President's Malaria Initiative

Supplemental Environmental Assessment: Mozambique Indoor Residual Spraying (IRS) Project

IRS Activities in 8 Select Districts in Zambezia Province, Mozambique, using World Health Organisation (WHO)-Approved Insecticide Class of Pyrethroids for five-year period (2011-2015).

Contract No. GHN-I-01-09-00012

Prepared for:
U.S. Agency for International Development/Mozambique

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August, 2011

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Submitted on:
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List of Acronyms

ACT	Artemisinin-based Combination Therapy
ADS	Automated Directives System
BCC	Behavior Change Communication
DHS	Demographic Health Survey
EIA	Environmental Impact Assessment
EMMP	Environmental Monitoring and Mitigation Plan
GFTAM	Global Fund to Fight AIDS, Tuberculosis, and Malaria
IEC	Information, Education, and Communication
IPTp	Intermittent Preventive Treatment in pregnancy
IRS	Indoor Residual Spraying
ITN	Insecticide-treated Net
LLIN	Long-lasting Insecticide-treated Net
M&E	Monitoring and Evaluation
MISAU	Ministry of Health
NGO	Nongovernmental Organization
PMI	U.S. President's Malaria Initiative
PPE	Personal Protective Equipment
RTI	RTI International
SEA	Supplemental Environmental Assessment
SUAP	Safer Use Action Plan
UNEP	United Nations Environment Program
UNFAO	United Nations Food and Agriculture Organization
USAID	U.S. Agency for International Development
USG	U.S. Government
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme

Executive Summary

Malaria is a major cause of morbidity and mortality in Mozambique. Approximately 6 million cases are reported each year. Malaria accounts for approximately 40% of all outpatient visits and 60% of pediatric hospital admissions. Malaria is also the leading cause of death among children admitted to pediatric services. Malaria transmission takes place year round with a seasonal peak extending from December to April. All 21.5 million people in Mozambique are considered to be at-risk of malaria, including an estimated 3.6 million children less than five years and almost one million pregnant women.

Mozambique was one of the four countries selected during the second year of the President's Malaria Initiative (PMI). The goal of PMI is to assist African countries, in collaboration with other partners, to reduce malaria mortality by 50% by rapidly scaling-up coverage of vulnerable groups with four highly effective interventions: artemisinin-based combination therapy (ACT), intermittent preventive treatment for malaria in pregnancy (IPTp), insecticide-treated bed nets (ITNs), and indoor residual spraying (IRS).

In 2008, PMI-supported IRS activities were conducted in six districts in Zambézia Province covering more than 412,000 structures and 1.45 million residents. Spray operations for the 2009 spray season covered approximately 500,000 structures and more than 2 million residents in the same target districts in Zambézia Province. In both years, the Government of Mozambique (GOM) procured DDT (an organocholorine) for use in highly populated urban and peri-urban areas and pyrethroids (deltamethrin) in towns where structures with finished or painted walls.

In 2010, PMI expanded its IRS program to cover the eight districts of Milange, Mocuba, Morrumbala, Namacurra, Nicoadala, Mopeia, Maganja da Costa, and Quelimane. As shown in Table below, Round 4 activities achieved a 98% coverage rate, spraying 618,290 structures and protecting a total of 2,945,721 residents in the province using a pyrethroid based insecticide.

Targeted Districts, Overall IRS Coverage, and Class of Insecticide Used by IRS Year/Spray Round

Spray Round	Targeted Districts	Coverage	Insecticide
Round 1(2007)	Quelimane, Nicoadala, and NamacurraMilange, Mocuba, and Morrumbala	97.1%	DDT/Pyrethroid
Round 2 (2008)	Quelimane, Nicoadala, and NamacurraMilange, Mocuba, and Morrumbala	95.7%	DDT/Pyrethroid
Round 3 (2009)	Quelimane, Nicoadala, and NamacurraMilange, Mocuba, and Morrumbala	97%	DDT/Pyrethroid
Round 4 (2010)	Quelimane, NicoadalaNamacurra, Milange, Mocuba, Morrumbala,Mopeia, and Maganja da Costa	98%	Pyrethroid

In 2011 spray activities will again target the eight districts previously sprayed, targeting an estimated 2,945,721 residents through judicious application of IRS to approximately 625,700 structures. This number is based on the actual number of structures sprayed in the 2010 IRS spray round. A breakdown of the target population protected by each district is shown in Table below.

Estimated Target Population by District for the 2011 IRS Campaign

District	Population Targeted
Quelimane	240,240
Nicoadala	427,393
Namacurra	255,519
Mocuba	726,404
Morrumbala	370,216
Milange	546,923
Maganja da Costa	257,102
Mopeia	121,924
Total	**2,945,721**

Spray targets for beyond 2011 are not currently known, but will be documented in Malaria Operational Plans and annual work plans developed by the implementing partner.

NMCP has developed a national entomology work plan for 2011 and has requested PMI support for national IRS entomology activities included in the work plan. The PMI supported activities from the work plan include resistance monitoring, insecticide residual efficacy testing, and mosquito density evaluations in various provinces as well as supporting the purchase of various materials and equipment for entomology programs in other provinces.

Key support to this national plan will be focused around building capacity for susceptibility studies in key provinces in order to encourage the use of clear resistance data to support insecticide selection for subsequent years of IRS. The contractor will carry out these activities by working with the NMCP, DPS, the Mozambique IRS Entomologist, the RTI IRS Regional Entomologist in Nairobi, and with expert consultants that have previous experience working in Mozambique on entomological monitoring for IRS.

Because Zambezia province is not included in the national entomology monitoring survey, RTI will fully support IRS entomological monitoring in the eight IRS districts of Zambezia province through technical assistance in field monitoring and evaluations and reporting.

This document serves as an amendment to the environmental documentation for IRS that was approved for Mozambique in 2010, carried out under the U.S. Agency for International Development's (USAID's) Malaria Control in Mozambique project. The previous environmental documentation covered use of three classes of World Health Organization

(WHO)-approved pesticides (pyrethroids, carbamates, and organochlorines) in all the malarias areas in Mozambique, and was prepared in accordance with the USAID 22 CFR (216), regarding and governing the use and application of pesticides.

In 2011, DDT will not be used in select districts in Zambezia. This decision was based on environmental sampling that demonstrated increased levels of DDT in crops stored in homes and in the soils surrounding houses after a spray round.

Summary of Findings from Mozambique DDT sampling (all data is in mg/kg)

	Median		**Mean**	
	Sample Point 1	**Sample Point 2**	**Sample Point 1**	**Sample Point 2**
Mozambique				
Indoor Crops	0.036	0.11	0.35	0.47
Soil from Entranceway	*0.091*	*0.39*	*0.32*	*1.1*
Soil from Runoff Channel	n/a	0.20	n/a	0.69

Italics denote statistically significant difference between rounds.

"Sample Point 1" samples were collected from September to November 2008, during the 2008 IRS round, in three districts (Namacurra, Nicoadala, and Quelimane). Samples were collected during the spray season but prior to actual spraying of sampled houses. The sites from which samples were collected had a mixed history of spraying – some had been sprayed three times, others only once, and others had never been never sprayed. Data from Sample Point 2 was collected in August 2009 (7-9 months after the 4th round of PMI-funded spraying) in Namacurra, Nicoadala, Quelimane, and Mocuba).

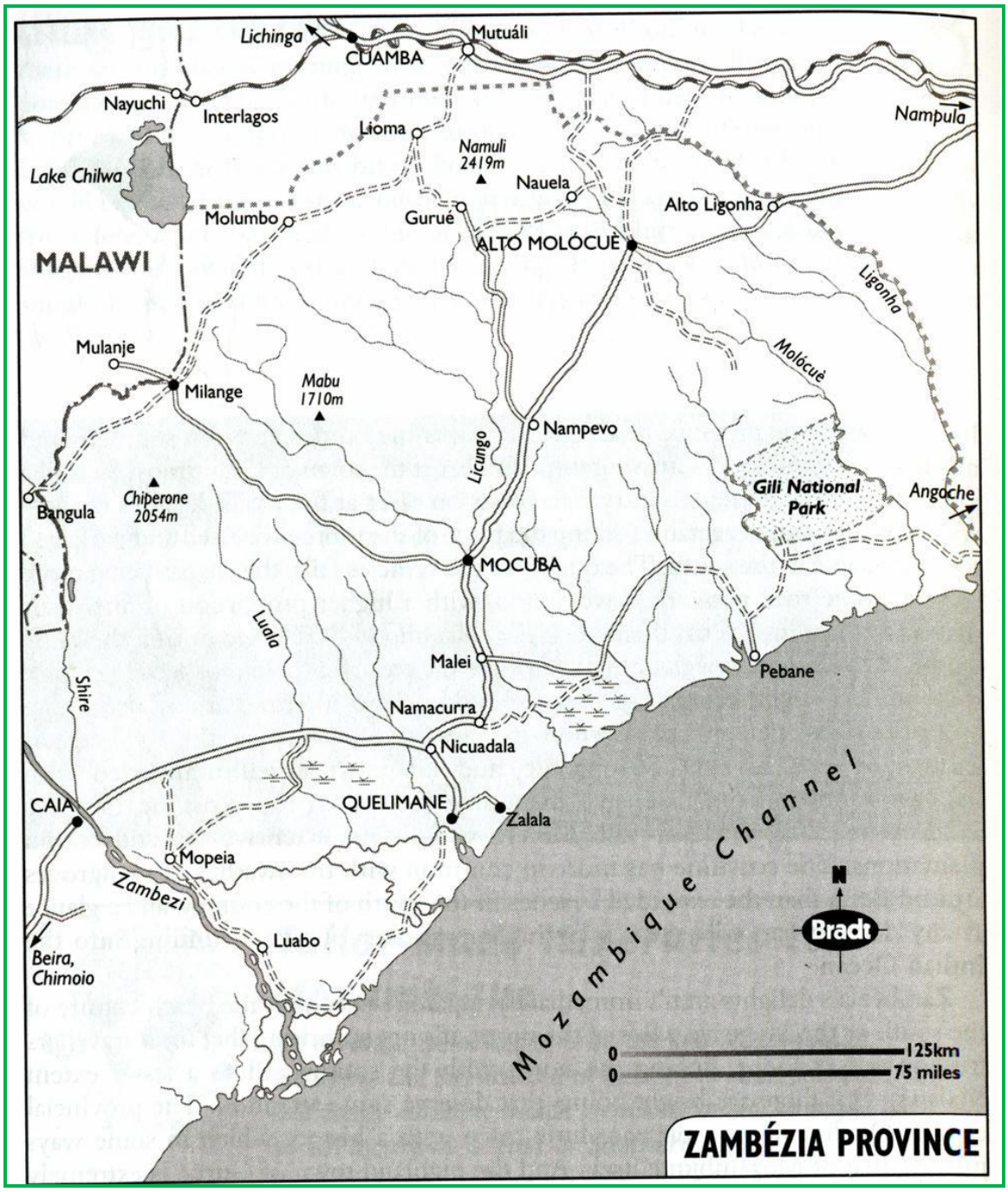
Median DDT concentrations for DDT in crops stored inside homes increased from 0.036 mg/kg in Sample Point 1 to 0.11 mg/kg in Sample Point 2; the increase was not statistically different. However, median DDT concentrations in crops in Mocuba were significant higher in 2010 (at 0.2 mg/kg) than in 2009 (0.043 mg/kg) (data for Mocuba specifically is not captured in the Table).

The increase in DDT concentrations from Sample Point 1 to Sample Point 2 was statistically significant in entranceway soils. Neither mean nor median DDT concentrations for entranceway soil exceeded the human SSL of 1.7 mg/kg, yet both mean and median DDT concentrations exceeded avian and mammalian eco-SSLs.

The proposed action in this document is to allow for a five-year IRS program using pyrethroids in Zambezia, with the exception of areas within 30ft from natural water bodies, wetlands, marshes, organic farming areas, beekeeping areas, national forests and parks. The following assessment draws heavily on the previous SEAs, as well as the Programmatic Environmental Assessment (PEA) for Integrated Vector Management (IVM), approved in March 2006 (http://www.ehproject.org/PDF/ehkm/ivm-env_assessment.pdf). Every year, PMI and its implementing partner will continue to work closely with NMCP when selecting insecticides, as resistance to pyrethroids might become an area of concern.

Figure 1. General Administrative map showing provinces in Mozambique

Figure 2. Map showing current PMI IRS region (Zambezia) in Mozambique in 2010



Adverse Impacts and Mitigation Measures

Based on USAID's experience with implementation of IRS in 15 other African countries under PMI, the most likely potential adverse health impact of the IRS intervention is unintentional pesticide exposure. Potential adverse effects may lead to acute yet transitory health impacts on beneficiaries and spray operators, including, among others, excessive sweating, salivation, headache, blurred vision, nausea, vomiting, stomach pain, giddiness, and slurred speech. Short-term exposures may affect the nervous system, liver, and kidneys, as well as cause respiratory failure and convulsions. To mitigate this risk, all individuals involved in the implementation of spraying—from spray operators to wash persons to

storekeepers—will be trained in the best management of IRS. In addition, community members will be informed on how to minimize direct exposure to insecticides (e.g., staying out of houses sprayed for two hours, removing furniture and food from houses prior to spraying, etc).

The highest risk to the environment is potential contamination to the biodiversity found in the province, such as rivers, lakes, wetlands, marshes, and forests. As part of the risk mitigation, mapping of structures within 30 feet away from bodies of water is underway; such structures will not be sprayed as a measure to minimize risk of contamination from spills.

Additional mitigation measures include utilization of personal protective equipment (PPE), best practice in store keeping and pesticide storage and management, best practices for reuse/disposal of contaminated water from operations, and enforcement of multiple supervisory layers.

Continued Adherence to the Original Safer Use Action Plan

PMI/Mozambique and its implementing partners will continue to adhere to the conditions detailed in the SEA, summarized below (originally noted in the 2010 SEA) and highlighted in the Environmental Mitigation and Monitoring Plan (EMMP) found in Section 6 of this report.

Policy, Planning, and Institutional Requirements

- Prohibit the use of IRS insecticides in sensitive ecosystems. In line with the established best practices for IRS, and relevant national and USAID policies, measures will be established to ensure adequate protection of sensitive ecosystems.
- Continue to monitor vector resistance, and apply vector resistance management strategies (such as rotation to other classes of insecticides) if resistance emerges. Ongoing involvement of the NMCP in entomological monitoring will provide a basis for sound decision making.
- Promote intersectoral collaboration frameworks and institutional arrangements to facilitate comprehensive approaches to vector control and associated pesticides management. Coordination between the NMCP and major stakeholders will be strengthened. This will include collaboration with the following:
    - Ministry of Agriculture (MINAG)—for appropriate integration of vector and pest management activities aimed at enhancing judicious use of insecticides, especially within rural farmer community settings.
    - The Ministry in charge of Coordination of Environmental Affairs (MICOA)—responsible for the enforcement of environmental monitoring and effective mitigation of the negative impacts from projects on the environmental resources.

Operational Requirements

RTI will work closely with NMCP to access relevant country-level authorization, support, or consent it may need from NMCP and other relevant national agencies to implement the IRS program. Operational requirements are as follows:

- Ensure quality assurance for commodity procurement and IRS operations, to minimize risks to human health and the environment. This will include ensuring legitimate procurement sources and verifiable chains of custody of commodities, as well as effective compliance inspections of IRS activities in the field.
- Ensure compliance with national regulations on pesticides and MISAU guidelines on IRS and vector control. Compliance with established national procedures for registering, importing, transporting, labeling, handling, use, storage, and disposal of pesticides.
- Train relevant categories of workers involved in IRS operations (e.g., district program managers/coordinators, spray operators, storekeepers, pesticide transporters, and supervisors) on best practices in accordance with national pesticides regulations and the recommendations/guidelines of WHO and this SEA. Criteria for reprimanding non-observance of best practices by these workers will be established.
    - Ensure use of appropriate PPE and best practices, including effective field supervision of spray operations, for adequate protection of spray operators and other handlers of pesticides.
    - Train health workers in the management of insecticide poisoning. This will include development of program-specific guidelines on poison treatment; designation of district hospitals within the target areas for appropriate treatment of insecticide poisoning; and training of IRS workers to recognize early danger signs of poisoning and appropriate action.
    - Enforce protection of fetuses and children who are breastfeeding against exposure from spray operations. Pregnant women and breastfeeding mothers will be excluded from direct handling of pesticides (e.g., spray operations, washers, etc.). Before each spray operation, pregnancy testing will be conducted for potential female handlers of pesticides.
    - Undertake information, education, and communication (IEC) activities for targeted communities and households to reduce exposure. These activities will provide information on removing food and cooking and water utensils; covering unmovable furniture with cloths prior to spraying; excluding spraying of rooms used by pregnant women or sick individuals who are unable to leave their homes; preventing reentry to sprayed rooms for at least 1 hour after spraying; sweeping floor residues before reentry of children or animals; and disposing dead insects in latrines or pits.
    - Establish strict practices to reduce environmental contamination. This will include comprehensive auditing of pesticide stocks and usage, as well as enforcing best practices related to the handling, washing, and disposing of pesticides; and progressive use of waste/wash water, ablution blocks, and evaporation tanks. IRS field activities should be in full compliance with the Ministry of Agriculture (Department of Plant Protection), as well as relevant USAID regulations and recommendations outlined in this SEA.

- Provide training support, as necessary, to strengthen the supervisory capacity of the MICOA within the target districts for day-to-day monitoring of IRS activities.

  In addition, MICOA will carry out routine inspections of all IRS districts, including unannounced spot inspections, to verify compliance with all relevant national regulations and guidelines, as well as procedures outlined in the safer use action plan. MICOA, in coordination with NMCP and RTI, will independently conduct compliance inspections of IRS activities and facilities in the IRS districts. MICOA will require increased support in order to provide the oversight role as necessary.

Conclusion

Once a year, a joint meeting will continue to be held by the technical partners (e.g., PMI, USAID program and activity managers, implementing partners, and MICOA) under the auspices of the NMCP to review evaluation findings, generate lessons learned, and identify priority areas that require strengthening and respective remedial actions. Efforts will be also be made to include feedback from targeted communities. This systematic approach will enable timely corrective actions and progressive strengthening of environmental safeguards and program compliance over time.

As required by USAID's Automated Directives System (ADS) 204.3.4, USAID will actively monitor ongoing activities for compliance with the recommendations in this SEA, and modify or end activities that are not in compliance.

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR
U.S. PRESIDENT'S MALARIA INITIATIVE
MOZAMBIQUE IRS PROJECT

Program/Activity Data:

Program/Activity Number: GHN-I-01-09-00012
Country/Region: Mozambique/Africa
Program/Activity Title: Indoor Residual Spraying Project

Funding Begin: 2011 Funding End: 2015

SEA Prepared By: Tito Kodiaga
Current Date: August 2011

IEE Amendment (Y/N): Y
Filename and date of original IEE: Supplemental Environmental Assessment/Amendment for all malarious regions in Mozambique, 2010.

Additional Elements:

(Place X where applicable)

CONDITIONS: ___X___ PVO/NGO: ____

Approval of Environmental Action Recommended

The U.S. Agency for International Development's (USAID's) Global Health Bureau has determined that the proposed indoor residual spraying (IRS) effort, as described in the Supplemental Environmental Assessment (dated July 2011), responds to the needs of the community and country as it relates to managing malaria in Mozambique, as well as conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, documents the environmental planning and impact analysis executed by the IRS team in preparation for the proposed action. The design and standards of operation of the IRS program are established to avoid and reduce any potential impact. USAID has concluded that the proposed action, when executed as described in the Supplemental Environmental Assessment (SEA) and the Programmatic Environmental Assessment (PEA), is consistent with USAID's goal of reducing malaria incidence in Mozambique while minimizing negative impact to environmental and human health.

Clearance

Mission Director, USAID/Mozambique: _____ Date: 9/1/2011

Todd Amani

Concurrence

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Teresa Bernhard

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Tom Ray

1.0 Background and Purpose

1.2 Malaria Burden in Mozambique

According to the PNCM's 2009 Annual Report, the burden of malaria in Mozambique is decreasing. The basis for this statement is the mortality and morbidity data collected through the existing health information system, the Weekly Epidemiologic Bulletin (BES). Comparing the same time period in 2008 and 2009, there were 5,168,684 reported malaria cases and 3,191 malaria deaths in 2008 versus 4,020,574 and 2,786, respectively, in 2009. Malaria cases included both clinically diagnosed as well as those that had laboratory confirmation by either blood smears or rapid diagnostic tests (RDTs). However, the accuracy of data collected from BES is questionable. Additionally, RDTs have been progressively implemented since 2008, and the impact of this intervention on case reporting is unknown.

Most of Mozambique has year-round malaria transmission with a seasonal peak from December to April (during the rainy season). Mozambique is, however, prone to natural disasters; such as drought, cyclones, and floods; and these may have contributed to increases in malaria transmission in recent years, particularly in low-lying coastal areas and along major rivers.

Plasmodium falciparum infections account for 90% of all malaria infections, with *P. malariae* and *P. ovale* responsible for about 9% and 1%, respectively. The major vectors in Mozambique are *Anopheles gambiae s.s., A. arabiensis, A funestus s.l.,* and *A. funestus s.s.* Among the major subspecies of the *A. gambiae* complex, *A. arabiensis* is more prevalent in the south and *A. gambiae* in the north *Plasmodium falciparum* infections account for 90% of all malaria infections, with *P. malariae* and *P. ovale* responsible for about 9% and 1%, respectively.

The major vectors in Mozambique are *Anopheles gambiae s.s.*, *A. arabiensis*, *A. funestus s.l.*, and *A. funestus s.s*. Among the major subspecies of the *A. gambiae complex*, *A. arabiensis* is more prevalent in the south and *A. gambiae* in the north.

The national census of 2007 documented the population of Mozambique to be approximately 21.5 million, with 1 million residents residing in urban Maputo and 1 million in the peri-urban Maputo. By 2010, it is projected that there will be 3.8 million children less than five and 1.1 million pregnant women. In the previous years, malaria transmission was assumed to be very low in Maputo city.

In April 2009, though, a rapid urban malaria assessment was conducted within the city limits of Maputo. Preliminary data from this assessment suggests on-going transmission at higher than expected levels, even in highly urban areas of the city.

The prevalence of malaria, diagnosed by rapid diagnostic tests, among febrile patients presenting for care to public health facilities was 11.9% in urban Maputo, 15.8% in peri-urban areas surrounding Maputo, and 19.4% in rural areas in Maputo Province. Based on these results, both urban and peri-urban areas of Maputo should be targeted for malaria prevention and control activities.

The President's Malaria Initiative (PMI) is a core component of the GHI, along with HIV/AIDS and tuberculosis. The PMI was launched in June 2005 as a 5-year, $1.2 billion initiative to rapidly scale up malaria prevention and treatment interventions and reduce malaria-related mortality by 50% in 15 high-burden countries in sub-Saharan Africa.

With passage of the 2008 Lantos-Hyde Act, funding for PMI has now been extended through FY2014. Programming of PMI activities follows the core principles of GHI: encouraging country ownership and investing in country-led plans and health systems; increasing impact and efficiency through strategic coordination and programmatic integration; strengthening and leveraging key partnerships, multilateral organizations, and private contributions; implementing a woman- and girl-centered approach; improving monitoring and evaluation; and promoting research and innovation.

Mozambique was one of four countries selected for the second year of the President's Malaria Initiative (PMI). The goal of PMI is to assist African countries, in collaboration with other partners, to reduce malaria mortality by 50% by rapidly scaling-up coverage of vulnerable groups with four highly effective interventions: artemisinin-based combination therapy (ACT), intermittent preventive treatment of pregnant women (IPTp), insecticide-treated bed nets (ITNs), and indoor residual spraying (IRS).

With the passage of the 2008 Lantos–Hyde Act and the launch by President Barack Obama of the GHI, PMI has been extended until Fiscal Year (FY) 2014. In implementing PMI, the United States Government is committed to working closely with host governments and within existing national malaria control strategies and plans.

Efforts will be coordinated with other national and international partners, including the Global Fund to Fight AIDS, TB, and Malaria (Global Fund), Roll Back Malaria (RBM), the World Bank Malaria Booster Program, the World Health Organization (WHO), UNICEF, non-governmental organizations (NGOs), and the private sector to ensure that investments are complementary and that RBM and Millennium Development goals can be achieved.

1.2.1 IRS's Objectives

The purpose of the program in Zambezia is to continue implementing IRS as an intervention aimed at reducing malaria transmission and prevalence using funds from the PMI. IRS is the organized, timely spraying of an insecticide on the inside walls of houses or dwellings. It is designed to interrupt malaria transmission by killing adult female mosquitoes when they enter houses and rest on the walls after feeding, but before they can transmit the infection to another person.

1.3 History of Malaria Control in Mozambique

The NMCP is in the process of drafting its strategic plan. In late 2010 the NMCP conducted a Malaria Program Review (MPR) under the guidance of WHO and RBM. This exercise is seen as the foundation for a revised and updated National

Plan which is scheduled to be completed by September 2011. The existing draft National Prevention and Control Plan for Malaria in Mozambique (which was written prio to the MPR) focuses on the scaling-up nationally of six key malaria prevention and control interventions:

1. **Integrated vector management (IRS, ITNs and environmental management):** IRS has been a core malaria control strategy in Mozambique for a number of years, with national targets aiming for coverage of at least 40% of the population. Free long-lasting ITN (LLIN) distribution focuses on people at risk of malaria outside the areas covered by IRS. A recently revised policy calls for universal access to LLINs (defined as one net for every two inhabitants).

2. **Prompt diagnosis and correct treatment:** To scale up and improve diagnosis, the NMCP adopted a policy that all persons with suspected malaria should be tested with a rapid diagnostic test (RDT) or microscopy prior to treatment at both facility and community level. The Ministério de Saude (MISAU) adopted artemether-lumefantrine (AL) as its first-line treatment in late 2009.

