



PRESIDENT'S MALARIA INITIATIVE



# The PMI Africa IRS (AIRS) Project

## Indoor Residual Spraying (IRS)

### Task Order Six

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT  
FOR IRS NATIONWIDE IN KENYA, USING  
PYRETHROIDS, CARBAMATES, ORGANOPHOSPHATES, AND  
CHLORFENAPYR (WHEN RECOMMENDED BY WHOPEP)  
CALENDAR YEARS 2017-2021

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*The views expressed in this document do not necessarily reflect the views of the United States Agency for International Development or the United States Government.*

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# ACRONYMS

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<b>AIRS</b>	Africa Indoor Residual Spraying Project
<b>CDC</b>	Centers for Disease Control and Prevention
<b>COR</b>	Contracting Officer's Representative
<b>DDT</b>	Dichlorodiphenyltrichloroethane
<b>EC</b>	Environmental Compliance
<b>ECO</b>	Environmental Compliance Officer
<b>EMMP</b>	Environmental Mitigation & Monitoring Plan
<b>EMMR</b>	Environmental Mitigation & Monitoring Report
<b>IP</b>	Implementing Partner
<b>IRS</b>	Indoor Residual Spraying
<b>LLIN</b>	Long-lasting insecticide-treated nets
<b>MCU</b>	Malaria Control Unit
<b>NEMA</b>	National Environmental Management Authority
<b>NMCP</b>	National Malaria Control Program
<b>PMI</b>	President's Malaria Initiative
<b>PPE</b>	Personal protective equipment
<b>SEA</b>	Supplemental Environmental Assessment
<b>SOP</b>	Spray Operator
<b>UNHCR</b>	United Nations High Commissioner for Refugees
<b>USAID</b>	United States Agency for International Development
<b>WHO</b>	World Health Organization
<b>WHOPES</b>	World Health Organization Pesticide Evaluation Schemes

# EXECUTIVE SUMMARY

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This document has been prepared to serve as the Supplemental Environmental Assessment (SEA) for Indoor Residual Spraying (IRS) in Kenya for the calendar years 2017-2021. Previous environmental documentation for PMI-supported IRS in Kenya authorized the use of the pyrethroid, carbamates and organophosphates classes of the WHOPEs-recommended pesticides within Nyanza Province from 2009 to 2016, and was prepared in accordance with the provisions of USAID 22 CFR (216) regarding the use and application of pesticides. This SEA proposes to reauthorize the use of the same three classes of WHOPEs-recommended insecticides, and to expand the authorization to include the use of chlorfenapyr (when recommended by WHOPEs or attains WHO prequalification). This SEA also seeks to authorize nationwide geographical coverage of PMI-supported IRS and also requests authorization for small-scale, closely-supervised hut trials using new IRS insecticides, such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPEs evaluation and country-level required documentation has been submitted.

Kenya was selected as a PMI focus country in FY 2007. Malaria is a major public health problem in Kenya. Although dramatic progress in malaria control was made in earlier years with the combination of IRS and distribution of LLNs, the NMCP has experienced some challenges in conducting IRS in recent years. As a result, malaria accounts for an estimated 18% of outpatient consultations and 10% of hospital admissions based on data from the routine health information system.

Changing or rotating insecticides of different classes over time is a leading way to manage insecticide resistance. In Kenya, entomological monitoring has demonstrated that local mosquitoes have developed some level of resistance to the pyrethroid class of insecticides, which has been the only class of insecticide used for IRS prior to 2016. A switch of IRS insecticides to the organophosphate, pirimiphos methyl, will begin in Migori County starting in February 2017.

The proposal to include chlorfenapyr is prompted by the need to increase the options for recommended insecticides available for spray activities. Chlorfenapyr, an active ingredient (AI) in the pyrrole chemical class is under WHOPEs review and if recommended for use will offer an additional option for insecticide rotation during the approved period of this SEA.

This SEA for IRS in Kenya outlines the monitoring and mitigation measures that will be employed by the PMI Implementing Partner (IP) to minimize or reduce the unintended adverse impacts of pesticide application. Those measures are found in the Safer Use Action Plan (Section 6), and summarized in the Environmental Mitigation and Monitoring Plan (EMMP) found in Annex A. All PMI IRS operations in Kenya will be performed according to the protocols and procedures found therein. These procedures do not change with the use of different classes of authorized pesticides, with the following exceptions:

1. The potential cumulative effects of organophosphate exposure (e.g., cholinesterase depression) require increased emphasis and training on the ability and responsibility of team leaders and senior personnel to daily monitor the appearance and behavior of their team members, and to recognize the symptoms of organophosphate exposure, in order to implement the appropriate response protocols. Biomonitoring is not required for the use of pirimiphos methyl formulations for IRS at the present time, but increased vigilance is essential.
2. Pirimiphos methyl formulations are supplied in plastic bottles, which if not controlled carefully may be used inappropriately once emptied of the insecticide formulation. In addition,

incineration of the bottles may cause harmful emissions. Because of these potential problems, the following procedures and protocols have been established:

- a. A triple rinse for the plastic bottles has been incorporated during the insecticide make-up procedure, whereby the insecticide container is emptied into the spray tank and then three times it is partially filled with clean make-up water, capped, shaken, and emptied into the spray tank. This ensures that the insecticide is used more efficiently, the container is thoroughly rinsed of pesticide, and it is safe for handling and subsequent processing. The risk of exposure due to insecticide residue in the container is essentially eliminated; however, the following procedure is also followed.
  - i. Recycling programs have been established to turn the plastic into usable products. As long as a suitable recycling program is available, through close supervision and chain of custody, and in partnership with the Kenya National Malaria Control Program (NMCP), the IP will ensure that the plastic remains segregated from other materials, and is recycled appropriately.

The PMI IP will implement the EMMP in Annex A, with guidance from PMI and NMCP, and with the assistance and involvement of the local communities. All senior staff in charge of implementation of IRS will be trained to monitor operations when in the field, in order to maximize supervisory oversight and ensure effectiveness of the mitigation measures during spraying operation. County coordinators will monitor environmental compliance during the IRS campaign. The IP completes the annual EMMR Form in Annex B, and submits it to USAID along with the annual end of spray report.

On an annual basis, a letter report will be submitted to the BEO (regional and pillar). It must contain information regarding program changes, entomological/resistance monitoring results and data, and program response to those results. It should also contain the results of environmental monitoring and how the program will improve any areas of deficiency. In the year that a new SEA is prepared and approved, the Letter Report is unnecessary.

The following assessment draws heavily on the Programmatic Environmental Assessment (PEA) for Integrated Vector Management (IVM), updated in September 2012, and many other references, as indicated in this document.

# PRINCIPAL PROPOSALS & CLEARANCE

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1. The Kenya Supplemental Environmental Assessment (SEA) (2008), as amended in 2011 (amendment #1) and 2013 (amendment #2), was valid for implementing PMI-supported IRS in selected regions of Kenya, using all WHO-recommended pesticides in the pyrethroid, carbamate and organophosphate classes for the period 2009-2016.
2. In order to continue with PMI IRS, PMI is seeking approval for a new SEA for a further five years (calendar years 2017-2021), and for the SEA scope to be maintained at nationwide.
3. It is proposed in this SEA to expand the permissible insecticide options to include chlorfenapyr, when recommended by WHOPEs, in addition to carbamates, pyrethroids, and organophosphates.
4. It is further proposed to allow for small studies or hut trials to evaluate new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPEs evaluation, and country-level required documentation has been submitted.
5. This SEA contains the condition that spraying will not be performed by PMI IPs within 30 meters of natural water bodies, wetlands or marshes, organic farming areas, beekeeping areas or core areas within protected forests, parks or habitats.
6. The Safer Use Action Plan in Chapter 6 provides detailed guidance on the performance of all activities associated with IRS. The attached Environmental Mitigation and Monitoring Plan (EMMP) (Annex A) summarizes the key required mitigation measures, as well as the monitoring and reporting requirements and schedule.
7. The preparation of this SEA renders a Letter Report unnecessary for 2017. In subsequent years, provided there are no changes to the program outside the scope of this SEA, a Letter Report will be submitted to PMI annually that will discuss significant changes in the IRS program for that particular year's spray campaign.
8. It is PMI policy that the first use of organophosphates in a given country requires the signature of the Africa Bureau and Global Health BEOs on the annual Letter Report. Use of organophosphates in subsequent years does not require BEO signatures. As organophosphates will be used in Kenya for the first time in 2017, BEO signatures will be required on this SEA and not required on subsequent annual Letter Reports.
9. This SEA contains a Pesticides Procedures section, which, together with the Safer Use Action Plan, constitutes the elements of a PERSUAP.

## **APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED**

### **2016-2021 SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT'S MALARIA INITIATIVE- INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN KENYA**

The United States Agency for International Development, Global Health Bureau has determined that the proposed IRS effort, as described in the 2017-2021 Supplemental Environmental Assessment: Indoor Residual Spraying for malaria control in Kenya responds to the needs of the community and country as it relates to managing malaria in Kenya, and also conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, it 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 and the PMI Programmatic Environmental Assessment for IVM (2012), is consistent with the Government of Kenya's and PMI's goal of reducing malaria incidence in Kenya while minimizing negative impact to the environment and to human health.

The proposed actions recommended for approval in this 2016 SEA are:

1. The continuation of IRS implementation using pyrethroids, carbamates, organophosphates, and/or chlorfenapyr when recommended by WHOPES, where appropriate, based on the evaluation of criteria such as transmission rate, vector susceptibility, residual effect, appropriate home and wall structure, economic factors, and ecological/human health impacts.
2. This SEA will have nationwide coverage where IRS may be implemented as decided by the National Malaria Control Program and PMI for the 5-year period from 2017 to 2021.
3. This SEA authorizes small, closely supervised studies or hut trials to study new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPES evaluation and country-level required documentation has been submitted.
4. Due to the need to protect the population in buffer zones of protected areas from malaria, and given the successful record of PMI in implementing IRS in Africa without significant environmental consequences, it is proposed to allow IRS in these buffer zones using the strict protocols and procedures contained in the PMI Best Management Practices (BMP) manual, and observing all precautions and prescriptions in this SEA.

The Safer Use Action Plan (Section 6) and the updated Environmental Mitigation and Monitoring Plan (EMMP) for Kenya (Annex A) provide detailed guidance on the performance of all activities associated with IRS. Through the use of this and other guidance, PMI has maintained an excellent record of success in executing IRS without substantial environmental or human health impact.

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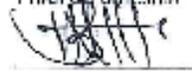
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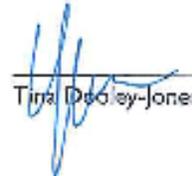
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# I BACKGROUND & PURPOSE

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## I.1 PRESIDENT'S MALARIA INITIATIVE

When it was launched in 2005, the goal of the President's Malaria Initiative (PMI) was to reduce malaria-related mortality by 50 percent across 15 high-burden countries in sub-Saharan Africa through a rapid scale-up of four proven and highly effective malaria prevention and treatment measures: insecticide-treated mosquito nets (ITNs); indoor residual spraying (IRS); accurate diagnosis and prompt treatment with artemisinin-based combination therapies; and intermittent preventive treatment of pregnant women<sup>1</sup>.

With the passage of the Tom Lantos and Henry J. Hyde Global Leadership against HIV/AIDS, Tuberculosis, and Malaria Act in 2008<sup>2</sup>, PMI developed a U.S. Government Malaria Strategy for 2009–2014. PMI's Strategy for 2015-2020 takes into account the progress over the past decade and the new challenges that have arisen.<sup>3</sup> Malaria prevention and control remains a major U.S. foreign assistance objective and PMI's Strategy fully aligns with the U.S. Government's vision of ending preventable child and maternal deaths and ending extreme poverty. It is also in line with the goals articulated in the Roll Back Malaria Partnership's Action and Investment to Defeat Malaria 2016-2030 and World Health Organization's Global Technical Strategy for Malaria 2016-2030. Under the PMI Strategy for 2015-2020, the U.S. Government's goal is to work with PMI-supported countries and partners to further reduce malaria deaths and substantially decrease malaria morbidity, towards the long-term goal of elimination.

PMI will assist Kenya to achieve the following targets in populations at risk for malaria by the end of 2020:

- Reduce malaria mortality by one-third from 2015 levels in PMI-supported districts, achieving an 80 percent reduction from PMI's original 2000 baseline levels.
- Reduce malaria morbidity in PMI-supported districts by 40 percent from 2015 levels.

## I.2 HISTORY AND SCOPE OF IRS IN KENYA

With the advent of dichloro-diphenyl-trichloroethane (DDT) as a residual insecticide and the availability of a number of anti-malarial drugs such as chloroquine and pyrimethamine, malaria control activities were undertaken on a large scale for the first time in Kenya between 1955 and 1974. In 1994, the Government of Kenya launched a five-year National Plan of Action for Malaria Control, with the main goal to develop an infrastructure that would ensure access to malaria prevention and curative services for those at risk, with the aim of substantially reducing illness and death.

Through 2010, the then Malaria Control Unit (MCU)'s IRS program targeted 16 highland, epidemic-prone districts in western Kenya. As ITN coverage expanded throughout Kenya, malaria prevalence fell sharply, particularly in those highland districts that had been targeted for IRS activities. Both the Global

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<sup>1</sup> See PMI Technical Guidance for further details. [http://www.pmi.gov/docs/default-source/default-document-library/tools-curricula/pmi-technical-guidance-\(march-2016\).pdf?sfvrsn=8](http://www.pmi.gov/docs/default-source/default-document-library/tools-curricula/pmi-technical-guidance-(march-2016).pdf?sfvrsn=8)

<sup>2</sup> See <http://www.gpo.gov/fdsys/pkg/BILLS-110hr5501enr/pdf/BILLS-110hr5501enr.pdf>

<sup>3</sup> See [http://pmi.gov/docs/default-source/default-document-library/pmi-reports/pmi\\_strategy\\_2015-2020.pdf](http://pmi.gov/docs/default-source/default-document-library/pmi-reports/pmi_strategy_2015-2020.pdf)

Fund and PMI funded IRS campaigns in the highland districts, with PMI providing concentrated technical assistance and capacity-building. Table I-1 presents the areas of Kenya where PMI has supported IRS since 2008 and the number of structures identified for the year.

**TABLE I-1: STRUCTURES IDENTIFIED PER SUB-COUNTY/COUNTY FOR PMI SUPPORTED IRS IN KENYA**

Spray Regions	Sub Counties/	FY 08	FY 09	FY 10	FY 11	FY 12
Rift Valley - Nandi North (Nandi County)	Nandi North, Nandi Central	125,808	175,745			
Rift Valley - Nandi South (Nandi County)	Nandi East, Nandi South, Tinderet	118,568	192,716			
Nyanza - Rachuonyo (Homa Bay County)	Rachuonyo North, Rachuonyo South	120,565	148,590	134,716	125,247	133,685
Nyanza - Homa Bay (Homa Bay County)	Homa Bay, Ndhiwa, Suba, Mbita					200,098
Nyanza - Greater Migori (Migori County)	Awendo, Uriri, Nyatike, Migori, Rongo			231,994	230,977	189,634
Nyanza - Nyando (Kisumu County)	Muhoroni, Nyando, Nyakach			136,997	128,819	119,817
<b>Total</b>		<b>364,941</b>	<b>517,051</b>	<b>503,707</b>	<b>485,043</b>	<b>643,234</b>

\*Target structures in districts/sub-counties were arrived at using geographical reconnaissance. These endemic districts (sub-counties) reflect the administrative divisions as of 2009. In 2010, the original three districts were split into 10 districts, while the fourth district sprayed in 2012 was split into three districts. As of 2013, Kenya was administratively split into 47 counties. The four districts sprayed in 2012 span parts of three different counties. Some sub-counties were dropped in 2013.

With the 2009-2017 Kenya National Malaria Strategy, the MCU (now National Malaria Control Program) phased out IRS in the highland, epidemic-prone districts and begun to focus on endemic districts, particularly those bordering the highlands. According to the national strategy, IRS was to be implemented for at least three years while ITNs were scaled up to achieve universal coverage.

Through 2012, the pyrethroid class of insecticides were used in all IRS conducted on the mainland. Pyrethroid resistance was detected in *Anopheles gambiae* s.s. in western Kenya. In 2010, observed resistance (in terms of percent mortality) in this species ranged from 38 to 67% for DDT, 72 to 84% for permethrin, and 37 to 58% for deltamethrin. This species had been significantly reduced by ITNs and until very recently was largely absent in the districts targeted for IRS. This species was most common in areas near the Ugandan border. As of late 2012, however, the range of *An. gambiae* s.s. was expanding eastward. Furthermore, pyrethroid resistance was observed in *An. arabiensis* in the areas that had been sprayed for four consecutive years. Given the increasing pyrethroid resistance in western Kenya, the National Malaria Control Program (NMCP) has advocated a shift from the pyrethroid class of insecticides, which are now being used solely for Long-Lasting Insecticide-treated Nets (LLINs) and not in IRS to mitigate the development of resistance.

With IRS efforts shifting away from the highlands, the NMCP moved to an epidemic surveillance and response system to detect rising cases of malaria and respond using a combination of targeted IRS and improved case management. PMI and other donors provided support for surveillance and monitoring to document the effectiveness of IRS in areas with high ITN coverage after the 2008 and 2009 spray rounds. These initial surveys indicated a reduction in the incidence of parasitemia and the prevalence of parasitemia and anemia. However, more recent national data from the 2010 Malaria Indicator Survey suggested that malaria prevalence in these areas remained high in spite of multiple interventions, including the scale-up of ITNs.

Malaria still remains a major public health problem in Kenya and accounts for an estimated 18% of outpatient consultations and 10% of hospital admissions based on data from the routine health information system.<sup>4</sup> About 80% of the Kenyan population is at risk for malaria.<sup>5</sup> Among the at-risk population, 27% (approximately 12 million people) live in areas of epidemic and seasonal malaria transmission where *P. falciparum* parasite prevalence is usually less than 5%. However, an estimated 28 million people live in endemic areas, and over a quarter (approximately 11 million people) live in areas where parasite prevalence is estimated to be equal to or greater than 20%. For the purposes of malaria control, the country has been stratified into four epidemiological zones to address the varied risks:

- **Endemic areas:** These areas of stable malaria have altitudes ranging from sea level in the coastal region to up to 1,300 meters around the Lake Victoria basin in western Kenya. Transmission is intense throughout the year with *P. falciparum* prevalence historically greater than 20% and high annual entomological inoculation rates. The coastal counties now have malaria prevalence ranging from 5 – 20%. Of the total population, 26% lives in a malaria-endemic zone.
- **Highland and epidemic-prone areas:** Malaria transmission in the western highlands is seasonal with considerable year-to-year variation. The entire population is vulnerable and case-fatality rates during an epidemic can be greater than in endemic regions. Approximately 39% of Kenyans live in these areas. The malaria prevalence in these areas ranges from 5 – 20%.
- **Seasonal malaria transmission areas:** This epidemiological zone includes the arid and semi-arid areas of northern and central parts of the country, which experience short periods of intense malaria transmission during the rainy seasons. Although the largest zone in terms of geographic size, only 14% of the population lives in areas where the malaria prevalence is between 1 – 5%.
- **Low malaria risk areas:** This zone covers the central highlands of Kenya including Nairobi. Approximately 21% of the population lives in this area.

In 2015, the population-adjusted *P. falciparum* prevalence for malaria prevalence by county was in the lake-endemic counties.<sup>6</sup> The 2015 Malaria Indicator Survey (MIS) indicated that malaria prevalence in the western lake endemic zone remained very high at 27%.<sup>7</sup>

### 1.3 PMI IRS COUNTRY COVERAGE

The PMI IRS program in Kenya started in June 2008, focusing on two highland districts (Nandi North and Nandi South) and one lowland area bordering the endemic areas (Rachuonyo Districts). The same areas were sprayed in 2009.

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<sup>4</sup> Ministry of Health (MOH) [Kenya]. Kenya Annual Malaria Report, 2013/2014. Nairobi: MOH, 2015.

