
**PMI | Africa IRS (AIRS) Project**

Indoor Residual Spraying (IRS 2) Task Order Six

# GHANA SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL, 2015-2020

NATIONWIDE
PYRETHROIDS, CARBAMATES,
ORGANOPHOSPHATES,
AND CHLORFENAPYR

MARCH 2015

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# GHANA

# SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

# 2015-2020

MARCH 2015

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Abt Associates, Inc.

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# EXECUTIVE SUMMARY

This document has been prepared to serve as a Supplemental Environmental Assessment (SEA) for IRS in Ghana. Previous environmental documentation for PMI-supported IRS in Ghana authorized the use of the pyrethroid, carbamate, and organophosphate classes of the WHOPES-recommended pesticides in the Northern Region of Ghana from 2010-15, 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 3 classes of WHOPES-recommended insecticides, expand the geographic coverage to nationwide, and to expand the authorization to include the use of chlorfenapyr, when approved by WHOPES, for IRS in Ghana. A further stipulation is that this SEA requests authorization of small-scale hut trials using chlorfenapyr.

Continuing spraying activities in high transmission areas in Ghana in partnership with the Government of Ghana will help improve the lives in many disadvantaged communities. In order to continue spraying activities in Ghana, the SEA needs to be reauthorized. In addition, changing or rotating insecticides of different classes over time and space is currently a leading way to manage resistance. It is also important to ensure that the pesticide used is effective for the duration of the malaria season in a given environment. The proposal to include chlorfenapyr is prompted by the need to increase the options of approved insecticides available for spray activities in Ghana. In Ghana, entomological monitoring has demonstrated that local mosquitoes have developed some level of resistance to the pyrethroid class of insecticides. The local mosquitos have been shown to be susceptible to the organophosphate, pirimiphos methyl, which is currently used for IRS. Chlorfenapyr, a new formulation of an Active Ingredient (AI) in the pyrrole chemical class is under WHOPES review, and if approved for use will offer an additional option for vector protection when needed.

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

1. The cumulative effects of organophosphate exposure are stressed in training, and more emphasis is placed on the responsibility of team leaders and senior personnel to constantly monitor the appearance and behavior of their team members, and to recognize the symptoms of organophosphate exposure.
2. Pirimiphos-methyl formulations are supplied in plastic bottles, which if not controlled carefully may be used inappropriately after being emptied of the 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 bottles has been incorporated during the pesticide make-up procedure, whereby the pesticide 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 pesticide container is thoroughly rinsed of pesticide, and is safe for handling and subsequent processing. The risk of exposure due to pesticide residue in the container is essentially eliminated; however, the following procedures are also followed.

b. Containers are punctured multiple times to eliminate the ability to reuse the containers, and,

c. 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 Ghana Environmental Protection Agency (EPA), the implementing partner will ensure that the plastic remains segregated from other supplies, is used to produce items such as patio flagstones, pavement blocks, garbage bins, or electrical conduit, and will not be used for products that contain consumables. The recycling programs have prevented many tons of carbon dioxide ($CO_2$) and other potentially toxic emissions from the incineration of plastic.

Ghana's entire population of 24.2 million (2010 Census) is at risk of malaria infection, but children under five years of age and pregnant women are at higher risk of severe illness due to lowered immunity. Malaria is ranked as a leading cause of under-five mortality, and according to the United Nations Children Fund[1], children of the poorest, uneducated rural mothers are most likely to die before they reach their fifth birthday.

Indoor Residual Spraying with the support of PMI in Ghana began in 2007 and covered districts in the Northern Region. In 2015, it is proposed to spray 5 districts in the Northern Region, but this SEA is written to accommodate the expansion or relocation of PMI support to any areas of the country.

Therefore the proposed action analyzed in this document is the continuation of IRS programming for 2015-2020, the geographical expansion of allowable PMI IRS programming to country-wide, using pyrethroids, carbamates, organophosphates, or chlorfenapyr (when recommended by WHOPES) where appropriate, based on pesticide resistance patterns throughout the country, and, to permit hut trials with potential alternative pesticides for evaluation of their effectiveness in IRS.

The following assessment draws heavily on the Programmatic Environmental Assessment (PEA) for Integrated Vector Management, approved in November 2012, and many other reference documents, as noted throughout this document.