3. **Intermittent preventive treatment in pregnancy:** Use of IPTp with SP was scaled-up nationally beginning in early 2006. Every pregnant woman should receive three monthly doses of IPTp during her pregnancy. Uptake figures are low (23% in MIS 2007) considering that more than 80% of pregnant women attend ANC at least once during their pregnancy.

4. **Emergency and epidemic preparedness and response:** Coordination between MISAU and the National Disasters Management Institute is intended to facilitate forecasting and timely detection of malaria outbreaks using health information systems data and weather forecasts.

5. **Health promotion and community participation and involvement:** To improve the knowledge of rural communities, the NMCP promotes increased community participation in developing solutions to significantly impact malaria mortality and morbidity. In addition, a cadre of community health workers, known as Agente Polivalente Elementares (APEs), is being revitalized. APEs will play a key role for the largely rural population in Mozambique in both health promotion and malaria case management.

6. **Program management, monitoring and evaluation, health system strengthening, including operational research:** Strengthened management and planning of malaria activities and capacity at all levels will direct limited resources more effectively; the consolidation and coordination of malaria-related systems to cope with rapid scale-up of malaria control interventions is a cornerstone of the strategy. Effective monitoring and evaluation (M&E) systems (including data collection, processing and use) and operational research will measure progress towards established milestones and help guide evidence-based decision-making.

1.3.1 IRS

The old draft of the 2010–2014 National Malaria Prevention and Control Plan has set the target for IRS coverage at 40% of the population, or about 8 million people. It is

not celar yet that this will be maintained but it is likely to be the case. PMI has been supporting IRS in Zambézia Province since 2007 and, in 2010, PMI expanded its geographic coverage of IRS within the province of Zambézia by spraying two additional districts. The addition of these two districts translates into approximately 646,000 households or nearly 3 million residents covered. With FY11 funding, PMI will again support spraying of eight districts in Zambézia Province, covering 3 million residents. PMI has also supported entomology monitoring in Zambézia Province. In addition, PMI will continue to provide entomology technical assistance through an entomologist placed with the PNCM who supports entomology monitoring of IRS activities conducted by MISAU outside Zambézia Province. Entomology facilities at the National Institute of Health in Maputo and in Zambézia Province have been refurbished with PMI support.

IRS has been a priority vector control intervention for MISAU in Mozambique and was considered the backbone of their malaria control strategy. For the 2009 IRS campaign, MISAU led a countrywide IRS program using Mozambique government funds along with PMI support for Zambézia Province and LSDI support for Maputo and Gaza Provinces. The MISAU-led program sprayed 2 million structures, protecting an estimated 6.2 million people. In total, 2009 Mozambican IRS campaigns (MISAU, PMI, and LSDI) covered 10 provinces, protecting about 42% of the population. At the end of the 2009 IRS campaign, the Minister of Health unexpectedly requested that IRS be expanded geographically, with at least one additional district to be sprayed in each province in 2010. However, due to financial restrictions, the expansion did not take place in most provinces outside of Zambezia.

Several neighboring countries – including South Africa, Zimbabwe, and Zambia – have large-scale IRS programs using dichlorodiphenyltrichlorethane (DDT). The LSDI, a private–public trilateral program among the governments of Mozambique, South Africa, and Swaziland, developed a program with the aim of reducing malaria in the region to encourage economic and tourism investments in the region. Since 2000, the LSDI has supported large-scale IRS in Maputo Province, initially using bendiocarb in two spray rounds per year. However, due to resource constraints, the LSDI will not conduct spraying in 2011.

At the request of the NMCP, PMI continues to focus on IRS operations in Zambézia Province, providing strategic, technical, operations, and management support for IRS activities, in collaboration with provincial and district health offices and the NMCP.

The primary insecticide used in Zambézia has been DDT, consistent with NMCP's strategy of using DDT in highly populated urban and peri-urban areas. Deltamethrin (a pyrethroid) was used in towns where structures with finished or painted walls were found. However, the MISAU in 2009 indicated that they will transition from DDT to pyrethroids during the 2010 spray season mainly due to concerns of insecticide resistance amidst lack of entomological data to guide decision making. All remaining stocks of DDT were to be used up during the 2009 campaign. Indeed, in 2010, as indicated by MISAU, the spray operations in Zambezia Province used a pyrethroid based insecticide instead of DDT. In 2011 a pyrethroid based insecticise will be used as the preferred choice of insecticide based on environmental sampling conducted in 2009 through 2010.

1.3.2 ITNs

National plan for ITNs: In January 2006, MISAU declared that malaria is a national emergency and, as such, malaria prevention and treatment services must be provided free-of charge to at-risk populations through the public health service. Children less than five and pregnant women were targeted for the ITN distribution from 2006 until 2009. These populations were reached either through mass campaigns targeted to children less than five or delivered to pregnant women during ANC visits.

The "old" draft National Malaria Control Strategic Plan for 2010 to 2014 outlines the new national ITN distribution policy, which focuses on universal coverage for the entire population at risk of malaria in areas that do not have IRS activities. This strategy foresees that the distribution to the high risk groups (children less than five and pregnant women) as one platform to reach the universal coverage in Mozambique. The policy also states that LLINs should continue to be distributed free-of-charge. Many large universal coverage campaigns are scheduled and in early 2011 2.2 million LLINs were brought in country from Global Fund Round 6 for several campaigns across Mozambique. Thse are scheduled to start in August and September of 2011.

1.3.3 Environmental Management

The NMCP strategic plan does not include environmental management in its approaches for malaria intervention.

1.3.4 Larviciding

The NMCP strategic plan does not include environmental management in its approaches for malaria intervention.

1.3.5 Major Partners in Malaria Control

<u>Global Fund to Fight AIDS, Tuberculosos, and Malaria (Global Fund)</u>
In 2010 Mozambique received a $28 million Round 2 grant from the Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund). This award is the first Global Fund grant to be pooled in the Ministry of Health's central basket funding. Mozambique has also been awarded a two-year, $36 million Round 6 grant, which began disbursing in 2008. In addition, the Lubombo Spatial Development Initiative (LSDI), a three-country control initiative— involving southern Mozambique, Swaziland, and South Africa— has received two, two-year $21 million grants from Global Fund (Round 2 and Round 6).

<u>World Bank</u>
In 2009, a five-year, $35 million World Bank health sector credit was approved that will allocate approximately $12 million to malaria control. This credit will primarily focus on system strengthening at the national and provincial levels, with a particular emphasis on three northern provinces. With additional support from the World Health Organization, UNICEF, and othernational and international partners, scaling up of malaria prevention and control interventions is well underway.

2.0 Alternatives, Including the Proposed Action

This section describes the alternatives that were considered in the preparation of the report, including those that were accepted or rejected.

Alternatives considered include the following:

- Preferred action: Establish a 5-year spray campaign that sprays in the select 8 districts in Zambezia province established by an evaluation of criteria such as transmission rate, vector susceptibility, and residual effect, appropriate use (type of home and wall structure) and ecological/human health impacts using pyrethroids, organophosphates, and/or carbamates. This does not include other PMI interventions uses such as ITNs, IPTp, and ACT, as these are part of a separate program.
- No action alternative: This action maintains the status quo, with three interventions, including ITNs, IPTp, and ACT for malaria cases, as well as BCC efforts.
- Alternative geographic regions: This alternative would restrict the 5-year program to only the high-transmission areas despite all of Mozambique being considered a high-risk area. This alternative does not yet allow the program to work in other high-risk areas apart from Zambezia Province, thus enabling PMI to reach its goal of rapidly scaling up interventions to vulnerable groups based on transmission.
- Alternative pesticides: This alternative would allow for use of pyrethroids, organophosphates and carbamates. However, a determination to use pyrethroids in the 2011 spray campaign and beyond (unless resistance develops) has already been arrived at when consideration were being made on alternative pesticide classes.

2.1 Preferred Action

The prefered action is to implement an IRS program in 8 select districts in Zambezia province. In 2001, an estimated 2,945,721 residents will be protected with PMI resources through judicious application of IRS to approximately 625,700 structures.

The choice of an IRS spray site is largely driven by the type of mosquito species and malaria prevalence or transmission rate in the area, including whether it is an endemic or epidemic-prone area. WHO's Global Malaria Program's (GMP's) guidance indicates that IRS is appropriate in: 1) unstable, epidemic-prone malaria transmission areas; 2) stable-endemic malaria areas with moderately intense but seasonal transmission; and 3) stable-hyper-endemic areas, where very intense seasonal or perennial transmission occurs. In most cases in sub-Saharan Africa, a given country may have several regions exhibiting the above-mentioned characteristics; hence, the overall decision on a site is determined or decided upon by the host country (e.g., Ministry of Health) and considers factors such as ITN coverage, infrastructure capacity, and ecological sensitivity.

The MOH, NMCP, and PMI have agreed to include the same eight districts from 2010 for the 2011 spray round. These districts are Milange, Mocuba, Morrumbala, Namacurra, Nicoadala, Mopeia, Maganja da Costa and Quelimane. The decision for the selection of these 8 districts was based on malaria transmission in the province, caseload, rainfall patterns, and the overall malaria control strategy for Zambezia. It however, excludes all the special habitatsin the targeted districts such as wetlands, marshes, and structures within 30feet of water bodies, as well as sensitive habitats, national forests, parks, and other protected habitats. In areas where beekeeping is practiced increased supervision and monitoring will be employed to avoid contamination.

The determination for using pyrethroids is based on susceptibility tests undertaken in 2011. Susceptibility status of malaria vectors as shown in **Figure 14** (Anopheles gambiae sl) in Zambezia Province indicate that all of the mosquito population tested were 100% susceptible to all classes tested. The tests for susceptibility included pyrethroids, organophosphates, organochlorine and carbamate classes of insecticides which are approved by World Health Organization.

2.1.1 IRS Application Process

The IRS application process is described below.

2.1.1.1 Pesticide Procurement

Once an insecticide class(es) for IRS is selected by a country (see Section 2.3 on insecticide selection criteria), the next stage is the procurement of the pesticides which are imported from the country of manufacture. Any pesticide selected must be registered for IRS use by the host government, in this case the Ministry of Agriculture.

The pesticide regulating body in Mozambique is the Agrochemical Registration and Control Section at Plant Protection Department of National Directorate of Agrarian Services – Ministry of Agriculture. This department is responsible for the registration and control of all pesticides (agricultural, veterinary, public health, and domestic use) and fertilizers.

The PMI program does not allow for procurement of pesticides that are not approved for IRS by WHO and the host government. See Section 2.3 of this report ***Figure 13***, for the entire list of WHO-approved pesticides for IRS.

The insecticides of choice from the approved classes (in this case pyrethroids) will be purchased using international practices in procurement—through competitive bidding and following the criteria for selection of best bids, as outlined in the bid documents.

Inventory of the insecticides will occur at all points of the freight. The insecticides first will be freighted to Maputo, where the contractor's logistics team will verify that the quantities supplied tallies with the request made as indicated in the way bill. The insecticides will then be transported directly to rented warehouses in the different districts in which the spray operations will be concentrated. During geographical

reconnaissance and logistics assessments, the need for refurbishments to central or district level warehouses to meet United Nations Food and Agriculture Organization (FAO) requirements for pesticide storage will be assessed. www.fao.org/docrep/V8966e00.htm.

2.1.1.2 Identification of Warehouses (Storage Facilities)

The procured pesticides are categorized as hazardous and toxic and can cause potential adverse impacts to human health, animals, and the natural environment, if not properly stored according to the international guidelines for storing pesticides. Before pesticides are procured or transported to the spray areas, suitable warehouse(s) must be identified, and they should meet FAO standards for pesticide storage. They include, among others, the requirement that stores are

- Spacious enough to store pesticides in bulk;
- Located as far as possible from flood plains, wetlands, markets, schools, and residential areas;
- Well-ventilated and allow for air circulation;
- Built of concrete or other solid material;
- Adequately roofed and that are not susceptible to leaks;
- Adequately secured to keep away intruders and animals; and
- Equipped with at least two exit accesses for emergency purposes.

During the logistical assessment, the program will determine the need for new warehouses and evaluate the old warehouses to ensure that they meet the above-mentioned requirements. They may require minor rehabilitation, particularly as related to enhancing security (by fitting new locks and doors), ventilation, and access.

2.1.1.3 Requesting Country's Ability to Regulate or Control the Distribution, Storage, Use, and Disposal of the Requested Pesticide

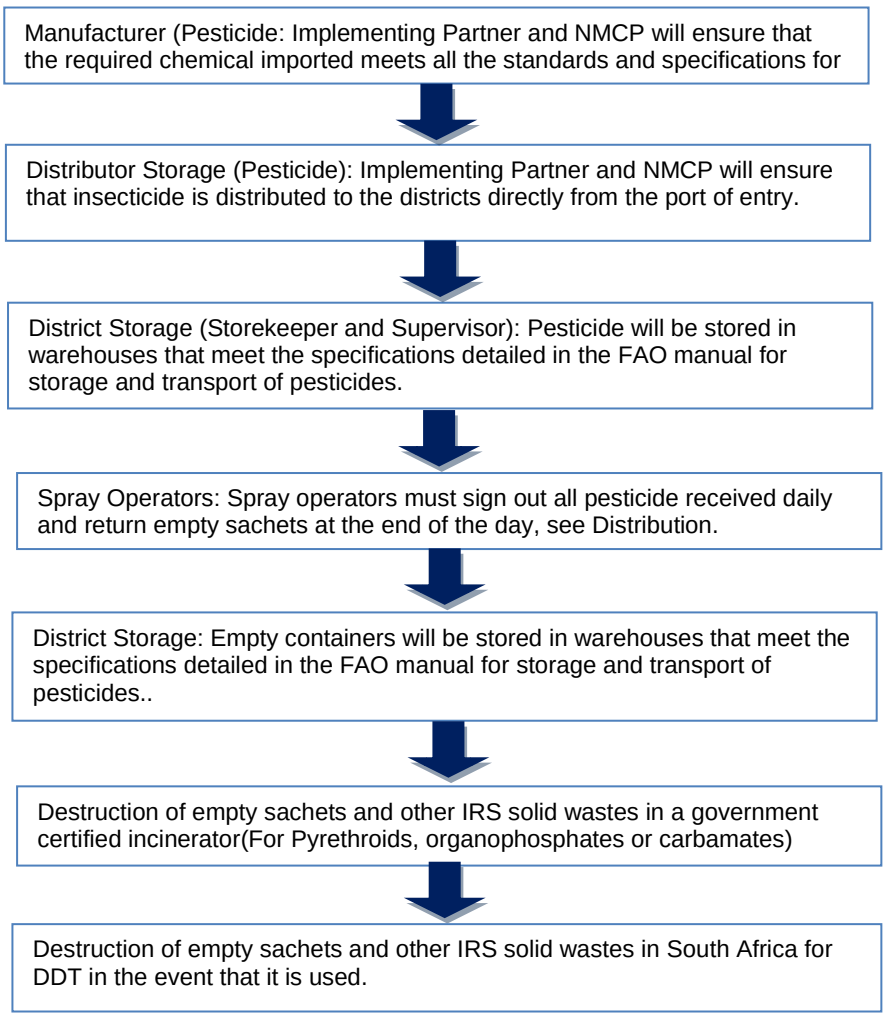
Mozambique has a fairly robust system and regulations for the control and distribution of pesticides. Agrochemical Registration and Control Section at Plant Protection Department of National Directorate of Agrarian Services – Ministry of Agriculture is solely responsible for the registration control and management of pesticides in the country. Under the Pesticide Control Regulation, there are detailed guidelines and frameworks governing the procurement, packaging and storage, as well as transport and disposal of pesticides in Mozambique.

However, despite the confidence in the regulatory framework and pesticide control, RTI will still work with the relevant authorities and will employ the following pesticide chain management in its Mozambique IRS programs to ensure control.

All facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of the Workers Safety and Social Services for employees, Environmental Act, Agriculture Act and any other relevant Mozambique standards on pesticides use and management. To that end, the following section and the EMMP describe the program requirements for storage, distribution, and transportation.

2.1.1.4 Supply Chain and Disposal Options

The supply chain of insecticide will be as follows:



2.1.1.5 Health and Safety in Warehouse(s)

The following measures are required in all warehouses in order to reduce cases of pilferage, exposure through leakages, and theft, and to ensure the health and safety of those accessing these facilities:

- Warehouse must be double-padlocked and guarded at all times.
- All the storage facilities must have thermometers installed for temperature recording.
- Soap and clean water for washing must be available at all times.
- Trained storekeepers must be present.
- Pesticide stacking position and height in the warehouses must be within the necessary level.
- The central warehouses must have at least two exit access routes in case of fire outbreak.
- Fire extinguishers must be available in the storage facilities and all workers trained on how to use them.

- Hazard warning notices must be placed in the outside of the store in the local language preferably.
- First-aid kits must be available in all the central warehouses and secondary stores

2.1.1.6 Insecticide Distribution and Management Process at District and Lower Levels

RTI has developed standard requisition, tracking, and monitoring forms that have been used in previous spray rounds to inventory, record, and track all the insecticides distributed and returned. These forms will be used in the program's new districts, and the store managers will receive training on how to use these forms. The steps below highlight the insecticide distribution process including recording and tracking methods:

- At reception at central warehouse, lot numbers of insecticide and quantities are registered on shelf inventory card.
- District requisitions are approved at the program office, where copies are maintained.
- Requisition goes to district warehouses where distribution takes place and is signed for, based on sachet numbers. Insecticides are distributed on a "first-in, first-out" system, so the insecticide that arrived first is distributed first. This avoids accumulation of expired stock.
- On reception at lower storage levels, all sachets are counted and stamped with the relevant stamp and registered on a stock card.
- Every morning before the spray operations begin, spray operators receive only enough can refills for the day's work (between 8–10 sachets) by the store manager, and must sign out all pesticide received daily in a log book.
- At the end of the day, empty and full sachets are returned and numbers checked against what was signed out. Returned empty and full sachets are logged into the log book by the store keeper or supervisor.
- Supervisor examines spray operator performance by comparing number of structures sprayed to can refills used to determine whether there is an over or under application.
- Store keeper must submit the following to central office for data entry on a daily basis: 1) insecticide stock balances; 2) sign-in/sign-out results; and 3) structures sprayed per spray operator.
- The next day, all previously signed but unused sachets are reissued and signed for by the relevant spray operator.
- At the end of each day and at the end of the spray round, stock remaining must equal the stock at start of the day minus the number of sachets distributed. Number of sachets distributed should be equal to number of can refills used.

Figure 3. IRS Storage Facilities in Zambezia Province

Secure Storage at Milanje & Nicoadala districts

2.1.1.7 PPE

Each spray team will consist of six or seven spray operators. Each spray operator will be provided with the following safety equipment (see ***Figures 4 and 5***) to be used during the spraying, in accordance with WHO and FAO specifications:

- Broad-rimmed hat/helmet;
- Face shield or goggles (face shield preferable);
- Dust mask or filtered mask;
- Two cotton overalls per spray operator;
- Nitrile rubber, neoprene, PVC, or butyl rubber gloves, without inside lining, and long enough to cover the forearm; and
- Rubber boots.

Figure 4. PPE used in the spray operations neatly packed in the warehouses (overalls and boots)

Figure 5. PPE used in the spray operations neatly packed in the warehouses (gloves and visors)

Scrupulous attention to personal hygiene is an essential component of the safe use of pesticides. For spray operators, safety precautions will depend largely on personal hygiene, including washing and daily changing of spray clothes. A schedule for carrying out and supervising personal hygiene, regular washing of protective clothes, and cleaning of equipment will be organized along the as follows (WHO, 2006):

- Spray operators will be provided with at least two uniforms to allow for daily changes.
- Washing facilities with sufficient water and soap will be made available in the field at appropriate locations.
- All work clothes must be removed at the end of each day's operations and a shower or bath taken. In circumstances where a full-body shower or bath is not feasible, face/neck and hands must be washed with soap and water.
- Work clothes will be washed daily.
- Particular attention will be paid to washing gloves, as wearing contaminated gloves can be more dangerous than not wearing gloves at all.
- Spray operators will wash before eating at the end of the daily spray operation.
- Eating, drinking, and smoking during work will be strictly forbidden at all times during the operation. If spray operators need to drink water in the course of the operation, they must clean their hands thoroughly to avoid any exposure.

2.1.1.8 Procurement of Other IRS Equipment

The following IRS equipment will be procured alongside with the insecticides and PPE, including the following:

2.1.1.9 Spray Nozzles

The program will procure 8002E nozzles for the spray cans, which are the standard size recommended by WHO.

2.1.1.10 Spray Cans

IRS spray operators use compression sprayers (see ***Figure 6***) to apply a measured amount of insecticide on the interior walls of houses and structures. A water-soluble insecticide is added to the sprayer, containing a pre-measured amount of water. The sprayer is pressurized, and the material is then applied to the interior walls of targeted homes and structures. After the day's spraying is complete, spray operators must clean the sprayer by following the manufacturer's recommendations to ensure their proper operation and calibration.

Spray pumps that will be used are Hudson X-Pert Disease Control Sprayers. All the spray pumps will be distributed to the districts based on the number of the spray operators. There will be reserve pumps used to replenish broken pumps that will need repairs.

Figure 6. Spray cans used in IRS operations

2.1.1.11 Pregnancy Tests

All female spray operators and washers will be subject to mandatory pregnancy tests before being recruited as spray operators or washers. Pregnant operators must not be included in the spray operations because of the possible effects pesticides can have on unborn children. Every month until operations are completed, repeat pregnancy testing must be done for female candidates/workers. However, pregnant workers will be assigned duties that do not involve pesticide exposure. Overall, all spray operators are subjected to a general physical examination to ensure that they are in good health.

2.1.2 Training of Spray Operators

Individuals recruited for IRS campaigns in the new districts, as well as spray operators in old districts, will receive intensive training on the use, operation, calibration, and repair of spray pumps and practical exercises during a 5-day period prior to the beginning of the spraying campaign. They will also receive training to understand proper hygiene, recognize the signs and symptoms of poisoning, and understand the referral procedure for any incidents involving poisoning. This training is conducted in accordance with WHO's *Manual for Indoor Residual Spraying* (WHO 2002). Potential spray operators must also pass written and practical tests at the end of training. As a result, spray operators will be prepared to conduct appropriate application of the insecticide.

Spray operators will initially be chosen based on their completion of primary school and their ability to read, write, and make calculations. They then will undergo medical exams to determine fitness for implementation of the activity. Pregnancy tests will be conducted as part of the medical exam to ensure that pregnant women are not included on the spray teams. This training will be conducted by RTI's staff in conjunction with NMCP.

Before going through spray operator training, physical examinations will be conducted by qualified government medical officers to identify those with obvious medical conditions that would preclude them from participating in IRS. Prior to spray operator training, no task are assigned to staff until they have completed the basic IRS spray operator training.

IRS spray operators will be trained by instructors in back-to-back sessions for five days in the same topics as described in the IRS WHO training manual, but with more emphasis on practical aspects of IRS.

Based on results from the post-IRS training test and on performance during the training, graduates will be assigned to various teams/categories of work, including the following:

- Spray operators;
- Supervisors;
- Team leaders;
- Washers;
- District managers;
- Pumps technicians; and
- Storekeepers.

The teams then receive additional specialized training, according to the specialized area of assignment.

2.1.2.1 Clinician Training

Clinicians in health care facilities will be given refresher courses on how to handle exposure incidents that are may occur when using pesticides. Acute exposure can happen through dermal contact, which could lead to skin and eye irritation, or ingestion, which could lead to poisoning.

2.1.2.2 Driver Training

All the drivers recruited for the operations will also receive training on safe transport of pesticides and steps to respond to spills or accidents.

Figure 7. Transportation vehicles used in 2010 operations

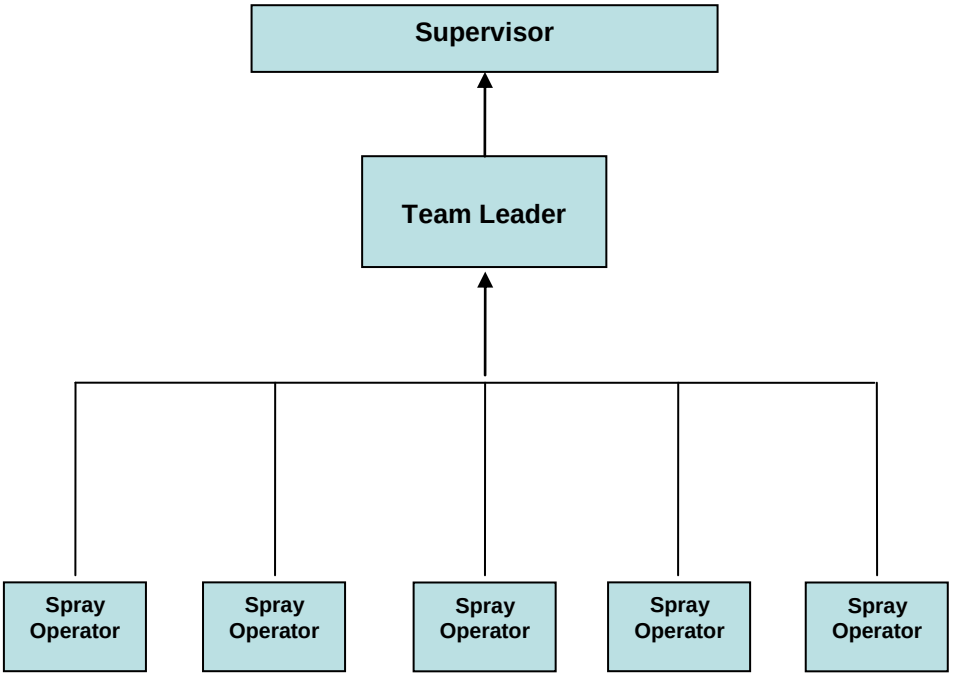
2.1.3 Supervisory Actions During IRS

The districts will be divided into IRS operational zones, each with an operational site where the progressive rinse occurs. These operational zones will be determined during logistics assessments and will be based widely on accessibility, access to water, and availability of appropriate storage infrastructure among others.