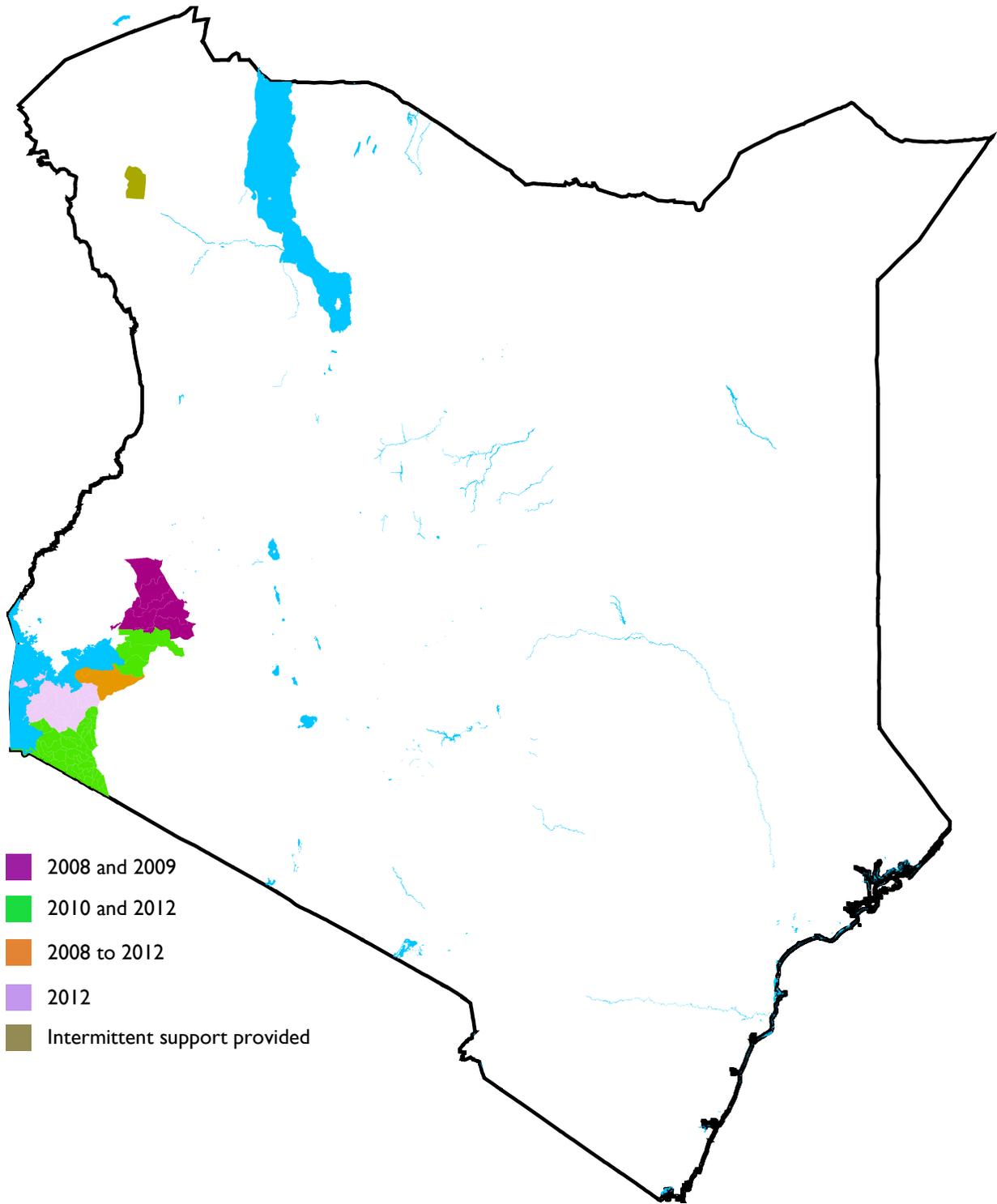
<sup>5</sup> Noor AM, Kinyoki DK, Ochieng JO, Kabaria CW, Alegana VA, Otieno VA, Kiptui R, Soti D, Yé Y, Amin AA, Snow RW. The epidemiology and control profile of malaria in Kenya: reviewing the evidence to guide the future vector control. Nairobi: DOMC and KEMRI-Welcome Trust-University of Oxford-Research Programme, 2012.

<sup>6</sup> PRESIDENT'S MALARIA INITIATIVE Kenya Malaria Operational Plan (MOP), 2017

<sup>7</sup> National Malaria Control Programme (NMCP), Kenya National Bureau of Statistics (KNBS), and ICF International. Kenya Malaria Indicator Survey 2015. Nairobi, Kenya and Rockville, Maryland: NMCP, KNBS, and ICF International, 2016.

Beginning in May of 2010, the PMI-supported IRS program expanded to cover three lowland districts along Lake Victoria which border highland, epidemic-prone districts: Nyando; Migori; and Rachuonyo

**FIGURE I-I: PAST PMI SPAY AREAS**



Source: Global Administrative Areas (<http://www.gadm.org/country>), World Resource Institute (<http://www.wri.org/resources/data-sets/kenya-gis-data>)

(which, as noted above, had been previously sprayed by PMI in 2008-09). These three districts were once again covered in 2011.

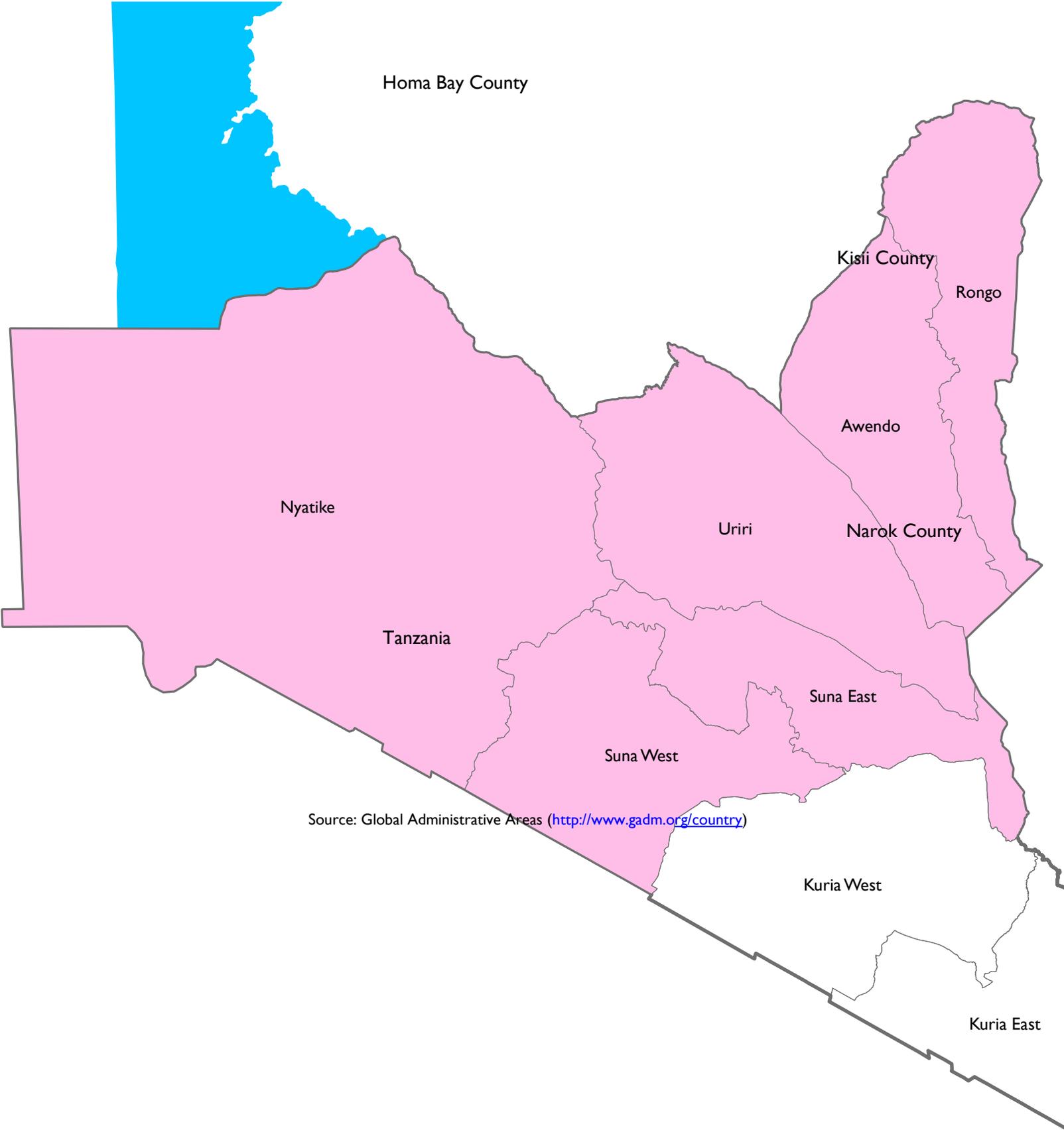
In 2012, PMI-supported IRS operations were expanded to a total of four lowland districts (Homa Bay was added). These districts are located in areas with some of the highest *P. falciparum* prevalence rates in the country. In 2013 Kenya was administratively split into 47 counties. While PMI had been the only partner supporting IRS up to 2012, the United Kingdom's Department for International Development proposed supporting one county in 2013. However, since 2013, besides some operations in the Kakuma Refugee Camps, IRS has not been conducted in Kenya. This has been a result of a number of operational difficulties. Figure 1-1 presents the location of the areas in Kenya that have been sprayed by PMI. Neither PMI nor the Kenya NMCP have sprayed the refugee camps in Kakuma, managed by the United Nations High Commissioner for Refugees (UNHCR), but have provided some form of support (including donation of insecticide) for some of the spray campaigns at Kakuma organized by UNHCR.

### 1.3.1 2017 CAMPAIGN SCOPE

In 2017, PMI will implement IRS as a vector control strategy in Migori County. PMI AIRS Kenya, the PMI implementer of IRS will spray six of the eight sub-counties in Migori: Awendo; Nyatike; Rongo; Suna East; Suna West; and Uriri. Working with the NMCP, PMI and other stakeholders, PMI AIRS Kenya will also be able to provide technical assistance for IRS in refugee camps managed by UNHCR. Figure 1-2 presents the map of Migori County and the location of the six sub-counties that will be sprayed in 2017.

Although these areas were sprayed in the past, no IRS has been undertaken since 2012. A pyrethroid class insecticide was used for IRS during the last IRS program and for the 2017 program an organophosphate class insecticide will be used for the first time.

**FIGURE I-2: 2017 SCOPE OF PMI IRS IN KENYA**



Source: Global Administrative Areas (<http://www.gadm.org/country>)

## 2 PROPOSED ACTION AND ALTERNATIVES

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This section describes the alternatives for malaria control that were considered in the preparation of this report, including those that were accepted or rejected. Alternatives considered include the following:

1. **Preferred action:** Establish annual IRS campaigns that spray pesticides of the pyrethroid, carbamate, and organophosphate classes and chlorfenapyr (when recommended by the World Health Organization Pesticide Evaluation Schemes (WHOPES)) in high-risk counties and sub-counties identified by the evaluation of criteria such as transmission rate, vector susceptibility, residual effect, appropriate home and wall structure, economic factors, and ecological/human health impacts.
2. **No action alternative:** This action would discontinue PMI support for IRS activities in Kenya.
3. **Spraying in alternative geographic regions:** This alternative would use different criteria to select alternative counties and sub-counties to spray.
4. **Using alternative pesticides:** This alternative would consider pesticides other than those recommended by WHOPES.
5. **Alternative technologies:** This alternative would consider methods other than IRS to achieve the stated goals of reduction in malaria mortality and morbidity.

### 2.1 DESCRIPTION OF PROPOSED ACTION

The preferred action is to implement an IRS program in selected communities, choosing among the pyrethroid, carbamate, and organophosphate classes (as well as chlorfenapyr, when recommended by WHOPES), considering current entomological, epidemiological, logistical, environmental, and economic conditions. The pesticide to be used will be determined by a process explained in Pesticide Procedures part b (Section 5.2).

### 2.2 NO PROJECT ALTERNATIVE

Indoor residual spraying is one of the critical interventions in the control of the spread of malaria. A no project alternative will result in rising rates of infections, transmissions, mortality and morbidity due to the increased prevalence of infected vectors. Therefore, the “no action alternative” does not meet the overall goals of the President’s Malaria Initiative and the Kenya National Malaria Control Program.

### 2.3 ALTERNATIVE IRS GEOGRAPHICAL SITES CONSIDERED

In IRS implementation in Kenya, areas considered as highly malarious and those areas that fit within the NMCP strategic plan are considered, while lower risk areas are not considered for IRS as an intervention. Using different criteria for selecting geographical sites would reduce the effectiveness and impact of IRS, decreasing progress towards the goals of the PMI program and the Kenya National Malaria Control Program.

## 2.4 USE OF ALTERNATIVE INSECTICIDE(S)

For IRS to be implemented, a pesticide recommended by the WHOPES must be selected for use. WHOPES is an international institution that analyses and recommends pesticides to be used in IRS based on their effectiveness, and toxicity to human health and the environment. The USEPA regulates and registers pesticide products and uses thereof in the United States, and provides guidance for foreign health interventions.

To date WHOPES has approved the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines and organophosphates. Other alternative insecticides are not eligible for use under PMI guidelines. Organochlorines (DDT) are not proposed for use in this SEA.

PMI and their implementing partner will monitor WHOPES proceedings towards recommendation of new pesticides, but will seek to amend this SEA before there is any decision to use new WHOPES recommendations.

It is proposed in this SEA to allow for small studies or hut trials to evaluate new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPES evaluation, and country-level required documentation has been submitted. The guidelines for laboratory testing and small and large-scale field trials are provided in *Test procedures for insecticide resistance monitoring in malaria vector mosquitoes* (WHO, April 2013).

## 2.5 ALTERNATIVE TECHNOLOGIES

A full range of known, available technologies is continually considered for use by the stakeholders in malaria prevention and control efforts. It has been determined that IRS plays a significant part in malaria prevention in concert with other technologies.<sup>8</sup> The specific focus of this PMI project is IRS, and the role that PMI plays in Kenya includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays, PMI, the National Malaria Control Program, and its partners would evaluate them and proceed accordingly.

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<sup>8</sup> PRESIDENT'S MALARIA INITIATIVE Kenya Malaria Operational Plan (MOP), 2017

# 3 AFFECTED ENVIRONMENT

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This section describes the critical environment that may be adversely affected by the implementation of the IRS program (pesticide application) if adequate and necessary mitigation and monitoring measures are not put in place. The critical ecosystems or activities within Kenya include surface water bodies (lakes, river, groundwater, marshlands and wetlands), air, soils, and economic and sustenance activities including agriculture, apiculture, fisheries and organic farming that might be adversely affected by the use of insecticides to non-target areas.

## 3.1 OVERVIEW OF COUNTRY

### 3.1.1 GEOGRAPHY

Kenya's territory lies on the equator and overlies the East African Rift covering a diverse and expansive terrain that extends roughly from Lake Victoria to Lake Turkana and further south-east to the Indian Ocean. It is bordered by Tanzania to the south, Uganda to the west, South Sudan to the north-west, Ethiopia to the north and Somalia to the north-east. Kenya covers 581,309 km<sup>2</sup> (224,445 sq. mi), and had a population of approximately 46.1 million people in 2015 with an estimated population growth of 2.6% per year; thus, Kenya's 2017 population is projected to be 48.5 million.<sup>9</sup>

### 3.1.2 DEMOGRAPHICS

Of the total population, children under age 5 account for 16% and children under age 15 account for 42%. Kenya has approximately 42 ethnic groups and has a predominantly agricultural economy with a strong industrial base. Kenya is ranked 145 out of 188 countries on the 2015 United Nation's Human Development Index, which measures life expectancy, adult literacy, and per capita income.<sup>10</sup> Life expectancy in Kenya has seen an overall downward trend since the late 1980s but increased to an estimated 62 years in 2013.<sup>11</sup> The mortality rate in children under five years of age has declined by 55% from 115 deaths per 1,000 live births in the 2003 Kenya Demographic and Health Survey (DHS) to 52 deaths per 1,000 observed in the 2014 DHS.<sup>12 13</sup>

## 3.2 ADMINISTRATIVE AND POLITICAL UNITS

Since 2013, Kenya has been divided into 47 counties as a result of the process of devolution as set forth in the 2010 Constitution of Kenya. Each County is subdivided in sub-counties. Figure 3-1 presents a map of the 47 counties of Kenya.

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<sup>9</sup> World Bank. See <http://www.worldbank.org/en/country/kenya>. Accessed 1 November 2016

<sup>10</sup> United Nations Development Programme. Human Development Report 2015.

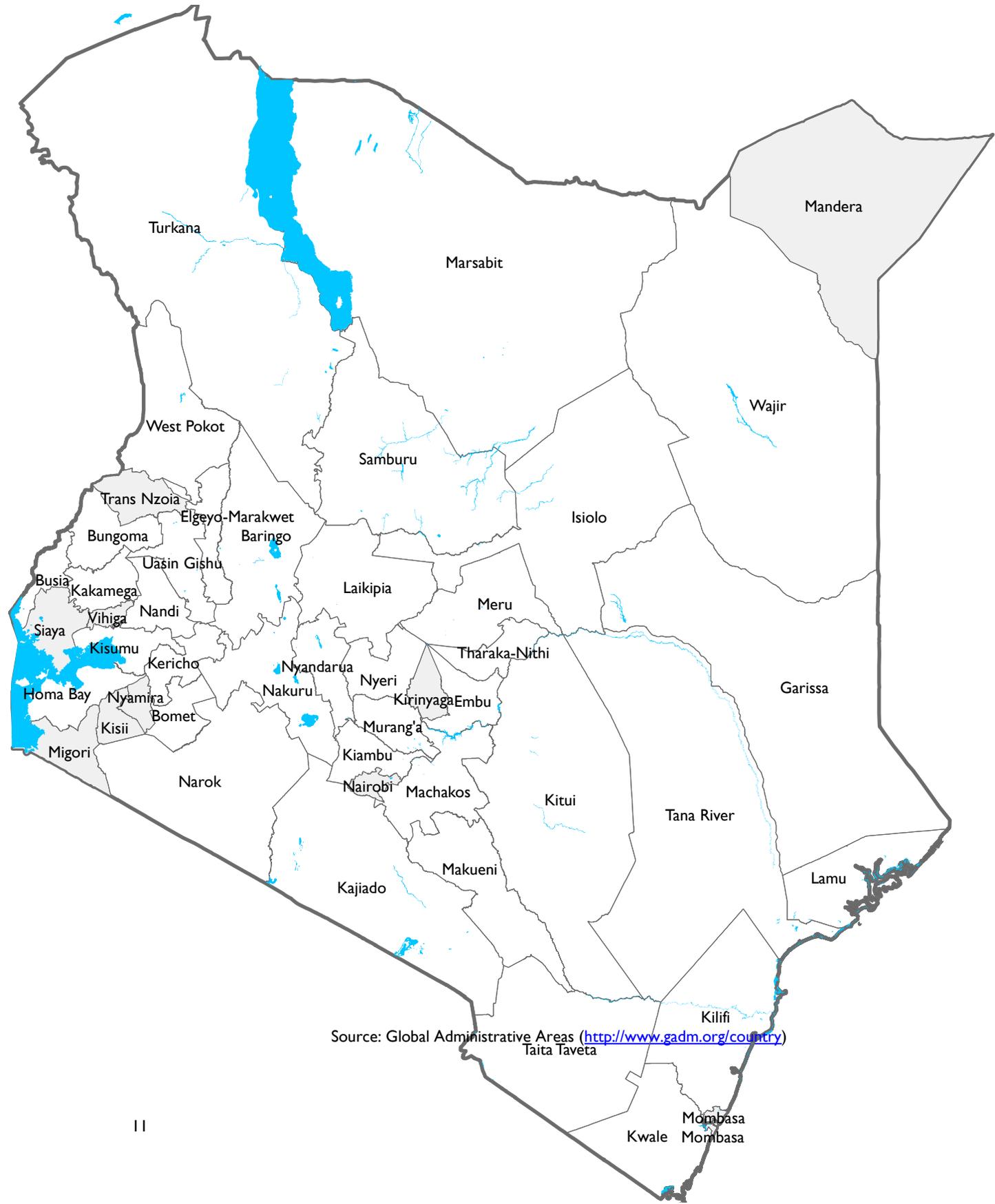
<sup>11</sup> UNICEF. State of the World's Children 2015.

<http://databank.worldbank.org/data/reports.aspx?source=2&country=KEN>. Accessed 25 May 2015.

<sup>12</sup> Central Bureau of Statistics (CBS) [Kenya], Ministry of Health (MOH) [Kenya], and ORC Macro. 2004. Kenya Demographic and Health Survey 2003. Calverton, Maryland: CBS, MOH, and ORC Macro.

<sup>13</sup> Kenya National Bureau of Statistics (KNBS), Ministry of Health (MOH) [Kenya], and ICF International. 2015. Kenya Demographic and Health Survey Key Indicators 2014. Nairobi, Kenya: KNBS, MOH, and ICF International.

**FIGURE 3-1: KENYA ADMINISTRATIVE UNITS**



Source: Global Administrative Areas (<http://www.gadm.org/country>)

Each county has a county government that administers the affairs of the county. Individuals responsible for malaria control at the county level sit in the County Ministry of Health offices.