[1] http://www.unicef.org/infobycountry/ghana_66835.html, (December 2012)

# PRINCIPAL PROPOSALS

1. The Ghana Supplemental Environmental Assessment (SEA) (2008), as amended in 2010 (amendment #1) was valid for implementing PMI-supported Indoor Residual Spraying (IRS) in selected districts in the Northern Region of Ghana, using all WHO-recommended pesticides in the pyrethroid, carbamate, and organophosphate classes for the period 2010-2015.
2. In order to continue with PMI IRS, the NMCP and PMI are seeking approval for a new SEA for a further 5 years (2015-2020).
3. It is also 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 expand the geographic coverage of potential PMI-supported IRS to Ghana nationwide.
5. It is further proposed to allow small studies or Hut Trials - To expand on PMI IRS Entomological Monitoring, PMI IRS program may conduct small studies or hut trials to study new IRS insecticides such as chlorfenapyr. The guidelines for laboratory testing and small and large-scale field trials are provided in Guidelines for Testing Mosquito Adulticides for Indoor Residual Spraying and Treatment of Mosquito Nets (WHO 2006). The following is the approach PMI IRS used to study chlorfenapyr in Nigeria, and may be used to guide activities in Ghana.
    a. The purpose of the proposed action is to measure the efficacy of chlorfenapyr (*and potentially other IRS insecticides as needed)* on key disease vectors. In order to do so, two key activities are proposed:
    b. Assess the insecticidal bioefficacy of key disease vectors to chlorfenapyr in comparison with alpha-cypermethrin and bendiocarb. In order to assess insecticidal bioefficacy, both susceptible and resistant strains of mosquitoes will be used. All tests will be performed at a controlled location. Mosquitoes will be exposed to insecticides in bottle assays and technicians will measure the amount of time needed to knock down and kill the mosquitoes.
    c. Compare the efficacy and residual life of chlorfenapyr applied as an indoor residual spray on relevant substrates with that of bendiocarb and alpha-cypermethrin at WHO recommended doses. This second activity will be carried out in experimental huts (four or five) located in a high endemic location.
6. This SEA contains the condition that spraying will not be performed by PMI implementing partners within 30 meters of natural water bodies, wetlands or marshes, organic farming areas, beekeeping areas or core areas within protected forests, parks or habitats.
7. The Safer Use Action Plan in Chapter 6 provides detailed guidance on the performance of all activities associated with IRS. The attached, updated Environmental Mitigation and Monitoring Plan (EMMP) (Annex A) summarizes the required mitigation measures, as well as the monitoring and reporting requirements and schedule.

8. The preparation of this SEA renders the preparation of a Letter Report unnecessary for 2015. In subsequent years a Letter Report will be submitted to USAID annually that will discuss significant changes in the IRS program for that particular year's spray campaign.
9. 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 have been used in Ghana since 2012, BEO signatures are not required on the annual Letter Reports.
10. This SEA contains an updated Pesticides Procedures section, which, together with the also-included Safer Use Action Plan constitute the elements of a PERSUAP.

Signature approval of this SEA will indicate acceptance of these proposals. Therefore, the following conditions will apply:

1. All WHOPES-recommended insecticides in the pyrethroid, carbamate, and organophosphate classes, and chlorfenapyr (when approved) will be eligible for IRS in all areas of Ghana from 2015-2020, except for within core protected areas and other sensitive areas.
2. This SEA will comprise a free-standing document fulfilling the environmental documentation requirements of US 22 CFR 216 for PMI IRS in Ghana from 2015-2020, unless changes are made to the program that are not covered or anticipated in this assessment.

## APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED

## 2015 SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT'S MALARIA INITIAVE- INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN GHANA

The United States Agency for International Development, Global Health Bureau has determined that the proposed indoor residual spraying effort, as described in the 2015 Supplemental Environmental Assessment: Indoor Residual Spraying for malaria control in Ghana responds to the needs of the community and country as it relates to managing malaria in Ghana, 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 Programmatic Environmental Assessment for PMI IVM (2012), is consistent with the Government of Ghana's and USAID's goal of reducing malaria incidence in Ghana while minimizing negative impact to the environment and to human health.