To ensure adequate supervision, the districts will have spray operators organized into teams of five to six spray operators and a team leader to ensure strict supervision during the implementation phase. A team will be under the management of one supervisor. RTI district teams (in each district) will provide oversight to ensure that the goal of providing overall IRS support (e.g., logistics, monitoring, and supervision), including ensuring that environmental safeguards are completed.

Supervisors will observe spray teams to ensure spraying occurs according to best practices. ***Figure 8*** is a schematic representation of the spray operation and supervision set up. Supervisors will travel between spray teams and will observe spray operators and team leaders in preparation, spray technique, and sprayer and PPE clean up during the IRS campaign, as well as compile all data collected by their respective teams.

Figure 8. Schematic diagram of spray operator organization and level of supervision



Each district will maintain an operational spray plan (or progress calendar), produced during the micro-planning and validated by the health team at the district level. The plan will indicate all communities to be sprayed during the spray operations.

At the end of each day, spray leaders at each operational site will meet with their manager to discuss the day's events, challenges faced, and recommendations for resolving problems. At the end of each spraying day, IRS partners' coordination meetings will be held with the IRS project, IEC implementers, and the district health team, presided by the district chief medical officer or designee. During these meetings, the partners will assess the progress of spray operations, ensure that the

planned work schedule is strictly adhered to, and make recommendations as necessary to the IRS project or IEC implementers.

The IRS district coordinator will hold a weekly meeting with the district chief medical officer and the IRS managers to discuss operational issues and their solutions. RTI will maintain records of program performance reports, which will demonstrate adherence to WHO technical standards, quality of training, supervision, procurement activities, and environmental compliance. Such reports include the pre- and mid-spray environmental compliance report, reports on core IRS indicators, and end-of-spray evaluation reports.

Regarding spray technique and spray operator discipline, monitoring will involve visiting the sprayed compounds and interviewing beneficiaries to ensure that spray operators respect household members, spray all eligible rooms, record the essential data in the relevant form, mix and apply insecticides at the right dosage, and pass the relevant health information to the household.

Supervision will also require observing each spray group at work, spray group leaders, spray team leaders, and spray operators, and checking spray team habits to ensure best practices for insecticide storage and solid waste management. Since the operators' reports are the basis for all reporting and data collection, supervisors will ensure that they are completed accurately and promptly at the end of the spraying day.

IEC effectiveness on beneficiary populations will be ascertained by visiting sprayed houses to discuss beneficiary impressions, as well as visiting unsprayed houses to discuss with heads of families why spraying is important.

2.1.4 Equipment Decontamination

Progressive rinse as a form of IRS effluent waste disposal will be introduced in the new districts before and during the operations. Prior to the commencement of the spray operations, soak pits will be constructed in the new districts, following the best management practices for locating soak pits.

Seven 200L barrels are placed in a line, as shown in ***Figures 9 and 10***. The first, third, fifth and seventh barrels are left empty, and the second, fourth, and six barrels filled with clean water. It is helpful if the barrels are wide and deep enough to submerge entire spray pump. Following are the steps taken when cleaning the spray pumps at the end of the day:

- Spray teams return to their staging areas at the end of spraying operations each day, where the spray pumps are depressurized and any leftover pesticide is poured in the first barrel (No. 1: empty).
- Approximately 2L of water are added to the spray pump from the second barrel (No. 2: filled with clean water). The spray pump is then closed and shaken so all inside surfaces are rinsed.
- The contents are then emptied into the third barrel (No. 3: empty).
- The spray operator then repeats the process two more times using the remaining barrels: No. 4 (full with clean water), No. 5 (empty for dumping), No. 6 (full with clean), and No. 7 (empty for dumping). Upon rinsing the spray

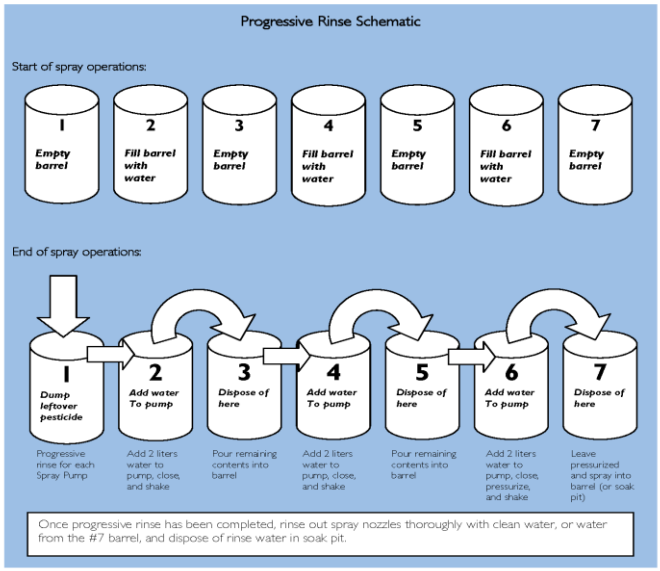
pump three times, the water emptied into the No. 7 barrel and should appear clean.

- Any remaining residue from the strainer and nozzles should be rinsed using water from No. 6 and poured into No. 7. At this point, the spray pumps are considered cleaned.

Figure 9. Spray operators conducting a progressive rinse

Any remaining liquid in the seventh container is quite dilute and will be disposed in a soak pit. The following day, spray pumps are filled with liquid from the first container, which holds undiluted insecticide, and the rinse water in third and fifth containers can be used to mix new insecticide.

Figure 10. Schematic diagram of progressive rinse



2.1.4.1 Construction of Soak Pits and Staging Areas

In 2010, the Mozambique program halted the use DDT and hence the previously constructed evaporation tanks were modified into soak pits which are the recommended infrastructures for the disposal of non DDT effluent wastes. DDT effluent wastes is disposed in evaporation tanks as shown in ***figure 12*** below.

The site for the soak pit were selected jointly with the assistance of the host government environmental authority at the district level (soak pits are usually sited at the highest point at the IRS depot/storage site and away from the natural path of run-off water). The size of the soak pit depends on the number of spray operators that the soak pit supports. On average, soak pits are 2m by 2m, excavated to a depth of 1m. The bottom of the pit is packed with sawdust followed by charcoal and stone aggregates. The area is then fenced off to keep domestic animals and children out of the soak pit area. Because there is no loose soil, soak pits also provide areas where washing and drying of overalls can be done. The entire soak pit area is fenced, complete with a lockable-access door to prevent unauthorized entry by children or animals.

The overall principle of the soak pit is to serve as a bio-bed, to absorb the toxic chemicals in the pesticide through a filtration process. When the waste water finally reaches underground, it has been purified and no longer contains the chemical components (see ***Figure 11***). Soak pits must be located away from sensitive ecosystems such as flood plains and wetlands or areas where water levels are too high to avoid underground contamination.

Figure 11. Outline of soak pit, including design

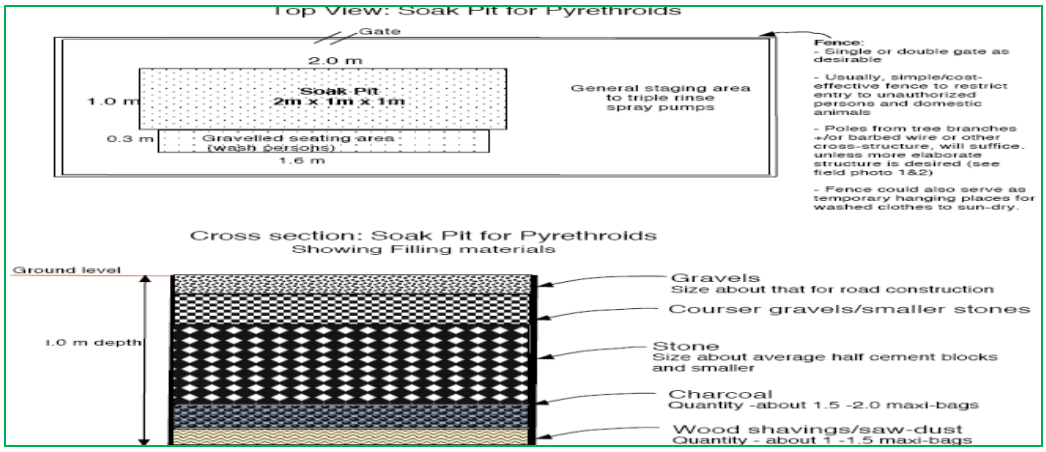


Figure 12. Evaporation tanks used in Zambezia during 2009 spray rounds converted into soak pits in 2010

To minimize possible ground contamination when washing overalls and gloves and during progressive rinse, all staging areas are required to have a constructed wash area. This is a cemented or leveled built space adjacent to the soak pit, where the progressive rinse and washing is done, to prevent contaminated water from coming into contact with the ground. The water is channeled to the soak pit through the wash area. Each of the newly constructed soak pits will have wash areas.

Drop-cloth and overalls wash-persons will be hired and provided with protective gear. Wash persons will wash overalls at a central location in tubs used exclusively for overall washing. Spray operators must also wash themselves (at minimum the face/neck and hands) after each day's operations, using wash basins specifically procured for that purpose or in a showering or bathing area. Spray operators should never wash themselves, their overalls, or their PPE in undesignated bodies of water. All wash-water will be disposed of in a soak pit, and construction of infrastructure for proper disposal of contaminated water will be financed by PMI.

2.1.5 IRS Solid Waste Disposal Preferred Option

IRS solid waste includes empty insecticide sachets and other contaminated IRS solid wastes, including used gloves, masks, and covering sheets. All require disposal in an environmentally and internationally accepted manner as prescribed by FAO/WHO, with regard to disposal of pesticide wastes. Incineration is highly recommended by the United Nations Environment Program (UNEP) and WHO/FAO in relation to pesticide waste disposal, especially for primary and secondary packaging materials and contaminated single-use clothing.

Generally, according to WHO/FAO[1], incinerators recommended for disposal of pyrethroids wastes meet the following key requirements:

- The recommended combustion temperature is between 1,100°C and 1,300°C.

[1] Food and Agriculture Organization of the United Nations (2008). *International Code of Conduct on the Distribution and Use of Pesticides: Guidelines on Management Options for Empty Pesticide Containers.* Rome: FAO. Accessed June 2, 2008. http:www.who.int/whopes/recommendations/ Management_ options_ empty_ pesticide_containers.pdf.

- An after-burner is required, with a residence time of at least two seconds.
- The incinerator should have emissions control, including particulate matter filters.
- Ash and slag produced by high-temperature incineration of pesticides are, in principle, considered inert unless determined otherwise and can be disposed as normal waste, preferably in a dug-out pit.

IRS wastes in Mozambique in the past has been repatriated to South Africa because it was mainly DDT wastes and there is no single facility in the country capable of incinerating this type of waste. Pyrethroid wastes accumulated in 2010 and 2011 will be incinerated in a MICOA certified facility most likely that owned by Enviroserve which is one of the leading waste management companies in Mozambique and certified by MICAO.

2.2 Alternative IRS Geographical Sites Considered

In this SEA, areas considered highly malarial, following entomological studies conducted by NMCP, and those areas that fit within NMCP's Medium-Term Strategic Plan, were considered. Areas that did not reflect high cases of malaria were not considered for IRS interventions.

Alternative accepted district sites in 2010 included (Mopeia and Maganja da Costa), which are identified by NMCP as requiring the most IRS interventions, due to high malaria transmission rates. In 2011, there will be no new additional districts and the same 8 districts will be targeted. It however, excludes all the special habitats such as wetlands, marshes, and structures within 30feet of water bodies, as well as sensitive habitats, national forests, parks, and other protected habitats. In areas where beekeeping is practicedincreased supervision and monitoring will be employed to avoid contamination. All methodologies remain the same.

2.3 Insecticide Class(es) Selected and Alternatives Considered

For IRS to be implemented, a WHOPES-approved pesticide must be selected for use. To date, WHOPES has so far approved the use of pesticides within the following 3 classes of pesticides: 1) pyrethroids; 2) carbamates; 3) organochlorines. ***Figure 13*** highlights the recommended insecticides for IRS in vector control. The proposed action includes the use of carbamates, organochlorines, DDT and pyrethroid formulations.

Figure 13. WHOPES-approved IRS pesticides

WHO recommended insecticides for indoor residual spraying against malaria vectors

Insecticide compounds and formulations (1)	*Class group (2)*	*Dosage (g a.i./m²)*	*Mode of action*	*Duration of effective action (months)*
DDT WP	OC	1-2	contact	>6
Malathion WP	OP	2	contact	2-3
Fenitrothion WP	OP	2	contact & airborne	3-6
Pirimiphos-methyl WP & EC	OP	1-2	contact & airborne	2-3
Bendiocarb WP	C	0.1-0.4	contact & airborne	2-6
Propoxur WP	C	1-2	contact & airborne	3-6
Alpha-cypermethrin WP & SC	P	0.02-0.03	contact	4-6
Bifenthrin	P	0.025-0.05	contact	3-6
Cyfluthrin WP	P	0.02-0.05	contact	3-6
Deltamethrin WP, WG	P	0.02-0.025	contact	3-6
Etofenprox WP	P	0.1-0.3	contact	3-6
Lambda-cyhalothrin WP, CS	P	0.02-0.03	contact	3-6

(1) CS: capsule suspension; EC = emulsifiable concentrate; WP = wettable powder.
(2) OC= Organochlorines; OP= Organophosphates; C= Carbamates; P= Pyrethroids.

Note: WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available on the WHO homepage on the Internet at http://www.who.int/whopes/quality/en/.

2.3.1 Preferred Insecticide Class

Since 2005, DDT has been the preferred insecticide of choice in Zambezia province but its use was halted in 2010 temporarily by NMCP until further notice due to the decion by NMCP to minimize possibility of vector resistance attributed to use of the insecticide over a long period of time. Pyrethroids were selected in 2010 as the preferred insecticide of choice and will be used in the province during the 2011 spray operations as well. The NMCP considered the following factors in making their preference, namely:

- Approval by WHOPES: Only insecticides approved by WHO (see ***Figure 13***) can be used in IRS. Organophosphates, carbamates, organochlorines, and pyrethroids are WHOPES-approved classes of pesticides for use in IRS; thus any can be used based on entomological data and host country registration status.
- Registration for use in-country: A key USAID and WHO requirement when considering inclusion of other pesticides for IRS is its registration status. According to the USAID 22 CFR 216, when dealing with a project that uses pesticides, a fundamental requirement is the registration status of such pesticides by the host government and WHO. ***Table 1*** highlights the registration status of all the pesticides under the pyrethroids, organophosphates, organochlorines and carbamates classes and which have been accepted for IRS in Mozambique, according to the Pesticide Action Network (PAN) Pesticide Database.

Table 1. Pyrethroid, organophosphate, DDT and carbamate registration status by the Government of Mozambique

Is the pesticide…	Lambda-Cyhalothrin	Bifenthrin	Cyfluthrin	Deltamethrin	Alpha-cypermethrin

Is the pesticide…	Lambda-Cyhalothrin	Bifenthrin	Cyfluthrin	Deltamethrin	Alpha-cypermethrin
Registered by the host country (for public health use)	YES	YES	YES	YES	YES
Is the pesticide…	**Bendiocarb**	**Propoxur**			
Registered by the host country (for public health use)	YES	YES			
Is the pesticide…	**Malathion**	**Fenitrothion**	**Pirimiphos-methyl**		
Registered by the host country (for public health use	YES	No	YES		

Source: Plant Protection Departamento, Ministry of Agriculture and Rural Development

- Vector susceptibility to the insecticide:

In March 2010, real entomological monitoring took place in Zambezia (mainly wall bioassay, susceptibility testing and monitoring mosquito species densities and composition) This data and previous available data were analysed and summarized in form of graphs and tables that can be used for decision making. The following is a summary of the key entomological indicators that were collected and analysed.

Mosquito larvae were collected from the field and reared to adults at the Quelimane Insectary. 2-5 days old mosquitoes were exposed in WHO insecticide treated papers in tubes for one hour. Knockdown was noted every ten minutes, after which they were transferred to holding tubes and kept for twenty four hours and a cotton pad soaked in 10% sugar solution was put on top of the holding tube. Final tallying of mortality was done after twenty four hours.

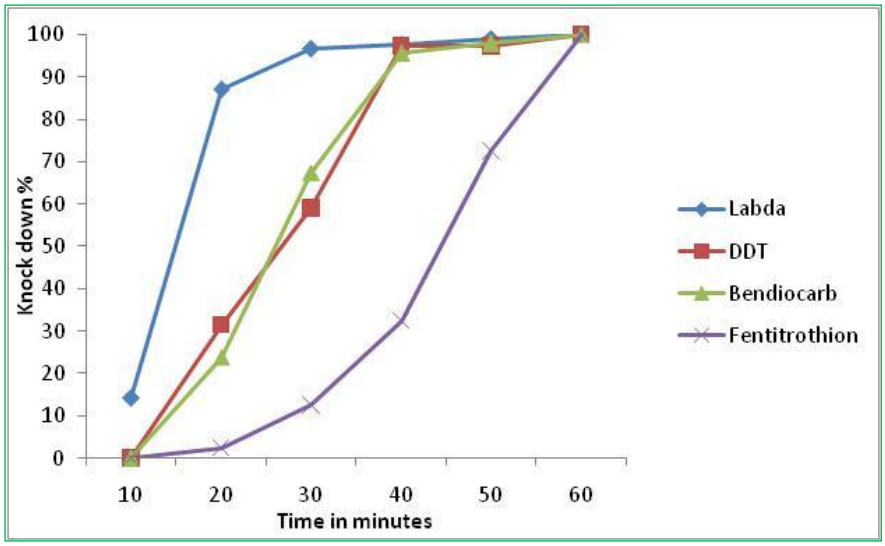


Figure 14: The rate of mosquito (Anopheles gambiae sl.) knock-down by the four classes of insecticide over a 1hr period.

Susceptibility status of malaria vectors is shown in the table above (Anopheles gambiae sl) in Zambezia Province. All of the mosquito population tested were 100% Susceptible to all classes tested. The number in parenthesis indicate the total tested

a. *Insecticide Decay Rates*

Insecticide decay rates were measured using WHO cone assays. Unfed female mosquitoes (reared in the insectary 2-5 days old) were carried to the field site in 40 cm3 cages covered with wet towels. Three WHO cones were fixed on the walls (top, middle bottom) of the sitting rooms of 10 sentinel houses in Mucuba district. Ten mosquitoes were introduced into each cone and held there for 30 minutes. At the end of the 30 minute exposures, mosquitoes were removed and placed in 1 pint paper cups and provided with sugar water. The mosquitoes were then placed inside a cooler box for transport to the insectary. Controls were run on each date to adjust for mortality that may have occurred during transit or handling.

Species	Population	DDT	Labda-Cyhalothrin	Deltamethrin	Bendiocarb	Fenitrothion
A. gam. s.l.	Mucuba	100 (73)	100 (85)	ND	100 (46)	100 (45)
	Maganja da Costa	ND	ND	100 (20)	ND	100 (20)

The controls bioassays were conducted by testing mosquitoes against untreated wooden boards or cartons.

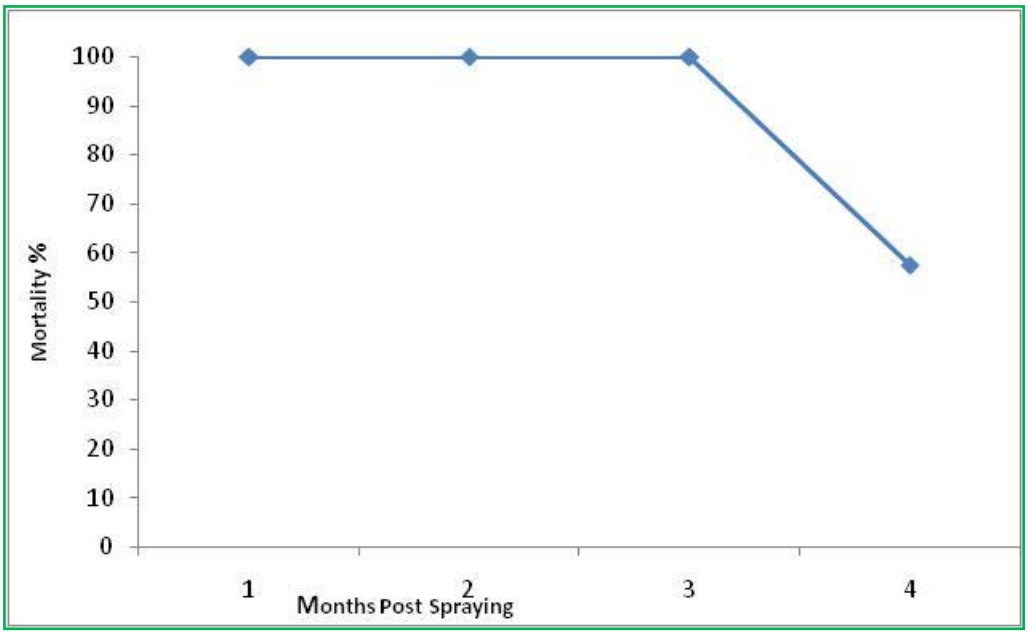


Figure 15: The decay rates of lambdacyhalothrin.

- Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area: The approximate durations of effective action for each compound are listed in ***Figure 13***. Three pyrethroids, known as longer-lasting pyrethroids, can last up to 11 months, based on various field trials (although this is not indicated in ***Figure 13***). Ideally, an insecticide is chosen whose residual efficacy lasts as long or longer than the length of the transmission season. The transmission season is six to seven months in Mozambique.
- Pesticide must be appropriate for use on the wall surfaces of the selected location: Structures in the targeted regions are mostly from mud walls or burned bricks. Near major towns and commercial centers, cement and brick-walled houses are predominant. Pyrethroids, organophosphates, DDT and carbamates are known to function well on mud and cement walled houses, hence suitability is achieved. ***Figure 16*** is a photo of a typical rural house in Zambezia.

Figure 16. Rural houses in Zambezia

(Mrs Julieta Labkeni & her family, Village Tapaliqwa, T.A Tenqua)

- Ecological impact: The IVM /PEA assessed the toxicity of IRS insecticides to nontarget organisms, including mammals, birds, fish, bees, and other aquatic organisms. Pyrethroids, organophosphates and carbamates are similar in toxicity to nontarget organisms. Apart from propoxur, which has a low toxicity consequence on fisheries and other aquatic organisms, the rest of the insecticides are all highly toxic to the organisms listed above. Similarly, all the insecticides from the approved classes are highly toxic to bees, except for pirimiphos methyl. In mammals, all the insecticides approved by WHO for IRS result in low-to-medium toxicity, except for lambda cyhalothrin and propoxur, which are categorized as highly toxic to mammals. In avi-fauna, only propoxur is categorized as highly toxic, with the rest categorized as low-to-medium in toxicity. Full results can be found in **Table 19** of the IVM PEA.
- Human health impact: The IVM PEA also assessed non-cancer risks associated with all WHOPES-approved insecticides by process (e.g., mixing insecticide, spraying, residing in sprayed house, etc.) and exposure pathways (e.g. inhalation, dermal, ingestion, etc.), and cancer risks by process where available (mainly for DDT and select pyrethroids). In general, pyrethroids and carbamates pose less non-cancer risks than organophosphates when risks are assessed via any pathway. Full results can be found in ***Tables 3, 4, 5, 6*** and ***7***, in Section 5.2.2 of this report. If organophosphates are used, decisions on insecticide type should be informed in part by the human health toxicity and risks associated with each compound and formulation.

2.3.2 Rejected Insecticide Classes

The use of DDT is rejected

2.3.3 No Project Alternative

IRS is a critical intervention in the control of malaria because it attacks the malaria vector and drastically reduces the vector population. As a result, it prevents or reduces transmission, hence minimizing incidence cases that would be addressed through a curative approach.

According to MISAU, the number of clinical malaria cases per year is estimated to be 17–20 million and results in approximately 100,000 deaths. The population groups most vulnerable to malaria are children under five years of age and pregnant women, due to their particular immunity status. However, all age groups are equally susceptible in epidemic-prone areas.

Malaria is a major cause of morbidity and mortality in Mozambique. Approximately 6 million cases are reported each year. It accounts for approximately 40% of all outpatient visits and 60% of pediatric hospital admissions. Malaria is also the leading cause of death among children admitted to pediatric services. Malaria transmission takes place year round with a seasonal peak extending from December to April. All 21.5 million people in Mozambique are considered to be at-risk of malaria, including an estimated 3.6 million children less than five years and almost one million pregnant women.

As described above, a no project scenario/alternative will mean the status quo is maintained and the malaria situation remains the same. In effect, households targeted under the IRS program will not have the benefit of IRS as an intervention. The no action alternative does not meet the PMI's overall goal: reducing malaria transmission and malaria-elated mortality in Africa; and reducing malaria mortality by 50% in up to 15 countries (total population: 175 million) across sub-Saharan Africa in 5 years.

3.0 Affected Environment

This section describes the critical environments that are likely to be adversely affected in the implementation of the IRS program (i.e., pesticide application), if adequate and necessary mitigation measures and monitoring are not put into place.

The NMCP projects that in the next 5 years, IRS interventions, with support from USAID and other partners such as GFTAM, are likely to expand throughout the country. All of Mozambique is categorized as as at risk of malaria prevalence, hence the need to adopt a national blanket coverage approach.