## 3.3 PHYSICAL ENVIRONMENT

### 3.3.1 CLIMATE

Kenya's climate varies by location from mostly cool every day, to always warm/hot. Along the coast, the climate is tropical, which means that rainfall and temperatures are higher throughout the year. Ambient temperatures change from cool to hot, almost every day in coastal cities like Mombasa, Lamu, and Malindi. The climate further inside Kenya is more arid. This climate is nearly devoid of rainfall, and temperature swings widely according to the general time of the day or night. This results in wide swings in the daytime temperature of about 12°C (22°F), almost every day.<sup>14</sup>

There are two dominant influences on the climate in Kenya: the onshore monsoon winds from the Indian Ocean, and altitude. The winds determine the onset of Kenya's two rainy seasons, with the hot northeast monsoon, *kaskazi*, blowing dry air in from the Persian Gulf from November to March/April and the warm, moist monsoon, *kusi*, blowing in from the southeast from April/May to October. It is the slightly cooler *kusi* that normally delivers the heaviest rain, a season known as the 'long rains', in late-April, May and early June. The relatively cool season, from late-June to October, gets much less rain. There's a second rainy season, the 'short rains', for a few weeks in November and December, followed roughly from mid-December to March by a dry season of hot, usually rainless, weather.<sup>15</sup>

Elevation is the other major factor in temperature levels, with the higher areas, on average, 11°C (20°F) cooler, day or night. The many mile-high cities have temperature swings from roughly 10.0°C to 26.1°C (50°F to 79°F). Nairobi, at 1,798 m (5,899 ft.), experiences temperatures within the range of 9.4°C and 26.7°C (49°F and 80°F). Similarly, Kitale, at 1,825 m (5,988 ft.), temperatures are between 51°F and 82°F (10.6°C and 27.8°C).

At lower altitudes, the higher temperatures drastically differ: starting the morning at temperatures higher than the highland daytime high, and the overnight low temperatures near sea level are nearly the same as the high temperatures of the elevated highlands. However, lower altitude locations such as Mombasa along the Indian Ocean have more moderate temperatures: a few degrees cooler in the daytime.

There are slight seasonal variations in temperature of about 4°C (7.2°F) cooler during the winter months. Although Kenya is centered at the equator, it shares the seasons of the southern hemisphere: with the warmest summer months in December–March and the coolest winter months in June–August.

On the high mountains, such as Mount Kenya and Mount Elgon, the weather can become bitterly cold for most of the year. Some snowfall does occur on the highest mountains.

The counties around Lake Victoria, which will be the initial focus of IRS activities, have a tropical humid climate. Kisumu County altitude rises from 1,100 m along the Kano Plain to 1,800 m above sea level in the Nyabondo Plateau. Migori County altitude ranges from 1,145 m to 1,800 m above sea level. The county has an inland equatorial climate, modified by the effects of altitude and nearness to Lake Victoria, both of which make the observed temperatures lower than is typical in equatorial climates. The recent climatic trends in Homa Bay are a combination of rising temperatures and variable rainfall. Temperature varies with altitude and proximity to the lake, and tends to increase towards the lowland with an

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<sup>14</sup> See <http://www.climate-charts.com/Locations/k/KN63741.php>, <http://www.climate-charts.com/Locations/k/KN63661.php>, and <http://www.climate-charts.com/Locations/k/KN63820.php>.

<sup>15</sup> See <https://www.expertafrica.com/kenya/info/kenya-weather-and-climate>

average of 17°C to 34°C. Temperatures are highest between December and March, with the hottest weather in February and the coolest in April and November.

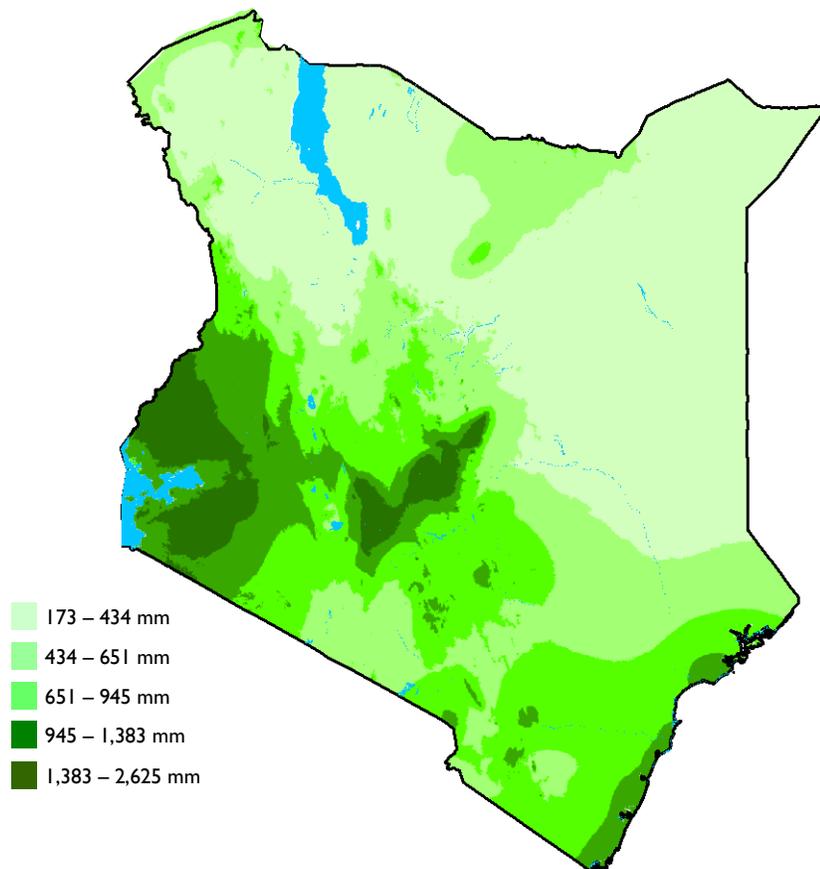
### 3.3.2 RAINFALL PATTERNS

Kenya experiences two rainy seasons (bimodal), namely the long-rains (March to May) and the short rains (October to December) seasons as the Inter Tropical Convergence Zone (ITCZ) migrates through the equator from south to north, and vice versa lagging the overhead sun by about 3 to 4 weeks. However, some areas in the western and central parts of the Rift Valley experience tri-modal rainfall pattern.

The western parts of the country do realize significant rainfall during the period June to August associated with influences from the tropical south Atlantic and incursions of the moist Congo air mass when the meridional branch of ITCZ has maximum eastward displacement over the region. The coastal region of Kenya is also wet during this period. The January to February period is generally dry over most parts of the country.

For the areas of recent IRS operation, the mean annual precipitation for Kisumu County is between 600 and 1,630 mm. The rains are bimodal and exhibit wide variation in distribution. Rainfall in Migori County is less than in a tropical equatorial climate, as it is caused by the convergence of the westerlies and southeast winds, which causes intense downpours in the afternoons. There are regional differences in rainfall in Homa Bay due to local air circulation: annual averages range between 700 and 1,800 mm, with first and second rains amounting to 250 mm to 1,000 mm and 50 mm to 700 mm respectively. The pattern of rainfall is generally bimodal, but the tendency for a trimodal regime can be observed around August and September. Evapo-transpiration is about 2,000-2,200 mm per year, which is high due to local winds. Figure 3-2 presents the distribution of average annual rainfall in Kenya.

**FIGURE 3-2: KENYA ANNUAL AVERAGE PRECIPITATION**



Source: Global Administrative Areas (<http://www.gadm.org/country>), World Resource Institute (<http://www.wri.org/resources/data-sets/kenya-gis-data>)

### 3.3.3 TOPOGRAPHY, GEOLOGY AND SOILS

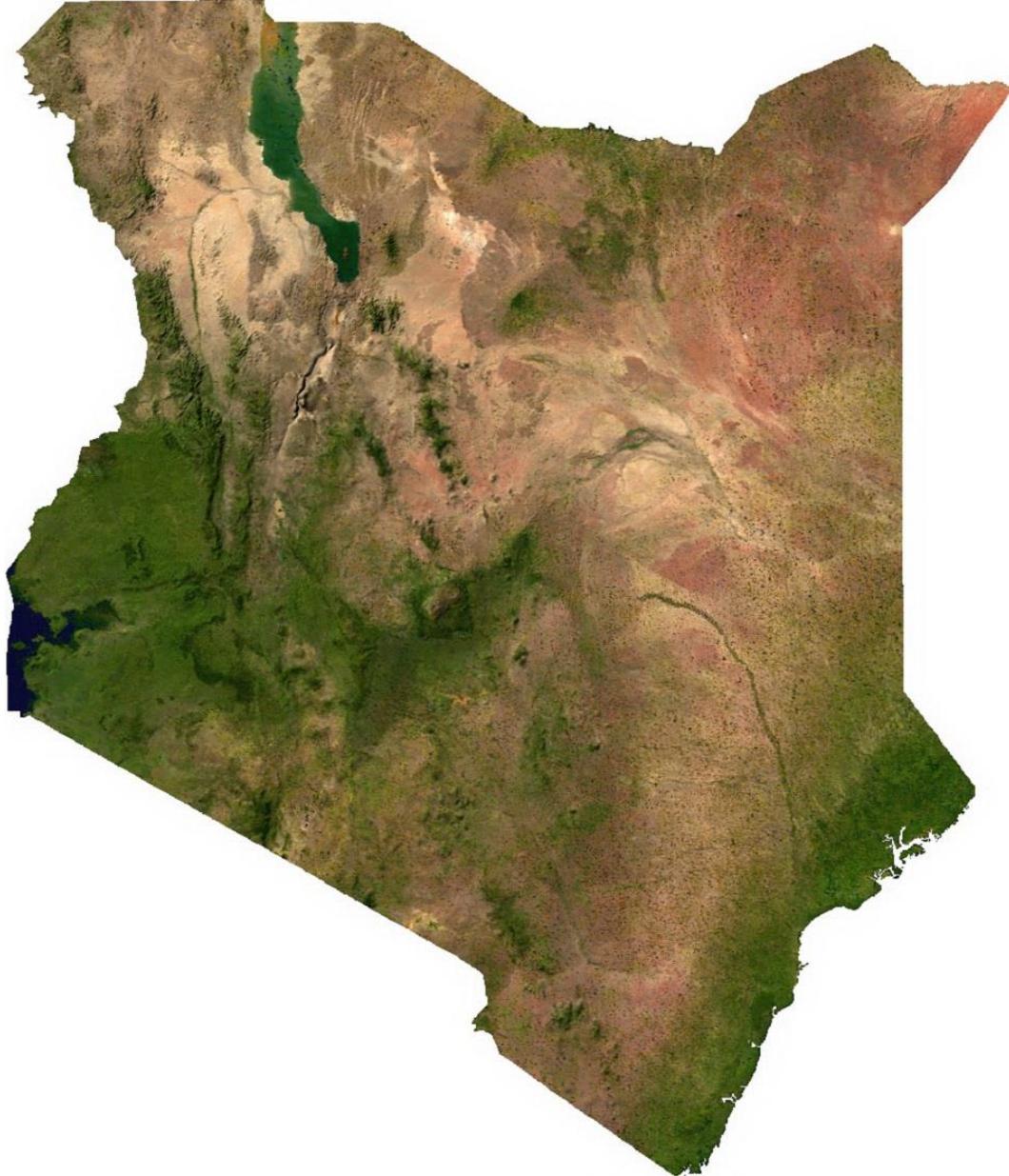
Kenya is notable for its topographical variety. The low-lying, fertile coastal region, fringed with coral reefs and islands, is backed by a gradually rising coastal plain, a dry region covered with savanna and thorn bush. At an altitude of over 1,500 m (5,000 ft.) and about 480 km (300 mi) inland, the plain gives way in the southwest to a high plateau, rising in parts to more than 3,050 m (10,000 ft.), on which most of the population and the majority of economic activities are concentrated. The northern section of Kenya, forming three-fifths of the whole territory, is arid and of semi-desert character, as is the bulk of the southeastern quarter.<sup>16</sup>

Mt. Kenya (5,199 m/17,057 ft.) – Kenya's highest mountain, Mt. Elgon (4,310 m/14,140 ft.), and the Aberdare Range (rising above 3,962 m/13,000 ft.) lie in the high plateau area known as the Kenya Highland. The plateau is bisected from north to south by the Great Rift Valley, part of the geological fracture that can be traced from Syria through the Red Sea and East Africa to Mozambique. In the north of Kenya, the valley is broad and shallow, embracing Lake Rudolf (Lake Turkana), which is about 207 km (155 mi) long; farther south the valley narrows and deepens and is walled by escarpments 600–900 m (2,000–3,000 ft.) high. West of the Great Rift Valley, the plateau descends to the plains that border Lake Victoria. Despite the location of Mount Kenya astride the Equator, it is perennially snow-capped. Other

<sup>16</sup> See Nations Encyclopedia (<http://www.nationsencyclopedia.com/Africa/Kenya-TOPOGRAPHY.html>)

isolated hills and mountains include Mount Kulal, Mount Nyiru and Mount Marsabit in the north of the country, and the Taita and Chyulu Hills in the south. The latter is one of the region's most recent volcanic formations. Figure 3-3 presents a satellite view of the topography of Kenya.

**FIGURE 3-3: KENYA LANDCOVER**



Source: Public Domain, <https://commons.wikimedia.org/w/index.php?curid=946626>

The geology of Kenya may generally be categorized into the following five major geological successions: Archean (Nyanzian and Kavirondian); Proterozoic (Mozambique Belt and Bukoban); Palaeozoic/Mesozoic sediments; Tertiary/Quaternary volcanics and sediments; and Pleistocene to recent soils, alluvial beach sands, evaporites, fossil coral reefs and sandstones at the beach – these are alluvial and lacustrine sediments of the Rift Valley. Also to be found are volcanic rocks of the Rift Valley from younger volcanoes (Opiyo-Akech, Omuombo, and Masibo, 2013).

In the Lake Victoria basin, lava deposits have produced fertile and sandy loam soils in the plateaus north and south of Winam Bay, while the volcanic pile of Mount Elgon produces highly fertile volcanic soils well known for coffee and tea production. The Rift Valley and associated highlands are composed of fertile dark brown loams developed on younger volcanic deposits.<sup>17</sup>

However, the most widespread soils in Kenya are the sandy soils of the semiarid regions between the coast and the Rift highlands. To the north of the Rift are vast areas covered by red desert soils, mainly sandy loams. Kenya's soils are subject to widespread erosion largely because of the lack of forest cover; overgrazing and cultivation, especially in the arid and semiarid regions, also contribute to soil loss.<sup>13</sup>

### 3.3.4 BIOLOGICAL ENVIRONMENT

#### 3.3.4.1 THE VEGETATION

Kenya contains diverse plant life. Along the Indian Ocean coast are forests containing palm, mangrove, teak, and sandalwood trees. Baobab, euphorbia, and acacia trees dot the lowland plateaus, while extensive tracts of savanna (grassland), interspersed with groves of acacia and some temperate forests, characterize the terrain of the highlands up to about 3,000 m (about 9,000 ft). The higher alpine zone contains giant senecio and lobelia shrubs.<sup>18</sup>

In the highlands between elevations of 2,100 and 2,700 meters (7,000 and 9,000 ft.), the characteristic landscape consists of patches of evergreen forest separated by wide expanses of short grass. Where the forest has survived human encroachment, it includes economically valuable trees such as cedar (*Juniperus procera*) and varieties of podo. Above the forest, a zone of bamboo extends to about 3,000 meters (10,000 ft.), beyond which there is mountain moorland bearing tree heaths, tree groundsel (a foundation timber of the genus *Senecio*), and giant lobelia (a widely distributed herbaceous plant). East and west of the highlands, forests give way to low trees scattered through an even cover of short grass.

The Semi-desert regions below 900 meters (3,000 ft.) give rise to baobab trees. In the still drier areas of the north, desert scrub occurs, exposing the bare ground. The vegetation of the coastal region is basically savanna with patches of residual forests. While the northern coast still bears remnants of forests, centuries of human occupation have virtually destroyed them in the south.<sup>19</sup>

#### 3.3.4.2 WILDLIFE <sup>20</sup>

Kenya is abundantly populated with a variety of wildlife populations that live mostly outside Kenya's numerous national parks and game reserves. Some of the wildlife populations are found in urban areas, in close proximity to human settlements, creating instances of conflict between humans and animals. In an effort to ameliorate the problem, a "parks beyond parks" program was introduced in the mid-1990s by the Kenya Wildlife Service. The plan attempted to include local communities in the management and distribution of income derived from wild animals in their communities, thus making people more tolerant of the presence of the animal.

The type of vegetation in each region seems to be related to the differentiation and distribution of its wildlife. The highland rainforests support a variety of large mammals, dominated by elephants and rhinoceroses, with bushbuck, colobus monkeys, and, occasionally, galagos (bush babies) also found within areas with this vegetation type. The bamboo zone contains varieties of duiker and some species of birds. Predators of the highlands include lions, leopards, and wildcats.

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<sup>17</sup> See <https://www.britannica.com/place/Kenya>

<sup>18</sup> See [http://www.countriesquest.com/africa/kenya/land\\_and\\_resources/plant\\_and\\_animal\\_life.htm](http://www.countriesquest.com/africa/kenya/land_and_resources/plant_and_animal_life.htm)

<sup>19</sup> See <https://www.britannica.com/place/Kenya>

<sup>20</sup> Based on information from the 2016 Encyclopedia Britannica <https://www.britannica.com/place/Kenya>

The grasslands between the forest zone and lower areas contain habitats for the most vibrant animal populations. These include hartebeest, wildebeest (gnu), zebra, gazelle, waterbuck, impala, eland, warthog, and buffalo, which are preyed on by lions, spotted hyenas, leopards, cheetahs, and wild dogs. Birdlife is much richer within this region, with the lakes and rivers inhabited by swarms of fish and occasionally by hippopotamuses and crocodiles. One of the world's largest populations of lesser flamingos can be found in Kenya's Great Rift Valley at Lake Bogoria, a soda lake (which is characterized by high salinity and alkalinity).

To the north and northeast of Kenya are the thorn bushes and thickets of the arid regions, which are populated with elephants, rhinoceroses, lions, leopards, giraffes, gerenuk, impalas, dik-diks, suni antelope, and buffalo. Hippopotamuses, crocodiles, and many varieties of fish are found in the large rivers, while the coastal waters contain abundant marine life, including butterfly fish, angelfish, rock cod, barracuda, and spiny lobsters.

### 3.3.5 MAJOR WATER BODIES <sup>21</sup>

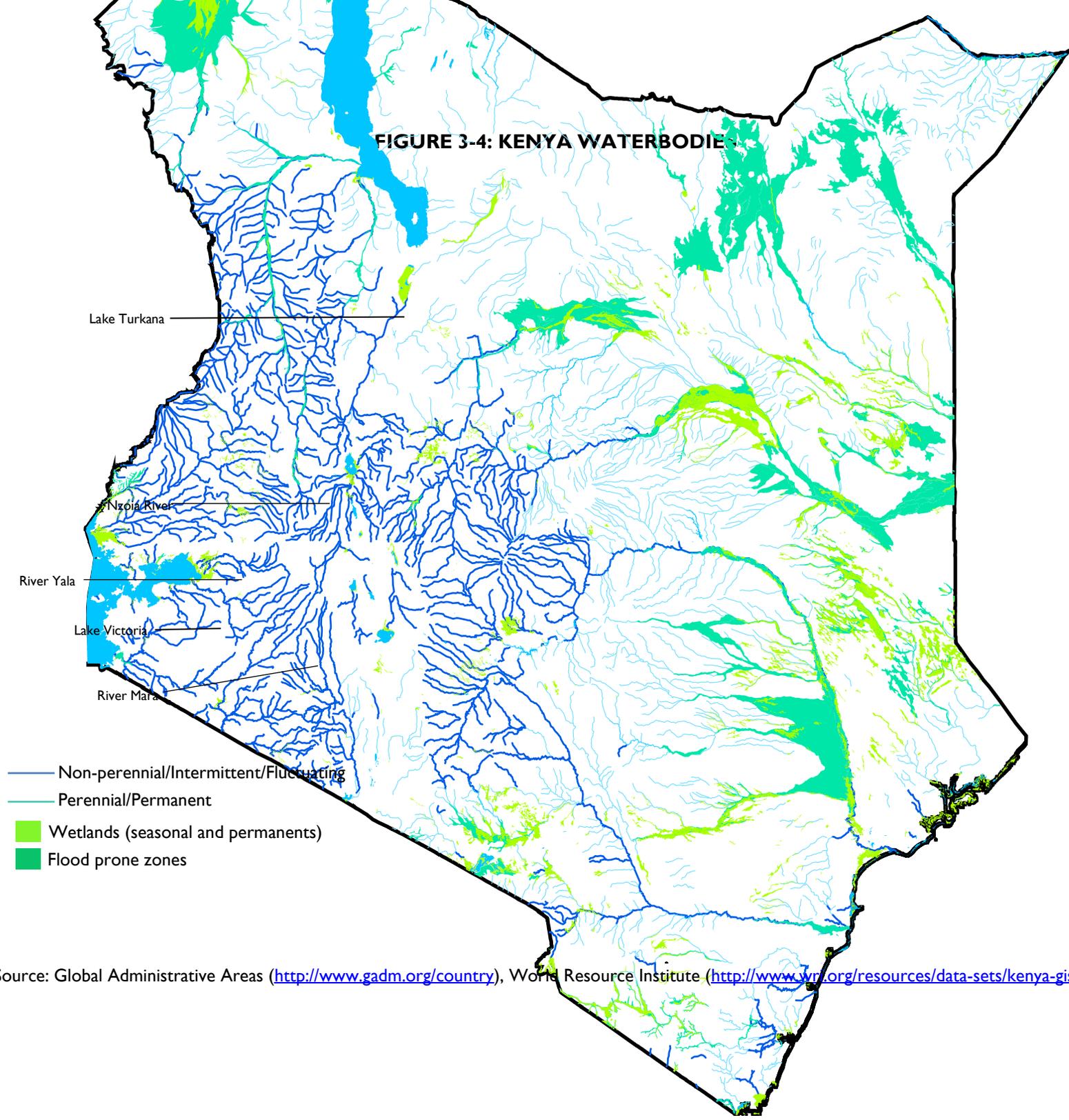
Kenya's drainage pattern originated when a large oval dome of rock arose in the west-central part of the country and created the Central Rift. This dome produced a primeval watershed from which rivers once drained eastward to the Indian Ocean and westward to the Congo River system and the Atlantic Ocean. Still following this ancient pattern are the Tana and Galana rivers, which rise in the eastern highlands and flow roughly southeast to the Indian Ocean. West of the Central Rift, however, the major streams now drain into Lake Victoria. These include the Nzoia, Yala, Mara, and Nyando rivers. Between the eastern and western systems, the rifting of the dome's crust has created a complex pattern of internal streams that feed the major lakes.