The proposed actions recommended for approval in this 2015 SEA are:

1. The continuation of IRS implementation using pyrethroids, carbamates, organophosphates, *and/or chlorfenapyr when recommended by WHOPES,* where appropriate, based on pesticide resistance patterns throughout the country, and,
2. This SEA covers all areas in Ghana where IRS may be implemented as decided by the National Malaria Control Program and PMI for the 5-year period from 2015 to 2020.
3. This SEA authorizes small, closely supervised studies or Hut Trials to study new IRS insecticides such as chlorfenapyr.

Due to the need to protect the population in these areas from malaria, and given the successful record of PMI in implementing IRS in Ghana without significant environmental consequences, it is proposed to allow IRS 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 updated Environmental Mitigation and Monitoring Plan (EMMP) for Ghana (Annex A) provides 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.

**CLEARANCE**:

Acting Mission Director: _____ Date: _____
USAID/Ghana Andrew Karas

**CONCURRENCE**:

Bureau Environmental _____ Date: _____
Officer/GH: Rachel Dagovitz

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| PMI Advisor: PMI/Ghana | Philip Ricks | Date: |
| Mission Environmental Officer: USAID/Ghana | Justice Odoi | Date: |
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# ACRONYMS

| | |
|---|---|
| ACTs | Artemisinin-based combination therapies |
| ADS | Automated Directives System |
| AI | active ingredient |
| AIRS | Africa Indoor Residual Spraying |
| BEO | Bureau Environmental Officer |
| BMP | Best Management Practices Manual |
| CDC | Centers for Disease Control and Prevention |
| COP | Chief of Party |
| CS | capsule suspension |
| DDT | dichloro-diphenyl-trichloroethane |
| EIA | Environmental Impact Assessment |
| EMMP | Environmental Mitigation and Monitoring Plan |
| EMMR | Environmental Mitigation and Monitoring Report |
| EPA | Ghana Environmental Protection Agency |
| FAO | Food and Agriculture Organization of the United Nations |
| FY | Fiscal Year |
| GFATM | Global Fund to fight AIDS, Tuberculosis and Malaria |
| GHI | Global Health Initiative |
| GOG | Government of Ghana |
| IEC | Information, Education and Communication |
| IEE | Initial Environmental Examination |
| IMF | International Monetary Fund |
| IRS | Indoor Residual Spraying |
| ITNs | Insecticide Treated Nets |
| IVM | Integrated Vector Management |
| LLINs | Long Lasting Insecticide Treated Nets |
| MFP | Malaria Focal Person |
| MEO | Mission Environmental Officer |
| MOH | Ministry of Health |
| MOP | Malaria Operational Plan |
| MSDS | material safety data sheet |

| | |
|---|---|
| NGO | non-governmental organization |
| NMCP | National Malaria Control Program |
| OPs | organophosphates |
| PAN | Pesticide Database – Pesticide Action Network |
| PEA | Programmatic Environmental Assessment |
| PERSUAP | Pesticide Evaluation Report and Safer Use Action Plan |
| PMI | President's Malaria Initiative |
| POPs | Persistent Organic Pollutants |
| PPE | personal protective equipment |
| REA | Regional Environmental Advisor |
| SEA | Supplemental Environmental Assessment |
| SOP | Spray Operator |
| ToT | Training of trainers |
| UNEP | United Nations Environment Program |
| USAID | United States Agency for International Development |
| USEPA | United States Environmental Protection Agency |
| USG | United States Government |
| WHO | World Health Organization |
| WHOPES | World Health Organization Pesticide Evaluation Scheme |
| WP | Wettable Powder |

# 1. BACKGROUND

## 1.1 PRESIDENT'S MALARIA INITIATIVE

Launched in 2005, the President's Malaria Initiative (PMI)[2] is a five-year, $1.2 billion expansion of U.S. Government efforts to reduce the intolerable burden of malaria and help relieve poverty on the African continent. The goal of PMI is to reduce malaria-related deaths by 50 percent in 19 countries in Africa that have a high burden of malaria by expanding coverage of four highly effective malaria prevention and treatment measures to the most vulnerable populations: pregnant women and children under five years of age (USAID 2005). These interventions include insecticide-treated mosquito nets (ITNs), indoor residual spraying (IRS) with insecticides, intermittent preventive treatment for pregnant women (IPTp), and prompt use of artemisinin-based combination therapies (ACTs) for those who have been diagnosed with malaria.