For this reason, this section describes the critical resources or activities that are likely to be negatively affected in the event that mitigation measures are not followed in pesticide application during the IRS. These critical ecosystems or activities include surface bodies of water (e.g., lakes, river, marshlands, and wetlands); soils; economic or livelihood activities, including apiculture, fisheries, and organic farming that might be adversely affected by application of pesticides.

3.1 Overview of Mozambique

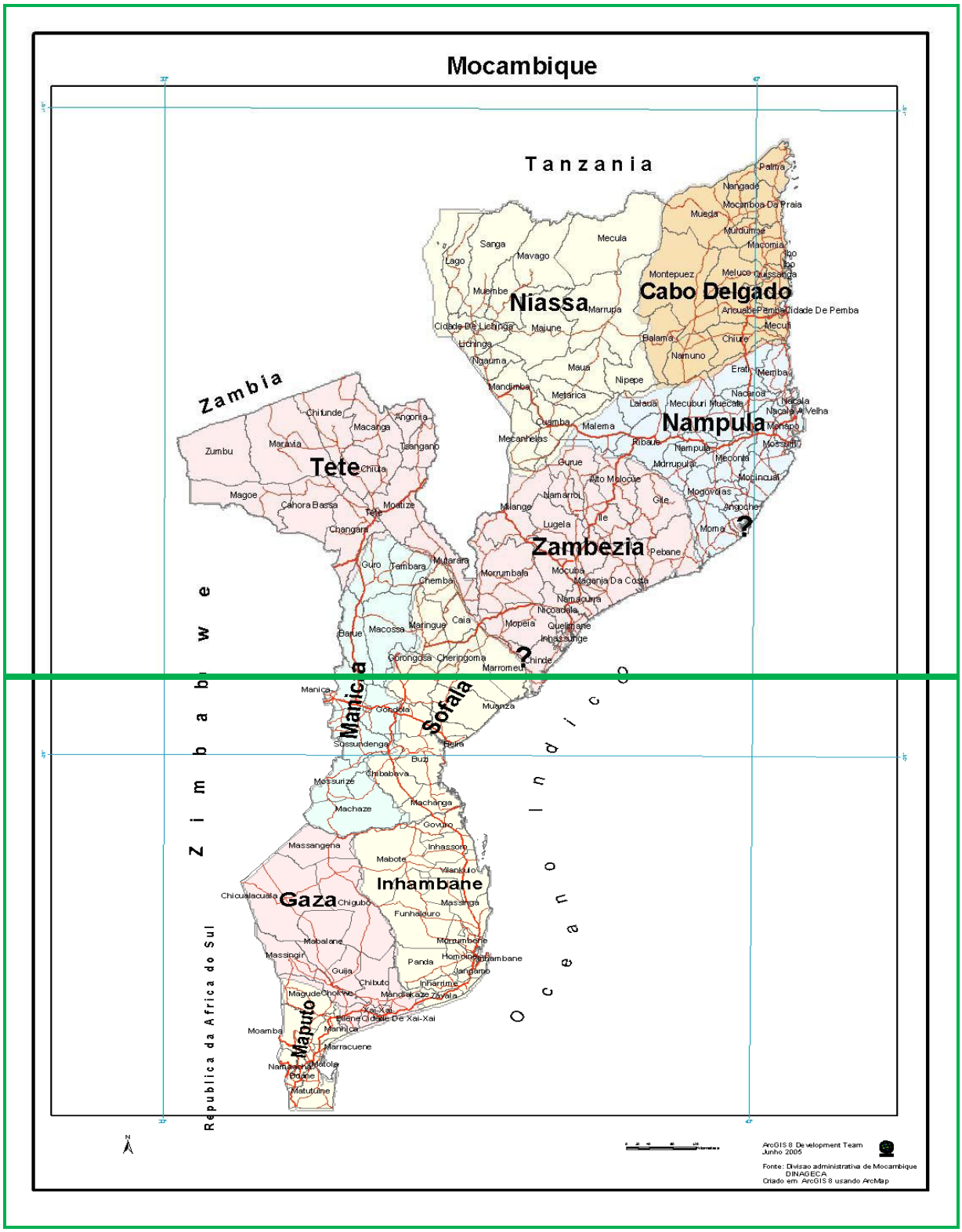
3.1.1 Position, population and Size

Mozambique is situated on the eastern seaboard of Southern Africa, between latitudes 10°27'S and 27°00'S and longitudes 30°12'E and 40°51'E (8). It has a land area of 799,380 km^2, including 1,300 km^2 of inland lakes and rivers. The country is bordered by the Indian Ocean to the east, Tanzania to the north, Malawi, Zambia, and Zimbabwe to the west, and the Republic of South Africa and Swaziland to the south.

Mozambique is a large country and population density is relatively low — 25 people per square kilometer. Relatively low population densities are characteristic of the miombo eco-region, where human populations were traditionally limited by low soil fertility and poor conditions for cattle pastoralism. Population distribution is not uniform in Mozambique, with more than 50 percent concentrated in the north, especially in Nampula and Zambezia Provinces. In the central zone, people are concentrated along the Beira Corridor, and in the south, around Maputo. More than 70 percent live along the coastal area, and about 80 percent live in rural areas.

3.1.2 Administrative and Political Units

Figure 17. Map of Mozambique, showing provinces and districts



3.1.3 Geographical Features

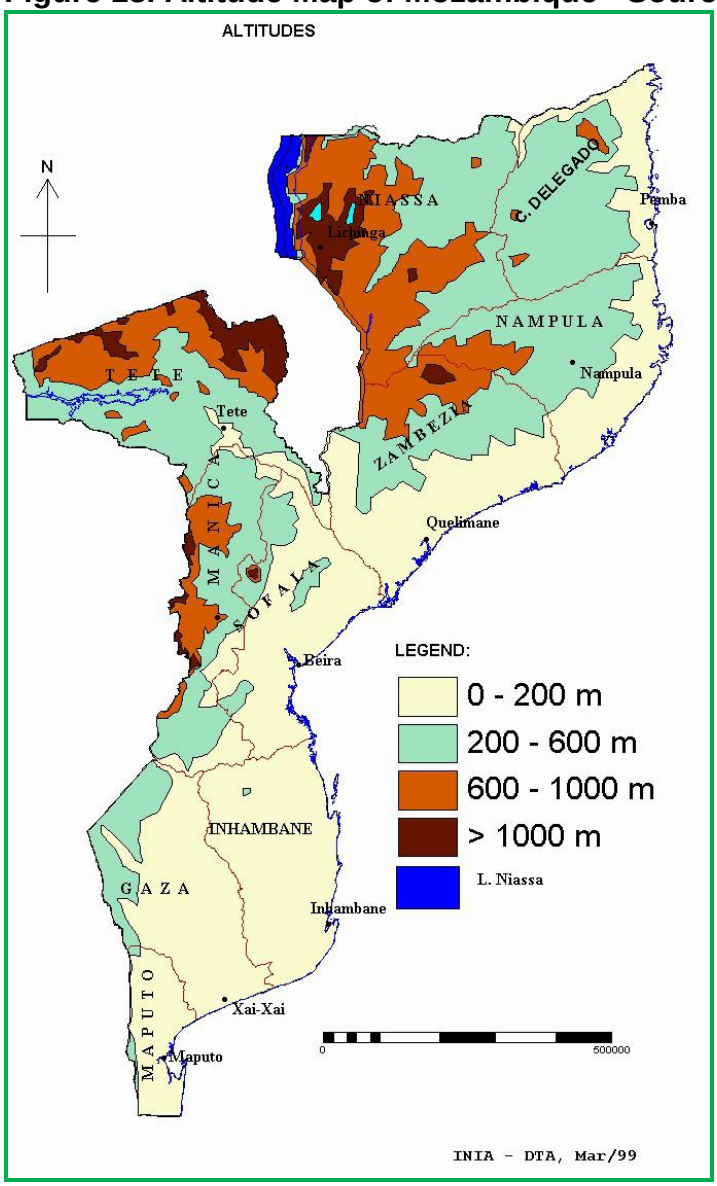
The country is generally low-lying, with coastal plains below 200 meters covering about 42% of the land, especially in the south and in a belt along the coast. Plateau areas, with average elevations between 200 and 500 meters, cover about 29% of the

country. Highlands ranging from 500 to 1000 meters cover about 25% of the land surface, with a large proportion occurring in the north and west. Mountain areas, with elevations above 1000 meters occupy about 4% of Mozambique, and are located along the border with Malawi and Zimbabwe (see Figure 18 and 19 showing Altitude and Topography Map).

Altitude

The country has a coastline of more than 2,500 km and is generally low-lying, with only 13 percent of the country above 1,000 m. The land ascends in a westward direction from the coast through a coastal lowland that is narrow in the north but broad in the south (44 percent of the total land area), through a sub-plateau zone to an extensive low-lying plateau of moderate height, and finally up to a narrow higher-lying area on the western border. The climate ranges from subtropical in the south to tropical in the center and north.

Figure 18. Altitude Map of Mozambique - Source: INIA

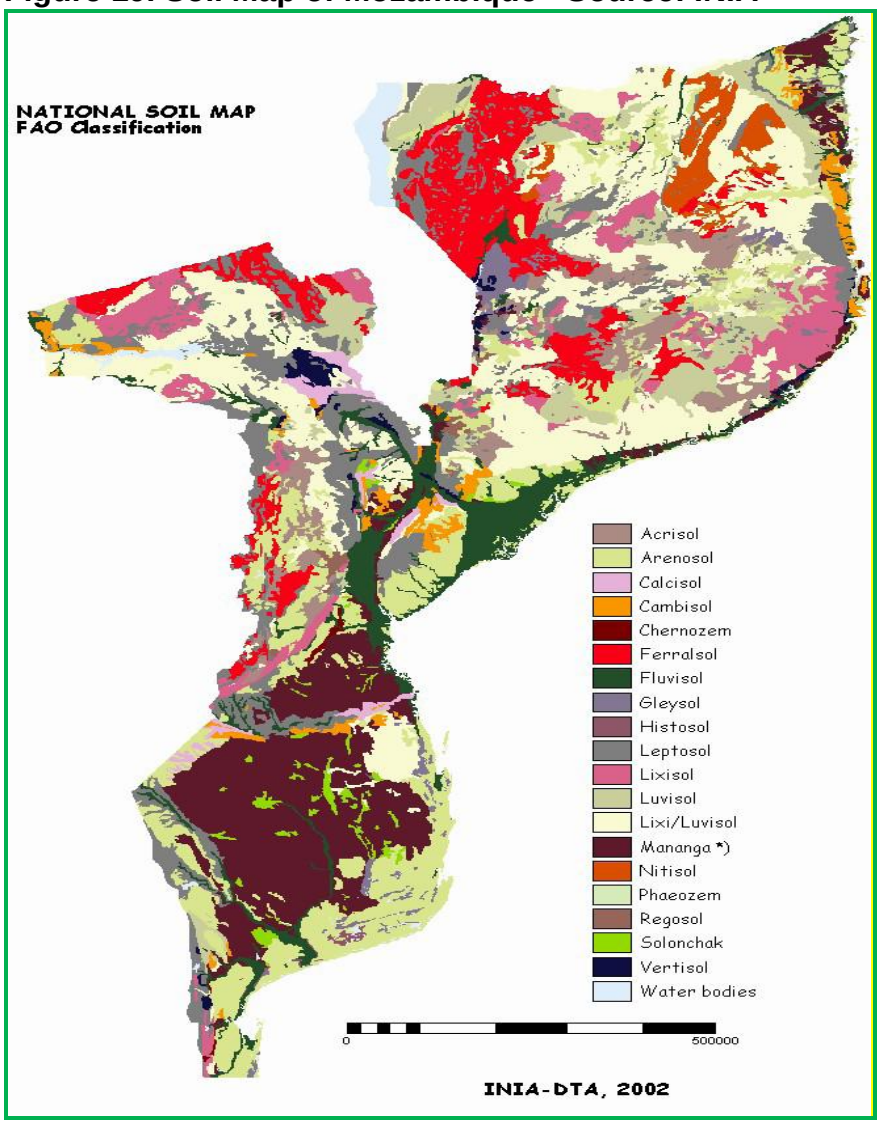


Soils

Soils in Mozambique are generally old and nutrient-poor. There are seven major soil groups in Mozambique according to the National Soils Map (National Institute of Agronomic Research [INIA], 1995). In general, all (except for fluvisols, which are found in river floodplains) are chemically poor and have low to medium fertility. The fertile fluvisols make up only about 6% of the soils of the country. In high altitude and rainfall areas, acidic ferralsols and acrisols are found; these soils have a low relative fertility. Arenosols, with very low fertility and a low water storage capacity, occur principally in the southern part of the country (Geurts, 1997).

Fertile soils with good agriculture potential are found as light clays in the north and most of the central and western parts of the country and as alluvial soils along the coast and alluvial flood plains (5). Sandy soils with limited agricultural potential are found in the low plateau in the southern part of Mozambique (5). A soil map of Mozambique is shown in the figure 19.

Figure 19. Soil Map of Mozambique - Source: INIA

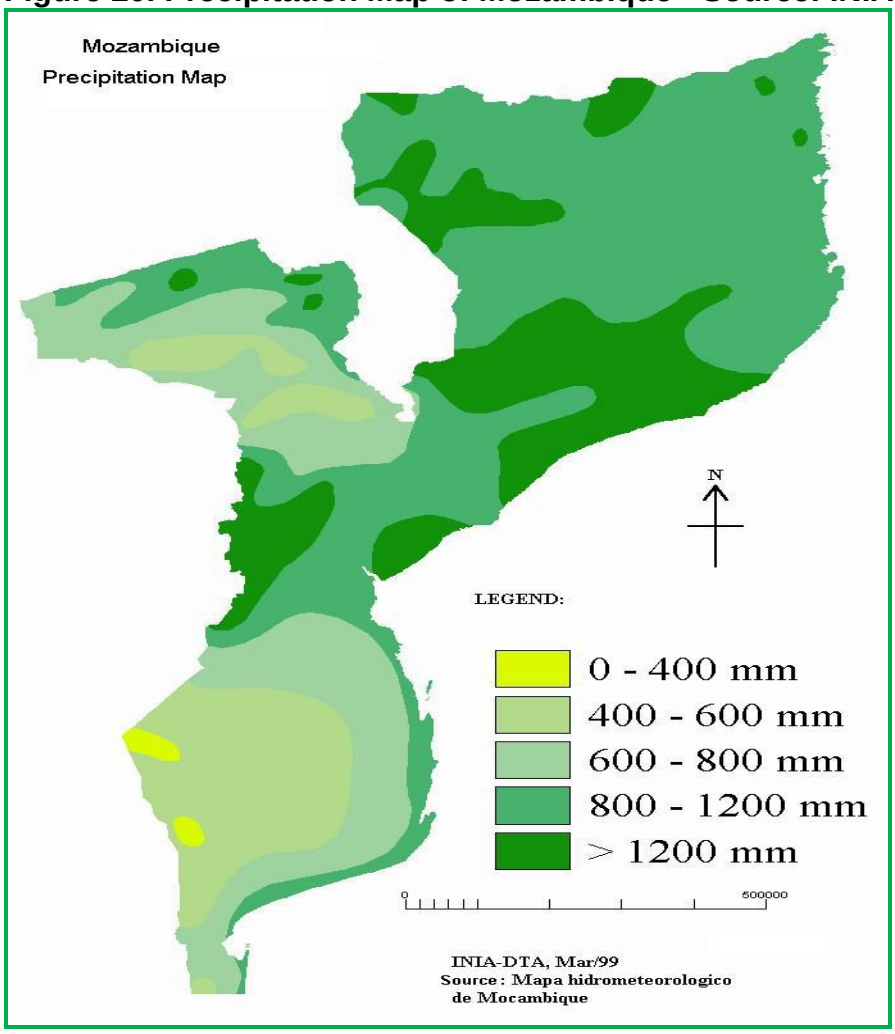


3.1.3.1 Climate

The climate of Mozambique is strongly influenced by altitude, proximity to the sea and latitude. It is semi-arid and subtropical in the south and tropical in the north, with strongly seasonal rainfall. There are two distinct seasons, a warm, wet season from November to March, and a cooler, dry season from April to October. Rainfall varies between about 1,400 millimeters a year near the Zambezi Delta to about 300 millimeters a year in the lowlands of the southern interior. The driest areas of the country lie in the interior of Gaza Province. Mountainous areas in the north and west have around 2,000 millimeters of rainfall a year (IIASA, 2002). Precipitation can vary dramatically from year to year. The coefficient of variation in precipitation ranges from 20 to 40%, with higher values occurring in the south (Reddy, 1984). Thus, droughts are common and natural.

The climate is diverse but primarily humid tropical in the northern and costal zones, and dry tropical in southern and interior zones. Average annual temperatures vary from 26-30°C, during the rainy season, and from 18-20°C, during the dry season. In mountainous areas, especially in the centre and north of the country, the climate may be modified by changes in the altitude. Altitude ranges from 0 in the eastern part of the country to more than 1000 m, in the north and central western parts (Figure 18.).

Figure 20. Precipitation Map of Mozambique - Source: INIA



3.2 Ecological Regions

Mozambique includes 14 ecological regions, of which seven have global importance: the Agulhas Current, the East African Coast, the Lakes of the Rift Valley, the East African Mangroves, the Forests of the South Rift Valley, East and Central Miombo, and the Savannas of the Zambezi Floodplains. However, to protect all important bio-diverse ecosystems in Mozambique there are two remaining areas to be designated officially for protection: Lake Niassa and the Inselberg Arquipelago in Zambezia Province. These two became part of the agenda of the action plan in the Conservation Policy and Strategy for Implementation.

Protected areas still face many challenges, and some are only protected on paper. Most of these areas are understaffed, underfunded, and without qualified personnel. Because these areas were either neglected during the war or only recently approved, human populations have for many years been living inside park boundaries and freely exploiting their natural resources.

3.3 Agro-Ecological Regions and Agriculture

The Inland Maputo and South Gaza Region (R1)

The Inland Maputo and South Gaza Region is a relatively small area covering an covering an Inland strip of Maputo Province and the southern interior land of Gaza Province. The major part of the region is under 200 meters altitude; the land of Namaacha reaches 500 meters altitude. The rains are concentrated from November to March, season characterized by great irregularity with respect to the beginning of the season, the duration of the season, and the quantity of precipitation. Rain can occur in this region during the cool season. The growing period during the rainy season has a moderately warm temperature regime (20-25 degrees). With the exception of the soils in the region of Pequenos Libombos, Moamba and the valley of the Limpopo, Incomati and Umbeluzi rivers, the soils are of sandy or sandy loam texture.

The family farmers cultivate the land during the rainy season and the cool season. During the rainy season they produce maize, cowpea, peanuts and cassava. The soil most preferred for cassava and groundnut is of light texture. Given the short duration of the growing season, short-cycle crop varieties are normally used. The production of sweet potato is carried out on the lowest land and along watercourses and where there are conditions of moisture retention. This region has large areas of pasture and a rural population that traditionally raises cattle and goats. In the region exist important areas of irrigation that could be increased in the medium term

The Coastal Region South of the Save River (R2)

The Coastal Region South of the Save River is an extensive area from southern Maputo Province to northern Inhambane Province that has one of the highest population densities in the country. There is a warm rainy season between November and March in most of the region, not including an area adjacent to the coast where rain can start in October and last until April. Rains can occur during the cool season, which has particular benefit for cassava and cashew. With the exception of alluvial land and certain low zones, the soils have a sandy texture.

The most important annual crops are maize, cowpea, groundnut, sweet potato and cassava. Depending on the type of land, the cropping of maize/cowpea and

cassava/groundnut are dominant. Due to the limited availability of land, there is a tendency to intercrop all four crops. The practice of shifting cultivation encounters difficulties due to the lack of land. As a result the fallow period has been reduced from 20 years with three of cropping, to five years with three years of cropping. Without the use of fertilizers where conditions allow, it can be expected that land productivity will decrease significantly. The production of cashew in this region is one of the most important sources of income for the rural population. The low areas and the river valleys are important for the production of rice.

Center and North of Gaza and the West Inhambane Region (R3)
The Center North of Gaza and the West Inhambane Region consists of a vast interior zone with relatively low level of population. It is one of the most arid regions of the county with an annual rainfall 400-600 mm. Concentrated in the period between November and February. Given the lack of soil moisture, sorghum and millet are also grown in the region. Maize has limited family farmers also have smallholdings of cattle and goats. Considering the duration of the crop growing period, short cycle varieties and techniques of moisture conservation would be important requirements to ensure an acceptable degree of food self-sufficiency for the rural population of this region.

Médium Altitude Region of Central Mozambique (R4)
The Medium Altitude Region of Central Mozambique is a region that includes land between 200 and 1000 meters above sea level located in the provinces of Sofala and Manica. It has an annual rainfall of 1000-1200 mm. Concentrated in the period between November and March. The crop growing period varies between 120 and 180 days. The majority of soils are light, with some occurrence of heavy soils. The average temperature during the crop growing period varies between 17.5 and 22 degrees Celsius. The crops of maize, sorghum, cassava and cowpea predominate. In the more moist areas, farmers cultivate sweet potato and rice. In this region there is good potential to produce cotton. It is a region with a moderate to high population.

Low Altitude Region of Sofala and Zambézia (R5)
The Low Altitude Region of Sofala and Zambézia embraces a strip of land on the coast of variable width that extends from the south of Sofala to Pabane district in Zambezia Province. Depending on the topography, the soils have a sandy texture alternating with regions of heavy texture (fluvisols and vertisols). In general the region has moderate to high annual rainfall (1000 – 1400 mm) and a corresponding evapo-transpiration range. The rainy period starts in November and ends between March and May, depending on the area.

In the heavy soils areas, the cultivation of rainfed rice predominates. In the regions of welldrained soils, the crops of maize, sorghum, millet, cassava and cowpea are found in association depending on the availability of land and water. Cashew and cotton are important cash crops in the farming systems.

Semi-arid Region of the Zambezi Valley and Southern Tete Province (R6)
The Semi-arid Region of the Zambezi Valley and Southern Tete Province consists of land from the driest region of the Zambezi watershed upstream from Mopeia district to the border of Zambia. Most of the land does not exceed 200 meters in altitude and the rainfall is 500-800 mm, concentrated between November and March. A zone more

downstream is more rainy and has two distinct regions of annual evapo-transpiration potential: one of 1200-1400 mm and an area with a large water deficit for most of the year and an elevated risk of crop loss. The crops of sorghum and millet predominate. No cassava is cultivated due to the complete absence of rain during the cool season and the elevated evapo-transpiration rate. There is great potential for the cultivation of cotton on well-drained land and rice on the margins of watercourses.

Médium Altitude Region of Zambeze , Nampula, Tete, Niassa and Cabo Delgado (R7)

The Medium Altitude Region of Zambezia., Nampula, Tete, Niassa and Cabo Delgado is a vast region including the land between 200 and 1000 meters in altitude (sub-planaltic, low planatic and mid-planaltic) in the interior of Zambézia, Nampula and southern Cabo Delgado and Niassa. The annual rainfall and potential evapo-transpiration of the region range between 1000 and 1400 mm. In terms of the average temperature during the growing season there are areas with above 25 degrees (classified as warm region) and others with temperatures between 20-25 degrees (moderately warm). The texture of the soils varies from sandy to clay, consistent with the topography.

Basically there are two types of cropping systems that differ by being dominated by maize or sorghum. Cassava is widely cultivated, and cowpea and groundnut are other important crops. In the most eastern part of the region cashew is very important, in almost all the region there is a high potential for the production of cotton, which has been practiced over several decades. This is an agricultural area with important human and agro-ecological potential

Coastal Litoral of Zambezia, Nampula and Cabo Delgado (R8)

The Coastal Littoral of Zambezia, Nampula and Cabo Delgado consist of a strip of land of varying width on ths coast from Pebane in Zambezia to Quionga in Cabo Delgado. The average temperature during the growing season is greater that 25 degrees. The annual rainfall ranges between 800 and 1200 mm, and the evapo-transpiration rate ranges between 1400 and 1600 mm. The soils generally are of sandy type, with heaver soils in the lowest areas. The production system is characterized by the production of cassava and millet. In the low areas rainfed rice is cultivated. Cashew has great importance for income for family farmers.

North Interior Region of Cabo Delgado – Mueda Plateau (R9)

The North Interior Region of Cabo Delgado includes the plateau of Mueda and Macomia and the surrounding areas of more that 200 meters altitude. The annual rainfall is between 1000 – 1200 mm, and the annual evapo-transpiration potential is between 1200 – 1400 mm. The rains are concentrated between December and March; the rains are normally regular. The soils are generally of loamy to sandy texture, with heavier soils occurring in the lowest areas. The dominant crop in the production system is maize. The crops of sorghum, Cowpea, cassava and sesame are also cultivated. Cashew is an important source of income.

High Altitude Region of Zambezia, Niassa, Angonia and Manica (R10)
The High Altitude Region of Zabezia, Niassa, Angonia-Maravia and includes land above 1000 meters, notably in the planaltic regions of Lichinga, Angonia, Maravia, high Zambezia, Serra Choa, Manica and Espungabera. The annual rainfall is greater that 1200 mm and average temperature during the period is between 15 and 22.5 degrees. The soil types are principally ferrasols of common beans and potatoes are also important. Given the high levels of rainfall, erosion and the loss of soil fertility are important problems. Finger millet is also cultivated in the areas and has important potential as a food and cash crop.

Agriculture is the main activity of the Mozambican population. About 84 percent of the economically active population works in agriculture, which contributes 30 percent (with considerable decrease every year due to increase from other sectors) of the gross domestic product. Pressure on arable land is considered to be relatively low though, considering the abundance of arable land and the low population density. For the country as a whole, only 12 percent of arable land is cultivated, although that varies considerably between provinces. Cropping rates are reported to be the highest in Gaza (72 percent), but much lower in Niassa and Tete (3 and 7 percent, respectively).