There are no major groundwater basins, and, apart from the Tana River, most of the rivers in Kenya are short and often disappear during the dry season. Lake Victoria, with a surface area of 69,484 sq. km (26,828 sq. mi), is the largest lake in Africa, the second largest freshwater body in the world, and a major reservoir of the Nile River. Lake Turkana, some 150 miles (240 km) long and 20 miles (30 km) wide, is the largest of the country's Rift Valley lakes. Other lakes in Kenya are rather small, and their surface areas fluctuate considerably. Figure 3-4 presents the surface water sources in Kenya, highlighting some of the major lake and rivers.

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<sup>21</sup> Information for this section is primarily taken from the 2016 Encyclopedia Britannica <https://www.britannica.com/place/Kenya>

**FIGURE 3-4: KENYA WATERBODIES**

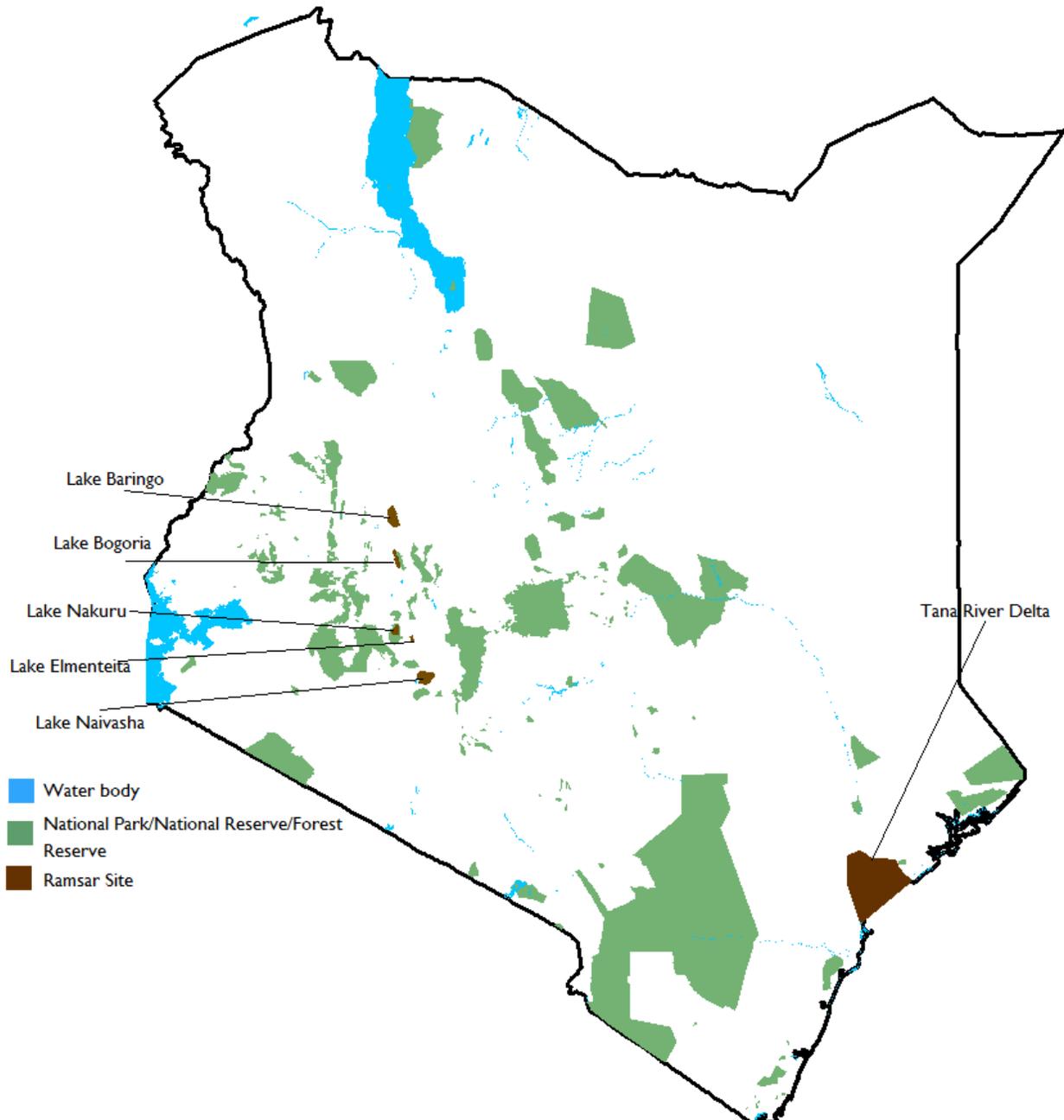


Source: Global Administrative Areas (<http://www.gadm.org/country>), World Resource Institute (<http://www.wri.org/resources/data-sets/kenya-gis-data>)

### 3.4 PROTECTED AREAS

Protected areas in Kenya are mainly comprised of water bodies (e.g., lakes, rivers, wetlands, and streams), National Reserves, National Parks, and Forest reserves. The protected areas in Kenya include 23 terrestrial National Parks, 28 terrestrial National Reserves, 4 marine National Parks, 6 marine National Reserves, and 4 national sanctuaries. Some of these protected areas have been identified as Ramsar sites. Figure 3-5 presents the protected areas in Kenya.

**FIGURE 3-5: PROTECTED AREAS IN KENYA**



Source: Global Administrative Areas (<http://www.gadm.org/country>), World Resource Institute (<http://www.wri.org/resources/data-sets/kenya-gis-data>), and RSIS [https://rsis.ramsar.org/ris-search/?f\[0\]=regionCountry\\_en\\_ss%3AKenya](https://rsis.ramsar.org/ris-search/?f[0]=regionCountry_en_ss%3AKenya)

### 3.4.1 RAMSAR SITES <sup>22</sup>

Kenya has 6 sites designated as Wetlands of International Importance (Ramsar) that cover an area of 265,449 hectares. These are located at Lake Baringo, Lake Bogoria, Lake Nakuru, Lake Naivasha, Lake Elmenteita, and the Tana River Delta.

#### **Lake Baringo**

Lake Baringo is located in Baringo County at 00°32'N 036°05'E and covers 31,469 hectares. This National Reserve consists of one of the two important freshwater (less-alkaline) lakes in the primarily arid Kenyan Rift Valley and its surrounding riparian zones; the central island, OI Kokwe, embodies the remains of a small volcano. It is part of the Great Rift Valley system of faults and cliffs and is fed by several freshwater inflows from the Mau and Tugen hills. The lake provides critical habitat and refuge for nearly 500 bird species, and some of the migratory water bird species are of regional and global conservation significance, with more than 20,000 individuals reported. The lake is an invaluable habitat for seven freshwater fish species, of which one (the tilapia *Oreochromis niloticus baringoensis*) is endemic to the lake. Local fisheries are particularly important for sustainable development of the local communities, for both economic and sport fishing. In addition, the site is a habitat for many species of animals, such as hippopotamus, crocodile and a wide range of mammals, amphibians, reptiles and invertebrate communities. Four ethnic communities around the lake depend upon it for food, through fishing, and for water supply, and a diversity of traditional religious functions are served by the lake and surrounding escarpments. Long term overgrazing and deforestation and diversion for irrigation of water from one of the inflowing rivers are seen as potential pressures, as are alien invasive species, such as *Pistia* (Nile cabbage), and the use of motor boats for water sports.

#### **Lake Bogoria**

The lake is located at 00°15'N 036°05'E and measures 10,700 hectares. It is a National Reserve also located in Baringo County. An alkaline soda lake hydrologically dominated by hot springs, located in Gregory Eastern Rift Valley, the site provides critical refuge for the lesser flamingo (*Phoenicopterus minor*), with a population of 1 to 1.5 million, and has high biodiversity values for more than 300 water bird species. The shoreline fringe and associated acacia woodland provide critical habitat for the endangered Greater Kudu and other mammals. The lake's stable water level makes it doubly important during periods of drought which reduce levels in other East African lakes. The regional climate is arid to semi-arid with low rainfall reliability. Tugen and Jemps pastoralists live in the area, and livestock grazing is the main land use at the site, but tourism, with attraction such as the wildlife, hot springs, spectacular cliffs and escarpments, and the rich indigenous culture, brings 200,000 visitors annually; in addition, the geysers are thought by some to have medicinal value.

#### **Lake Nakuru**

Lake Nakuru is within the Lake Nakuru National Park in Nakuru County, located at 00°22'S 036°05'E. It measures 18,800 ha and is a very shallow, strongly alkaline lake, with surrounding woodland and grassland set in a picturesque landscape. It is fed by four seasonal rivers and the permanent Ngosur River, and represents one of the highest producers of biomass among Kenya's southern Rift Valley alkaline lakes. A number of ecosystems including sedge marshes, seasonally flooded and dry grasslands, swampland riparian forests, and various types of scrubland support some globally endangered mammal species such as the black rhino and the hippo, as well as regionally endangered bird species like the African Darter (*Anhinga rufa*), Great Egret, the range-restricted Grey-crested Helmet-shrike, the Lesser kestrel and the Madagascar pond heron. The lake supports on average 24% of the Lesser Flamingo and

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<sup>22</sup> This section is based on information available from the Ramsar Sites Information Service (RSIS) [https://rsis.ramsar.org/rsis-search/?f\[0\]=regionCountry\\_en\\_ss%3AKenya](https://rsis.ramsar.org/rsis-search/?f[0]=regionCountry_en_ss%3AKenya) Accessed October 26, 2016

10% of the Greater Flamingo world populations. As the site is a national park, the only activity which takes place within it is tourism. Archeological caves which were used by early man are found in the area. In the surroundings, agriculture is the largest land use activity: it ranges from small to large-scale farms, cultivating wheat, barley, maize, coffee, and potato crops. Beef and dairy farming is also practiced in the area, some of which is for commercial production. The main threats within the site are linked to invasive plant species and fencing, which prevents animal migrations. Activities in the lake catchment are more significant, however, and include the expansion of Nakuru Township, forestry, and agricultural activities which worsen water quality and increase erosion and sedimentation.

### **Lake Naivasha**

Lake Naivasha is also in Nakuru County at 00°45'S 036°21'E and covering 30,000 ha. It is located in a high altitude trough of the Rift Valley and is one of the few freshwater lakes in Kenya (and eastern Africa). The site comprises a crater lake, river delta, and a separate lake dominated by blue-green algae and soda-tolerant plants. It also supports a complex vegetation of terrestrial, riparian, and littoral plants, which in turn provide safe haven, foraging and breeding ground for many resident and migrant bird species, as well as other wildlife. Hundreds of hippopotamus and several species of large mammals including buffalo and waterbuck live in the riparian area. More than 350 species of water birds frequent the site, including 1% of the world population of *Fulica cristata*: 15,000 individuals. The local people depend on the lake for their water supply, and human activities include wildlife and livestock ranching, agriculture, tourism, pastoralism and fishing. Private game sanctuaries and conservation areas exist on the site. The most significant activity, however, is the intensive irrigated greenhouse floriculture and horticulture - Kenya is currently the leading exporter of cut flowers and Naivasha supplies about 75% of these. Although the sector employs thousands of Kenyans and significantly contributes to the GDP, it also poses a threat to the site's integrity due to pesticide and fertilizer use, removal of fringing swamps, and over-abstraction of water. Lake Naivasha Riparian Association (LNRA), which was one of the Ramsar Wetland Conservation Award winners in 1999, has been at the forefront in finding lasting solutions to land use conflicts in collaboration with Kenya Wildlife Service (KWS) and other relevant government departments. Through these efforts, the Lake Naivasha Management Plan has been developed to guide the conservation of the lake's resources.

### **Lake Elmenteita**

Lake Elmenteita is the third Ramsar site in Nakuru County (00°46'S 036°23'E; 10,880 ha). This shallow saline, alkaline lake provides a favorable environment for diatoms and the blue-green alga *Spirulina platensis*, which lie at the bottom of the food chain of several bird species. An average of over 610,000 birds (from over 450 species, including 80 waterfowl species) has been counted in the area during the annual censuses. The lake acts as an important dispersal area for Lesser Flamingo, hosting an average of 28.5% of its world population and playing an especially important role when food is limited in other saline Rift Valley lakes like Nakuru and Bogoria. During the dry season, black lava islands situated in the western part of the lake provide the only suitable nesting and breeding grounds for Great White Pelicans in the Rift Valley region. Local inhabitants depend on the hot springs around Chamka for domestic freshwater supply, subsistence irrigation and water for livestock. The nomadic Maasai also use the area as a grazing and salt-licking site for their livestock. Salt, sand and diatomite are mined from the site at both small and large-scale, but most of the riparian land around the site is reserved for biodiversity conservation. Tourism and recreational facilities at the site are an important foreign exchange earner and employer.

### **Tana River Delta**

The Tana River Delta Ramsar Site (02°27'S 040°17'E; 163,600 hectares) is an Important Bird Area (IBA). It is the second most important estuarine and deltaic ecosystem in Eastern Africa, comprising a variety

of freshwater, floodplain, estuarine and coastal habitats with extensive and diverse mangrove systems, marine brackish and freshwater intertidal areas, pristine beaches and shallow marine areas, forming productive and functionally interconnected ecosystems.

This diversity in habitats permits diverse hydrological functions and a rich biodiversity including coastal and marine prawns, shrimps, bivalves and fish, five species of threatened marine turtles and International Union for Conservation of Nature (IUCN) red-listed African elephant, Tana Mangabey, Tana River Red Colobus, and White-collared Monkey. Over 600 plant species have been identified, including the endangered *Cynometra lukei* and *Gonatopus marattioides*.

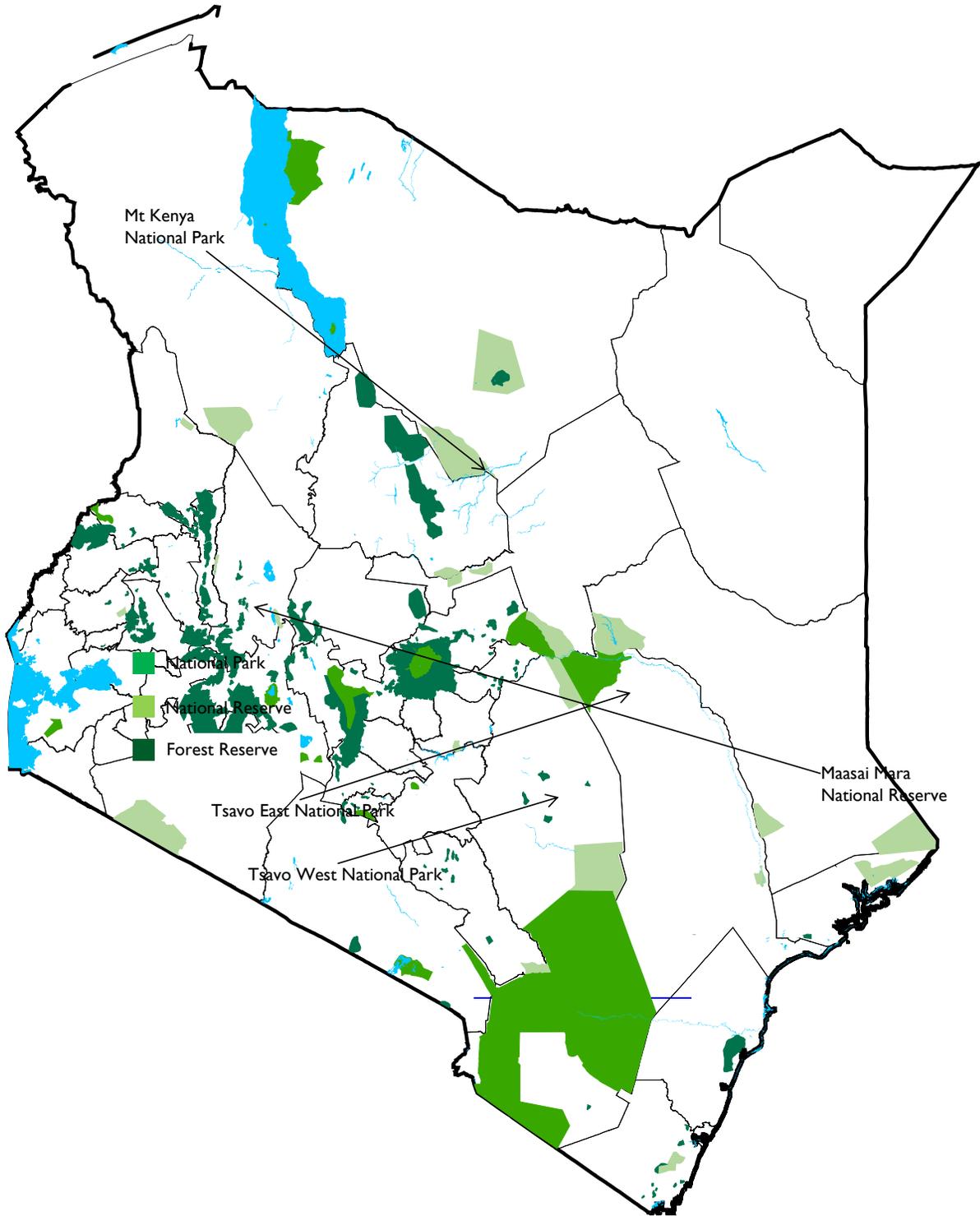
As one of the only estuarine staging posts on the West Asia - Eastern Africa coastal flyway, it is a critical feeding and wintering ground for several migratory water birds such as waders, gulls and terns. The main human activities include fishing, small-scale family-oriented agriculture, mangrove wood exploitation, grazing, water supply, tourism and research (ongoing research on the protection and monitoring of breeding turtles and the conservation of dugongs).

### 3.4.2 FORESTS AND RESERVES IN KENYA

Protected areas in Kenya are categorized either as parks or reserves. Figure 3-6 presents the distribution of parks and reserves in Kenya. The two labels indicate the human activities allowed within these areas. In parks, there is complete protection of natural resources and the only activities allowed are tourism and research. On the other hand, in reserves, various human activities – for instance, fishing in marine reserves or firewood collection in terrestrial reserves – are allowed under specific conditions. About 8% of the Kenya's land mass is protected area for wildlife conservation. These protected areas are gazetted landscapes/seascapes that have been surveyed, demarcated and gazetted either as National Parks and/or National Reserves. It is worth mentioning that a lot of Kenya's wildlife lives outside Protected Areas. This is because most of the protected areas are not fully fenced, and hence wildlife move in and out of these areas in search of pasture and water during certain periods within the year. In addition, some of the wildlife found in the parks and reserves migrate over long distances during the year. As a result, Kenya participates in a number of transboundary efforts in efforts to protect the endangered species involved.

About 6.99% of the land area of the country has been demarcated as forest land: with a wide range of forest ecosystems ranging from montane rainforests, savannah woodlands; dry forests and coastal forests and mangroves. Even though forests occupy only a small portion of the land, they are extremely important in the domestic economy. Most of the area of forest reserves is wooded bush, bamboo, and grass; the remainder consists of planted softwoods, which now support a domestic paper industry. Forests are vital for conserving Kenya's soil and water resources, but they are increasingly threatened by a fast-growing population that constantly demands more fuel and settlement areas. As fuel, wood is used primarily for domestic cooking, but deforestation threatens the supply. A tree-planting program has been initiated to grow quick-maturing indigenous and exotic species in ecologically suitable areas.

**FIGURE 3-6: MAP OF PARKS AND RESERVES IN KENYA**



Source: Global Administrative Areas (<http://www.gadm.org/country>), World Resource Institute (<http://www.wri.org/resources/data-sets/kenya-gis-data>)

## 3.5 AGRICULTURE AND ORGANIC FARMING

### **Agriculture**

Agriculture plays an important role in Kenya's economy. Although its share of gross domestic product (GDP) has declined – from more than 40% in 1964 to less than 20% in the early 21st century – agriculture supplies the manufacturing sector with raw materials and generates tax revenue and foreign exchange that support the rest of the economy. Moreover, it employs the majority of the population.