The 2008 Lantos-Hyde Act (H.R. 5501 (110th))[3] authorized an expanded PMI program for 2009-2013. PMI is a key component of the U.S. Government's Global Health Initiative, which was announced by President Obama in May 2009. As a result, the PMI strategy (USAID 2010a) was revised to achieve Africa-wide impact by halving the burden of malaria in 70 percent of at-risk populations in sub-Saharan Africa – or approximately 450 million people. Now in its seventh year of funding, PMI has expanded to 19 countries plus one region. PMI, in partnership with National Malaria Control Programs (NMCPs) and in support of country-level strategic plans, is providing technical, managerial, and commodity support for IRS campaigns in all PMI countries that implement IRS.

## 1.2 PROGRAM OBJECTIVES

Under the GHI, PMI will assist Ghana 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 countries, achieving a greater than 80 percent reduction from PMI's original 2000 baseline levels.
- Reduce malaria morbidity in PMI-supported countries by 40 percent from 2015 levels.
- Assist at least five PMI-supported countries to meet the WHO criteria for national or sub-national preelimination.

The PMI/Ghana strategy includes all of the major interventions supported by PMI. The emphasis and level of support for each of the interventions takes into consideration the contributions from the Government of Ghana (GOG), Global Fund, Department for International Development (DFID), and other stakeholders to ensure priority interventions are scaled up, gaps are filled, and regional variations in malaria epidemiology and progress to-date are addressed.

[2] See http://www.pmi.gov/

[3] See http://www.govtrack.us/congress/bills/110/hr5501

## 1.3 HISTORY AND SCOPE OF IRS IN GHANA

PMI began supporting IRS in Ghana in 2007, with a focus on local capacity building, strict environmental compliance, and entomological monitoring. In consultations with the Ghana Health Service (GHS), a cluster of districts in the Northern Region was selected for spraying due to their high malaria burden (>40% parasitemia, children under 5), less healthcare and economic infrastructure, and a relatively short malaria transmission season.

Within the first two years, the President's Malaria Initiative (PMI) Africa Indoor Residual Spraying (AIRS) Project demonstrated that IRS can be scaled up quickly and safely in the more remote rural areas of the country. In 2008, working in close collaboration with GHS and local communities, the program protected 601,000 people in five districts. By 2011, the program had expanded to cover a population of 926,000 in nine districts (see Table 1). Each year, the program exceeded the previous 90% national target for coverage of local structures found. Entomological monitoring sites are located in two IRS districts, Bunkpurugu-Yunyoo, Savelugu-Nanton, one district from which IRS was withdrawn in 2013, Tolon Kumbungu, and one control area (non-IRS), Tamale municipality.

**TABLE 1: PMI IRS COVERAGE (NORTHERN REGION), 2011-2015**

| Year | Number of Districts Sprayed | Insecticide Used | Number of Structures Sprayed | Coverage Rate | Population Protected |
|---|---|---|---|---|---|
| 2011 | 9 | Pyrethroids | 354,207 | 92% | 926,699 |
| 2012 | 9 | Organophosphates in 3 districts, pyrethroids in 6 district | 383,142 | 93% | 941,240 |
| 2013 | 4 | Organophosphates | 197,655 | 91% | 534,060 |
| 2014 | 4 | Organophosphates | 205,230 | 83% | 570,572 |
| 2015* | 5# | Organophosphates | 231,345 | TBD | 596,706 |

* Projected based on draft work plan

# From 2014 to 2015, part of West Mamprusi District was split off to form Mamprugu Moaduri District

In 2015, PMI will conduct an IRS campaign that covers five districts (Bunkpurugu-Yunyoo, East Mamprusi, Mamprugu Moaduri, West Mamprusi, and Kumbungu) in the Northern Region of Ghana and will target approximately 231,345 structures and protect 596,706 with the long-lasting organophosphate Actellic CS. To contribute toward the NMCP and PMI objective of national IRS capacity-building, PMI facilitated the establishment of a Malaria Vector Control Oversight Committee (MaVCOC), to help the NMCP coordinate and guide IRS implementation in the country. The committee includes partners such as AngloGold Ashanti Malaria Control Program (AGAMal), the Noguchi Memorial Institute for Medical Research (NMIMR), the Ghana Environmental Protection Agency (EPA), and other IRS partners. This forum has been meeting quarterly since 2009. The committee assists the NMCP in meeting national objectives for quality control, environmental compliance, and insecticide resistance management and has established and disseminated national IRS standard operating procedures, and facilitated information exchange and coordination of efforts.