Cropping rates for land devoted to shifting agriculture are also reported to be modest —17 percent on average — which is equivalent to a rotation period of about one year in six. Cabo Delgado province is reported to have the highest cropping rate for shifting agriculture in Mozambique, with a rotation period of about one year in four. Food production systems are extensive, with low productivity. In an average year, these systems can supply basic foodstuffs, but the diet would be insufficiently diversified and a significant degree of food insecurity would still occur at the household level (Action Plan for the Reduction of Absolute Poverty {PARPA}, 2001).

Shifting cultivation is an ancient agricultural production system commonly practiced in Mozambique. Shifting cultivation can be sustainable if rotation cycles are sufficiently long so that natural vegetation recovery can take place, but under increasing human population pressures, the cycle is shortened, and can result in soil fertility and crop yield declines.

The FAO estimates that 36 million ha of land are arable, but the area cultivated for arable and permanent crops was estimated by the National Forest Inventory at 5.6 million ha. The total land used for cropping and mixed farming systems is projected to remain to be less than 40 percent through 2020. An unknown but significant amount of land is leased to (large) private firms and individuals, and lays fallow. This land thus is generating neither income nor employment. Of this land, 4 to 5 million ha have been estimated to be for biofuel production. If these large tracts of land are put into production, we may expect a large demand for water and water infrastructure. Although in the south this can be a major constraint, the central and northern provinces have better water resources and environmental conditions.

3.4 Fisheries and Fresh Water Resources

Thirty-nine major rivers drain into to the Indian Ocean along Mozambique's 2,700 km coastline. In the north, the Rovuma River forms the border with Tanzania. It is the third largest river in Mozambique. Six other seasonal rivers discharge along the

northern coast in Cabo Delgado and Nampula Provinces. These rivers have low sediment loads and consequently, marine turbidity is low and extensive coral formations occur in the coastal waters of these estuaries. Most of Mozambique's rivers have a torrential regime, with high flows during the rainy season and low flows the rest of the year. Of the 11 major river basins, seven are shared with other countries.

The Zambezi River, the most important in the country, feeds into Lake Cahora Bassa and the dam. The Zambezi Delta covers about 18,000 km^2. The huge dual impoundments of Kariba and Cahora Bassa are thought to have affected the downstream flooding region and the ecology of the Zambezi Delta. Also, the recent approved GRM projects in the The country is rich in fish resources, which are largely commercially exploited. Although the majority of the sector-generated income comes from marine fisheries, inland fisheries are central to the survival of many poor communities, providing an important source of food and income. Within the fisheries context, water resources management can directly affect the resource base and habitat of freshwater fisheries, and indirectly affect marine and coastal zone fisheries by reducing the amount of water reaching the sea.

The Pungue River rises in Zimbabwe and discharges into the Indian Ocean south of Beira, collecting numerous tributaries en route, and constitutes an important river system for conservation purposes of which the Urema River, which flows south through the Gorongosa National Park, services important freshwater ecosystems, birds, and large and small mammals. The Pungue River forms the southern boundary of Gorongosa Park, creating a natural barrier. The Limpopo River, in southern Mozambique, is the country's second-largest river. Flows in the Limpopo River are variable and it is often dry in long sections during the winter. An important tributary is the Elephants River, which, together with Limpopo, constitutes an important contributor for the conservation of Kruger National Park in South Africa and the Great Limpopo Trans-frontier National Park. It is therefore important to monitor carefully all new developments along these river systems.

From a regional perspective, Mozambique has abundant surface water resources (216 km^3/year). However, more than 50 percent of the water resource comes as cross-border flow (116 km^3/year) and the remainder is generated within the country. Mozambique thus has little control over its supply of freshwater. The Zambezi represents almost 50 percent of the water resource available (106 km^3/year), of which 88 km^3 comes from outside. Furthermore, all major rivers in the south originate in neighboring countries.

Exploitation of marine resources by the local industrial fishery sector in Mozambique appears to be sustainable as officially reported. Little variation in total landed catches has been officially reported in the last eight years. These fisheries are controlled mostly by limiting the number of licenses and monitoring landed catches. However, semi-industrial and artisanal fisheries are more difficult to monitor or control, and minimal data are available on total landings or catch rates. From the little available data, it appears that levels of exploitation are excessive in many areas (particularly around the major centers) and stocks are overexploited. Use of illegal fishing methods (such as dynamite, poison, and fine mesh nets, such as mosquito nets) has also

contributed to a reduction in fish stocks and habitat (such as coral reefs and seagrasses) (Hoguane et al. 2002).

3.5 Wildlife Resources

There was an increase in percentage of the national territory under protected area from 11.4 percent in 1992 to 15 percent in 2007. New conservation areas were created, namely Quirimbas National Park and Limpopo National Park. New areas of importance for biodiversity have also been identified. There has also been significant improvement in management of existing ex-situ conservation infrastructure, particularly in plant and animal gene banks and botanic gardens. This is a sign of the importance the country attaches to the integrated conservation strategy approach. Mozambique has six categories of protected areas, covering 147,345 km^2, which represents 18 percent of the total country's surface area **(See Figure 21).**

Although most protected areas were established before independence in 1975, only the Gorongosa National Park had a sufficient level of administration and infrastructure to receive tourists; the others did not have management structures or tourist facilities before 1975.

Three new protected areas (Limpopo, Quirimbas National Park, and Chimanimani Game Reserve) were established between 2001 and 2002. Limpopo and Chimanimani have been converted into Trans-frontier Conservation Areas (TFCAs) through establishment of links with conservation areas in neighboring countries (South Africa and Zimbabwe). Two more protected areas (Lake Niassa and *Ilhas Primeiras e Segundas*) have been proposed and preparatory work is at an advanced stage.

Three more TFCAs are planned: the Niassa-Cabo Delgado TFCA (linking terrestrial and marine conservation areas with others in Tanzania and possibly Malawi), the Zimoza TFCA (linking a community natural resource management area in northwest Mozambique with conservation areas in Zimbabwe and Zambia), and the Libombo TFCA (linking conservation areas in Mozambique and South Africa).

These TFCAs, as described in the country biodiversity and tourism strategies, are large, defined areas that include core protected areas and multiple-use ("interstitial'") areas where the primary management objective is to promote environmentally sustainable development compatible with the TFCA's conservation goals. There is a strong focus on including local communities and other stakeholders, and sustainable use of the natural resources by communities, particularly through sustainable tourism, as required by Mozambique's Biodiversity Strategy and Action Plan. Much of the richest and best preserved biodiversity and natural habitat in Mozambique (and southern Africa in general) is in areas adjacent to national borders, in many cases contiguous with terrestrial and/or marine protected areas and well-established nature tourism sites in neighboring countries.

Preservation of habitats and ecological links, such as migration corridors and watercourses, on both sides of the border provides a unique opportunity to protect large, intact ecosystems that span a wide range of altitudes and climatic zones. The TFCAs are important for wildlife conservation and tourism development in Mozambique, as they include large natural areas of natural vegetation and represent important global biodiversity resources.

The conservation areas (and indeed the different zones of the TFCAs) offer varying levels of protection to fauna and flora within their boundaries, as prescribed by the Forestry and Wildlife Law. National parks (and the core protected areas of the TFCAs) offer total protection to all flora, fauna, landscapes, and geology within their boundaries.

No hunting or livestock rearing, natural resource exploitation, land modification, or alien species are permitted in these areas. Natural reserves provide total protection for specified plant and animal species and/or ecosystems, while other resources may be exploited within norms established by a management plan. Areas of historic and cultural value (communal use zones) are set aside for forests with religious interest, and sites of historical and cultural use. Resource use in these areas is only permitted in accordance with customary practices and norms of communities. Multiple-use (or buffer) zones are typically established around protected areas. Resource use in these areas is permitted in accordance with an established management plan.

Recently (2004) the Marromeu Complex in the Zambezi River Delta where the Marromeu Game Reserve and four hunting areas are located was proclaimed a Ramsar Site under the convention and a Wetland of International Importance. This is the only wetland area protected in the country.

Protected area management in Mozambique falls under two government institutions. The Ministry of Tourism for all National Parks, Reserves and Hunting Areas and the Ministry of Agriculture for Forest Reserves. Protected Areas can also be proclaimed under the Historical and Cultural Heritage Law (Ministry of Education) and under the Fisheries Law (Marine Reserves).

A number of areas of outstanding ecosystem, biological and/or scenic value have been identified in Mozambique and are considered to warrant special attention (SMEC International, 2001). They are:

The Gorongosa Mountain - Rift Valley Complex. Once considered an important world spot with the largest concentration of biodiversity per unit area (Tinley, 1995). This area encompasses the isolated massif of Gorongosa Mountain and the southernmost section of the African Rift Valley. The mountain supports montane forests and heath grasslands on its summits. Several endemic and near-endemic plants and animals occur within the mountain's habitats. The Rift Valley in Mozambique is a floodplain ecosystem composed of variety of wetlands habitats. The diversity of habitats in the Rift Valley makes it one of the finest wildlife grazing ecosystems in Africa. The southern portion is protected within the Gorongosa National Park.

The Cheringoma Plateau comprises tropical forests containing a mixture of local endemics with equatorial and southern African flora. The forest on the plateau contains several commercially important hardwood species.

The Zambezi Delta Grasslands and Swamps cover about 18,000 km^2. The delta is of great socio-economic and cultural value. Marromeu Buffalo Reserve in the southern portion of the delta. The Zambezi Delta represents an important wetland for resident and migratory bird species. In 2004, the Marromeu Complex became the first

Ramsar site in Mozambique. It includes more than 680,000 ha of dry forest and woodland savanna, floodplain grassland, deep-water swamp, coastal dunes, and mangrove forest. It supports a great diversity and abundance of wildlife, including Cape buffalo, waterbuck, sable antelope, Lichtenstein's hartebeest, Burchell's zebra, and African elephant.

The Great Inselberg Archipelago. This series of habitats occurs south of the Lurio River, occupying a rectangular area of 500 km by 160 km. This Inselberg Archipelago presents a remarkable landscape of tall granite core remnants in a savanna plain. Several of the montane areas have high biodiversity moist forests.

The Chimanimani Massif,
although relatively small in area, is characterized by an exceptionally high diversity of habitats and species. The massif supports a rich endemic flora. Endemic fauna are two frogs and one reptile. Large mammals are well-represented in the area and include buffalo, eland, and sable. More than 160 bird species have been recorded in the Chimanimani Massif, some of which are endemic to the Afro-montane regions of eastern Africa. There are wellpreserved rock paintings throughout the area depicting all local and lowland big game of the region.

The Maputaland Centre of Endemism (26,734 km^2) is defined as that part of southern Mozambique and northeastern Natal. It is bounded in the north by the Inkomati-Limpopo River, in the west by the western foothills of the Libombos, in the south by the St. Lucia estuary, and in the east by the Indian Ocean. It contains extensive wetland areas. The flora consists of 2,000 to 3,000 species, of which at least 168 species/infraspecific taxa are endemic/near-endemic to the center. Of the more than 472 species of birds in the area, 47 subspecies are endemic/near-endemic.

Coastal Barrier Lakes. A characteristic feature of the *Ponta do Ouro to Bazaruto* coast is the extensive system of coastal lakes behind the dunes. The coastal lakes provide habitat for many bird species. Besides their importance biologically, these coastal systems have a high scenic value. A proposal has been developed to declare the Maputaland Wetlands (between *Ponta do Ouro* and *Inhaca* island) a Natural World Heritage Site.

Pebane Evergreen Coastal Forests. The Evergreen Coastal Forests in northern coastal Zambezia Province are of high biological importance. A new (and possibly endemic) tree species was discovered in these forests in 1998. A rich and diverse reptile fauna occurs in the coastal forests of Pebane. In 1998, two reptile species were discovered — a snake and a dwarf day gecko — both endemic to the area.

Coastal and Marine Systems

Mozambique has the longest coastal line in the eastern African region, extending from the Rovuma River mouth to *Ponta D'Ouro* about 2,700 km. It encompasses ecosystems such as coastal wetlands of international significance, mangrove forests, coastal dunes, intertidal mud flats, seagrass beds, coral reef, open water, and island habitats that are home to a rich and diverse assemblage of plant and animal species. This region has also the highest population density, with about 35 percent of the total population living in and depending on coastal natural resources for their livelihoods.

The WWF through its Coastal and Marine Program has a special interest in the eastern African coastal and marine region and has conceptualized and proposed concrete conservation actions (WWF, 2005).

The Mozambican coastal line falls under three WWF coastal and marine sub-eco-regions. The Coral Coast Sub-region, where coral reefs are the predominant ecosystem, encompasses coastal and marine areas between the Rovuma River mouth and *Ilha de Mozambique*. The Swamp Coastal Region includes areas south of *Ilha de Mozambique* to Save River and incorporates important sub-tidal and mangrove habitats of the Zambezi River Delta and its offshore banks — a productive fisheries area, especially for shrimp.

The Parabolic Dunes Sub-region extends from the Save River to *Ponta D'Ouro* and is characterized by coastal lakes, inland pools, sandy shore, and parabolic dunes and is a center of endemism in Mozambique.

Along the Mozambican coastal area, nine biodiversity conservation priority areas covering 66,800 km² have been identified for their contribution to flora and fauna species diversity, as breeding grounds for migratory avifauna and several aquatic species, including humpback whales, dugongs, and sea turtles, and for their extensive coral reefs. These centers of biodiversity are the Mtwara-Quirimba, the Nacala-Mossiril, *IlhasPrimeiras e Segundas*, Zambezi River Delta System, Sofala Bay, Bazaruto Archipelago, Inhambane Bay, Inharrime Complex, and Maputo Bay-Machangulo Complex.

Protected areas established in these centers of biodiversity are the Quirimbas National Park (Mtwara-Quirimbas), the Marromeu National Reserve and Zambezi River Delta Ramsar Site (Zambezi River Delta System), the Bazaruto National Park (Bazaruto Archipelago), and the Maputo Elephant National Reserve (Maputo Bay-Machangulo Complex). Although other protected areas have been proposed for the *Ilhas Primeiras Segundas*, four other centers of biodiversity remain unprotected.

In terms of fisheries, the industry is dominated by the Sofala Bank industrial shrimp fishery, and there are no real opportunities for other fisheries to match its profitability and scale in the near future — rent is estimated at $10-30 million annually, exports at $70 million annually, and license fees at $5 million. Artisanal and subsistence fisheries are also of crucial importance in terms of economic buffer and employment opportunities.

Although the majority of sector-generated income is from the marine fisheries sector, inland fisheries are central to survival of many of the country's poorest populations, providing an important source of food and income. Within the fisheries context, water resource management can directly affect the resource base and habitat of freshwater fisheries, and indirectly affect marine and coastal zone fisheries by reducing the amount of water reaching the sea.

Threatened Species

The conservation status of Mozambique's biodiversity resources is mostly unknown, partly due to the lack of a national biodiversity inventory, the lack of systematic

monitoring of species, and the fact that the little information that is available is scarce and disperse. About 900 species have been recorded for southern Africa, of which 581 have been recorded in Mozambique. There are a number of near-endemic and restricted range Chimanimani, Chiperone, and Namuli Mountains.

The botanical resources of the country are rich, with 6,000 species of higher plants, of which 5,500 species have been recorded and classified. Among these, 250 species are endemic and 46 are threatened (Micoa, 1996).

A total of 222 mammal species has been recorded as threatened since 1970, of which one (the white-bellied red squirrel) is confined to Namuli Mountain. It is considered the only pure endemic species. Others, such as the Blue Niassa Wildebeest, Burchell's bohmi Zebra, and Johnson's Impala are sub-species and are confined to the north.

Although mammal species diversity is high, populations of these species, especially the larger mammals, have been significantly reduced inside and outside of protected areas, due to lack of enforcement during the armed conflict (1981-1992). Gorongosa National Park and Marromeu Reserve suffered massive declines in large mammals such as elephant, buffalo, and waterbuck. Niassa Reserve in northern Mozambique was less affected by the armed conflict, and is the only protected area that still supports significant populations of large mammals such as elephant, buffalo, sable antelope, greater kudu, and leopard.

At the national level, several large mammal species are thought to be extinct or on the verge of extinction. These include the black and white rhino, giraffe, roan antelope, tsessebe, the mountain reedbuck, and the African wild dog. Seven other species, including the African hunting dog, Selinda veld rat, woodland mouse, and chequered elephant shrew, are threatened.

The freshwater and marine wetlands of Mozambique are important sites for migratory and resident aquatic bird species. One of the most important wetland sites in Mozambique is the Zambezi Delta, where more than 50 species of aquatic birds have been recorded. The delta supports numerous vulnerable and threatened bird species of global concern. The conservation status of the birds of Mozambique is under consideration, but a preliminary estimate indicates that at least 24 bird species are of conservation concern. Out of 900 bird species recorded in southern Africa, 581 are found in Mozambique. Although there are species considered near-endemic or with a restricted range, little conclusive information is available on endemism and conservation status.

Only fish species in Lake Malawi-Niassa and in major river systems such as the Zambezi, Limpopo, Pungue, and Nkomati have been documented. The lower Zambezi has by far the greatest fish biodiversity of any river system, while Lake Malawi-Niassa has the most diverse fish fauna of any lake in the world, with an estimated 800-plus fish species, most of which are endemic. The conservation status of fish species in Mozambique is not known. About 1782 species of fish have been recorded, of which approximately 800 are freshwater represented in Lake Niassa.

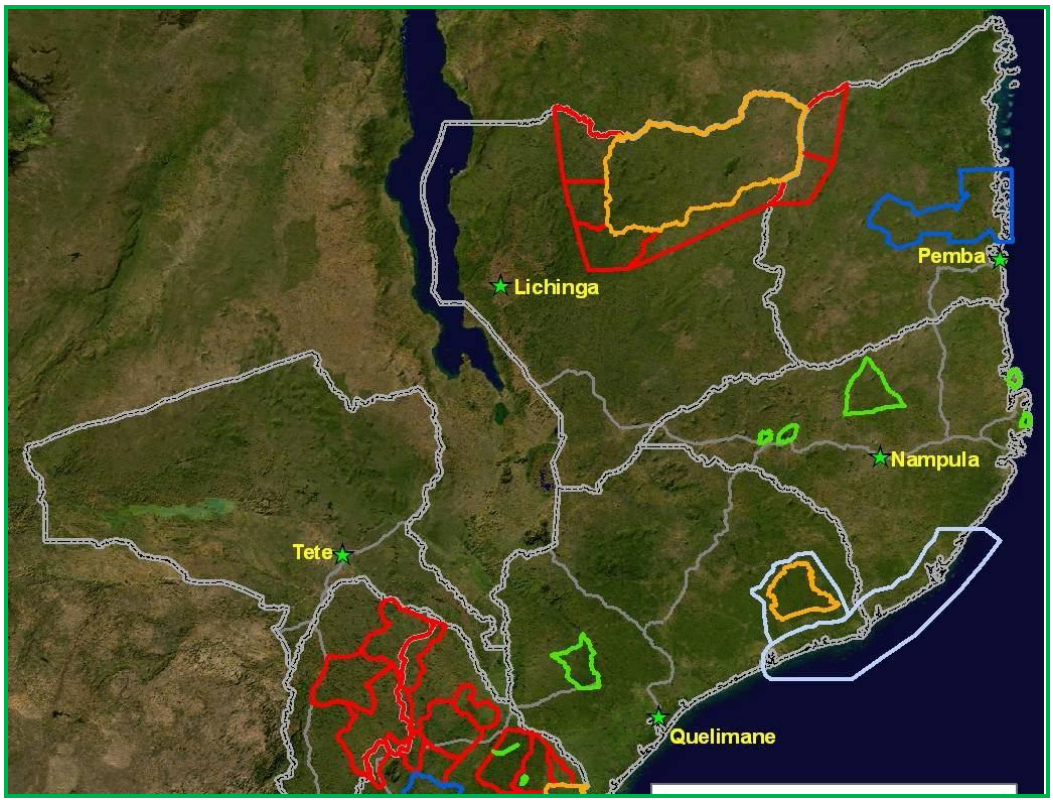
There are 167 species of amphibians and 79 species of reptiles, but both of these figures are considered underestimated. The reptile group includes five species of sea

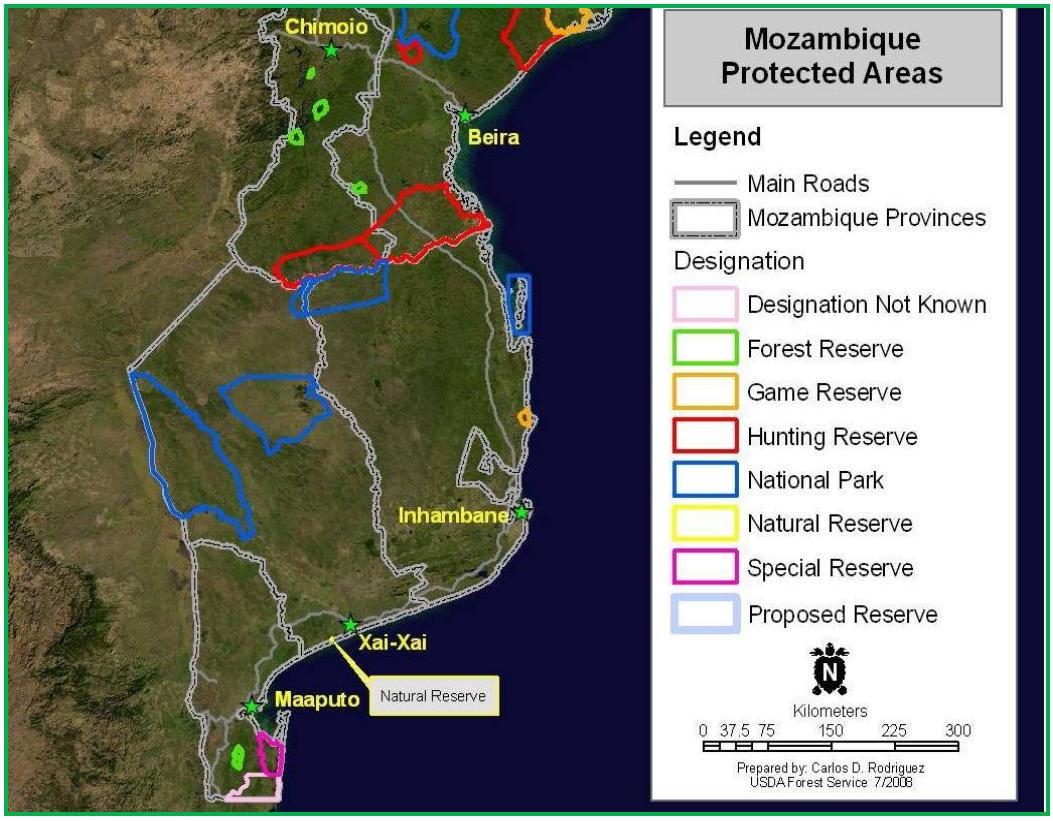
turtle. There are three terrestrial endemic reptile species; six (including the sea turtles) are considered threatened. Twenty-eight amphibian species are considered endemic, but there is no information on their conservation status.

Preliminary data show more than 150 species of coral in the marine habitats, but little or no information exists on their conservation status.

Insects are considered the second most numerous group after plants, with 3,074 species, of which only one is considered endemic, but there is no information on their status.

Figure 21. Map showing protected areas in Mozambique





3.6 Forestry

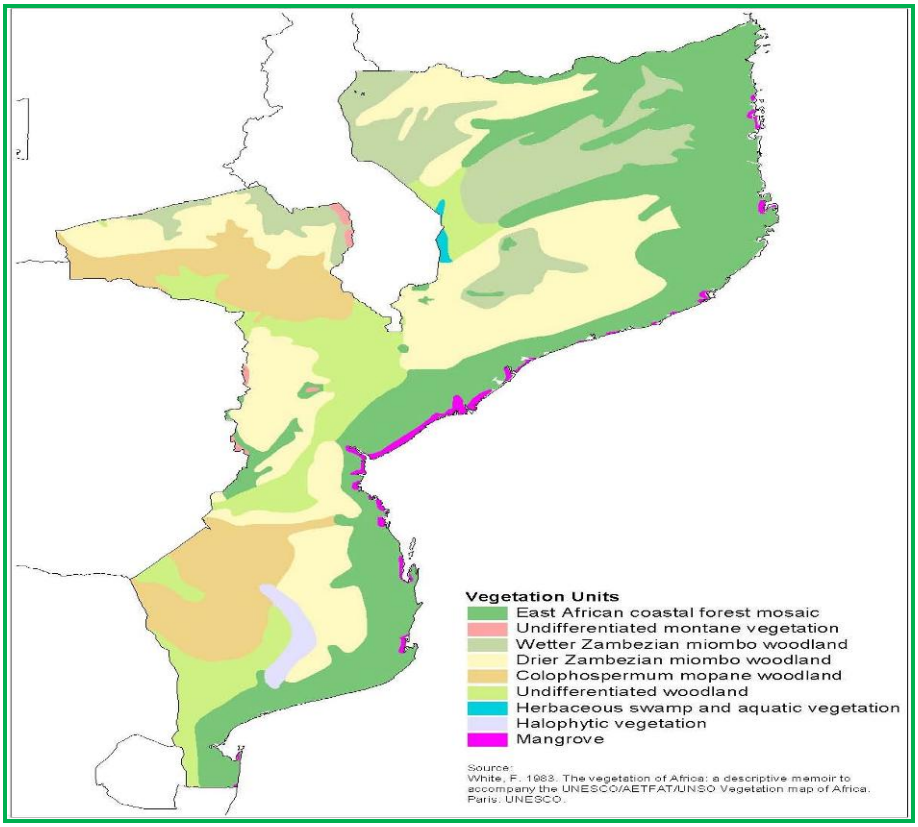
The National Administration of Lands and Forests in Mozambique through the Integrated Project of Agriculture Development carried out a National Forest Inventory from 2005 through 2007. The main objective was to evaluate the extension and floristic composition of the country forest resources. A new land cover map was developed as a result of the inventory.