Tea and fresh flowers are the key foreign-exchange earners. Sisal, cotton, and fruits and vegetables also are important cash crops. Coffee, historically an important foreign exchange earner, still contributes to the economy but began declining in importance and earnings in the 1990s, owing in part to market instability and deregulation. Kenya supplies the majority of the pyrethrum (a flower used to create the non-synthetic pesticide pyrethrin) to the world market. National boards that controlled key export crops such as coffee, tea, and cotton were deregulated beginning in the early 1990s.

The major crops for domestic consumption are corn (maize) and wheat. Sugarcane was an export crop in the 1970s and '80s, but by the '90s domestic demand exceeded the supply, and it had to be imported. Livestock (including cattle and goats) is raised and dairy goods are produced primarily for domestic use, and the government maintains a reserve supply of such commodities as skim milk powder, cheese, and butter. Surplus animal and dairy products are exported.

Despite the importance of agriculture to the economic well-being of the country, the lack of water, infrastructure, and arable land (less than 10% of Kenya can be used for agriculture) seriously constrains further expansion. Although the government has made efforts to increase irrigation, it is estimated that only 20% to 25% of potentially irrigable area has been developed.

Fish and marine products represent a small but growing portion of Kenya's economy and are locally important. Freshwater fish from Lakes Victoria and Turkana constitute the bulk of the catch. The encroaching water hyacinth on the surface of Lake Victoria threatened this fishery in the 1990s, although this nuisance was countered by several strategies, including the introduction of weevils into the environment. Most of the weed has been successfully eliminated, although the potential for resurgence remains.

#### *Organic Farming*<sup>23</sup>

The growth and development of organic agriculture (farming) in Kenya was initially an initiative of Non-Governmental Organizations and private organizations like the Kenya Institute of Organic Farming (KIOF), formed back in 1986. However, from the mid-1990s, efforts were shifting from isolated individual to more collaborative with the establishment of organizations such as the Kenya Organic Farmers Association (KOFA), initiated by farmers participating in KIOF extension and training programs. The association published organic farming standards for members based on standards by International Federation of Organic Agriculture Movements and the European Union. KOFA wanted particularly to develop a vibrant organic market - both locally and internationally - for their produce. Larger companies and commercial farmers already in the export market, though, have organized themselves into the Kenya Organic Producers Association (KOPA).

The organic farm sector itself is basically organized around a minor number of large farm enterprises, or various supply organizations, based on purely commercial, community, faith or simply farmer cooperation involved in packaging, domestic or export sales. More than half of organic farming

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<sup>23</sup> Based on Kledal et al., 2010.

producers are concentrated in areas where most of the out-growers are connected in relation to the labor intensive crop production within horticulture.

The total organic area is distinguished between what is agricultural land and what is considered wild and extensive production. The agricultural land consisted of 4,535 hectares, which together with the area for wild and extensive collection reaching 73,851 hectares, amounted to a total 78,438 hectares certified organic. The domestic market for organic produce is mainly limited to around the capital city. The major exports are within the six major product categories produced: fresh vegetables and tropical fruits, essential oils, herbs, nuts, coffee and tea.

### 3.6 BEE KEEPING

Traditionally, honey in Kenya was collected from wild bees in forests. Honey has become very popular with many people in Kenya which has fostered the growth of beekeeping. A 2007 study in northern Kenya found that honey production is expanding in Kenya, but data on production trends, processing and marketing is fragmented (Lengarite, Kagunyu, and Wayua, 2007). Estimates place the proportion of actual to potential Kenya honey production (estimated at 100,000 metric tons) at 20%. The arid and semi-arid lands yield only crudely processed honey for urban markets. About 80% of Kenya consists of arid and semi-arid lands (ASALs) which have high potential in production of honey, and apicultural activity is a major occupation in these areas due to the abundance of bee flora. Non ASAL regions also practice beekeeping. Modern beekeeping in Kenya started towards the end of 1960s and has since become an important enterprise in the livestock sub-sector. Almost 80% of the Kenya honey comes from the traditional log hive. However, a reasonable amount of hive products is obtained from Kenya Top Bar and Langstroth hives.

# 4 ENVIRONMENTAL & HEALTH IMPACTS

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## 4.1 POTENTIAL POSITIVE EFFECTS OF THE IRS PROGRAM

### 4.1.1 DIRECT POSITIVE EFFECTS

The direct positive impacts of the IRS program are the reduction in child and adult malaria morbidity and mortality that will result in a reduction in human suffering. In addition, economic losses due to absenteeism or inability to work will be reduced. Other positive impacts include reduced incidence of miscarriages, low birth-weight, adverse effects on malaria-induced fetal neurodevelopment, and reduced incidence of malaria-related childhood and maternal anemia, complications, and organ failure. There is also the benefit of elimination of other household insects, as well as vermin in some cases.

### 4.1.2 INDIRECT POSITIVE EFFECTS

IRS will build human and institutional capacity by providing broad-based training to a large number of people associated with IRS operations. From this training, there will be an increase in knowledge and understanding of both IRS-specific and general health and environmental risks and impacts, as well as methods of mitigation of those risks. One of the goals of the IRS program is to build in-country capacity to the point where IRS can be conducted by national or local government, or by the self-organization of communities, without large-scale external assistance or intervention.

By reducing the malaria burden, the IRS program will improve the education level amongst children of school age, as a result of the reduction in the number of school days missed, and improve the productivity of the workforce as a result of the reduction in missed work days and days of reduced productivity.

The IRS program will indirectly contribute to the enhancement of the local economy in that IRS staff and workers will receive payment for their work. At least some of the money that they receive will be spent and injected into the local economy with a magnification effect, improving revenues for various businesses and per capita income.

In addition, the implementation of IRS requires certain local purchases of products and services, such as building and construction materials, rental of building space and vehicles, and hiring of local labor for the construction or renovation of storehouses and soak pits. PMI has also committed to environmentally sustainable operations, which in some cases has stimulated business activities such as recycling. Again, these revenues are injected into the economy with potentially positive and significant magnification effects.

Finally, a reduction in household pests from IRS may result in a reduction in other diseases carried by the pests.

## 4.2 POTENTIAL ADVERSE IMPACTS

Adverse impacts of the IRS project are those unintended effects of the project that can compromise the well-being of the environment and/or human health. Potential adverse impacts are listed below.

## 4.2.1 DIRECT POTENTIAL ADVERSE EFFECTS

### *CONTAMINATION OF SURFACE WATER COURSES AND UNDERGROUND WATER*

During IRS implementation, it is possible to accidentally release insecticides into water bodies during the transportation and storage of pesticides, application of insecticides to walls, and clean-up of IRS equipment and PPE. It is also possible to have a release that will affect surface or groundwater through washing in areas other than the soak pit, or improper disposal of leftover pesticide. A spill into surface water bodies is a key concern in IRS because it could lead to contamination of water routinely used for multiple domestic purposes. Fish and other aquatic organisms that are vital to a healthy ecosystem could also be wiped out.

Contamination of underground water resources is possible through improper disposal of leftover pesticide on the ground, especially if there is a high water table. However, the impacts of this risk are likely to be insignificant, primarily because pesticide disposal is strictly controlled and supervised, and the sites for soak pits are carefully chosen according to the criteria in the PMI BMPs. Secondly, most formulations of pyrethroids, OPs, carbamates and chlorfenapyr move slowly through soil, and degrade quickly when exposed to sunlight, hydrolysis, or microbial action in the soil. If wash areas and soak pits are properly constructed and employed, liquid pesticide traces will be captured in the charcoal layer of the soak pit or organic matter in soil, and held until degradation by natural processes.

### *POTENTIAL IMPACTS TO NON-TARGET ORGANISMS FROM PESTICIDES*

The degree of toxicity of the four WHOPES-recommended pesticide classes and chlorfenapyr to birdlife, aquatic life and insects, as well as pesticide persistence and bio-accumulation potential is documented in Table 5-3 in Section 5.5.1 of this SEA.

### *SPECIAL NOTE: IMPACTS ON BEES*

Spraying in areas near beehives can lead to the death of the bees, which are vulnerable to all WHO-recommended pesticides. In addition, spraying near hives can lead to contamination of edible honey. These risks must be mitigated at all times. Bee keeping in Kenya is mainly conducted away from the household and the sale of honey provides significant income to the residents. The project will identify locations where beehives are kept, and observe a 30 meter no-spray buffer zone around them. Bee-hive owners will be advised accordingly. In some communities, the bee hives are kept close to the home. AIRS Kenya will advise all homeowner with hives close to the home to relocate them at least 30 meters away from homes before the home is sprayed.

## 4.2.2 INDIRECT ADVERSE EFFECTS

Upon termination of the IRS program, PMI will properly dispose of the IRS equipment and will no longer supervise its use. IRS equipment that may be disposed of includes spray tanks, used or clean boots, wash basins, progressive rinse barrels, etc. that are still in operable condition. Improper use of this equipment could lead to contamination of the environment or adverse health effects as noted.

In general, if PMI supports the procurement of insecticide or disposition of unused insecticide to the Government of Kenya, this activity is required to be mentioned in the annual Letter Report, in addition to this SEA. This type of support requires annual environmental compliance monitoring by PMI and/or the IP, requires that PMI and/or the PMI IP provide environmental training in the PMI IRS BMPs, and language must be inserted into the government to government agreement that PMI must provide technical assistance for insecticide selection to ensure quality/appropriateness of the product. Similarly, if PMI supports the procurement, loan, or disposition of spray pumps or personal protective equipment to the Government of Kenya, these activities must be mentioned in the annual Letter Report, in addition to

this SEA. These activities do not require environmental compliance monitoring, however, PMI and/or the PMI IP must provide environmental training in the PMI IRS BMPs. These requirements relate to the use of non-DDT insecticides by the Government of Kenya. The conduct of IRS by the Ministry of Health with communities, using properly working equipment left behind by PMI may temporarily, and in a minor way increase the total pesticide load on the environment. However, since the IRS equipment will be in operable conditions and capacity has been built among the County Medical Officers, it is expected that spray operations will be according to BMPs, and the total pesticide load on the environment is expected to be less than if the donation is not made.

## 4.3 HUMAN EXPOSURE RISKS/IMPACTS

### 4.3.1 WORKER AND RESIDENT EXPOSURE PATHWAYS

During the IRS spraying process, spray personnel are at risk of 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-spraying, spraying and post-spraying phase of the IRS operations. Beneficiaries can also be exposed during each of these phases, and additionally over the life of the pesticide on the wall. Exposure risks of all WHO-recommended pesticides in relation to cancer and non-cancer endpoints are presented in IVM PEA 2012. The exposure risk for cancer and non-cancer endpoints is presented at different stages of the pesticide application including mixing, spraying, post spraying, dermal risk, etc.

### 4.3.2 PRE SPRAYING EXPOSURE PATHWAY

Preparing pesticide solutions during the IRS requires pouring the pesticide in the spray pump and agitating it to ensure ample mixing with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, from releases of pesticide vapors and liquids. Vapor releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapors or the particulates or be exposed through dermal contact. Spills could also pose significant risk, especially for children who ingest the resulting residues that are left on surfaces such as food, floors, soil, as well as absorbing additional doses from eating plants and animals contaminated during the preparation for spraying.

### 4.3.3 EXPOSURE DURING SPRAYING

Inhalation of aerosol droplets during spraying is the main process for worker exposure during IRS, however, dermal exposure through spills or absorption onto cotton overalls is also a significant risk. Especially in the case of OPs, the dermal hazard is significant, and can cause cholinesterase depression. 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 the floors and incidental ingestion by children who may come in contact with the spills before they are cleaned up.

### 4.3.4 EXPOSURE DURING DISPOSAL (INCLUDING PROGRESSIVE RINSING)

Disposal is a key issue with IRS intervention that utilizes 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. Once the pesticide gets into the soil, it can migrate to groundwater, which may be used as a water supply via household wells. In this manner, ingestion

exposure can occur from drinking contaminated surface water. Residents may also be exposed to this contaminated water by dermal contact when it is used for cleaning or cooking purposes.

#### 4.3.5 OCCUPANT LONG-TERM EXPOSURE FROM RESIDUE

Residents of sprayed structures, especially crawling babies and children, will have a finite exposure risk due to physical contact with sprayed surfaces, as well as small amounts released from substrate walls, ceilings, and eaves, due to physical surface breakdown.

### 4.4 PESTICIDE- AND PROCESS-SPECIFIC POTENTIAL HEALTH IMPACTS

#### 4.4.1 INHALATION EXPOSURE AND RISK DURING MIXING

Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

#### 4.4.2 DERMAL EXPOSURE AND RISK DURING MIXING

On the WHOPES list of insecticides to be used in IRS only three (DDT, etofenprox (pyrethroid) 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

#### 4.4.3 INHALATION EXPOSURE AND RISK DURING SPRAYING

Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

#### 4.4.4 DERMAL EXPOSURE AND RISK DURING SPRAYING

Of the proposed pesticides, fenitrothion and pirimiphos-methyl have non-cancer risks (cholinesterase depression) due to dermal exposure

#### 4.4.5 RESIDENT DERMAL EXPOSURE AND INGESTION RISK AFTER SPRAYING

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

#### 4.4.6 RESIDENT EXPOSURE AND RISK DUE TO CHRONIC INGESTION AFTER SPRAYING

There are four insecticides with potential impact due to chronic ingestion by drinking insecticide contaminated water. These are Cyfluthrin, Permethrin and Etofenprox (pyrethroids) and propoxur (carbamate). Best management practices are recommended.

#### 4.4.7 RESIDENT DERMAL EXPOSURE AND RISK DUE TO BATHING USING CONTAMINATED GROUNDWATER

Cyfluthrin and etofenprox (pyrethroids) have potential impact for dermal exposure using contaminated groundwater. When best management practices are applied in IRS, this risk is significantly reduced.

#### 4.4.8 RESIDENT EXPOSURE AND RISK DUE TO REUSE OF PESTICIDE CONTAINERS

Only deltamethrin is considered to have potential for acute ingestion hazard from using pesticide containers. However, residents will have no access to pesticide containers used in IRS. The pesticide containers are carefully inventoried and stored in IRS storage facilities which are securely double locked. When an appropriate recycling system is available, they will be disposed by recycling into non-consumer products. Otherwise they will be landfilled after washing and puncturing, or as a last resort, incinerated.

#### 4.4.9 WORKER EXPOSURE AND RISK DUE TO INHALATION DURING SPILLAGE

According to information presented in the IVM PEA, etofenprox and propoxur have potential to impact workers through inhalation during spillage. The workers are trained on how to handle spillage and must be equipped with appropriate PPE.

#### 4.5 CUMULATIVE IMPACT

Organophosphates are the pesticides with the highest potential for cumulative impacts. Pyrethroids, carbamates, and most organophosphate formulations break down readily in the environment, limiting the risk of cumulative environmental impact, especially if disposal sites are well-chosen and BMPs are followed.

However, repeated exposures to organophosphates result in cumulative cholinesterase depression, with increasingly severe effects. For this reason it is exceptionally important that PPE is worn properly and at all times when pesticide contact is possible. It is also incumbent upon team leaders to monitor the health of their spray operators on a daily basis, and to look for any signs of cholinesterase depression. Formulations of the organophosphate pirimiphos-methyl have been used for several years and in several countries without any report of observed symptoms of cholinesterase depression.

Additionally, there are indications that the capsule suspension form of Actellic® is more resistant to environmental degradation than either Actellic® EC, or the other WHOPES-recommended pesticides. This may result in a temporary build-up of concentration within the soak pit prior to degradation.

# 5 PESTICIDE PROCEDURES

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Title 22 of the United States Code of Federal Regulations, Part 216 (22 CFR 216) mandates the consideration of twelve factors when a project includes “assistance for the procurement or use, or both, of pesticides”. As the PMI IRS Kenya program includes assistance in both of these aspects, it is subject to this regulation. This section therefore addresses each of the twelve factors for the IRS Malaria Control Program in Kenya.

## 5.1 THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY’S REGISTRATION STATUS OF THE REQUESTED PESTICIDE

Pesticides registered for IRS or a similar use in the United States and the host country government will be preferred in this IRS project. Some of the pesticides on the WHOPES list are not registered with the USEPA for economic, technical, or regulatory reasons. There is a very limited market in the US for IRS, and as a result, registrations for this use of these pesticides have been voluntarily withdrawn, or never filed. However, US 22 CFR 216.3(b)(1)(iii) allows for the use of pesticides not registered for the same or similar use by USEPA, provided that:

1. The proper assessments are performed,
2. The assessments include an evaluation of the factors in Sections 5.1-5.12 of this document, and
3. Notification is provided to, and authorization received from the host country government for the use of the pesticide in-country.

PMI works closely with host country governments, with full and clear disclosure, and provides any necessary assistance in the mitigation of risk from the use of these WHOPES pesticides. This SEA, supported by the PMI IVM PEA, and distributed to the NMCP and National Environmental Management Authority (NEMA), provides the assessment, notification and mitigation requirements of US regulations. USAID/PMI is therefore empowered, upon acceptance of this document and the receipt of formal authorization from a competent Kenyan authority, to use in all Kenya WHOPES-recommended pesticides in the pyrethroid, carbamate, and organophosphate classes, and chlorfenapyr when recommended by WHOPES.

## 5.2 THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

In addition to the above criteria, insecticide selection for any PMI supported program is subject to the following considerations.

### 5.2.1 PRIMARY CRITERIA FOR CHOOSING PESTICIDES

**Approval by the World Health Organization Pesticide Evaluation Scheme:** Only insecticides recommended by WHOPES can be used in IRS. Certain pesticides in the organophosphate, carbamate, pyrethroid and organochlorine classes are WHOPES-recommended for use in IRS. Table 5-1 shows the list of WHO-recommended pesticides. Chlorfenapyr is not yet recommended by WHOPES, but authorization is requested in this SEA to use it for hut trials, and for IRS when and if it receives a WHOPES recommendation.

**TABLE 5-1: WHOPES RECOMMENDED PESTICIDES WITH EFFECTIVE DURATION**

Updated: 2 March 2015

**WHO recommended insecticides for indoor residual spraying against malaria vectors**

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

**Chlorfenapyr 240 SC:** The current assessments of Chlorfenapyr SC (class group: pyrrole) are available in the report of the 16<sup>th</sup> WHOPES Working Group meeting, 22–30 July 2013 and the report of the 17<sup>th</sup> WHOPES Working Group meeting, 15–19 September 2014 (both reports available at: <http://who.int/whopes/resources/en/>).

**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/>.

<sup>1</sup> CS = capsule suspension; EC = emulsifiable concentrate; SC = suspension concentrate; SC-PE = polymer enhanced suspension concentrate; WG = water dispersible granules; WG-SB = water dispersible granules in sealed water soluble bags; WP = wettable powder; WP-SB = wettable powder in sealed water soluble bags.

<sup>2</sup> OC = organochlorines; OP = organophosphates; C = carbamates; PY = pyrethroids.

Note: Chlorfenapyr is still undergoing testing so is not included in this table.

**Registration for use in Kenya:** In the case where the insecticide proposed for use in IRS is not registered in Kenya, PMI will work with manufacturers and distributors, as well as the NMCP, the Ministry of Health, and other regulatory bodies to obtain special authorization for the use of the pesticide, where possible.

**Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area:** As seen in the table above, all pyrethroids, carbamates, and organophosphates are expected to stay active and effective for 3 to 6 months after application; however, the effective duration varies under different climatic conditions and other factors. Three pyrethroids, known as longer-lasting pyrethroids, can last up to eleven months based on various field

trials. For this reason, pyrethroids have traditionally made the best choice for extended seasons. However, in order to manage vector resistance, it has proven to be necessary to periodically switch the class of pesticides used in IRS.

**Pesticide must be appropriate for use on the wall surfaces of the selected location:** Various types of materials are used for outer walls of residential structures in Kenya. The 3 main types are mud/wood (34.8); stone (22.4%); and brick/block (17.1%). Other materials used include, mud/cement; wood only; corrugated iron sheets; grass/reeds; and tin. In the rural areas, 48.9% had walls made of mud/wood followed by those made of brick/block (14.9%). In the urban areas, 44.9% are dwelling units whose main type of wall materials is stone. This is followed by brick/block at 20.6 per cent. Some of these materials (for example, corrugated iron sheets, and tin) are used for the walls of temporary structures and constitute non-sprayable structures for IRS.

**Local vector susceptibility to the insecticide:** Resistance to insecticide develops when a hereditary feature is selected in an insect population that reduces the population's sensitivity to a given insecticide. In Kenya, vector susceptibility studies have confirmed the effectiveness of pirimiphos methyl in the IRS target areas. Resistance to pyrethroid insecticides has been identified in many areas over the last few years. Entomological monitoring that began in December 2015 included monthly pyrethrum spray catches, light traps, window exit traps as well as human landing catches for five consecutive nights in February 2016. The predominant vector species was *An. funestus* in all traps with initial high numbers following the short rains in late 2015 but declining through March of 2016. Insecticide resistance testing was conducted in April 2016 at five sites, including three in Migori County where IRS will be conducted in 2017. The results, listed in Table 5-2, indicate that there is resistance to the pyrethroids but susceptibility to both bendiocarb and pirimiphos-methyl. The primary species collected were *An. gambiae* s.l. in four of the sites while *An. funestus* was tested at one site in Migori County. PCR testing indicated the *An. gambiae* s.l. were primarily *An. arabiensis*. Resistance to pyrethroids was observed in both species.