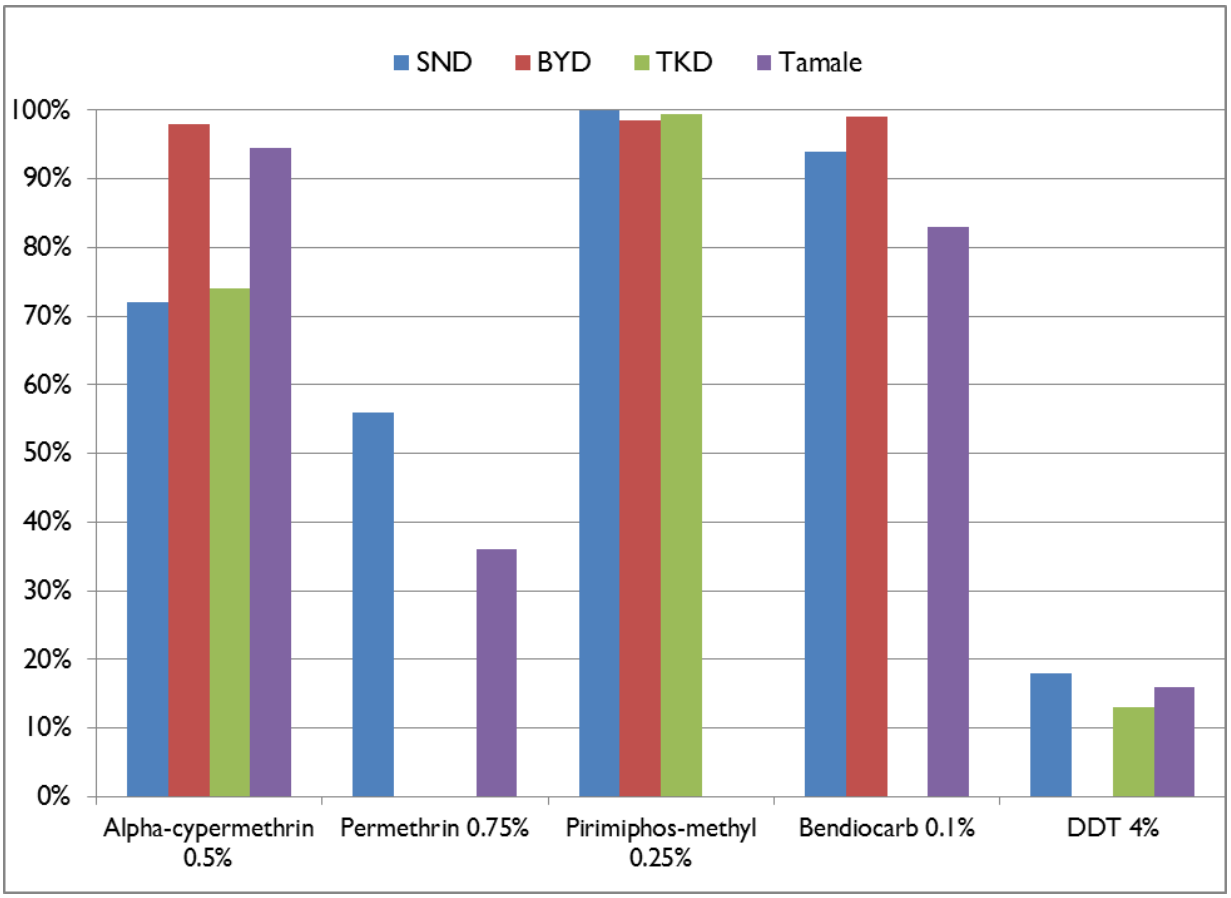
In addition to PMI sponsored IRS in Ghana, with Abt Associates as the Implementing Partner, the Global Fund provided a grant to further scale up IRS with AGAMal, a not-for-profit subsidiary of the gold mining company that bears the same name, as the Principal Recipient. The original AGAMal plan was to eventually cover 40 districts with two rounds of spraying, but a reduction in the 2014-2018 Global Fund allocation has necessitated the modification of these plans. Since 2009, the AGAMal spray program has

covered up to 25 districts, but the coverage was reduced to cover only 10 districts in 2015, based on the level of allocated funding. In 2013, the program was extended to include the Upper West Region. If the Global Fund awards additional funds above the current allocation, it is possible that additional districts would be covered by AGAMal IRS. However, following PMI's lead, which only sprays once a year and has reduced the number of spray days from 53 to 36, AGAMal will now spray only once a year and reduce their spray season from five to three months in Upper West Region, actions that are expected to save considerable funding in future years.

