20,000	20,000	20,000	20,000	10,000	**90,000**
Pest specialist	5,000	5,000	5,000	5,000	3,000	**23,000**
M&E	10,000	10,000	10,000	10,000	10,000	**50,000**
Meetings with Stakeholders	10,000	10,000	10,000	10,000	10,000	**50,000**
Total	**115,000**	**115,000**	**115,000**	**115,000**	**100,000**	**560,000**

12. BIBLIOGRAPHY

Agriculture Sector Development Programme (ASDP). 2003.

Agricultural Sector Development Program (ASDP-ASSP). 2004. Integrated Pest Management Plan (IPMP).

Khatibu, F. H.; Kibbassa, J.; Hirji, R. and W.D. Newmark. 2009. Balancing Conservation and Sustainable Development: Lessons from the Lower Kihansi Hydropower Project in Tanzania.

Khatibu, F. H; Mwikila, D.; Kibola, A. and Cheche, G. 2008. Assessment of Community Grant Schemes funded by LKEMP: Kilolo, Mufindi and Kilombero Districts.

Kihansi Catchment Conservation Management Project (2013). Draft proposal

LKEMP. 2004. Updated Environmental Management Plan (EMP) for the Lower Kihansi Hydropower Project.

LKEMP. 2005a. Landscape Wide Conservation Plan for the Upstream Kihansi Catchment.

LKEMP. 2005b. Toxicological Surveys for the Presence of Pesticides at Kihansi Gorge and its Catchment Areas. Consultancy Report prepared by the Tropical Pesticides Research Institute (TPRI), Tanzania.

LKEMP. 2009. Monitoring for the Presence of Pesticide Residues at Kihansi Gorge and its Catchment Areas. Consultancy Report prepared by the Tropical Pesticides Research Institute (TPRI), Tanzania.

LKEMP. 2011. Implementation Completion Report.

Lower Nzoia National Irrigation Project – IPMP 2013.

Misinzo, G. 2011. Development of Resistance to Chytridiomycosis in Kihansi Spray Toad (*Nectophrynoides asperginis*) Consultancy report prepared by the Sokoine University of Agriculture.

Mittermeier, R.A., Gil, P.R., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. and G. A.B. Da Fonseca. (2004) *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. Cemex, Mexico City, Mexico.

Mkhandi, S. and Birhanu, B.Z. (2007) "Hydrological Studies for Kihansi Catchment". Ecological Monitoring report for the Lower Kihansi Environmental Management Project.

Mwansasu, S. 2007. Land Cover (In: An Ecological Monitoring Programm for the Lower Kihansi Gorge Ecosytem.

Newmark, W.D. (2002) *Conserving Biodiversity in East African Forests: A Study of the Eastern Arc Mountains.* Ecological Studies No. 155. Springer-Verlag, New York.

The Environmental Management Act. 2004.

The National Agricultural and Livestock Policy. 1997.

The National Environmental Policy. 1997.

The National Strategy for Urgent Actions on Land Degradation and Water Catchments. 2006.

The National Water Policy. 2002.

The Plant Protection Act No. 13. 1997.

The Rural Development Policy. 1996.

The Tropical Pesticide Research Institute (TPRI) Act No. 18. 1997.

The Water Resources Management Act. 2009.

The World Bank Operational Policies 4.01, 4.04 and 4.09.

Appendix 1. Major weeds of Tanzania

Family	Common Names	Scientific Names
Amaranthaceae	Devil's horsewhip Pigweed, Spiny pig weed	*Achyranthhes aspera* *Amarathus dubious* *A. spinosus*
Commelinaceae	Wondering jew	*Commelina benghalensis* *C. African C. diffusa*
Asteraceae (Compositae)	Starbur, Goat weed, Black jack	*Acanthospermum Hispidum,* *Ageratum conyzoides,* *Bedenpilosa biternata* *B. schimperi B. steppia*
Cyperaceae	Nutgrass, Watergrass	*Cyperus rotundus, C. escutenters* *C. difformis, Kyleinga squanuleta*
Euphorbiaceae	Asthma weed Blue weed Castor oil plant	*Euphorbia hirta,* *E. prostrate, E. inaequalaters,* *Ricinus communis*
Poaceae (Graminae)	Star grass Couch grass Wild rice Sword grass	*Cynodon dactylon,* *Digitaria scalarum,* *Oryza barthii,* *Imperata cylindrica*
Caesalpiniaceae	Mauritius thorn	*Caesalphinia decapetala*
Mimosaceae	Wait a bit thorn Whistling thorn	*Acacia brevispica,* *A. hockii*
Malvaceae	Flower of an hour	*Abutilon mauritano, Hibiscus triomnum, Sida acua, S. alba*
Asteraceae (Compositae)	Wild lettuce, Mexican marigold	*Launaea cornuted, Lactic caponises,* *Tagetes minute*
Brassicaceae (Cruciferae)	Rape	*Brassica napus*