**TABLE 5-2: INSECTICIDE RESISTANCE TESTS, 2016 (% MORTALITY)**

Species	County	Sub County	Pyrethroid		Carbamate	Organo phosphate
			Deltamethrin	Permethrin	Bendiocarb	Pirimiphos methyl
<i>An. gambiae</i> s.l.	Homa Bay	Homa Bay	72	75	100	100
<i>An. gambiae</i> s.l.	Homa Bay	Ndhiwa	60	73	100	100
<i>An. gambiae</i> s.l.	Migori	Rongo	73	69	100	100
<i>An. gambiae</i> s.l.	Migori	Urii	84	75	75	100
<i>An. funestus</i>	Migori	Awendo	85	85	93	100
<i>An. funestus</i>	Migori	Rongo	NA	NA	100	100
<i>An. funestus</i>	Migori	Urii	NA	NA	100	100

Source: President's Malaria Initiative, Kenya Malaria Operational Plan (MOP), 2017

Kenya has developed an IRS business plan and an Insecticide Resistance Management plan to guide IRS activities in the country. To support these vector control objectives, Kenya aims to develop capacity at the county level to implement entomological surveillance and insecticide resistance monitoring.

Starting in 2017, in conjunction with the NMCP building the capacity for entomological surveillance at the county level, PMI will support entomological surveillance and insecticide resistance monitoring in up to 16 sites, primarily focused in endemic counties in western Kenya, although additional sites will be assessed for insecticide resistance in central as well as coastal Kenya. Entomological surveillance will include monthly monitoring of mosquito densities through pyrethrum spray catches and light traps. In addition, a smaller number of sites will include window exit traps and outdoor resting traps as indoor collections often yield low numbers of mosquitoes. Insecticide resistance monitoring will be done at a subset of sites to include both WHO susceptibility assays of all four insecticide classes as well as CDC bottle assays to measure the intensity of pyrethroid resistance in the population.

**Ecological impact:** Kenya boasts of a diverse wildlife throughout the country, but especially in the national parks and protected areas, and it is extremely important that IRS does not in any way diminish this biodiversity. The ecological impact of the WHOPES pesticides is well-documented, recently in the 2012 PMI IVM Program Environmental Assessment (IVM PEA). However, if BMPs for IRS are strictly followed, the release to the environment, and therefore the impact to the environment, should be negligible. More information on ecological impact of the proposed pesticides is found in sections 5.5 and 5.7 below, as well as other sections of this document.

**Human health impact:** The 2012 IVM PEA assessed cancer and non-cancer risks associated with all WHOPES-recommended insecticides by process (e.g., mixing insecticide, spraying, residing in sprayed house, etc.) and pathway (e.g. inhalation, dermal, ingestion, etc.), and cancer risks by process and pathway where available (mainly for DDT and select pyrethroids). In general, pyrethroids and carbamates pose less non-cancer risks via any pathway than organophosphates when risks are assessed, but the risks of organophosphates can be managed by following standard PMI IRS procedures and protocols (BMPs).

### 5.2.2 SECONDARY SELECTION CRITERIA:

- Appropriate packaging for safety and standard delivery tools
- Unit cost of insecticide
- Timely delivery of the insecticide to the preferred point of delivery
- Local representation of supplier in host country
- Technical assistance with training and troubleshooting by supplier

## 5.3 THE EXTENT TO WHICH THE PROPOSED PESTICIDE USE IS PART OF AN INTEGRATED PEST MANAGEMENT (IPM) PROGRAM

IPM is defined as “an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials (pesticides) are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.”<sup>24</sup>

IPM is often used in an agricultural context, but similar in nature is the concept of Integrated Vector Management (IVM).

The major characteristics of IVM include:

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<sup>24</sup> <http://www.ipm.ucdavis.edu/IPMPROJECT/about.html>

- Methods based on knowledge of factors influencing local vector biology, disease transmission, and morbidity;
- Use of a range of interventions, often in combination and synergistically;
- Collaboration within the health sector and with other public and private sectors that impact vectors;
- A public health regulatory and legislative framework.

Use of IVM for the control of the malaria vector population is practiced using two primary interventions, insecticide-treated nets, and indoor residual spray. Environmental management for malaria control is limited to some common sense safeguards, such as limiting standing water which can serve as a breeding ground for mosquitoes. USAID/PMI does not support environmental management as a vector control method. Because of the life-cycle requirements and the adaptability shown by malaria vectors, these practices have not demonstrated large-scale effectiveness.

PMI strategy has been that IRS will be implemented as a component of IVM for malaria control. PMI supports an evidence-based approach and will continue to review health management information systems and entomologic data to determine where best to deploy IRS.

## 5.4 THE PROPOSED METHOD OR METHODS OF APPLICATION, INCLUDING AVAILABILITY OF APPROPRIATE APPLICATION AND SAFETY EQUIPMENT

IRS involves spraying an insecticide with long lasting residual activity on indoor wall and ceiling surfaces where mosquitoes usually rest. The pesticide then dries up and leaves a crystalline deposit on the sprayed surface. A lethal dose of the insecticide is absorbed when the mosquito rests on the surface, which kills the mosquito.

Pesticide will only be applied using pressurized spray equipment approved for the pesticide in use, and by trained spray operators wearing gloves, overalls, hard hats with face shields, neck shields, and boots. All necessary PPE for this activity is supplied by PMI, and its use is supervised and enforced throughout the course of the campaign. Spray operators are trained in and use spray patterns that have proven effective for providing long-lasting toxicity toward the malaria vector mosquito.

The spray operators who implement IRS use backpack compression sprayers 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. After the day's spraying is complete, spray operators reserve in a collection drum any pesticide left in the spray pump, clean the sprayer following PMI BMPs to maintain proper functioning of the pump and to guard against release of and/or exposure to pesticides, and reuse leftover pesticide on the following day. They also follow the pump manufacturer's recommendations to ensure their proper operation and calibration.

## 5.5 ACUTE AND LONG-TERM TOXICOLOGICAL HAZARDS ASSOCIATED WITH THE PROPOSED USE AND MEASURES AVAILABLE TO MINIMIZE SUCH HAZARDS

The IVM PEA assessed the toxicity of WHO-recommended IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and other aquatic organisms. Table 5-3 provides graphic information on the toxicity and some of the other characteristics of the WHOPES pesticides. In general, most of them are toxic to bees, fish, and other aquatic organisms, and less so to mammals and birds.

**TABLE 5-3: PESTICIDE TOXICITY TO NON-TARGET SPECIES**

IRS Insecticide	Mammal	Bird	Fish	Other Aquatic	Bee	Persistence	Bioaccumulate
Alpha-cypermethrin (P)	Low Toxicity	Low Toxicity	High Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	High Toxicity
Bendiocarb (C)	Medium to High Toxicity	High Toxicity	Medium to High Toxicity	Medium to High Toxicity			
Bifenthrin (P)	Medium to High Toxicity	Medium to High Toxicity	High Toxicity	High Toxicity	High Toxicity	Data Not Found	Low Toxicity
Cyfluthrin (P)	Medium to High Toxicity	Low Toxicity	High Toxicity	High Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity
DDT (OC)	Medium to High Toxicity	Low Toxicity	High Toxicity	High Toxicity	Low Toxicity	High Toxicity	High Toxicity
Deltamethrin (P)	Medium to High Toxicity	Low Toxicity	High Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	High Toxicity
Etofenprox (P)	Low Toxicity	Low Toxicity	High Toxicity	High Toxicity	High Toxicity	Low Toxicity	Low Toxicity
Fenitrothion (OP)	Low Toxicity	High Toxicity	Low to Medium Toxicity	High Toxicity	High Toxicity	Low Toxicity	Medium to High Toxicity
Lambda-cyhalothrin (P)	High Toxicity	Low Toxicity	High Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	High Toxicity
Malathion (OP)	Medium to High Toxicity	Medium to High Toxicity	Low to Medium Toxicity	Low to Medium Toxicity	High Toxicity	Low to Medium Toxicity	Low to Medium Toxicity
Pirimiphos-methyl (OP)	Medium to High Toxicity	Low Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	High Toxicity	Low Toxicity
Propoxur (C)	High Toxicity	High Toxicity	Low to Medium Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	Medium to High Toxicity
Chlorfenapyr (PR)	Medium to High Toxicity	High Toxicity	High Toxicity	High Toxicity	High Toxicity	Medium to High Toxicity	Medium to High Toxicity

Source: IVM PEA 2012

**Key**

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

“Indoor” being an important operative word in IRS, the risks to biodiversity from spray operations are minimal if PMI BMPS are followed. The BMPs have been designed to prevent any significant release to the environment, and a strong, automated, smart-phone-based supervisory system ensures that BMPs are followed or non-compliance is immediately corrected. The reader is referred to Annex E of the 2012 IVM PEA for greater detail about pesticide toxicity.

**5.5.1 HAZARDS**

The two broad categories of hazard are release and exposure to humans and domestic animals, and releases causing environmental damage. Release and exposure may occur at any point, from the production or importation of the pesticide through transportation, storage, distribution, pesticide make-up, spray application, clean-up, and final disposal, as well as post-spray due to improper spray deposition on household articles, or improper behavior of beneficiaries regarding sprayed surfaces.

In humans, both organophosphates and carbamates can produce cholinesterase depression if the proper protective measures are not utilized and exposure results. Cholinesterase inhibition results in overstimulation of the nervous system, with symptoms that include nausea, dizziness, confusion, and respiratory paralysis and death at very high exposures (U.S. EPA, 2000). The two classes of insecticides differ in their impact on human health in that with carbamates, the cholinesterase inhibition is temporary, and may dissipate in as little as 2-3 hours, providing the exposure is eliminated. With organophosphates, the inhibition is longer-lasting and cumulative, and thus more dangerous.

## 5.6 THE EFFECTIVENESS OF THE REQUESTED PESTICIDE FOR THE PROPOSED USE

Pesticides are selected for IRS based on technical efficacy and economic efficiency in the intended use, along with other extrinsic variables. Complete selection criteria can be found in Section 5.2 of this SEA. Knowledge of vector susceptibility is critical to planning and evaluating the effectiveness of the IRS program. It enables timely forward planning to (i) manage the development of the resistance and (ii) evaluate new or alternative insecticides for possible future introduction should a change of pesticide be required. Resistance testing is done to (i) establish a baseline susceptibility of the local vectors for future reference, (ii) monitor changes that occur as time progresses, (iii) identify the mechanisms of resistance and cross-resistance to inform the resistance management strategy that will be adopted, and (iv) evaluate the susceptibility of the local vectors to potential alternative insecticides, should there be a need to change pesticide.

Prior to each campaign, it is necessary to measure vector resistance in the target areas, to ensure that acceptable kill levels will be achieved. A resistance monitoring program has been established by PMI, and the results from this ongoing program are the primary determinants of the choice of pesticide and other supplementary actions.

Pesticide efficacy is also affected by vector behavior, insecticide quality, and the residual action of the pesticide. The probability of vector-pesticide contact depends on whether the targeted vector feeds indoors (endophagic) and rests indoors (endophilic), as this increases the likelihood of the vector resting on the sprayed wall. The efficacy of the pesticide to kill may be compromised if the vector exits after feeding without resting on the wall, or if the vector feeds outdoors (exophagic) and rests outdoors (exophilic). Three of the four major malaria vectors in Kenya, *An. gambiae* s.s., *An. arabiensis*, and *An. funestus*, are mainly endophagic and endophilic. This makes them suitable targets for IRS.

Vector resistance may differ in origin, intensity, type, and significance for vector/disease control in a given population. The evaluation of the significance of resistance to vector control should therefore consider the biochemical and genetic characteristics of the resistance, as well as the eco-epidemiology of the disease and operational characteristics. Resistance also tends to be highly focal (i.e., limited to a definite area). It is therefore important to ascertain the spatial distribution of the observed resistance to better inform the resistance management strategy to be employed and the geographical extent to which it will apply (e.g., what geographical area a possible change in pesticides for IRS should cover).

The residual efficacy of the pesticide being used for IRS is crucial to evaluating the implication of vector resistance. The wall surface to which the pesticide is applied is a factor affecting residual efficacy, and must be taken into account. It is important that bioassays on various wall surfaces be carried out at specified intervals after the IRS operation in order to determine the period and level of residual activity in a given locality and the sprayed surface.

A third major factor affecting the effectiveness of the pesticides is their quality (specification). If the active ingredient, for example, is not up to the recommended specification and concentration, it may lead to under-dosage of deposited pesticide, which then contributes to intervention failure. Storage of pesticide for too long a time, or in extremely hot warehouses can lead to breakdown of the active ingredient. Poor pesticide quality may present additional risks to the pesticide handlers and spray operators who may be exposed. For this reason, samples of the pesticide will be taken prior to shipment to Kenya, and analyzed for the concentration of the active ingredient. If feasible, susceptibility testing should also be performed, but seasonal dips in vector population usually limit this activity. In all PMI IRS warehouses the temperature is monitored and controlled as much as possible to avoid temperatures that could alter the chemistry or the characteristics of the pesticide.

## 5.7 COMPATIBILITY OF THE PROPOSED PESTICIDE WITH TARGET AND NON-TARGET ECOSYSTEMS

The pesticides are compatible with the target environment (walls, ceilings, eaves) in that they dry on these surfaces, and are not released to receptors or the general environment to any great extent. The dried pesticide remains on the sprayed surfaces, and performs as designed, killing vector mosquitoes that rest on them, and the exposure to non-target organisms and ecosystems is very limited.

The WHOPEs recommended pesticides are incompatible with the non-target ecosystems (humans, animals, and the environment), in that, if they are released to the environment in large quantities, they would have negative effects on land and water based flora and fauna (See Table 5-3). However, the IRS implementation process is designed to ensure that to the maximum extent possible, pesticides are deliberately and carefully applied to the walls and ceilings of dwellings, and do not come in contact with humans, animals, or the environment. IRS implementation is also planned to minimize and responsibly manage the liquid wastes through the reuse of leftover pesticides, the triple rinsing of equipment, and the daily washing of PPE with rinse water treatment to remove trace pesticide. Wherever possible, recycling is incorporated into the waste management plan, particularly in the case of plastic bottles used for pesticide containers. Where it is not feasible to recycle materials, they are either washed thoroughly and disposed of in a landfill, or contaminated solid wastes are incinerated in an approved incinerator that will destroy the pesticide and prevent environmental contamination (see section 6.1.11). The Environmental Mitigation and Monitoring Plan in Annex A details the measures that have been and will be enacted to prevent contamination of ecosystems. In addition, there are solid and liquid waste management plans contained in the Safer Use Action Plan of this SEA (Chapter 6).

## 5.8 THE CONDITIONS UNDER WHICH THE PESTICIDE IS TO BE USED

Chapter 3 of this document provides a detailed account of the environmental conditions in Kenya under which the pesticide is to be used. IRS is scheduled to be performed prior to the rainy season in each location to maximize the effectiveness of IRS, and to avoid logistical complications from the degradation of transportation infrastructure due to flooding and washout.

During IRS, particular attention will be paid to any sensitive areas identified in Chapter 3, including water bodies, schools, hospitals, any area where organic farming is practiced, where bee-keeping or natural bee habitats are established, etc. In addition, bird-nesting habitats will be protected, and all insecticides will be kept away from all water habitats and resources. Prior to spraying, geographical reconnaissance will include identification of households in sensitive areas, and the IP will train sprayers to identify houses that should not be sprayed. IRS will be prohibited within 30 meters of sensitive ecosystems. If pesticide drift is observed, spraying will be halted until the cause has been determined. Drift could be a result of spraying an inappropriate surface with gaps that allow pesticide to escape, so the wall surface

must be evaluated for fitness for spraying, and the structure potentially disqualified. Alternately, if drift is caused by excessive wind (especially if spraying eaves outdoors) operators must wait until wind conditions subside. The IP will consult with competent services of the NEMA regarding the application of pesticides in or near ecologically sensitive areas, such as wetlands, lake shore, river edge and protected areas and follow their policies and guidelines, unless the conditions prescribed herein are more strict, in which case the SEA will have precedence. Strict supervisory control will also be established to prevent contamination of agricultural products.

## 5.9 THE AVAILABILITY AND EFFECTIVENESS OF OTHER PESTICIDES OR NON-CHEMICAL CONTROL METHODS

In Kenya, as in many countries, a full range of malaria control methods are employed, and in some circumstances, one method may be favored over another. However, PMI has determined that IRS is part of the overall effort to decrease malaria morbidity and mortality in Kenya and in many other countries.

This IRS program is limited to using those pesticides that are on the WHOPES list of recommended pesticides. WHO currently recommends 15 formulations from four chemical classes for IRS, each with a specific dosage regime, duration of effectiveness, and safety rating. Each of these agents has been evaluated for effectiveness within the program, and continued monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign. One goal of this SEA is to broaden the options for pesticide use to four recommended pesticide classes (including chlorfenapyr in the pyrrole class, if and when it is recommended by WHOPES), but excluding organochlorines class, to combat periodic resistance development.

Non-chemical means of malaria vector control are examined and discussed briefly under section 5.3, Integrated Pesticide/Vector Management (IPM/IVM), but are generally not effective on a large scale. For example, while elimination of standing water breeding habitats is a logical and sensible concept, the malaria mosquitoes only need the smallest of aquatic habitats to successfully reproduce, and it is nearly impossible to eliminate all of these minute breeding habitats.

## 5.10 THE REQUESTING COUNTRY'S CAPACITY TO REGULATE AND CONTROL PESTICIDES DISTRIBUTION, STORAGE AND USE OF THE REQUESTED PESTICIDES

Compared to many countries where IRS is being implemented, Kenya has substantial capacity to prevent pilferage of insecticide in an IRS program, provided that the appropriate infrastructure and personnel for pesticide handling and storage are provided. The Pesticide Control Products Control Board (PCPB) is the body that ensures that all the pesticides that enter the country are registered. Through the Pesticide Control Act, only registered pesticides are allowed in the country.

All facilities used for storage, distribution and transportation of insecticide products should comply with relevant requirements of the Work Injuries Benefits Act, Occupational Safety and Health Act, Public Health Act, Pest Control and Product Act, Water Act, Agriculture, Fisheries and Food Authority Act, and the Environmental Management and Co-ordination Act as amended in 2015. To that end, the following sections and the EMMP describe the program approach and strategy for storage, distribution and transportation.

The insecticide to be procured shall meet the packaging, labeling and other requirements specified by the PCPB. This section of the SEA outlines and reviews the existing legislation, policies, and institutions, and identifies requirements, as well as gaps and conflicts in the relevant legal and institutional

arrangements, that would hinder or guide the development of the project in line with the national laws applicable to the IRS program.

There are a number of laws and institutions significant to the implementation of this IRS program, as discussed below.

### 5.10.1 RELEVANT INSTITUTIONS

NEMA was established under the Environmental Management and Coordination Act (EMCA) No. 8 of 1999, as the principal instrument of government in the implementation of all policies relating to the environment. It became operational on July 1, 2002 following the merger of three government departments, namely: the National Environment Secretariat (NES), the Permanent Presidential Commission on Soil Conservation and Afforestation (PPCSCA), and the Department of Resource Surveys and Remote Sensing (DRSRS). However, following government restructuring in March 2003, DRSRS reverted to its departmental status under the then Ministry of Environment and Natural Resources (MENR). There was a transition period characterized by the integration of previous departmental activities and appointment of the first Board of Management.

### 5.10.2 LAWS AND REGULATIONS

#### **Environmental Management and Co-ordination Act (EMCA) of 1999 and Amendment Act of 2015**

This is the principle Act and primarily remains the overarching piece of legislation that ensures the protection of the environment in Kenya. The EMCA of 1999 provides the legal framework for the management of the environment and other related issues in Kenya. The following sections are pertinent to this document.

**Section 93** of the Act prohibits the discharge of hazardous substances or chemicals into any waters or other segments of the environment. A person who is responsible for the discharge shall pay the cost of removing the substance or chemicals including the cost incurred by the government in restoring the environment which has been damaged.

**Section 94** requires that the NEMA establish standards relating to pesticides and other chemicals, and those standards shall define the concentration of pesticide residue in raw agricultural commodities, processed foods and animal feed. Currently, these standards have not yet been included in any statutes. It is important to establish standards, and when the standards are established, they shall be enforced by the NEMA in respect of all produce. NEMA requires concerned actors to constantly collect data on pesticide residues. At the moment, there is not system for dealing with this problem.

**Section 95** imposes a requirement for the registration of pesticides and toxic substances and provides that any person who intends to manufacture, import or process a new pesticide or toxic must apply to the authority for registration. At the moment, this registration process to be administered by NEMA is the exact parallel of that required by the Pest Product Control Act. It is an offence to distribute, sell, import or receive any unregistered pesticide or toxic substances. A person who contravenes this section shall be liable to a fine of one million shillings or imprisonment for two years or both. Additionally, NEMA is allowed to seize the product and destroy it.