The area of forest land cover is estimated in 40.1 million ha. Of this, 26.9 million ha are potential areas for wood production and 13.2 million ha are for conservation purposes.

3.7 Natural Vegetation

The main vegetation type in Mozambique is savanna woodland. It covers 70 percent of Mozambique's land area and can broadly be divided into two types: miombo and mopane woodlands. Miombo is the most extensive and covers much of Niassa, Cabo Delgado, Nampula, Zambezia, Sofala, Manica, and Inhambane Provinces. Other important vegetation types include Acacia woodland (found in the southern and central parts of the country), dune forest (which occurs on high dunes along the coast between the southern border and Bazaruto Island), a sub-littoral woodland (found inland from the dune forest in the sub-littoral zone between Ponto do Ouro and Macia), lowland palm savanna (in coastal areas in Nampula, Sofala, and Inhambane Province), vegetation on alluviums in the Zambezi Delta and the lower Limpopo and Nkomati Valleys, and mangroves, which are well-developed in the northern and central sectors of the coast and less so along the southern sector.

Figure 22. Vegetation Map of Mozambique



3.8 Beekeeping

Through a series of volunteer assignments, ACDI/VOCA has helped local bee-keeping associations to make the transition from traditional, environmentally destructive tree bark hives to Kenyan top bar hives in various provinces including Zambezia. This change has enabled the beekeepers to manage their hives, resulting in better quality and increased production. The improved honey quality led to higher prices and a 425 percent growth in yields. Collective marketing allowed beekeepers to reduce transportation costs and raise the average profit per liter of honey sold by 250 percent.

ACDI/VOCA produced a wide range of business training manuals, developed by volunteers and staff for entrepreneurs with basic levels of formal education, in addition to illustrated leaflets and brochures in Portuguese and local languages focusing on specific areas of technical assistance designed for semi-literate entrepreneurs.

Figure 23. Modern Beehive in Zambezia

4.0 Environmental Regulations

This section of the SEA outlines and reviews the existing legislations, policies, and institutions and identifies requirements, as well as gaps and conflicts of the relevant legal and institutional arrangements, that would hinder or guide the project's development in line with the national laws applicable to the IRS program. There are a number of legislations that bear significance to the implementation of this IRS program. These legislations include the following:

4.1 Environmental Framework Act, 1997

MICOA is the agency responsible for coordinating environmental issues in Mozambique. The agency's Environmental Framework Act (Act 20 of 1997) provides for the participation of local communities, among others, in the development of policy and laws for NRM, management of protected areas, and policing environmental norms and regulations.

Provisions in the law reinforce the view that communities in protected areas retain their rights, and can use them to negotiate returns on income generated on what is "still their land", even if these protected areas are re-classified for specific conservation purposes (CTC, 2003). An EIA Act (Decree 45/2004) provides the framework for managing environmental effects of development. The EIA Act requires that all sectoral legislation in Mozambique be revised to conform to the Act. Although on paper, EIA regulations follow internationally accepted processes (screening, scoping, consultation, assessment of impact, review, and monitoring and evaluation), in practice, numerous problems limit the effectiveness of the process. These include inconsistencies in substance and style across ministries and departments on environmental management, because roles and responsibilities and modes of cooperation have not been properly defined.

EIA Regulations (Decree No. 76 of 1998)

The National Environmental Management Programme is the guiding policy for environmental protection and EIA is mandatory to all activities that may cause significant impacts. The Framework Environmental Act establishes the regime of the environmental licensing based on an EIA. Decree No. 76/98 of 29 December 1998 defines the EIA Regulations (comprising 19 Articles).

Article 2 specifies the range of development projects requiring some form of EIA, and is applicable to all public or private activities that may have a direct or indirect impact on the environment.

Article 3 defines MICOA's responsibilities to issue and publicise general directives on EIA procedures, approve the terms of reference, review EIAs and issue environmental licenses.

Article 4 specifies document requirements. To begin an EIA the proponent must present to MICOA a description of the activity, an executive summary of the project and the salient environmental and socio-economic features of the project location.

Article 5 defines pre-assessment procedures. All activities not covered in the Appendix of the EIA regulations but capable of causing significant environmental impact are subject to a pre-assessment by MICOA to determine the level of EIA required.

4.2 Pesticide Act

The pesticide regulating body in Mozambique is the Agrochemical Registration and Control Section at Plant Protection Department of National Directorate of Agrarian Services – Ministry of Agriculture. This department is responsible for the registration and control of all pesticides (agricultural, veterinary, public health, and domestic use) and fertilizers.

4.3 Forest Law

According to the Forest Law (Act n° 10 of 7th July 1999), all the forest and wildlife resources in Mozambique belong to the State. The main objectives of this law are to protect, conserve, develop and utilize the forest and wildlife resources of the country in rational and sustainable ways for economic, social, and ecological benefits for current and future generations. The Law and its Regulations also stress that the State may delegate the power of forest resource management, including the objectives of replanting forests and restocking wildlife, to local communities, associations or to the private sector.

5.0 Environmental Consequences

This section addresses the potential direct and indirect impacts of the IRS program in Mozambique.

5.1 Potential Positive Effects

The direct positive impacts of the IRS program generally will be reduction in malaria morbidity and mortality.

5.1.1 Indirect Effects

The IRS program will also contribute to the local economy in the following ways. Spray operators, washers, mobilizers, and supervisors will all receive a daily payment for their work. Vehicles will be hired at a cost to transport the spray teams. There will also be capacity building in the form of training of the hundreds of personnel associated with IRS operations.

5.2 Potential Adverse Impacts-Biophysical Environment

Adverse impacts of the project are unintended effects that may compromise the well being of the environment and human health.

5.2.1 Contamination of Surface Water Courses and Underground Water

Spills in water bodies (surface) is a key concern in IRS because it could lead to contamination of water routinely used for domestic purposes, and also because pyrethroids, organophosphates and carbamates are categorized as toxic to fish and other aquatic organisms with the exeption of fenitrothion and malathion that have a low toxicity to fish. Thus, the primary concern for IRS would be the possible release of the insecticides into existing water bodies from accidental spills during the transportation of the pesticides, application of insecticides to walls, and clean up of IRS equipment. Contamination of underground water sources is possible during the disposal of rinse water following daily progressive rinse. However, the impacts of this risk are likely to be insignificant because pyrethroids, organophosphates and carbamates disintegrate/degrade very rapidly when exposed to sunlight.

5.2.2 Impacts to Birds, Fishes, and Other Organisms from Pesticides

Table 4 illustrates the degree of toxicity of the four WHOPES-approved pesticide classes to birdlife; aquatic life; and insects, especially bees, including the degree of persistence and bio-accumulation.

Table 2. Pesticide toxicity

IRS insecticide	Mammal	Bird	Fish	Other aquatic	Bee	Persistence	Bioaccumulate 2
Alpha-cypermethrin							
Bendiocarb							

Bifenthrin							
Cyfluthrin							
DDT		2					
Deltamethrin							
Etofenprox							
Fenitrothion							
Lambda-cyhalothrin							
Malathion							
Pirimiphos-methyl							
Propoxur							

Source: IVM PEA.

[1] Bioaccumulation in the environment, not in mammalian bodies (mammalian detoxification produces different results).
[2] Low toxicity, but high chronic or bioaccumulation affect on raptors, pelicans.

Key	
High Toxicity	
Medium to High Toxicity	
Medium Toxicity	
Low to Medium Toxicity	
Low Toxicity	
Data Not Found	

5.2.2.1 Summary of Toxicity of Pesticides to Avifauna, Aquatic Life, Mammals, and Insects by Class

<u>Pyrethroids</u>

- All pyrethroids are highly toxic to bees, fish, and other aquatic organisms, except Deltamethrin, which has low toxicity to other aquatic organisms.
- Birds are moderately affected by Bifenthrin and Deltamethrin (low to medium toxicity). All other pyrethroids have very low toxicity to birds.
- In mammals, only lambda cyhalothrin is highly toxic to mammals. Alpha-cypermethrin and etofenprox have very low toxicity to mammals while bifenthrin, cyfluthrin, and deltamethrin have low to medium toxicity.
- In terms of persistence in the environment, only cyfluthrin has more characteristics of persistence. The rest of the pyrethroids have low to medium toxicity.
- Bifenthrin does not accumulate in the environment. Potential for bio-accumulation in aquatic organisms for deltamethrin and cyfluthrin is relatively low while alpha-cypermethrin and lambda-cyhalothrin is medium.

Organophosphates

Organophosphates have various characteristics and impacts on different organisms depending on the type of insecticide.

- Fenitrothion has low toxicity on mammals and fish and is not persistent in the environment. However, it is highly toxic to bees, birds, and other aquatic organisms such as crustaceans and aquatic insects; it has a medium toxicity to aquatic worms. Fenitrothion has moderate to medium potential to bioaccumulate in organisms.
- Malathion is only highly toxic to bees. It has very low impacts on fish and other aquatic organisms. It has very low potential to bioaccumulate in organisms and to persist in the environment. Its impact on mammals and birds is low to medium toxicity.
- 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 bioaccumulate in organisms.

Carbamates

- All carbamates are highly toxic to bees. Propoxur is low in terms of toxicity to fish but is highly toxic to other aquatic organisms. Bendiocarb has low toxicity to fish and other aquatic organisms.
- Birds are least affected by propoxur (low to medium toxicity) but bendiocarb has very high toxicity to birds.
- In mammals, bendiocarb has a very low toxicity to mammals while propoxur has a high toxicity to the same.
- In terms of persistence in the environment, both insecticides have low to medium characteristics of persistence.
- Propoxur and bendiocarb does not accumulate in the environment.

5.2.2.2 Mitigation Measures

To minimize contamination of surface water bodies, spraying will be avoided in households that are within 30m from the natural water bodies mentioned in Section 3 of this report. During the detailed logistical assessment expected to be carried out in June/July 2011, all the targeted houses will be mapped, and those within the specified limits in terms of distance will not be sprayed based on the mapping exercise. Further, mixing of the insecticides before spraying will occur within structures targeted for spraying that act as secondary containments for any spills. This way, rapid clean up of any spill can be made within the confines of the home such that the pesticide cannot spill into any water body.

To minimize potential contamination of underground water sources, all operational sites will have soak pits constructed.

5.2.3 Impacts on Bees and Agriculture

As discussed in Section 3 of this report, beekeeping is another potential source of income in Zambezia Province. It is currently practiced in a traditional way but through the support of ACDI/VOCA a US based Non Governmental Organisation, efforts to introduce modern technology hives are gaining momentum signaling growth in this sector.

Spraying in areas that bees inhabit can lead to the death of bees, which are vulnerable to pyrethroids. The hives in the two regions are generally, though not exclusively, located far away from the spray houses, thereby minimizing interaction between the bees and the pesticide. However, drift from careless spraying remains a concern, as it can cause death if the drift moves toward the hives. This should be mitigated at all times.

5.2.3.1 Mitigation Measures

During training, all spray teams, supervisors, team leaders, and IEC teams will be instructed that spraying should not take place in areas where beehives are very close to targeted structures, or at the request of the home owner. Bees have a tendency of foraging for food early in the morning and if spraying occurs at these times in these areas the drift effect could lead to their deaths.

5.3 Human Exposure Risks/Impacts

Table 3, 4, 5, 6, and ***7*** in highlight the exposure risks of all WHOPES-approved pesticides in relation to cancer and with respect to exposure dosage, hazard quotient, and the life time average daily dose (LADD). The exposure risk for cancer is presented at different stages of the pesticide application, including mixing, spraying, post-spraying, dermal risk, etc. Generally, a hazard quotient between 1 and 10 and LADD of x10-6 is generally acceptable risk. It is important to note that the included risk numbers are sans personal protective gear.

5.3.1 Inhalation Exposure and Risk During Mixing

- Apart from DDT, only Etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.
- The predicted dose level for noncancer for Etofenprox (1.8E-04 mg/kg-day) is far higher than the lifetime average daily dose. This means that the risk to cause cancer from inhalation of these insecticides is very minimal.

5.3.2 Dermal Exposure and Risk During Mixing

On the list of insecticides to be used in IRS only three (DDT and Etofenprox [pyrethroids] and propoxur [carbamate]) have been determined to be carcinogenic at dermal exposure levels of 8E-07 mg/kg-day for etofenprox and 4E-06 mg/kg-day for propoxur.

5.3.3 Inhalation Exposure and Risk During Spraying

Apart from DDT, only Etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded. DDT will not be used in this country.

5.3.4 Resident Dermal Exposure and Risk After Spraying

The only concerns are to adults when using Cyfluthrin and Etofenprox (pyrethroids) and propoxur (carbamate). The risk, however, is very low.

5.3.5 Resident Exposure and Risk due to Ingestion After Spraying

Here, the only concerns are to adults when using Cyfluthrin and Etofenprox (pyrethroids) and propoxur (carbamate). The risk is also very low.

5.3.6 Resident Exposure and Risk due to Chronic Ingestion After Spraying

There are four insecticides with potential adverse effects caused by drinking insecticide contaminated water. These are Cyfluthrin, Permethrin, and Etofenprox (pyrethroids) and propoxur (carbamate). Permethrin has never been used for IRS.

5.3.7 Resident Dermal Exposure and Risk due to Bathing with Contaminated Groundwater

Cyfluthrin and Etofenprox (pyrethroids) have potential adverse dermal effects when using contaminated groundwater for bathing. With the best management practices applied in IRS, this risk is significantly reduced.

5.3.8 Resident Exposure and Risk Due to Reuse of Pesticide Containers

Only Deltamethrin is registered to have potential risks for acute ingestion from reusing pesticide containers to store food or water. However, residents have no access to pesticide containers used in IRS. The pesticide containers are only available in IRS storage facilities, which are securely double locked.

5.4 Worker Exposure and Risk due to Inhalation During Spillage

According to information presented in the PEA, Etofenprox, and Propoxur have potential to impact workers through inhalation during spillage. The workers are trained on how to handle spillage and on the appropriate use of PPE.

5.4.1 Exposure Risk during Pesticide Preparation and Mixing

Table 3. Adult worker intermediate inhalation exposure and risk

Pesticide	Non-cancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	1.8E-05	4E-06	NA	NA
Bendiocarb	2.3E-04	1E-01	NA	NA
Bifenthrin	2.9E-05	4E-03	NA	NA

Pesticide	Non-cancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Cyfluthrin	2.9E-05	1E-01	NA	NA
DDT	1.2E-03	2E+00	1.1E-05	4E-06
Deltamethrin	1.5E-05	1E-03	NA	NA
Etofenprox	1.8E-04	2E-03	1.6E-06	8E-09
Fenitrothion	1.2E-03	3E+00	NA	NA
Lambda-cyhalothrin	1.8E-05	2E-02	NA	NA
Malathion	1.2E-03	5E-02	NA	NA
Pirimiphos-methyl	1.2E-03	2E+00	NA	NA
Propoxur	1.2E-03	3E-01	1.1E-05	4E-08

Table 4. Adult worker intermediate dermal exposure and risk

Pesticide	Non-cancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	1.8E-03	4E-04	NA	NA
Bendiocarb	2.4E-02	1E-01	NA	NA
Bifenthrin	3.0E-03	1E-02	NA	NA
Cyfluthrin	3.0E-03	1E-03	NA	NA
DDT	1.2E-01	2E+02	1.1E-03	4E-04
Deltamethrin	1.5E-03	1E-04	NA	NA
Etofenprox	1.8E-02	4E-02	1.6E-04	8E-07
Fenitrothion	1.2E-01	1E+01	NA	NA
Lambda-cyhalothrin	1.8E-03	2E-02	NA	NA
Malathion	1.2E-01	2E-01	NA	NA
Pirimiphos-methyl	1.2E-01	2E+02	NA	NA
Propoxur	1.2E-01	1E-02	1.1E-03	4E-06

5.4.2 Exposure Risk During Spraying

Table 5. Adult worker intermediate inhalation exposure and risk

Pesticide	Noncancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk

Pesticide	Noncancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	9.7E-04	2E-04	NA	NA
Bendiocarb	1.3E-02	6E+00	NA	NA
Bifenthrin	1.6E-03	2E-01	NA	NA
Cyfluthrin	1.6E-03	8E+00	NA	NA
DDT	6.5E-02	1E+02	6.0E-04	2E-04
Deltamethrin	8.1E-04	8E-02	NA	NA
Etofenprox	9.7E-03	1E-01	9.0E-05	5E-07
Fenitrothion	6.5E-02	2E+02	NA	NA
Lambda-cyhalothrin	9.7E-04	1E+00	NA	NA
Malathion	6.5E-02	2E+00	NA	NA
Pirimiphos-methyl	6.5E-02	9E+01	NA	NA
Propoxur	6.5E-02	2E+01	6.0E-04	2E-06

5.4.3 Exposure Risk Post-application

Table 6. Adult and child resident acute dermal exposure and risk

Pesticide	Receptor	Non-cancer		Cancer	
		Absorbed Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	Adult	1.1E-02	2E-03	NA	NA
	Child	1.7E-02	3E-03	NA	NA
Bendiocarb	Adult	1.5E-01	3E-01	NA	NA
	Child	2.3E-01	5E-01	NA	NA
Bifenthrin	Adult	1.9E-02	1E-01	NA	NA
	Child	2.9E-02	1E-01	NA	NA
Cyfluthrin	Adult	1.9E-02	6E-03	NA	NA
	Child	2.9E-02	1E-02	NA	NA
DDT	Adult	7.6E-01	2E+03	4.2E-05	1E-05
	Child	1.1E+00	2E+03	Not Calc	Not Calc
Deltamethrin	Adult	9.5E-03	1E-03	NA	NA

Pesticide	Receptor	Non-cancer		Cancer	
		Absorbed Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
	Child	1.4E-02	1E-03	NA	NA
Etofenprox	Adult	1.1E-01	3E-01	6.3E-06	3E-08
	Child	1.7E-01	4E-01	Not Calc	Not Calc
Fenitrothion	Adult	7.6E-01	8E+01	NA	NA
	Child	1.1E+00	1E+02	NA	NA
Lambda-cyhalothrin	Adult	1.1E-02	1E-01	NA	NA
	Child	1.7E-02	2E-01	NA	NA
Malathion	Adult	7.6E-01	2E+00	NA	NA
	Child	1.1E+00	2E+01	NA	NA
Pirimiphos-methyl	Adult	7.6E-01	5E+01	NA	NA
	Child	1.1E+00	8E+01	NA	NA
Propoxur	Adult	7.6E-01	8E-02	4.2E-05	2E-07
	Child	1.1E+00	1E-01	Not Calc	Not Calc

Table 7. Adult and child resident acute ingestion exposure and risk

Pesticide	Receptor	Non-cancer		Cancer	
		Absorbed Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	Adult	5.3E-03	1E-03	NA	NA
	Child	8.0E-03	2E-03	NA	NA
Bendiocarb	Adult	7.1E-02	1E-01	NA	NA
	Child	1.1E-01	2E-01	NA	NA
Bifenthrin	Adult	8.9E-03	4E-02	NA	NA
	Child	1.3E-02	7E-02	NA	NA
Cyfluthrin	Adult	8.9E-03	3E-03	NA	NA
	Child	1.3E-02	4E-03	NA	NA
DDT	Adult	3.6E-01	7E+02	1.9E-05	6.6E-06
	Child	5.3E-01	1E+03	Not Calc	Not Calc

Pesticide	Receptor	Non-cancer		Cancer	
		Absorbed Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Deltamethrin	Adult	4.4E-03	4E-04	NA	NA
	Child	6.7E-03	7E-04	NA	NA
Etofenprox	Adult	5.3E-02	1E-01	2.9E-06	1E-08
	Child	8.0E-02	2E-01	Not Calc	Not Calc
Fenitrothion	Adult	3.6E-01	4E+01	NA	NA
	Child	5.3E-01	5E+01	NA	NA
Lambda-cyhalothrin	Adult	5.3E-03	5E-02	NA	NA
	Child	8.0E-03	8E-02	NA	NA
Malathion	Adult	3.6E-01	7E-01	NA	NA
	Child	5.3E-01	1E+01	NA	NA
Pirimiphos-methyl	Adult	3.6E-01	2E+01	NA	NA
	Child	5.3E-01	4E+01	NA	NA
Propoxur	Adult	3.6E-01	4E-02	1.9E-05	7E-08
	Child	5.3E-01	5E-02	Not Calc	Not Calc

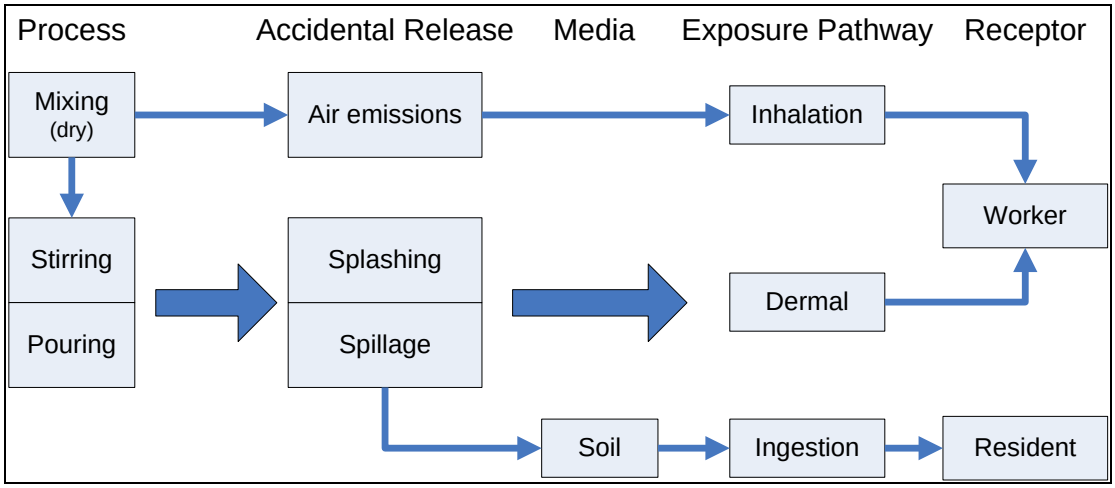
5.5 Worker and Resident Exposure Pathway

Throughout the IRS spraying process, spray personnel are at risk for unintentional or deliberate exposure through accidents or poor and improper handling of the spray chemical. Worker exposure to the chemical could arise during the pre- and post-spraying phases of the IRS operations.

5.5.1 Pre-spraying Exposure Pathway

Preparing pesticide solutions during IRS will involve pouring the pesticide in the spray can to ensure ample mixing with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, mostly from releases of pesticide vapors and solutions. Vapor releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapors or particulates or may be exposed through dermal contact. Spills could also pose significant risk, especially for children who ingest the resulting residues left on surfaces such as floors. ***Figure 24*** shows the possible modes of exposure during preparation of pesticides for IRS.

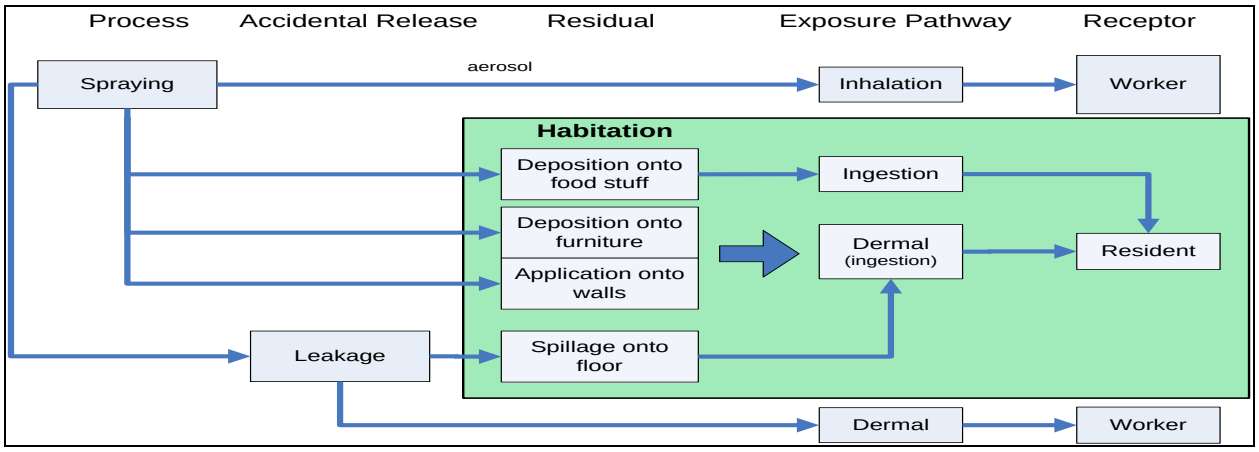
Figure 24. Conceptual model for possible exposure pathways from preparation of pesticide



5.5.2 Exposure during Spraying

Inhalation of aerosol vapors during spraying is the main process for worker exposure during IRS. Residents are mainly exposed through dermal contact with sprayed surfaces and incidental ingestion of insecticide after their houses have been sprayed, especially when food or drink are left in the house during spraying. Leaky equipment can also lead to insecticide exposure through dermal contact with floors and incidental ingestion by children who may come in contact with the spills before they are cleaned. ***Figure 25*** shows the possible modes of exposure during preparation of pesticides for IRS use by the sprayers.