As AGAMal/Global Fund has become the largest implementer of IRS in the country, PMI's overall objective has shifted from scale up to maintenance of high quality operations, with a focus on efficacy monitoring, optimization of design, and targeting for increased impact. With MaVCOC helping to institutionalize a culture of evidence-based decision making in IRS, both the AGAMal/Global Fund and PMI programs have increased their investments in entomologic and epidemiologic monitoring over time.

Pyrethroids had been used since the inception of the PMI IRS program in Ghana. Across the five spray rounds of 2008-2012, entomologic monitoring detected the gradual emergence of pyrethroid resistance, leading Ghana's MaVCOC to recommend a transition to a long-acting organophosphate. In 2012, six of the nine PMI-spray districts and in 2013 all four of the districts were sprayed with a long-acting organophosphate, Actellic CS 300 (pirimiphos methyl). Monthly wall bio-assays in 2013 demonstrated pesticide efficacy of >80% mortality for a duration of at least six to eight months, which was comparable to the previously used pyrethroids. Figure 1 shows the susceptibility status of local *An. Gambiae* mosquitoes measured in 2014. In addition, for 2015, the NMCP has dropped Savelugu-Nanton, due to low IRS coverage (68%), mainly due to spray fatigue after 7 years of spraying, and low transmission (EIR=0 in 2014). Instead Kumbungu, from which PMI IRS was withdrawn after 2012, will be included in 2015 as a PMI IRS spray-district in the Northern Region.

**FIGURE 1: 2014 INSECTICIDE SUSCEPTIBILITY STATUS OF LOCAL *AN. GAMBIAE* S.L. MOSQUITOES FROM ENTOMOLOGICAL SENTINEL SITES AGAINST WHO RECOMMENDED INSECTICIDES FOR IRS.**



# 2. PROPOSED ACTION AND ALTERNATIVES

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, organophosphate, and chlorfenapyr classes in high-risk districts and sectors identified by the evaluation of criteria such as transmission rate, vector susceptibility, and residual effect, appropriate home and wall structure, and ecological/human health impacts. To also allow small, closely supervised studies or Hut Trials to study new IRS insecticides such as chlorfenapyr.
2. **No action alternative:** This action would discontinue PMI support for IRS activities in Ghana.
3. **Spraying in alternative geographic regions:** This alternative would use different criteria to select alternative districts and sectors to spray.
4. **Using alternative pesticides:** This alternative would consider pesticides other than those recommended by WHO.
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, organophosphate classes, and 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 summarized below and more fully explained in Pesticide Procedures part b (see section 4.2).

As part of the above, the PMI IRS Implementing Partner will not perform IRS within Ghana's core protected areas. Protected areas in Ghana have a core protected area, with stringent regulations restricting uses, entry, and activities, and buffer areas with less stringent protection. In general, the buffer areas are designed to protect the environment while allowing sustainable use of resources. PMI will only perform IRS within buffer areas of Ghana's protected areas, as allowed by national and local regulation, if needed and required by the NMCP to protect the population in these areas from malaria, using the strict protocols and procedures contained in the PMI Best Management Practices (BMP) manual, and observing all precautions and prescriptions in this Supplemental Environmental Assessment (SEA).

### 2.1.1 CHOICE OF PESTICIDE

The insecticide class selected for each campaign of a PMI-supported IRS program is dependent on a number of criteria:

#### *2.1.1.1 PRIMARY CRITERIA FOR CHOOSING PESTICIDES:*

- Recommended by the World Health Organization Pesticide Evaluation Scheme (WHOPES)

- Permitted for public health use in Ghana
- Residual effect for a period longer than, or equal to, the average duration of the malaria transmission season in the selected areas
- Appropriate for use on the wall surfaces of the selected locations
- Local vector susceptibility to the insecticide
- Ecological impact
- Human health impact

#### *2.1.1.2 SECONDARY SELECTION CRITERIA:*

Based on these primary factors, a request for bids is tendered in accordance with US and Ghana open competitive procurement rules. In evaluating the resulting bids, secondary criteria are considered, including:

- 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

The insecticide of choice will be purchased using best procurement practices (competitive bidding and use of the above selection criteria outlined in bid documents). Should the economic and technical comparison between formulations be neutral (similar cost and vector susceptibility), then relative toxicity of formulations will be considered when making procurement decisions.