EMCA of 1999 and the 2015 Amendment provides for the following subsidiary legislations:

- a) Environmental Impact Assessment and Audit Regulations 2003

This is a subsidiary legislation that operationalizes the Act on Environmental Impact Assessments and Environmental Audits (EIA/EA). The EIA/EA regulations require that all projects listed in the second

schedule, which includes pesticide application, be subjected to an EIA. The EIA includes public participation and the regulation requires that, during the process of conducting an environmental impact assessment study, the proponent shall, in consultation with NEMA, seek the views of persons who may be affected by the project. The EIA regulation specifies that the analysis and approval of Environmental Impact Assessments be done by NEMA.

Under Sections 68 and 69, EMCA requires that all ongoing projects be subjected to annual environmental audits as further expounded in Regulation 35 (1) and (2) of Legal Notice 101 of June 2003. Part V of the Legal Notice 101 defines the focus and scope of EA studies as including an appraisal of all the project activities, within the perspective of environmental regulatory frameworks, environmental health and safety measures and sustainable use of natural resources.

b) Environmental Management and Co-ordination (Water Quality) Regulations, 2006

This regulation provides for sustainable management of water resources, including prevention of water pollution and protection of water sources (lakes, rivers, streams, springs, wells and other water sources).

It is an offence under this Regulation for any person to throw or cause to flow into or near a water resource any liquid, solid or gaseous substance or deposit any such substance in or near it, as to cause pollution. This Regulation further makes it an offence for any person to discharge or apply any poison, toxic, noxious or obstructing matter, radioactive waste or other pollutants or permit the dumping or discharge of such matter into the aquatic environment unless such discharge, poison, toxic, noxious or obstructing matter, radioactive waste or pollutant complies with the standards for effluent discharge into the environment.

The Regulation requires every licensed person generating and discharging effluent into the environment to carry out daily effluent discharge quality and quantity monitoring and to submit quarterly records of such monitoring to NEMA or its designated representatives. The proponent shall be required to adhere to the above mentioned provisions throughout the project cycle.

c) Environmental Management and Co-ordination (Waste Management) Regulations, 2006.

This regulation provides details on handling, storage, transportation, treatment and disposal of various waste streams including:

- Domestic waste
- Industrial waste,
- Hazardous and toxic waste
- Pesticides and toxic substances
- Biomedical wastes and
- Radioactive waste

Part II of the Waste Management Regulations outlines the following General provisions:

*Responsibility of Waste generator*

- 1) No person shall dispose of any waste on a public highway, street, road, recreational area or in any public place except in a designated waste receptacle.
- 2) Any person whose activities generate waste shall collect, segregate and dispose or cause to be disposed of such waste in the manner provided for under these Regulations.

- 3) Without prejudice to the foregoing, any person whose activities generates waste has an obligation to ensure that such waste is transferred to a person who is licensed to transport and dispose of such waste in a designated waste disposal facility.

#### *Segregation of waste*

- 4) Any person whose activities generate waste, shall segregate such waste by separating hazardous waste from non-hazardous waste and shall dispose of such wastes in such facility as is provided for by the relevant Local Authority

#### *Cleaner Production*

- 5) Provides categories of cleaner production methods that should be adopted by waste generators in order to minimize the amount of waste generated and they include:
  - a) Improvement of production process through-
    - i) Conserving raw materials and energy
    - ii) Eliminating the use of toxic raw materials and wastes
    - iii) Reducing toxic emissions and wastes
  - b) Monitoring the product cycle from beginning to end by-
    - i) Identifying and eliminating potential negative impacts of the product
    - ii) Enabling the recovery and re-use of the product where possible, and
  - c) Incorporating environmental concerns in the design and disposal of a product.

#### *Waste Transportation*

- 6) No person shall be granted a license to transport waste unless such person operates a transportation vehicle approved by NEMA upon recommendation from the relevant lead agency.
- 7) Any vehicle used for transportation of waste or any other means of conveyance shall be labelled in such a manner as may be directed by NEMA.
- 8) NEMA in consultation with the relevant lead agency may designate particular geographical areas as areas for operation for licensed waste transporters.
- 9) Mode of waste transportation:
  - a) the collection and transportation of such waste is conducted in such a manner that will not cause scattering, escaping and/or flowing out of the waste;
  - b) the vehicles and equipment for the transportation of waste are in such a state that shall not cause the scattering of, escaping of, or flowing out of the waste or emitting of noxious smells from the waste;
  - c) the vehicles for transportation and other means of conveyance of waste shall follow the scheduled routes approved by NEMA from the point of collection to the disposal site or plant; and
  - d) the transporter or his agent(s) possess at all times during transportation of the waste, a duly filled tracking document as set out in Form III of the First Schedule to these Regulations and shall produce the same on demand to any law enforcement officer.

### **Pest Control Products Act cap 346**

This Act regulates the import/export manufacture distribution and use of products which are used for the control of pests and of the organic function of plants and animals. This is an Act that regulates the import/export and use of pesticides. The Act establishes the Pest Control Products Board and makes it

the function of the Board to register pest control products. It requires that every person who desires to register a pest control product shall make an application to the Board. The Board may refuse to register the product if its use would lead to unacceptable risk or harm to

- Things on or in relation to which the pest control product is intended to be used; or
- To public health, plants, animals or the environment.

The Act specifies that

(1) No person shall manufacture, package, store, display, distribute, use or advertise any pest control product except in accordance with conditions prescribed by regulations made under this Act.

(2) No person shall package, label or advertise any pest control product in a manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character, value, quality, composition, merit or safety.

(3) No person shall import into, or sell in, Kenya any pest control product unless that product has been registered, packaged and labelled in accordance with regulations made under this Act and conforms to the standards specified in those regulations.

### **The Agriculture, Fisheries and Food Authority Act**

The Agriculture, Fisheries and Food Authority Act is the successor to the repealed Agriculture Act. This is an Act of Parliament to promote and maintain a stable agriculture, provide for the conservation of the soil and its fertility, and stimulate the development of agricultural land in accordance with the accepted practices of good land management and good husbandry. The overriding philosophy and orientation of the Agriculture, Fisheries and Food Authority Act is one of creating structures to strengthen regulation through various bodies..

### **The Public Health Act**

The Public Health Act outlines how different aspects of a project have to be undertaken to ensure the safety and health of users and neighbors. The Act gives guidelines on construction, maintenance and inspection of drainage system, septic tanks, cesspool or latrines. In implementing the IRS project, the PMI actors and partners has to carry work in line with requirements and provision of this Act.

## **5.11 THE PROVISIONS MADE FOR TRAINING OF USERS AND APPLICATORS**

The effectiveness of the IRS program depends on the availability of adequately trained spraying personnel, well-maintained equipment, and competent supervision, as well as end-user acceptability and compliance. PMI has developed guidelines for IRS operations (“Best Management Practices (BMP) for Indoor Residual Spraying in Vector Control Interventions”, updated 2015), and provides a training manual “Spray Operator Pocket Guide” (A. Were, (2014)). Other resources include the *Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning*, USAID PMI’s IVM PEA (USAID, 2012 Updated), as well as this SEA, all of which provide precautions and recommendations on many aspects of IRS operations. The IRS BMP manual and the PMI IVM PEA requirements are the primary references and have precedence, but the other documents may be used as a reference. It is not incumbent upon the IP to comply with non-PMI documentation except where required by law. However, PMI/USAID requirements are usually stricter than others’, so there should not be a conflict.

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Kenya. The contractor will continue to provide technical

support for environmental compliance, with a medium-term goal of building national capacity to progressively transfer responsibilities. Preparations will include the following:

- A training of trainers program, in which potential supervisors, storekeepers and team leaders are trained on all aspects of IRS operation. Areas of training shall include planning of IRS, household preparations, record keeping, community mobilization, rational/judicious use of insecticides including sprayer and PPE cleaning, personnel management, environmental aspects of IRS – including geographical reconnaissance, and data recording and analysis.
- The training of temporary workers recruited from local areas and trained as spray team members (operators, team leaders, and wash persons). New operators will receive five to seven days of training prior to the spray operations.

## 5.12 THE PROVISIONS MADE FOR MONITORING THE USE AND EFFECTIVENESS OF THE PESTICIDE

Two kinds of measurements are needed to provide a complete understanding of the effectiveness of pesticide that is being used for IRS. Direct methods measure the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors. These methods rely on entomological evaluations on pesticide contact bioassays and related pesticide resistance methodologies as recommended by WHO. The second broad level of measuring the effectiveness of the pesticides relates to the primary goal of reducing the local disease burden. These efforts will require specialized entomological and epidemiological skills and the assessment of the impact of vector control operations, and possibly the assignment of the contributory impact of the IRS operations. This latter measurement is usually done through a combination of methodologies such as measuring the changes in parasite inoculation rates, passive case detection at health centers, and periodic community fever and parasite surveys (active case detection).

Another key characteristic of pesticide effectiveness is the longevity of the treatment. This characteristic has important economic and health implications: the program must adjust its spray schedule to make sure that there is active pesticide on the walls of homes during critical breeding periods. Unfortunately, the guidance that is provided with regard to effective period for each pesticide is very broad (e.g. 3-6 months), and the effective period is probably subject to complex environmental factors such as heat, humidity, and substrate (wall, ceiling) composition.

However, pesticide manufacturers are well aware of the need for duration of effectiveness, and in some cases are reworking their formulations to provide greater longevity. This is the case for pirimiphos-methyl organophosphate, which has been formulated as a capsule suspension (CS) that may extend the effectiveness of the application out to six months. Because of the length of the malaria season in Kenya, this characteristic may be critical to the success of IRS. Therefore pirimiphos-methyl in the CS formulation will be used for PMI spraying in the selected counties in 2017.

# 6 SAFER USE ACTION PLAN

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This section outlines the safer use action plan proposed for the potential adverse impacts outlined in Section 4. The primary mitigation measures include delivery of a mix of IEC approaches targeting the residents and spray operators and all IRS personnel, training of spray operators and strengthening supervision and monitoring, and provision of appropriate PPE and facilities for the storage and disposal of pesticides and contaminated waste. The mitigation measures, along with monitoring and reporting information, are compiled in the EMMP found in Annex A.

## 6.1 IMPLEMENTATION CONDITIONS

During implementation, PMI/Kenya and its PMI IRS IPs will adhere to the conditions detailed in this Safer Use Action Plan, and in the Environmental Monitoring and Mitigation Plan (EMMP), Annex A of this report.

### 6.1.1 QUANTIFICATION OF PESTICIDE REQUIREMENTS

The PMI IRS IP will conduct an annual logistics assessment for all targeted sub-counties for planning and procurement of the correct quantity of materials, including insecticides. Purchase of insufficient pesticide will lead to shortages, delays, and possibly the inability to spray all targeted areas. Purchase of too much pesticide may lead to expiration of the pesticide before it can be used up, which creates serious storage and disposal problems.

### 6.1.2 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 while at the same time could expose the residents and spray operators to hazards related to altered toxicological characteristics.

The PMI program will procure the insecticide from a reputable supplier. Pesticide batches will be analyzed for the concentration of the active ingredient prior to shipment to Kenya. Additional sampling and testing may be performed upon arrival. Delivery of all insecticide to the central warehouse will be supervised by PMI and NMCP before being dispatched to the Counties where spray operations will be concentrated.

### 6.1.3 PESTICIDE TRANSPORT

After the receipt of insecticide at the central warehouse, insecticides are transported to the County warehouses (during the campaign) by road. During transportation, there is a risk of vehicle accidents and consequent insecticide spillage. It is essential that the vehicle type and speed of transport be matched to the conditions. Drivers must take no chances.

A lockable box truck is the expected vehicle to transport insecticides from central to sub-county stores. If box trucks are not available, the IP will notify the COR to receive instructions for an alternative security mechanism. All vehicles must be in good condition and pass the Pre-Contract Vehicle Inspection performed by the Environmental Compliance Officer or their qualified designate, using a smart phone. If

during transport the pesticides are to be left unattended for any period of time, including lunch breaks or overnight stops, a lockable box truck is required.

Prior to long-distance transport of the insecticide from the customs warehouse or central storage facility, drivers will be trained about general issues surrounding the insecticide and how to handle emergency situations such as accidents or spillage. Training for long-distance transport will include the following information:

- Purpose of the insecticide (indoor usage for malaria protection, not for agricultural or any other outdoor use)
- Toxicity of the insecticide
- Security issues, including implications of the insecticide getting into public access.
- Hazardous places along the routes to be taken, and mitigation measures.
- Steps to take in case of an accident or emergency (according to BMP standards)
- Combustibility and toxicity of the combustion byproducts of insecticide

Drivers hired for transport of insecticide within a county and spray team members during the spray campaign will receive training in:

- Operator transportation best practices and vehicle requirements from PMI IRS BMP #2, Worker and Resident Health and Safety.
- Health and safety as provided to spray operators, with the exception of sprayer operation and spray practice.
- Handling an accident or emergency according to BMP standards.
- Handling vehicle contamination.
- Vehicle decontamination procedures.

Figure 6-1 below provides a list of key responses to mitigate the impact of the insecticide spills.

**FIGURE 6-1: EMERGENCY RESPONSE TO A SPILL**

**IN CASE OF INSECTICIDE SPILLS**

1. Control, contain and clean up the spill
2. Don protective clothing prior to attempting to clean the spills.
3. It is imperative to avoid fire as a result of the accident and a fire extinguisher should be deployed just in case. The engine must be shut off and smoking in the area strictly prohibited.
4. Onlookers and bystanders must be kept away from the accident site.
5. If the crew has come in contact with the pesticides, they must remove contaminated clothing immediately and wash the pesticide off their skin.
6. For major spills send for help immediately; drivers must have cell phones and an emergency number for use in such cases.
7. People must be kept away and the spill covered with earth, sand, etc.; no attempt should be made to wash away the spill with water or other substances.
8. Vehicles that are used for transporting large quantities of pesticides are required to be equipped with a bucket of sand, sawdust or soil, a shovel, and fire extinguisher.

Because vehicles used for insecticides transportation can be used for the transport of other goods, it is important to ensure that vehicles are decontaminated after use. The 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, overalls, and rubber boots to wear for cleaning the vehicle. All cloths used in wiping down the interior and bed of the vehicle will be washed with soap and water. If pesticide is transported over water, BMP #10, Water Transport (PMI IRS BMP Manual, 2015) must be followed in every detail.

#### **6.1.4 QUALIFICATION OF WAREHOUSES (STORAGE FACILITIES)**

IRS pesticides can cause adverse impacts to human health, animals, and the natural environment if not properly stored according to PMI BMPs. Before insecticides are procured or transported to the spray areas, suitable warehouse(s) must be assessed to ensure that they can meet BMP standards. During the geographical reconnaissance and logistics assessments, the need for new or rehabilitation of previously used program warehouses to meet PMI IRS BMP standards for pesticide storage will be assessed. The standards include:

- Located at least 30 meters from flood plains, wetlands and water bodies, markets, schools, dwellings, beehives, and protected areas. Warehouses may not be located in the buffer zones of protected areas, or in schools.
- Spacious enough to store insecticides in bulk and to store other IRS commodities separately

- A separate space for the storekeeper's office.
- Well ventilated and allowing for air circulation
- Built of concrete or other solid material
- Impervious flooring, or floor must be completely covered by a leak-free tarpaulin
- Watertight roofing
- Barred and screened windows
- Preferably two exits from the pesticide storage area for emergency purposes
- Fire extinguisher

In addition to the above, all facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of Kenya in pesticide regulations. During the logistical needs assessment, the PMI IRS IP will identify warehouses at the county level that can meet these requirements. PMI cannot provide funds for the construction of new buildings, but can assist in the modification or renovation of existing facilities

### 6.1.5 QUALIFICATION OF LIQUID WASTE DISPOSAL FACILITIES (WASH AREAS, SOAK PITS)

Pyrethroids, OPs and carbamates degrade quickly when exposed to environmental action such as photolysis, hydrolysis, and bacterial action. If wash areas and soak pits are properly constructed in appropriate locations and used according to BMPs, liquid pesticide waste will be captured in the charcoal layer of the soak pit and held until it breaks down by these natural processes.

Site considerations for locating IRS cleaning and waste management facilities (progressive rinse, wash areas, soak pits) include soil type, topography, vertical distance to ground water, and proximity to schools, lakes, streams, and other sensitive areas. Ideally, disposal facilities should be located adjacent to the storage facilities, where they can be more easily protected and monitored. However, the setting or the function of buildings provided for storage are not always appropriate for setting a wash area, so it may need to be placed some distance away. Due to access limitations and distance to some spray sites; it may be more feasible to locate a small wash facility in an appropriate area near the spray site.

Soak pits must be located at least 30 meters from any sensitive areas such as water bodies, flood plains, habitat, schools and other public buildings, areas protected by regulations, and areas of high groundwater. They should be located on relatively high ground to increase the vertical distance to groundwater. The general area should be level, but the wash area must be constructed to slope gently toward the soak pit or toward the collection point that is piped to the soak pit.

Although the soak pit captures the majority of pesticide from wash waters, small amounts may pass through and enter the soil below. Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or microbiological degradation. Clay soils have a high capacity to absorb many pesticides, but if hard-packed, may have limited percolation abilities. Sandy soils have a much lower capacity to absorb pesticides, but liquids percolate rapidly. Where possible, locate facilities on fine textured soils with organic content and good absorptive properties to capture and degrade trace amounts of pesticide. Hard packed clay or rocky soils are not appropriate.

Pesticides may move in water runoff as compounds dissolve in water or attach to soil particles. Facilities should be located on high, level ground to minimize exposure to runoff. Avoid steep slopes or natural runoff flow lines. Where necessary, curbs or berms will be constructed around wash areas to divert storm water runoff away from the soak pit, and to contain any spills or overflows. In very rainy areas or

seasons, it may be necessary to cover the soak pit and wash area when not in use with a tarpaulin, to prevent flooding of the soak pit and subsequent runoff of pesticide-contaminated water.

### 6.1.6 WAREHOUSE/STORAGE RISK MANAGEMENT

In order to mitigate risks associated with pesticide storage, the following will serve as warehouse/storage best management practices:

- A trained storekeeper will manage each facility and will wear gloves, mask, overalls, and boots when in the pesticide area of storage.
- No smoking or eating will be allowed within 30 meters of the pesticide storeroom.
- Pesticide storage facilities must have thermometers installed for daily temperature recording.
- Soap and clean water will be available at all times in all the facilities.
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed.
- A fire extinguisher will be available in the storage facilities and all site workers will be trained on how to use this device.
- Warning notices will be placed outside of the store with skull and crossbones pictogram, and warnings in the local language
- Insecticides must be lifted off of the floor via pallets or shelves.
- First aid kits must be fully stocked and available in all the central warehouses and secondary stores. Security and inventory management of first aid supplies is mandatory.

#### *ACCIDENTAL WAREHOUSE FIRES*

Inhalation of toxic fumes in the event of a storehouse fire is a major risk of IRS. The risk can be minimized, however, by following BMPs for storage, including prohibiting lighted materials in or near the warehouse or in the vicinity of pesticides during transport to/from vehicles, providing fire extinguishers, and proper ventilation of storerooms.

### 6.1.7 FETAL EXPOSURE (PREGNANCY TESTING)

All female candidates for spray teams will be tested for pregnancy before being recruited into the spray operations and every thirty days until operations end. Provided their work history has been acceptable, females who have been hired and later found to be pregnant will be re-assigned to positions that do not have the potential for exposure to insecticides. Women who are breastfeeding cannot have any contact with pesticides, and are thus prohibited from spraying of pesticide or washing contaminated items.

### 6.1.8 SPRAY OPERATOR EXPOSURE

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps, including hands-on exercises prior to the beginning of the spraying campaign. They will also be trained to understand proper hygiene, to recognize the signs and symptoms of poisoning, and to understand the referral procedure for any incidents involving poisoning. This training will be conducted in accordance with the IRS Training Guide for Spray Operations (USAID, 2009) and the 2015 IRS BMP manual. Potential spray operators must also pass written and practical tests at the end of training.

Training for monitoring spray operators for symptoms of pesticide exposure will be mandatory for team leaders and supervisors, as well as for storekeepers and other senior personnel. Any case of an operator or beneficiary displaying symptoms of exposure will require the immediate completion of a

standard Incident Report Form by the County Coordinator, who will forward the report to the COP and AIRS home office DECS and TPM, who will review the report before it is sent to the PMI (COR) Team and the PMI Resident Adviser in Kenya.

For malathion and fenitrothion OPs, it may be necessary to monitor the level of acetyl cholinesterase in any worker who may have been exposed to contamination. Occupational exposures to OP insecticides are measurable using blood cholinesterase and urinary excretion of chemical biomarkers. WHOPES Working Group recommendations stated that, “provided that operational guidelines are followed, routine cholinesterase monitoring of spray men during IRS programs is not required” for Actellic® CS. At the present time, biomonitoring is not required for PMI IRS, but increased supervision and monitoring are.