Figure 25. Conceptual model for possible exposure pathways from IRS

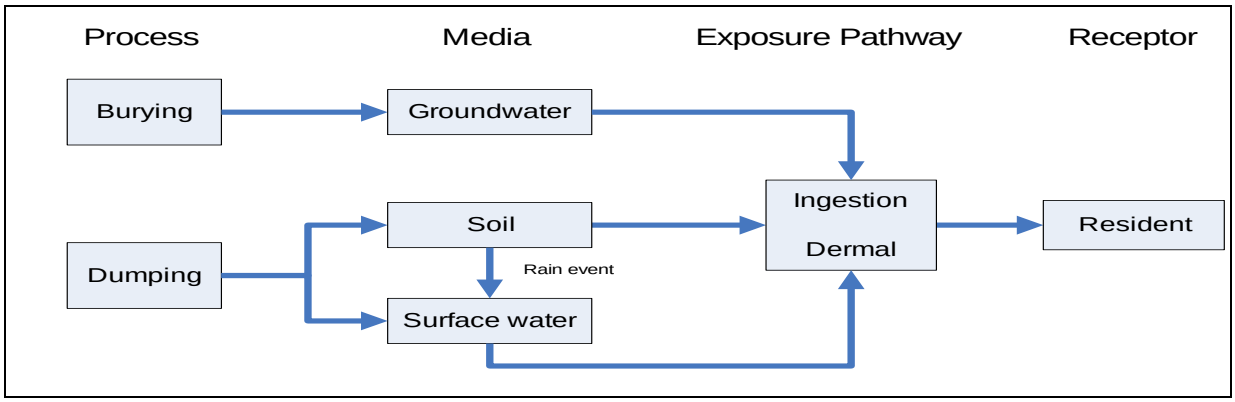


5.5.3 Exposure during Disposal (including Progressive Rinsing)

Disposal is a key issue with IRS interventions that utilize pesticides, especially during the decontamination process and disposal of the liquid effluent that will arise from washing and progressive rinse. Both burying and dumping can lead to dermal exposure to residents who come in contact with the soil or water in which the pesticide was disposed. Ingestion exposure can occur from drinking contaminated surface water. Once the excess formulation gets into the soil, the pesticide can reach

the groundwater, which may be used as a water supply via household wells. Residents may then be exposed to this contaminated water by ingestion or by dermal contact when it is used for cleaning or drinking purposes.

Figure 26. Conceptual model for possible exposure pathways from disposal of excess pesticide formulation



5.6 Mitigation Measures

This section outlines the various measures proposed to mitigate against any of the potential adverse impacts likely to occur and outlined above. The primary mitigation measures include delivery of a mix of IEC approaches, targeting the residents and spray operators and team. Measures also include provision of PPE and training to spray personnel, as well as thorough and consistent supervision and monitoring.

5.6.1 Mitigation Measures for Residential Exposure

District authorities and implementing partner program staff will work with relevant committees and NGOs to carry out an IEC campaign to sensitize residents to IRS activities, in accordance with WHO guidelines. IEC campaigns (as well as IRS program team leaders and supervisors who will also instruct residents on best practices prior to spraying) should focus on the following elements of residential safety during an IRS program:

- Clear homes of mats or rugs, furniture, cooking, and food prior to spraying; if furniture cannot be moved out of the home, then move it to the center of the room and cover it.
- Stay outside the home during spraying and for 2 hours after spraying.
- Move and keep all animals outside the home during spraying, and for two hours after spraying.
- Sweep any insects killed from the spraying and drop them in latrine pits.
- Sweep floors free of any residual insecticide that may remain from the spraying.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using bed nets for protection against malaria.

- If skin itches after re-entrance into home, wash with soap and water; for eye irritation, flush eyes with water; and for respiratory irritation, leave the home for fresh air. For ingestion, if soap and water are unavailable, or if symptoms persist, contact program staff or go to nearest health facility which has the appropriate medical intervention.

5.6.2 Measures to Reduce Exposure During Pesticide Transport

Prior to long-distance transport of insecticide from customs warehouse/central storage facilities to the targeted districts, drivers will be informed about general issues surrounding the insecticide and how to handle emergency situations (e.g., road accidents). Training for long-distance transport from the distributorship to the district storage facilities will include the following information:

- Purpose of the insecticide;
- Toxicity of the insecticide;
- Security issues, including implications of the insecticide getting into the public;
- Steps to take in case of an accident or emergency (according to FAO standards); and
- Combustibility and combustion byproducts of insecticide.

Drivers hired specifically for the spray campaign period will receive

- Training provided to spray operators (with the exception of sprayer operation and spray practice);
- Handling an accident or emergency (according to FAO standards); and
- Handling vehicle contamination.

Because vehicles will be rented for the program, it is important to ensure that pesticide contamination in vehicles does not have negative impacts when vehicles are subsequently used for other purposes (e.g., food transport). To prevent pesticide runoff from vehicle washing, drivers will also be responsible for wiping the vehicle bed with a damp cloth prior to washing the exterior of the vehicle. Finally, drivers will be responsible for cleaning and decontaminating the interior of the vehicle and exterior bed at the end of the spray campaign. Drivers will be provided with gloves to wear for cleaning the vehicle. All cloths used in wiping down the interior and bed of the vehicle will be washed with spray operator overalls.

5.6.3 Mitigating Foetal Exposure and Pregnancy Testing

All potential female spray candidates will be tested for pregnancy before being recruited into the spray operations. Women found to be pregnant will be reassigned to positions that require less exposure to insecticides. The same applies to spray operators who are breastfeeding.

5.6.4 Mitigating Spray Operator Exposure

Each spray operator will be provided with safety equipment listed below, in accordance with WHO and FAO specifications. These PPE will be replaced

frequently whenever wear and tear is identified or reported; however, respirators will be replaced everyday.

- Broad-rimmed hat/helmet;
- Face shield or goggles (face shield preferable);
- Respirators—disposable and replaced on a daily basis;
- Two sets of cotton overalls per spray operator;
- Nitrile rubber, neoprene, PVC or butyl rubber gloves, without inside lining and long enough to cover the forearm; replaced if torn or if wear and tear is noticed; and
- Rubber boots.

Workers should be closely monitored for acute symptoms, because there will always be some level of exposure. In addition, work-day duration should be monitored to limit exposure as required by safety recommendations (Najera and Zaim, 2002).

Table 8 summarizes of the acute human side effects of pyrethroids and carbamates and ways for treating each of the outlined side effects or symptoms.

Monitoring of acute exposure among spray operators will be undertaken by reviewing of Incident Report Forms that are made available to every spray team and filled out daily by supervisors. Any exposure incident is normally recorded and action is taken, i.e., immediate treatment following guidance given, or referral to the health facilities for further treatment.

Similarly, residential exposure will be monitored using the reported cases of exposure or those reported in the health centers. During the IEC campaign, residents are similarly made aware of the steps to take if exposed; if acute symptoms are encountered, residents are advised to report to the nearest health facility. Thus, reported cases at health facilities or by IEC mobilizers will serve as the principal monitoring strategy for exposure incidents.

Per consultation with WHO and a number of pesticide occupational safety and health experts in the United States, USAID requires cholinesterase monitoring for two compounds of the organophosphate class (malathion and fenitrothion). Should either of these compounds be used, the PMI Mozambique team will submit to USAID Global Health and Africa Bureau Environmental officers the following:

- A bio-monitoring plan for the upcoming year that outlines
    - Who is to be monitored;
    - The frequency of monitoring;
    - The benchmarks used in the blood monitoring;
    - The ways workers are informed of the process and the use of the tests included signed consent forms; and
    - Other factors pertinent to a bio-monitoring program.
- An annual post-spray report (can be included in the environmental compliance report) that shows the following:

- Levels of AChE activity and any changes;
  - Names are not to be given
- Any interventions that were required; and
- Any issues that arose as a product of the bio-monitoring program.

Table 8. Summary of acute exposure symptoms and treatment

Pesticide Type	Human side effects	Treatment
Malathion	Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase in the blood and brain. Exposure to high levels can result in difficulty breathing, vomiting, blurred vision, increased salivation and perspiration, headaches, and dizziness. Loss of consciousness and death may follow very high exposures to malathion.	Oral exposure to malathion should be treated with rapid gastric lavage unless the patient is vomiting. Dermal exposures should be treated by washing the affected area with soap and water. If the eyes have been exposed to malathion, flush them with saline or water. People exposed to malathion who exhibit respiratory inefficiency with peripheral symptoms should be treated via slow intravenous injection with 2–4 mg atropine sulfate and 1,000–2,000 mg pralidoxime chloride or 250 mg toxogonin (adult dose). Exposure to high levels of malathion that result in respiratory distress, convulsions, and unconsciousness should be treated with atropine and a re-activator. Morphine, barbiturates, phenothiazine, tranquillizers, and central stimulants are all contraindicated
Fenitrothion	Fenitrothion is the most toxic to man of the insecticides approved for residual house spraying, and has a relatively low margin of safety. Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor.	Dermal exposure to fenitrothion should be treated by removing contaminated clothing, rinsing the skin with water, washing the exposed areas with soap and water, then seeking medical attention. If fenitrothion gets into the eyes, they should be rinsed with water for several minutes. Contact lenses should be removed if possible and medical attention should be sought. Ingestion of fenitrothion should be treated by rinsing the mouth and inducing vomiting if the person is conscious. Inhalation exposures require removal to fresh air and rest in a half-upright position. Artificial respiration should be administered if indicated and medical attention should be sought.
Pirimiphos-methyl	This is also a cholinesterase inhibitor. Early symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, stomach pains, blurred vision, constricted pupils, slurred speech, and muscle twitching. Later there may be convulsions, coma, loss of reflexes, and loss of sphincter control.	Organophosphate poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spray operators (in the case of dispersed operations) should be trained in first-aid and emergency treatment of organophosphate intoxication. The affected person should stop work immediately, remove any contaminated clothing, wash the affected skin with soap and clean water and flush the skin with large quantities of clean water. Care must be taken not to contaminate others, including medical or paramedical workers. Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic organophosphate insecticides are used in areas without easy access to medical care. **Atropine sulfate**. Administer atropine sulfate

Pesticide Type	Human side effects	Treatment
		intravenously or intramuscularly if intravenous injection is not possible. **Glycopyrolate** has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.
Deltamethrin	Acute effects include irritability, headache, salivation, sweating, fever, anxiety, rapid heart beat, diarrhea, dyspnea, tinnitus, runny nose, vomiting, edema, hepatic microsomal enzyme induction, peripheral vascular collapse, serum alkaline phosphatase elevation, tremors, ataxia, convulsions leading to muscle fibrillation and paralysis, and death due to respiratory failure. Dermatitis is expected after dermal exposures. Dermal symptoms including itching, burning, and paraesthesia.	If exposed, immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Bifenthrin	Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness. No skin inflammation or irritation observed; however, can cause a reversible tingling sensation. In-coordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses.	Depends on the symptoms of the exposed person. Casual exposures require decontamination and supportive care. Wash affected skin areas promptly with soap and warm water. Medical attention should be sought if irritation or aresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline.
Lambda-cyhalothrin	Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning. Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions. Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis.	Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.
Alpha-cypermethrin	Acute exposure symptoms include skin rashes, eye	Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas

Pesticide Type	Human side effects	Treatment
	irritation, itching and burning sensation on exposed skin, and paraesthesia. Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful	with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.
Cyfluthrin	Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Etofenprox	Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Bendiocarb	Bendiocarb is a broad-spectrum carbamate insecticide. Bendiocarb exhibits its toxic effects through reversible cholinesterase inhibition and is considered moderately toxic in mammals. In humans, symptoms of bendiocarb toxicity include excessive sweating, salivation, headache, blurred vision, nausea, vomiting, stomach pain, giddiness, slurred speech, tightness in the chest, and muscular twitching. The effects of chronic bendiocarb exposure have not been well documented in humans. In the RED Fact Sheet for bendiocarb, EPA reported that for most of the residential scenarios, including	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.

Pesticide Type	Human side effects	Treatment
	exposure to treated surfaces, there were risks of concern for children and adults. Additionally, bendiocarb is not expected to have reproductive effects in humans at the expected exposure levels. It has not been shown to be mutagenic in animals. EPA has classified bendiocarb as "noncarcinogenic to humans."	
Propoxur	Propoxur is a broad-spectrum nonsystemic carbamate insecticide. It exhibits its toxic effects through reversible cholinesterase inhibition and has moderate toxicity in mammals. The liver and the nervous system are the main organs affected by propoxur in both humans and animals. Short-term exposures may cause effects on the nervous system, liver, and kidneys, as well as respiratory failure and convulsions. In humans, symptoms of acute oral poisoning include red blood cell cholinesterase inhibition with mild transient cholinergic symptoms including nausea, vomiting, sweating, blurred vision, and tachycardia. Long-term inhalation exposures in humans results in cholinesterase inhibition, headaches, nausea, and vomiting. EPA has classified propoxur in Group B2 as a "probable human carcinogen."	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4% sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.

5.6.5 Mitigation Measures Against Warehouse/Storage Exposure

To mitigate risks associated with pesticide storage, the following points will serve as mitigation steps:

- All primary pesticide storage facilities will be double-padlocked and guarded on a 24 hour basis.
- 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 rounds of spraying.

5.6.6 Mitigation Measure for Disposal of Wash Water

This is described in Section 2 of this report.

5.6.7 Mitigating Exposure Impacts through Container Reuse

Best practices emphasize that no matter how many times a container is cleaned, it should never be used to carry anything other than pesticides. Any container once used to contain potentially harmful chemicals should never be used to hold household items or food, especially water. The containers that will be used to ship the chemical in the country will not be allowed to get out of the warehouse.

5.6.8 Pesticide Exposure and Treatment.

The following drugs listed in ***Table 9*** below are recommended for use in case of exposure to the insecticides. The project will ensure that all the health facilities around the spray sites are stocked with these recommended drugs and that all the responsible staff receive training on emergency treatment to pesticide exposure.

Table 9. Drugs recommended for treatment of exposure

Name of drug	Active ingredients
Promethazine	Promethazine Hydrocloride
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	Salbutamol 100 mcg, suspended inert aerosol
Salbutamol tablets	Salbutamol sulphate 4 mg
Activated charcoal	Activated charcoal

All the spray operators, including supervisors, will receive detailed training on the emergency steps to take if accidental chemical exposure occurs, including ingestion, or eye or dermal contact. This training will be conducted by the district health officers and will be made up of drills to test knowledge of the operators.

5.6.9 Warehouse/Store Keeping Training

All the store keepers and managers will be trained on sound storekeeping practices and procedures to ensure that all the stock coming in and out of the storage facilities can be traced accordingly. This is a mechanism aimed at preventing pilferage of pesticides.

5.6.10 Supervision

Supervisors will observe spray teams (in a ratio of approximately 1 supervisor to 5–6 spray teams) to ensure spraying occurs according to best practices. Supervisors will travel between spray teams and will observe spray operators and team leaders in the preparation, spray technique, and sprayer and PPE clean up during the IRS campaign, They also will compile all data collected by their respective teams. Team leaders will also provide supervision in a ratio of approximately 1 team lead per 5–6 spray operators.

Supervisors and additional district and NMCP personnel will receive a 5-day training of trainer's course, according to WHO best professional practices, and will also receive additional training on personnel management, environmental aspects, entomological monitoring, geographical reconnaissance, and data recording and analysis. After each day's spray activities, supervisors will collect sachet packing material to track the amount of insecticide used, and will ensure that spray operators practice proper personal hygiene to avoid prolonged insecticide exposure.

5.7 Pesticide Quality Assurance

The procurement and use of pesticides that do not meet the necessary quality assurance standards can compromise the overall spray quality and desired vector action. They also may expose the residents and spray operators to hazards related to altered toxicological characteristics. As such, the IRS Implementing Partner will test the quality of insecticides used in the IRS program. The batches to be used in 2011, to be procured will be tested to determine quality.

5.8 Cumulative Impact

Pyrethroids, organophosphates, and carbamates degrade very quickly when exposed to light and to the external environment, thus the cumulative adverse impacts of this project is insignificant. The long-term use of any pesticide could lead to insecticide resistance. To minimize this cumulative impact, insecticide resistance must be actively monitored. The proposed action is designed with the concept of insecticide rotation and mosaic, which will reduce the future incidence of vector resistance.

5.9 Environmental Consequences Summary

The main environmental consequences of IRS application in Mozambique can be summarized as follows below.

5.9.1 Risk to Bio-Physical Environment

IRS is a highly controlled indoor activity in terms of chemical application that involves only very small doses of the chemical at low concentrations. Furthermore,

the pesticides of choice with the exception fo DDT by the Mozambique government, including organophosphates, pyrethroids and carbamates, all disintegrate rapidly in the external environment and bind easily with soil. However, DDT is highly persistent on the environment and for this reason presents a high risk in case of leaks into the environment. Results of monitooing sampling and analysis of different mediums (soil, crop, air) show that the IRS activities could be causing an environmental risk based on the levels of detections after the IRS activities.

Unless there is deliberate application of pyrethroids on the river basins, lakes, and wetlands within the country, contamination of these natural water bodies is unlikely if not minimal. The mitigation measures incorporated in the program remain sufficient to ensure no release to the external environment.

Exposure to the water bodies, even though highly unlikely due to the indoor application of the pesticide, is nevertheless a risk factor. This is particularly problematic in the event of accidental spills during transportation or deliberate, direct application by spray to bodies of water. This release would cause contamination of the water resources and consequently cause the death of aquatic life and other aquatic resources.

Wild animals, including avi-fauna and bees, are also not at a risk from pesticide exposure because all the protected areas in Mozambique are under the supervision of MICOA; no settlements are allowed in these areas. Since IRS only targets areas with high population and settlements, by default these protected areas are not eligible for IRS, in effect translating to limited or no risk.

5.9.2 Human Exposure

Exposure to human beings can occur during the application process and is capable of adversely affecting the spray operator, especially if the proper use of PPE is not followed or deliberate exposure to pesticides occurs. Similarly, the target residents are likely to be exposed if adherence to the required time before re-entering the house is not followed. Pyrethroids and carbamates pose very little risks to human health, albeit with a difference in risks in terms of toxicity.

5.9.3 Agricultural Exposure

5.10 Conclusion

In summary, the potential environmental consequences of the proposed use of pyrethroids, in Mozambique concern the bio-physical environment and the socioeconomic environment, especially human health risks. Impacts on the bio-physical environment include potential contamination of the various unique biodiversity in Mozambique, including water resources, coastal landforms, wetlands, and wildlife resources among others. Impacts on the socioeconomic environment include risk of impacting the beekeeping industry, particularly in areas where apiculture is practiced. Human health impacts related to insecticide exposure include dermal exposure impacts, inhalation related impacts and ingestion related consequences.

The table below is a decision criteria matrix showing the factors are considered in combination (e.g., malaria control, environmental effect, health risk cost effectiveness, etc). The matrix shows that pyrethroids are the most cost effective, and have country preference as well as are considered less detrimental to human health and the environment.

Organophosphates and carbamates have the disadvantage of higher human health risk and higher cost with lower country preference as compared to pyrethroids which is the preferred insecticide class.

However, should vector susceptibility or cost change over time it is highly likely that organophosphates or carbamates will become the pesticide preference for the country.

At the same time, it is important to note that all the 3 pesticide classes, when used with all the compliance and mitigation measures have acceptable risk to human health and the environment and therefore are considered part of the proposed action.

Likewise, the potential risk to the environment from spills or catastrophic incidences is too high for the alternative action to be considered (spraying in regions of sensitive, protected or special habitats).

Because the no action alternative, the alternative geographic locations, and alternative pesticides do not allow for the achievement of PMI's goals and because the risk associated with the program (when implemented as described in the 2007 PEA) and this SEA the preferred alternative, a 5-year program using pyrethroids, organophosphate, and carbamates in varying districts, based on described criteria, is the chosen action.

An EMMP has been prepared as part of this report and will be implemented primarily by RTI, with the oversight responsibility of implementation provided by relevant government ministries such as agriculture, environment, health; MICOA; and USAID.

Table 10. Decision criteria matrix

Criteria	Pesticide choice	Susceptibility	Socio-economic Impact	Cost	Country preferences	Human and ecological impacts	Total
IRS Zambezia Province	Organophosphate	+++	+++	___(more expensive than pyrethroids	+ (dependent on susceptibility studies and data)	-Cholinesterase inhibitor	3
	Carbamates	+++	+++	- (more expensive than pyrethroids and OPs	+ (dependent on susceptibility studies and data)	-- - (due to human health AChE impacts)	3
	Pyrethroids	+++	+++	0	+ Available data shows susceptibility, cost effectiveness and hence country preference		2
No Action		0	- - -	+++	- - -	+++ (from saved lives)	-0

Key/Legend

0= net zero effect
-=net negative effect
--=moderate negative effect
---=significant negative effect

+=positive effect
++=moderate positive effect
+++=significant positive effect

6.0 Environmental Monitoring and Mitigation Plan

This Environmental Mitigation and Monitoring Plan (EMMP) presents the best management practices and mitigation measures identified for the project, responsibilities for the implementation of the EMMP, and monitoring and reporting measures. This EMMP is the guiding document that will be provided to the Mozambique's IRS management team and will be used as the tool for ensuring adherence to mitigation and monitoring practices.

6.1 Scope of the EMMP

The EMMP consists of a series of components defined by project phase: pre-, during, and post-spray (see ***Tables 11–13***).

6.2 EMMP

The EMMP presents a program by which the contractor and NMCP will assure initial and ongoing compliance with environmental requirements and guidelines. The plan also includes descriptions of activities proposed for mitigating environmental and social impacts.

Table 11. Pre-spraying phase

Impact	Mitigation Measure	Monitoring Indicator	Responsibility
Accidental spills of insecticides during road transportation to warehouse and spray sites **(Human Health and Environmental impacts)**	Ensure that the drivers identified to haul the insecticide to the spray sites are well trained on the FAO standards and guidelines for the storage, transport, and stock control for pesticides	number of road accidents and spills reported records showing drivers training	Contractor –Team responsible for IEC Ministry of Agriculture Ministry of Environment,
Possible environmental contamination caused by warehouse exposure due to poor siting of warehouses, pilferage and vermin attack of the stored pesticides before spraying	Ensure the selected warehouse is sited away from a flood plain area, water course, wells, schools, markets	Storage facility located outside of floodplain, away from nearby schools, hospitals, water courses	Contractor – Ministry of Agriculture Ministry of Environment
	Secure the selected warehouse and apply all the guidelines for Storage and Stock Control manual by FAO	Storage facilities secured as per the FAO Storage and Stock Control Manual	Contractor – Ministry of Agriculture Ministry of Environment
Accidental fires and injuries in the warehouses	All warehouses must be equipped with a fire extinguisher, thermometer, exit doors, and warning signs, and proper stacking position and height as stipulated in the FAO Storage and Stock Control Manual.	Presence of fire fighting equipment, warning signs and at least three exits access in the warehouse	Contractor – Ministry of Agriculture Ministry of Environment
	All the workers handling pesticides or other products and equipment in the storage facilities must all have PPE including goggles, gloves, boots, overall, dust masks etc.	Availability of PPE to all the workers	Contractor –Team responsible for IEC
	All spray operators and store managers must be trained on how to operate the fire extinguishers and what to do in case of fire outbreaks. Develop an Emergency Response Plan	Training in fire prevention and fighting Develop an Emergency Response Plan	Contractor –Team responsible for IEC

Table 12. Spraying phase potential impacts

Impact/Issue	Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring Frequency	Responsibility
Fetal exposure could be caused by using expectant female operators in the spraying	Pregnancy tests to ensure pregnant women are not on the spray teams; prohibition of breastfeeding women on spray teams Education of women regarding risk and presentation of consent forms	Percentage female spray operators who took pregnancy tests Percentage female spray operators who indicated they were not breastfeeding Percentage of female spray operators who have signed consent forms	Once before spray operations begin and then after every 30 days for repeat purposes	MISAU at the district level with support from RTI in terms of procuring of test kits
	Reassign women spray operators who become pregnant during the campaign to tasks that minimize occupational exposure to insecticides	Number of expectant females reassigned to storekeeping work, etc.	Periodically reassign as the cases are identified	RTI COP, Logistician and MISAU relevant staff
Spray operators, drivers, and storekeepers exposure due to negligence or lack of PPE, or un-intentional exposure caused by accidents	Provide PPE to all the workers, supervisors, team leaders, and store managers. Train the team leaders, sprayers, supervisors, and store keepers on emergency procedures to take if exposure occurs accidentally i.e. dermal, eye or ingestion emergencies. Ensure that each team leader and supervisors effectively monitor the spray operations	Record indicating training has been conducted. Ability to respond as required when exposure incidents are encountered. Availability of PPE for all spray teams, including store keepers, drivers	Training to be undertaken once during the overall ToT Daily monitoring of operators by team leaders to ensure full use of PPE	RTI COP and Logistician

Impact/Issue	Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring Frequency	Responsibility
	diligently and take action to correct any noncompliance issues noted right away.			
	Procurement of sprayers manufactured according to WHO specifications; procurement and proper use of PPE by spray operators, team leaders and supervisors (cotton overalls, face shield, dust mask, broad-rimmed hat, rubber gloves, gum boots) procurement of PPE for wash persons.			
	Prohibition of eating, drinking and smoking during work;			
Cholinesterase inhibition on spray operators if OP is used especially Malathion WP	A blood sampling and Cholinesterase testing to be undertaken every 2 weeks and SOPs exposed will be removed from the field until they recover	Availability of a monitoring plan Number of SOPs tested and availability of results	Every 2 weeks all spray operators must be subjected to this test.	MISAU and RTI
Residential exposure	IEC campaign, instruct residents to: Clear homes of mats or rugs, furniture, cooking implements, and food prior to spraying	Households cleared and well prepared before the spraying	Daily basis by the team leaders and supervisors	RTI – IEC mobilization team, relevant Ministry of Health and Ministry of Environment
	Move all furniture out of the house and for immovable ones, take to the center of the	Furniture covered and or moved to the center of the houses	Cases of residential exposure attributed to lack of or inadequate	RTI-IEC Mobilization team, spray operators