### 6.1.9 BENEFICIARY EXPOSURE

The IP will strive to monitor any suspected cases of residential exposure that suggest adverse events with the insecticide used. During the IEC campaign, residents are made aware of the steps to take if exposed, and, especially if acute symptoms are encountered, the advice is 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 beneficiary exposure incidents.

NMCP, and the PMI IRS IP and other partners will work with relevant institutions at all levels to carry out an IEC campaign/BCC to sensitize residents to IRS activities, in accordance with WHO guidelines and also Kenya Malaria Strategy 2009-2018 and PMI Malaria Operational Plans. The IEC campaign carried out by IRS project leaders should focus on the following elements of residential safety during an IRS program:

- Clear homes of mats or rugs, furniture, cooking implements and foodstuffs prior to spraying; if furniture cannot be moved out of the home, then move it to the center of the room and covered with impermeable material.
- Stay at least 10 meters from the home during spraying, and for two hours after spraying.
- Move and keep all animals at least 10 meters from the home during spraying, and for two hours after spraying.
- After two hours, open all windows and doors and air the house out for ½ hour.
- Sweep up any insects killed from the spraying and drop them in latrine pits before allowing re-entry by children and animals.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using mosquito nets for additional protection against malaria.
- If skin itches after reentrance 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 which has the appropriate medical intervention.
- If spraying during the rainy season, the teams should use the following Contingency Plan which will minimize exposure of household effects.

### **During the rainy season:**

- Each spray operator must be given adequate covering material (3m by 3m minimum), which should be used to cover household effects moved to the center of the room (only if necessitated by rain, etc.) More than one sheet may be required, depending on the size of structures and the amount of belongings.
- Materials can also be moved into structures that are not targeted to be sprayed, e.g., an isolated kitchen or domestic animal shelter.
- Move the household effects to one room which will not be sprayed on that particular day, but the next day.
- The spray teams should pay close attention to any signs of potential rains so that they prepare the communities accordingly.

### **When it rains in the middle of spraying:**

- Stop the spraying activities.
- Cover the household effects with an impermeable material. These materials should have already been procured by the program and given to each operator.
- After the rains stop and the weather is considered good, spraying can continue.

## **6.1.10 PESTICIDE EXPOSURE AND TREATMENT**

All spray operators, team leaders, and supervisors will receive detailed training on the emergency steps to take if accidental exposure of the chemical occurs including ingestion, inhalation, eye or dermal contact with the chemical. This training will be conducted by the County Coordinators and government technical services and will include drills to test knowledge of the operators. However, most interventions for acute exposure will have to be provided by medical professionals at the nearest health clinic, so transporting the exposed person to the health clinic will be the priority.

The PMI IRS IP will confirm that all the health facilities around the spray sites have in their store the recommended treatment drugs, and that all the staff responsible for administering emergency treatment to pesticide exposure receives appropriate training. Annex D provides additional information on symptoms and treatment protocols.

## **6.1.11 SOLID AND LIQUID CONTAMINATED WASTE MANAGEMENT**

Non-contaminated wastes or those that can be cleaned thoroughly with soap and water will be reused or recycled whenever possible, or disposed of in a municipal landfill if there is no appropriate recycling outlet.

Liquid contaminated wastes will be disposed of on a daily basis in soak pits that are carefully sited and designed according to the criteria in the PMI BMP manual. The soak pit is designed so that pesticides are absorbed by the charcoal layer, and held until environmental processes result in the degradation of the pesticide. Thus, there should be no contaminated liquid waste to deal with at the end of the spray season.

Contaminated solid wastes are incinerated in incinerators that are capable of destroying the pesticide and preventing environmental contamination. Incinerators recommended for disposal of contaminated wastes fall into two categories, those that meet:

- ❖ Basel Convention technical standards for all insecticides that do not contain greater than 1% halogens,
- ❖ WHO/FAO standards: to be used if we are using DDT or insecticides which contain > 1% halogens.

**For wastes containing less than 1% halogens (e.g., chlorine, bromine):**

- The recommended combustion temperature is >850 °C.
- An afterburner is required, with a residence time of at least two seconds.
- The incinerator must have emission control, including particulate matter filters.
- Ash and slag produced by high-temperature incineration of pesticides are best incorporated into concrete and buried in a secure location.

**For wastes containing greater than 1% halogens:**

- The recommended combustion temperature is between 1100-1300 °C.
- An afterburner is required, with a residence time of at least two seconds.
- A quench rinse for the gas stream that causes a rapid temperature drop to below 250 °C
- The incinerator must have emission control, including particulate matter filters.
- Ash and slag produced by high-temperature incineration of pesticides are best incorporated into concrete and buried in a secure location.

Incineration is not recommended for polyvinyl chloride or other chlorinated wastes such as gloves and boots. Gloves and boots no longer usable for IRS can be easily decontaminated with soap and water and then offered to spray team members, or disposed of as normal nonhazardous waste.

Empty plastic containers should not be incinerated due to the difficulty inherent in burning them cleanly, and the nuisance and toxic emissions that may result. Once punctured to prevent reuse, plastic bottles can be triple rinsed and recycled at an appropriate facility, or land filled.

Cardboard boxes previously containing intact insecticide sachets or bottles are not considered as contaminated waste. Incineration is not recommended for cardboard boxes unless they have been contaminated by pesticide leakage, or used for the storage of other contaminated wastes. In many cases uncontaminated boxes can be recycled, or can also be disposed of as normal nonhazardous wastes. The EMMP in Annex A gives details on the steps and measures that will be taken to prevent negative impacts on the non-target ecosystems from liquid and solid IRS waste materials and disposal practices.

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# Annex A: Environmental Mitigation & Monitoring Plan

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**Please See the EMMP next page**

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
Use of insecticides	I. Occupational risks for workers involved in IRS campaigns (e.g., risks from insecticide exposure and vehicular accidents), especially women of child-bearing age	<ul style="list-style-type: none"> <li>a. Inspect and certify vehicles used for pesticide or spray team transport prior to contract.</li> <li>b. Train drivers</li> <li>c. Provide cell phone, personal protective equipment (PPE) and spill kits during pesticide transportation.</li> <li>d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.</li> <li>e. Health test all spray team members for duty fitness.</li> <li>f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE.</li> <li>g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps.</li> <li>h. Provide adequate facilities and supplies for end-of-day cleanup.</li> <li>i. Enforce spray and clean-up procedures.</li> </ul>	<ul style="list-style-type: none"> <li>a-d. Environmental Compliance Officer (ECO).</li> <li>e-g. Operations Manager (OM).</li> <li>h. ECO</li> <li>i. Chief of Party (COP), Technical Project Managers (TPM) and headquarters environmental staff.</li> </ul>	<ul style="list-style-type: none"> <li>a. Transport vehicles have a valid inspection certificate on-board.</li> <li>b. Drivers have a certificate of training completion.</li> <li>c. Transport vehicles are equipped with cell phone, spill kit, and PPE.</li> <li>d. Storekeeper has records of pregnancy testing for all female team members.</li> <li>e. Storekeeper has medical exam results for all team members.</li> <li>f. Spray operators wear complete PPE during spraying and clean-up.</li> <li>g. Operators mix pesticide properly, and the pump does not leak.</li> <li>h. All facilities are compliant, and materials required for clean-up are present.</li> <li>i. Inspections are performed as scheduled, corrective action is taken as needed.</li> </ul>	<ul style="list-style-type: none"> <li>a-c. ECO inspection of vehicles in the field.</li> <li>d-e. ECO inspection of health records at IRS operational sites.</li> <li>f-h. ECO performs pre-spray inspections of inventories and training records, and mid-spray inspections of PPE use and spray operator performance.</li> <li>i. Monitoring of on-line database for submission of inspection reports.</li> </ul>	<ul style="list-style-type: none"> <li>a-c. 2 inspections per week.</li> <li>d-e. One inspection per campaign, additional inspection if new hires or more than 30 spray days.</li> <li>f-h. ECO pre-spray inspections 2/campaign, ECO mid-spray inspections 5 times/week.</li> <li>i. Weekly</li> </ul>

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	2. Safety risks for residents of sprayed houses (e.g., risks from inhalation and ingestion of insecticides)	<p>a. IEC campaigns to inform homeowners of responsibilities and precautions.</p> <p>b. Prohibit spraying houses that are not properly prepared.</p> <p>c. Two-hour exclusion from house after spraying</p> <p>d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside.</p>	<p>a-b. IEC officers, OM, ECO</p> <p>c. ECO</p> <p>d. Spray operators (SO) and Team Leaders (TL)</p>	<p>a. Pre-spray IEC campaigns were executed. Homeowners know responsibilities.</p> <p>b. All houses being sprayed are properly prepared.</p> <p>c. Homeowners observe 2 hour exclusion.</p> <p>d. Lack of incident reports, or incident reports with proper response noted.</p>	<p>a. OM- IEC work records,</p> <p>ECO- mid-spray inspections.</p> <p>b-d. ECO mid-spray inspections</p>	<p>a. Inspect work records 1/campaign,</p> <p>b-d. ECO mid-spray inspections 3/wk.</p>
	3. Ecological risk to non-target species and water bodies from use of insecticides (during mixing and spraying)	<p>a. Spray indoors only.</p> <p>b. Train operators on proper spray technique.</p> <p>c. Maintain pumps.</p>	<p>a-c. TL, District Coordinator (DC), OM, ECO</p>	<p>a. Operators spray only inside of houses.</p> <p>b. Operators are trained and know and use proper spray techniques.</p> <p>c. Pumps are maintained and operated to eliminate leaks and erratic spraying.</p>	<p>a. ECO mid-spray inspections.</p> <p>b-c. Training records, ECO mid-spray inspections</p>	<p>a. ECO inspections 3/wk.</p> <p>b. ECO inspection of training records 1/campaign.</p> <p>b-c. ECO mid-spray inspections 5/wk.</p>

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	4. Environmental risk from disposal of insecticide (both liquid and solid waste)	<p>a. Choose sites for disposal of liquid wastes, including mobile soak pit sites according to PMI BMPs.</p> <p>b. Construct fixed and mobile soak pits with charcoal to adsorb pesticide from rinse water.</p> <p>c. Maintain soak pits as necessary during season.</p> <p>d. Inspect and certify solid waste disposal sites before spray campaign.</p> <p>e. Monitor waste storage and management during campaign.</p> <p>f. Monitor disposal procedures post-campaign.</p>	<p>a-c. Abt OM, ECO, DC</p> <p>d-f. Abt ECO</p>	<p>a. Operations sites meet PMI BMPs.</p> <p>b. Fixed and mobile soak pits are sited and constructed according to the PMI BMP manual.</p> <p>c. Fixed and mobile soak pits perform properly throughout the spray season.</p> <p>d. Disposal sites have the capacity and policies to properly dispose of wastes.</p> <p>e. Solid wastes are stored and managed according to PMI BMPs.</p> <p>f. Waste disposal has taken place as agreed and certificates of disposal received.</p>	<p>a-b. ECO Pre-spray inspections</p> <p>c-f. ECO mid- and post-spray inspections and monitoring.</p>	<p>a. 2/campaign</p> <p>b. 1/campaign</p> <p>c. 5/week</p> <p>d. 1/campaign</p> <p>e. 3/week</p> <p>f. Continuous during disposal</p>
	5. Risk of diversion of insecticides for unintended or uncontrolled use	<p>a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</p> <p>b. Reconcile number of houses sprayed vs. number of sachets/bottles used.</p> <p>c. Examine houses sprayed to confirm spray application.</p> <p>d. Perform physical inventory counts during the spray season.</p>	<p>a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO</p>	<p>a-d. All pesticide management records are reconciled.</p>	<p>a-b, d. Inspection of pesticide management records. Storekeeper performance checklists.</p> <p>c. ECO mid-spray inspections.</p>	<p>a-b, d. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District Coordinators</p> <p>c. 1/campaign by country headquarters. 2/campaign by ECO</p> <p>d. 2/campaign/ store-room</p>

# Annex B: EMMR Form

Implementing Organization:

Geographic location of USAID-funded activities:

Period covered by this Reporting Form and Certification:

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
Ia. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport.			
Ib. Driver training			
Ic. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation.			
Id. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.			
Ie. Health fitness testing for all operators			

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
If. Procurement of, distribution to, and training on the use of PPE for all workers with potential pesticide contact.			
I g. Training on mixing pesticides and the proper use and maintenance of spray pumps.			
I h. Provision of adequate facilities and supplies for end-of-day cleanup,			
I i. Enforce spray and clean-up procedures.			
2a. IEC campaigns to inform homeowners of responsibilities and precautions.			
2b. Prohibition of spraying houses that are not properly prepared.			
2c. Two-hour exclusion from house after spraying			

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
2d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside.			
3a. Indoor spraying only.			
3b. Training on proper spray technique			
3c. Maintenance of pumps			
4a. Choose sites for disposal of liquid wastes, including mobile soak pit sites, according to PMI BMPs.			
4b. Construct fixed and mobile soak pits with charcoal to adsorb pesticide from rinse water.			
4c. Maintain soak pits as necessary during season.			
4d. Inspection and certification of solid waste disposal sites before spray campaign.			

<b>Mitigation Measure</b>	<b>Status of Mitigation Measures</b>	<b>Outstanding issues relating to required conditions</b>	<b>Remarks</b>
<b>4e. Monitoring waste storage and management during campaign.</b>			
<b>4f. Monitoring disposal procedures post-campaign.</b>			
<b>5a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</b>			
<b>5b. Reconciliation of number of houses sprayed vs. number of sachets/bottles used.</b>			
<b>5c. Visual examination of houses sprayed to confirm pesticide application.</b>			
<b>5d. Perform physical inventory counts during the spray season.</b>			

# ANNEX C: STAKEHOLDER CONSULTATIONS

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## **PMI/USAID**

- Dr. Mildred Shieshia – Resident Malaria Advisor-PMI USAID
- Dr. Robert T. Perry – Malaria Technical Advisor- PMI/USAID, Kenya
- Wilkister Magangi – Environmental Compliance monitoring Specialist, USAID Kenya
- Daniel Wacira – Program Management Specialist (Malaria), USAID Kenya

## **National Malaria Control Program**

- Dr. Waqo Ejersa – Head, NMCP
- Dr. Ahmeddin Hassan Omar – NMCP, Focal Point, NMCP
- Dr. Solomon Karoki – NMCP, Entomologist
- Paul Kimaiyo Kiptoo – NMCP, Program Officer, Vector Control

## **Ministry of Health**

- Florence Ngere – Migori County Malaria Control Coordinator
- Simon Okuthe – Malaria Focal Person, Nyatike sub-county
- Samuel Akuku – Malaria Focal Person, Suna West sub-county
- Dr. Okomo Gordon – County Director of Health, Homa Bay
- Dr. Gerald Akeche – Deputy Director, Quality Assurance & Standards, Homa Bay
- Obae Nyaberi – County Public Health Office, Homa Bay
- Mrs. Clara Ahenda – County Malaria Control Coordinator, Homa Bay
- Dr. Omondi Owino – County Director of Health, Siaya
- Dr. Julius Oliech – Deputy County Director of Health, Siaya
- Peter Omoth – County Malaria Control Coordinator, Siaya
- Dr. David Oluoch – County Director of Health, Kakamega
- Zablon Onyango – Deputy County Public Health Officer Kakamega
- Dr. Faustina – County Malaria Control Coordinator, Kakamega
- Richard Nyamai – County Disease Control & Surveillance Unit, Kakamega

## **NEMA**

- David Ong'are – Director, Compliance, Enforcement and Field Operations
- Mr. Ouma – Deputy Director, Migori County
- Mr. John Maniafu – Director, Homa Bay County
- Leonard Ofula – Director, Siaya County
- Samuel Nyaga – Environmental Officer, Kakamega

### **Kenya Forest Services**

- Mr. Abraham – Kakamega Forest Guide

### **Norwegian Refugee Council**

- Fred Magumba – Area Manager, Kakuma
- Emmanuel Ouko – WASH Coordinator
- Jacklyne Otieno – WASH Officer

### **International Rescue Committee**

- Alex Musili – Senior Field Coordinator, Kakuma

### **Kenya Medical Research Institute/CDC, Kisumu**

- Dr. Simon Kariuki
- Dr. Aaron Samuels

### **Environmental & Combustion Consultants Ltd.**

- Philip Mwabe

### **EcoPost**

- Mrs. Lorna Ruto

### **Beneficiary Feedback**

The feedback from the beneficiary consultations was very positive. Since 2012, the last year IRS was conducted in most counties in Kenya, the number of reported malaria cases and deaths have steadily increased in a number of counties. This has resulted in very high demand for IRS operations. The malaria programs in every county we visited were all expecting (and asking for) PMI to begin IRS operations in their sub-counties next year (or very soon). One County Health (Homa Bay) Head asked for AIRS Kenya to let him know when the next round of meetings to select IRS target counties is to be held with the NMCP in order for them to make their case.

The experience of the one area with spray operations in 2016, the Kakuma Refugee Camps, was very positive. This was mainly a result of the switch of insecticide to Actellic 300 CS. Beneficiaries reported of complete elimination of most pests (including other bothersome insects, and snakes). The only complaint was with the smell of the insecticide used. However, some beneficiaries remarked that they could not discern the smell after a couple of weeks. A few beneficiaries (workers at the camps) refused their rooms being sprayed as a result of the smell.

# Annex D: Summary of Acute Exposure Symptoms & Treatment of IRS Pesticides

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## Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Carbamate

Carbamates	Human side effects	Treatment
Bendiocarb	Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.	The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.
Propoxur	Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.	The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.

### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended organophosphates

Organo-phosphate	Human side effects	Treatment
Malathion	<p>Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase.</p> <p>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.</p>	<p>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).</p> <p>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, tranquilizers, and central stimulants are all contraindicated.</p>
Fenitrothion	<p>Fenitrothion is the most toxic to man of the insecticides recommended for residual house spraying, and has a relatively low margin of safety.</p> <p>Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor.</p>	<p>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.</p> <p>Contact lenses should be removed if possible and medical attention should be sought.</p> <p>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.</p>

<b>Organo-phosphate</b>	<b>Human side effects</b>	<b>Treatment</b>
Pirimiphos-methyl	<p>Pirimiphos-methyl 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.</p>	<p>OP poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spray men (in the case of dispersed operations) should be trained in first-aid and emergency treatment of OP intoxication.</p> <p>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.</p> <p>Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic OP insecticides are used in areas without easy access to medical care.</p> <p>Atropine sulfate is recommended. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible.</p> <p>Glycopyrolate has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.</p>

### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended pyrethroids

Pyrethroids	Human side effects	Treatment
Bifenthrin	<p>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.</p> <p>No skin inflammation or irritation observed; however can cause a reversible tingling sensation.</p> <p>Incoordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses.</p>	<p>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.</p> <p>Medical attention should be sought if irritation or paresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline.</p>
Deltamethrin	<p>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.</p>	<p>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.</p> <p>Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate.</p> <p>Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</p>
Lambda-Cyhalothrin	<p>Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning.</p> <p>Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions.</p> <p>Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis.</p>	<p>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.</p>

<b>Pyrethroids</b>	<b>Human side effects</b>	<b>Treatment</b>
Alpha-Cypermethrin	<p>Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia.</p> <p>Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful</p>	<p>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.</p>
Cyfluthrin	<p>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue.</p> <p>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.</p>	<p>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.</p> <p>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.</p>
Etofenprox	<p>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue.</p> <p>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.</p>	<p>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.</p> <p>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.</p>

### Summary of Acute Exposure Symptoms and Treatment for Chlorfenapyr

Human side effects	Treatment
<p>As chlorfenapyr is a rather new product there are not many cases of poisonings where the symptoms were described.</p> <p>For the time being, one patient, exposed to vapors of chlorfenapyr, first exhibited general fatigue, hyper-perspiration, nausea and vomiting. He was initially diagnosed as being dehydrated.</p> <p>Another patient, who ingested the chemical in a suicide attempt, initially presented with hyper-perspiration, headache and cough. Symptomatic management was initiated, but after seven days she suffered neurological and respiratory deterioration, causing her death.</p>	<p>Symptoms following exposure should be observed in a controlled setting until all signs and symptoms have fully been resolved. If ingested, control any seizures first. Chlorfenapyr can produce abnormalities of the hematopoietic system, liver, and kidneys. Do not use emetics.</p> <p>Monitoring complete blood count, urinalysis, and liver and kidney function tests is suggested for patients with significant exposure. If respiratory tract irritation or respiratory depression is evident from inhalation, monitor arterial blood gases, chest x-ray, and pulmonary function tests.</p> <p>Significant esophageal or gastro-intestinal tract irritation or burns may occur following ingestion. Consider gastric lavage after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation.</p> <p>Activated charcoal binds most toxic agents and can decrease their systemic absorption if administered soon after ingestion. Immediate dilution with milk or water may be of benefit in caustic or irritant chemical ingestions. Rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool.</p> <p>Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury.</p> <p>Carefully observe patients with inhalation exposure for the development of any systemic signs or symptoms and administer symptomatic treatment as necessary. If exposure is to the eyes, immediately irrigate exposed eyes with copious amounts of room temperature water (better with 0.9% saline) for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persists, the patient should be seen in a health care facility.</p> <p>For dermal exposure remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.</p>