Impact/Issue	Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring Frequency	Responsibility
	house and cover accordingly		IEC	
	Advise residents to stay outside the home during spraying and for two to four hours after spraying	Residents stay outside of the hours until the recommended time lapse		
	Move and keep all animals outside the home during spraying, and for four hours after spraying. Sweep up any insects killed from the spraying and drop them in latrine pits Sweep floors free of any residual insecticide that may remain from the spraying	Animals kept away from the houses until the recommended time after spraying		
	Advise not to re-plaster or paint over the sprayed walls after spraying and keep using bed nets for protection against malaria	Number of houses not plastered or painted after the spraying period		
	If skin itches after re-entrance into home, wash with soap and water; for eye irritation, flush eyes with water; for respiratory irritation, leave the home for fresh air; for ingestion, if soap and water are unavailable, or if symptoms persist, contact program staff or go to nearest health facility	Cases of reported exposures to the health facilities		

Impact/Issue	Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring Frequency	Responsibility
Acute effects of pesticide exposure	Ensuring treatment medicines for insecticide exposure listed in SEA mitigation section are available at the district level. Ensure first aid kits are available in the storage facilities and the transport vehicles	Availability of exposure treatment medicine in the hospitals Percentage of treatment medicines available at health facilities Availability of first aid kits in storage facilities and hired vehicles	Once before spraying begins and then periodically to check if the medicines are finished in the health centers and if the first aid kits require replacement.	RTI COP and MISAU
Community exposure, fetal exposure	Prohibition of spraying in homes where sick persons or pregnant women are living and cannot move outside the home *and* stay outside the home during and 4 hours after spraying Prohibition of spraying in homes where food, utensils and flooring have not been removed from the house, and where furniture has not been removed outside *or* moved to the middle of the room and covered with a cloth by the spray operator	Residents outside house during spraying (previously mentioned) Residents stay outside for four hours after spraying (previously mentioned) Occurrence of skin/eye/throat irritation (previously mention Food and goods outside house during spraying (previously mentioned	Daily basis	RTI Supervisors, Team Leaders

Table 13. Post-spraying phase

Impact	Mitigation Measure	Monitoring Indicator	Monitoring Frequency	Responsibility
Pilferage and community exposure, environmental contamination from any remaining pesticides not used	Keep storage facilities up to standards described in FAO Storage and Stock Control Manual; Storage of all insecticides, empty packaging, barrels and tubs in storage facilities	Presence of a dedicated and trained storekeeper Insecticide stored separately from food and medicine (previously mentioned) Stock records up-to-date Facility double-padlocked and guarded Facility physically secure At the end of the spray round, [stock remaining] = [stock at start] – [no of sachets distributed] No. sachets distributed should be equal stock records up-to-date Cases of theft or pilferage reported	Daily accounting of insecticide and tally of used sachet Periodic monitoring of the warehouse to ensure that it does not have structural problems.	RTI, Ministry of Environment
Community exposure from vehicles and secondary warehouses	End-of-program cleaning/decontamination of interior and exterior of vehicles End-of-program cleaning/decontamination of the interior of all secondary warehouses. Collection of all the IRS solid wastes at the secondary storage facilities and transferring to central warehouse.	Evidence of Interiors and exteriors of vehicles cleaned daily Evidence of cleaning of all the secondary warehouses Cases of passenger exposure	Daily Secondary warehouses will be cleaned at the end of spray operations however daily cleaning of the warehouses will be done for hygiene reasons	RTI, drivers/rental company, logisticians, store keepers, and managers at the secondary warehouses.
Environmental Contamination And Resident Exposure From	Sprayer progressive rinse, spray operator bathing, washing of overalls, PPE, and	Reported cases of residential exposure Evidence of progressive rinsing during	Daily	RTI, Ministry of Environment

Impact	Mitigation Measure	Monitoring Indicator	Monitoring Frequency	Responsibility
IRS spray disposal activities	cloths used to cover furniture, Ensure that a soak pit is constructed for disposing residual water after clean up Storage of empty sachets until disposal option selected by the country. Procurement and distribution of barrels for progressive rinse, and washtubs for personal hygiene; inscription of program barrels and tubs as district health office property to deter sale and domestic use in event of pilferage	all post spray clean ups Evidence of soak pits in all the return sites for clean up designed and constructed in the acceptable format Evidence of empty sachets stored in sealed barrels awaiting recapture by manufacture Availability of wash barrels and tubs with program inscription		
Spray operator exposure due to lack of washing after spraying	Ensure all spray sites have washrooms with adequate water and soap for washing	Reported cases of operator exposure Soap and clean water available at all times (previously mentioned) Adequate numbers of shower/bathing facilities available for spray operators (designated wash basins at a minimum) (previously mentioned)	Daily	RTI COP
Residential exposure from contact with secondary warehouses	Decontaminate by cleaning all the 105 secondary warehouses to ensure that exposure incidents are minimized. Collect all the IRS solid waste to the central warehouses for further disposal	Level of decontamination of warehouses after spray operations end	Decontamination to occur at the end of the spray operations. Daily cleaning and collection of waste to be undertaken.	RTI store manager and keepers

6.3 EMMP Implementation

This EMMP will be implemented by RTI and NMCP, which are directly involved in this project. However, other institutions such as MICOA may undertake their own environmental management actions.

6.3.1 Environmental Framework Act

MICOA is the oversight institution over the environment in Mozambique and has the authority to monitor environmental compliance of all the projects implemented in the country. The authority mandated by MICOA includes:

6.3.1.1 Oversight Monitoring

As the lead agency responsible for the protection of environment in Mozambique, MICOA is authorized to play the leading oversight role of monitoring the activities of project according to the Environmental Framework Act.

6.3.1.2 Site Inspection Visits

6.3.1.3

MICOA is also authorized to undertake site visits to inspect and verify for themselves the nature and extent of project impacts. MICOA is expected to undertake routine site visits to inspect and verify for themselves the extent to which all projects implemented in Mozambique adhere to the mitigation measures proposed in this EMMP or vice versa and determine necessary action. Increased support to MICOA may be necessary in order to enable it to provide adequately its oversight support role.

6.3.2 RTI/NMCP

RTI and NMCP will undertake monitoring of the activities to ensure internal compliance is achieved. The inspection and monitoring will be undertaken by the RTI environmental compliance inspector based in Nairobi and will occur during the pre-spray and spray phases. The inspector will endeavor to ensure that all the mitigation measures highlighted in the EMMP are being followed. He will produce an internal compliance inspection report that will be shared with MICOA and USAID.

6.3.3 USAID

USAID is the main development partner in this project and provides all the funds that will be used for IRS implementation, including ensuring mitigation measures are in place. USAID's role will include routine and periodic monitoring of the project activities to ascertain the extent to which compliance with the EMMP is being upheld by the implementing partners. USAID will review compliance inspection reports submitted by RTI to determine the level of compliance and will also undertake periodic field visits to determine the same. Based on the field visits and compliance reports prepared, necessary actions will be undertaken.

6.4 Annual Documentation

On an annual basis the PMI Mozambique team, in collaboration with the Implementing Partner, will submit to the GH Bureau Environmental Officer and Missino Bureau Environmental Officer a letter report that addresses the following issues:

1. Compliance issues and improvements from the previous year
2. Vector susceptibility
3. Current country pesticide registration status
4. Future year pesticide use plan to include rationale for locations, (transmission rates, susceptibility, vector behavior etc) pesticide selection etc
5. Other factors that contributed to the current year proposed plan.
6. Potential environmental impacts not foreseen in the Supplemental Environmental Assessment

1.0 References

1. African Development Bank. Mozambique 2006-2009 Country Strategy Paper, April 2006. http://www.afdb.org/pls/portal/docs/PAGE/ADB_ADMIN_PG/ percent20MOZ percent20FINAL.PDF
2. CIA. Mozambique, The World Fact Book 2008. https://www.cia.gov/library/publications/the-world-factbook/print/mz.html
3. MICOA. Estrategia Ambiental para o Desenvolvimento Sustentavel de Mocambique, July 2007.
4. MICOA. Mozambique's Third Report to the Convention on Biological Diversity, September 2006. http://www.cbd.int/countries/?country=mz
5. MICOA. National Biodiversity Strategy and Action Plan Provincial Briefings, March 2004.
6. MICOA. Mozambique's Strategy and Action Plan for the Conservation of Biological Diversity in Mozambique July 2003.
7. Micoa. First National Report on the Conservation of Biological Diversity in Mozambique, 1997.
8. MITUR. Mozambique's Conservation Policy and Strategy of Implementation, June 2008.
9. Ministry of Planning and Development/Mozambique. January 2008. The Contribution of Tourism in Mozambique, Past and Present. Discussion Papers, No. 57E.
10. Nathan Associates. Draft, Sustainable Financing of Protected Areas in Mozambique, October 2007.
11. Overseas Development Institute. Environmental Institutions, Public Expenditures and the
12. Role for Development Partners: Mozambique Case Study, February 2008.
13. Parker, V. Atlas of the birds of central Mozambique, Avian Demographic Unit, 2005.
14. SADC Regional Biodiversity Strategy (http://www.sabsp.org/strategy/index.html)
15. Smithers, R.H.N. and Tello, J.L.P.L. Check List and Atlas of the Mammals of Mozambique. Museum Memoir, Number 8, 1970.
16. Winrock International. Land Use and Forestry Carbon Off-Set Projects,paper prepared for USAID Environment Officer's Training Workshop, July 1999.
17. World Bank. Country Assistance Strategy Progress Report, February 2006. http://wwwwds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/05/16/00 0090341_20060516104127/Rendered/PDF/35319.pdf
18. Draft country program document for Mozambique (2007-2009). Executive Board of the United Nations Development Programme and of the United

Nations Population Fund. April 20, 2006. Annual session 2006. 12-23 June 2006, Geneva

Consultancy Report

INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

Indoor Residual Spraying (IRS) IQC IRS2TO1

Mozambique IRS Program

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Consultancy Dates:

Scope of Work for the Consultants

Background

Mozambique is implementing indoor residual spraying (IRS) for malaria control as part of an integrated vector control management strategy. USAID provides support for the implementation in Zambezia province of Mozambique. RTI International (RTI) has been identified as USAID's principal implementing partner to support IRS activities in Mozambique. Spraying was carried out from August to December 2010

in Quelimane, Nicoadala, Namacura, Mocuba, Milange, Morrumbala, Mopeia and Maganja da costa districts. Entomological monitoring is one of the IRS core components for which RTI provides support. Entomological monitoring is essential to determine whether vector control interventions such as Indoor Residual Spraying (IRS) are properly applied and remain effective. It is also important to insure susceptibility of vector mosquitoes to the insecticides being used. RTI provides technical assistance for entomological monitoring to complement capacity within the National Malaria Control Program (NMCP).

General objective

To provide technical support and guidance in the entomological monitoring component of the IRS program and to supply a report on entomological indicators for decision making for the 2011 IRS round in Mozambique.

Specific Activities

1. Hold in-briefing and de-briefing sessions with the PMI country mission.
2. Analyze data collected by field entomologist and draft a report for NMCP and PMI on findings.
3. To ascertain whether the in-country technicians have adequate skills in applied field entomological techniques after having completed training with the entomology technician consultant (Enock Mpanga). Provide any additional necessary training in field entomology activities that relate to the technician's responsibilities.
4. To review the appropriateness of the already availed field literature and bench aids for technicians in all entomological monitoring techniques and to suggests improvements if necessary.
5. Develop a schedule of entomological monitoring which covers the PMI IRS entomological monitoring indicators.
6. Work with the RTI monitoring and evaluation staff to include the entomology data into the IRS M&E database.
7. Review the algorithms for entomology work flow from field to Maputo and vice versa. (Mosquitoes from the field get sorted out, recorded and preserved for transmission to the national level. In addition, about 5% of Culicines should be preserved and forwarded together with anopheles.)
8. Review data records and management tools including specimen preservation and handover for further processing in Maputo.
9. In collaboration with in-country entomologist(s) at the national level develop data analysis and reporting methodology appropriate for the PMI IRS entomology monitoring for high level reporting and dissemination.

Summary of Activities

1. Held in-briefing and de-briefing sessions with the IRS country partners including PMI, WHO (Malaria NPO), NMCP (Dusecaria and Maria Podja) , INS (Macassa), DPS in Quelimane (Dr. Judy) and RTI

2. Trained technologists on entomological monitoring, mosquito rearing, mosquito identification, mosquito samples processing and data recording (both theory and practical).
3. Developed Standard Operation Procedures for entomological monitoring and mosquito rearing.
4. Developed data recording forms and insectary record sheet
5. Developed job aids and algorithms to guide the technicians in their work
6. Held discussions with the RTI M&E focal person on the entomological monitoring (indicators, data collection schedules, SOPs and data handling).
7. Collected mosquito larvae from the field, reared them into adults and conducted susceptibility testing to the four classes of insecticides.
8. Collected and identified common *Anopheles* species
9. Conducted wall bioassay on some houses
10. Analysed and summarized wall bioassay and insecticide susceptibility data

Main Outcomes

2. In-briefing and De-briefing Sessions

From these sessions, the following observations were made:

a. The partners recognise the importance of strengthening the entomology monitoring component of the IRS M&E system
b. There is concern over continuity of entomological activities as there is no clear leadership in this area
c. There exist entomological monitoring data and reports but their dissemination and use for decision making is limited.
d. There are many mosquito samples (7,000) that requires laboratory processing (PCR& ELISA) and NMCP is concerned over this issue and requested the support of partners to ensure that these samples are processed.

3. Training of Technologists

In Quelimane, the government had recently posted two technologists to add into the two that were charged with entomological monitoring. Therefore, the newly posted technologist required training in entomology. Initially, the two existing technologists had been trained by the entomology technician consultant (Enock Mpanga). During the training, the technsologist were joined by the Malaria Control Focal Person for the province of Zambezia (Mr. Nacima), the RTI M&E personnel (Dan Lole and Joel), and a technologist from INS in Maputo. During the training, the following key topics were covered:

- Entomological monitoring (Importance, indicators , monitoring schedules, SOPs and data handling)
- Mosquito rearing (SOPs)
- Mosquito identification (Key)
- PSC
- Wall Bioassay

- Susceptibility testing
- Larval collection
- Mosquito sample processing
- Data recording (forms) and preliminary analysis (tables and graphs).

For each of the topics, notes, SOPs, identification keys, flow charts, data record forms or guidelines were developed and left behind for interpretation into the Portuguese language as well as sharing with DPS. These materials were also given with RTI Nairobi (Rodaly Muthoni).

Photo: Training of technologists on mosquito larval collection

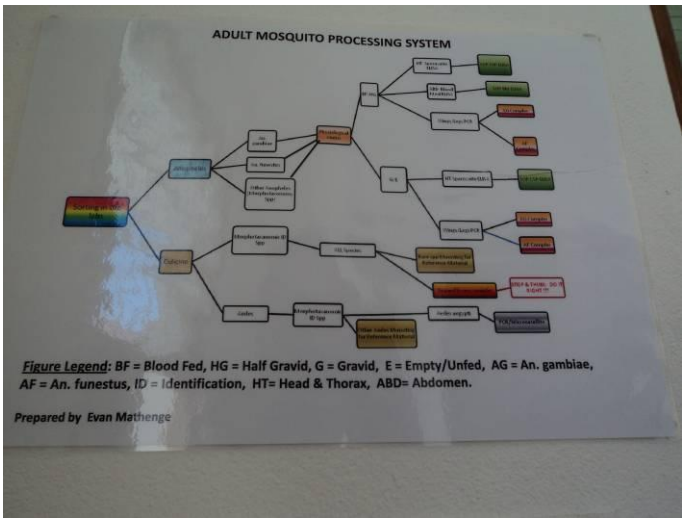

Photo: Bench aid (mosquito processing algorithm)

After the training, the technologists were requested to develop a one month work plan for entomological monitoring. The consultants together with the RTI entomologists are following up on this as well as the entomological monitoring itself

4. Entomological Monitoring

As part of the training, the indicators, the methods of data collection and recording as well as the monitoring schedules were developed and agreed upon. In addition, during this period, real entomological monitoring took place (Mainly wall bioassay,

susceptibility testing and monitoring mosquito species densities and composition) This data and previous available data were analysed and summarized in form of graphs and tables that can be used for decision making. The following is a summary of the key entomological indicators that were collected and analysed.

a. Insecticide Susceptibility Testing

Mosquito larvae were collected from the field and reared to adults at the Quelimane Insectary. 2-5 days old mosquitoes were exposed in WHO insecticide treated papers in tubes for one hour. Knockdown was noted every ten minutes, after which they were transferred to holding tubes and kept for twenty four hours and a cotton pad soaked in 10% sugar solution was put on top of the holding tube. Final tallying of mortality was done after twenty four hours.

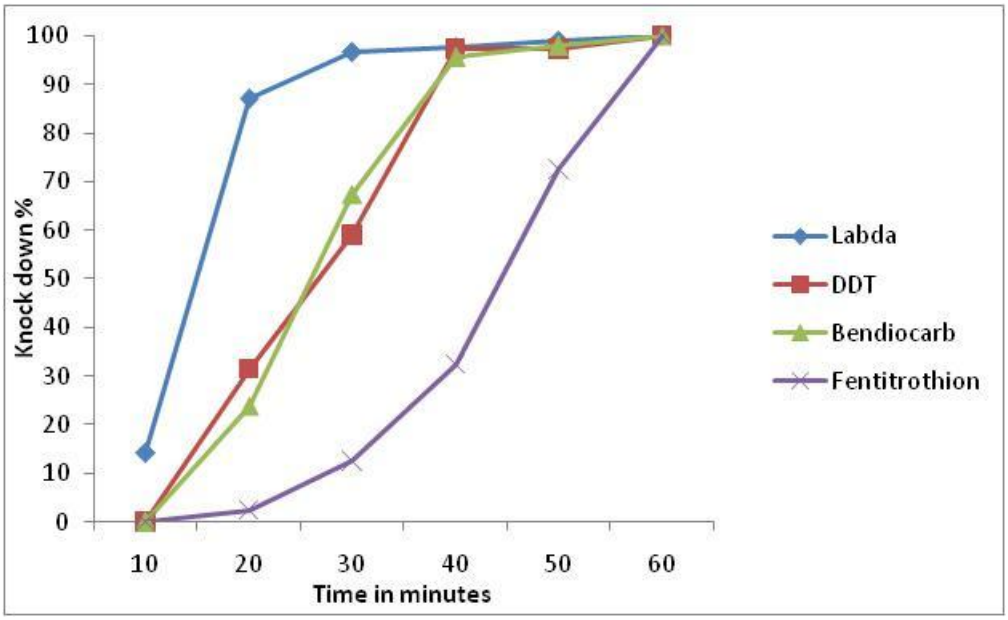

Figure 1: The rate of mosquito (*Anopheles gambiae sl.*) knock-down by the four classes of insecticide over a 1hr period.

Species	Population	DDT	Labda-Cyhalothrin	Deltamethrin	Bendiocarb	Fenitrothion
A. gam. s.l.	Mucuba	100 (73)	100 (85)	ND	100 (46)	100 (45)
	Maganja da Costa	ND	ND	100 (20)	ND	100 (20)

Table 1: Susceptibility status of malaria vectors (*Anopheles gambiae sl)* in Zambezia Province. All of the mosquito population tested were 100% Susceptible to all classes tested. The number in parenthesis indicate the total tested

b. Insecticide Decay Rates

Insecticide decay rates were measured using WHO cone assays. Unfed female mosquitoes (reared in the insectary 2-5 days old) were carried to the field site in 40 cm^3 cages covered with wet towels. Three WHO cones were fixed on the walls (top,

middle bottom) of the sitting rooms of 10 sentinel houses in Mucuba district. Ten mosquitoes were introduced into each cone and held there for 30 minutes. At the end of the 30 minute exposures, mosquitoes were removed and placed in 1 pint paper cups and provided with sugar water. The mosquitoes were then placed inside a cooler box for transport to the insectary. Controls were run on each date to adjust for mortality that may have occurred during transit or handling. The controls bioassays were conducted by testing mosquitoes against untreated wooden boards or cartons.

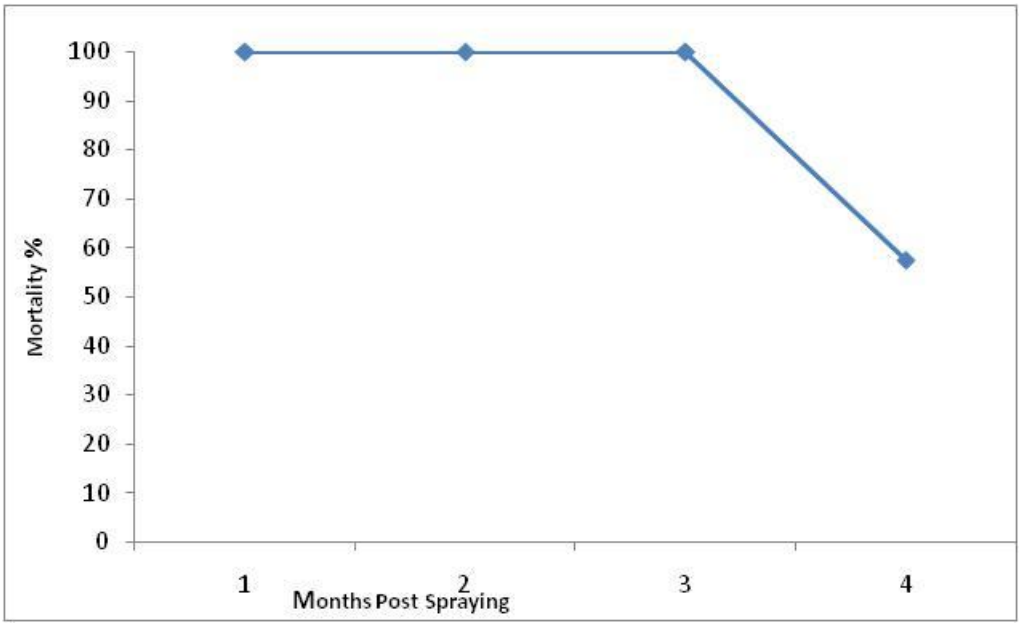

Figure 2: The decay rates of labdacyhalothrin.

c. Vector Density

Initially vector density was conducted by the use of window exit traps. However, a quick exploratory look at the resulting data indicated this method did not yield any useful information. Therefore there was a switch over to pyrethrum spray catches (PSC). For this period, density was estimated monthly using pyrethrum spray catches (PSC) in sentinel houses in the target districts. PSCs were conducted by laying white sheets on the floors of a house and then spraying the inside of the house with an insecticide that rapidly knocks down insects inside. After the houses were sprayed, the windows and doors were closed for 10-15 minutes. The sheets were then examined for any mosquitoes that had fallen to the ground. Mosquitoes were transferred to petri dishes lined with damp filter paper and returned to the laboratory for identification and further processing. The number of people who slept in the house the previous night as well as the presence or absence of a mosquito net was recorded.

Table 2: Mean mosquito house resting densities in sprayed and non-sprayed houses as determined by the PSC method. NB: Only culicine mosquitoes were recovered from the houses.

District	House status	Mean Density	Biting rate
Nicodala	Sprayed	12.3	0.11
	Not sprayed	44.7	0.66
Quelimane	Sprayed	5.0	0.19
	Not sprayed	8.3	0.06
Mocuba	Sprayed	7.5	0.43
	Not sprayed	7.3	1.22
Namacurra	Sprayed	8	0.26
	Not sprayed	6.5	0.31

d. Species Composition

Since no *Anopheles* mosquitoes were recovered by the PSC method, collection of *Anopheles* larvae was carried out in four districts. These larvae were raised to adults and identification done using taxonomic keys. The Anopheles species identified were *An. gambiae sl.*, *An. funestus* and *An. natalensis*.

Table 3: Relative abundance (%) of Anopheles species in four districts in the province of Zambezia.

District/Species	*An. gambiae*	*An. funestus*	*An. natelensis*
Maganja da Costa	84.3	15.7	0
Murumbaru	36.2	8.7	55.1
Mocuba	98.3	1.7	0
Nicoadala	100	0	0

Conclusions

- *Anopheles gambiae* sl. in Mocuba district is fully susceptible to the four classes of insecticides.
- The main *Anopheles* in the province of Zambezia are *An. gambiae sl.*, *An. funestus* and *An. natalensis*.

- Labdacyhalothrin is has a residual efficacy of at least three months but this residual efficacy period is not adequate to cover the transmission period.
- By using the PSC sampling method, no *Anopheles* species were found resting indoors in four districts by the use of PSC.
- Window exit traps do not yield valuable data
- The field collected mosquito samples have not been analysed (PCR and ELISA)
- There is a leadership gap in entomological monitoring in RTI

Recommendations

- A supervisor/coordinator for entomological monitoring should be recruited and the technician from Maputo (Maccasa) should be engaged frequently to transfer his skills to the newly posted technologists.
- A comprehensive entomological monitoring plan should be developed on a monthly basis.
- PSC should be used for monitoring mosquito house resting densities
- Vector susceptibility testing should be carried out in the remaining districts.
- The data collected form Zambezia by LATH (Anna Paula) should be availed to the malaria control focal point in Quelimane and RTI
- Although labdacyhalothrin proved to be efficacious for a period of three month, a different formulation (or insecticide) should be considered as the malaria transmission period in the Province of Zambezia is longer than three months.
- The field collected mosquito samples should be urgently analysed to give useful information (mosquito infection status and species) in good time for timely and appropriate decision making.
- Since no anopheles species were recovered indoors by PSC whereas *Anopheles* larvae were found in relatively high densities, there is a need to design and implement a vector behaviour study.