#### *2.1.1.3 PESTICIDE CHAIN OF CUSTODY*

Once the pesticide is procured, it proceeds through the following sequence:

Pesticide Supplier

↓

Quality assurance

↓

Ghana – Customs

↓

Transportation of pesticides from the harbor to the regional central warehouse

↓

PMI District Storage (Regional logistic officer and District Logistics Assistant)

↓

Sub-district Storage (Store Assistant, Site Manager)

↓

Spray Team Supervisors/Leaders/Operators

↓

District Storage (Storekeeper, empty containers)

↓

Incineration/Recycling (Environmental Compliance Officer, Logistical Assistant)

Inventory of insecticides will be taken at all shipping points. The insecticides will be shipped to Tema harbor, where the contractor's procurement and logistics team will inspect the shipment and verify that the quantities supplied tallies with the request made as indicated in the way bill. The insecticides will then be transported in closed containerized trucks to a secure central district warehouse. From the regional central warehouse, the insecticides will be transported by truck to rented warehouses in the proposed sub-districts where the spray operations will commence, to be issued on a daily basis to team leaders and then to spray operators for IRS use.

### 2.1.2 Preparations for Spray

Prior to spraying, the contractor or implementing partner will:

- Conduct preliminary logistical assessment to quantify eligible house structures, target population, spray equipment, insecticide, and spray teams and identify suitable sites and facilities for pesticide storage and disposal of effluent waste.
- Develop selected sites for year-round and temporary storage of IRS equipment and insecticide, and construct effluent waste disposal facilities as necessary.
- Identify sensitive areas (water bodies, protected habitat, aquacultural activities, etc.) to avoid during IRS.
- Promote acceptance of IRS in the targeted communities through information, education and communication (IEC) activities. Households have the opportunity to "opt-out" of participation in IRS after hearing the IEC messages on benefits and risks.
- Train spray teams in a variety of positions, including site managers, team leaders, spray operators, washers, store assistants, security guards, and water fetchers.
- Procure, transport, and store all necessary spray and personnel protective equipment (PPE), insecticides, and consumables.
- Implement the Environmental Mitigation and Monitoring Plan (EMMP) in Annex A of this SEA throughout all processes.

## 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 goal of the Ghana NMCP and PMI, which is to reduce malaria mortality by 50% in up to 15 countries in sub-Saharan Africa in five years.

## 2.3 Alternative IRS Geographical Sites Considered

Although this SEA proposes to allow IRS in all 10 regions in Ghana, in IRS implementation, 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 in a given year. Using different criteria for selecting geographical sites would reduce the effectiveness and impact of IRS, decreasing progress towards the goals of the Ghana NMCP and PMI.

## 2.4 USE OF ALTERNATIVE INSECTICIDE(S)

For IRS to be implemented with PMI support, a pesticide recommended by the World Health Organization (WHO) under the World Health Organization Pesticide Evaluation Scheme (WHOPES) must be selected for use. WHOPES is the institution that analyses and recommends the pesticides that should be used in IRS based on their effectiveness, cost, and toxicity to human health and the environment.

To date WHOPES has recommended the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines, and organophosphates. This SEA also covers chlorfenapyr in anticipation of this new insecticide – currently under WHOPES review – being fully recommended by WHOPES for IRS and being registered for public health use in Ghana in the near future. Currently, there are no other pesticides eligible for use in PMI-sponsored IRS, so deliberations are confined to these classes of pesticides. This proposed action for Ghana includes the use of organophosphates, carbamates, pyrethroid, and chlorfenapyr formulations. The proposed action excludes the use of DDT.

## 2.5 ALTERNATIVE TECHNOLOGIES

A full range of known, available technologies is continually considered for use by the stakeholders in the malaria prevention and control efforts. It has been determined that IRS plays a significant part in malaria prevention in concert with those other technologies.[4] The specific focus of this PMI effort and the role that PMI plays in Ghana includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays, the NMCP, PMI and its partners would evaluate them and proceed accordingly.

[4] PRESIDENT'S MALARIA INITIATIVE: Ghana Malaria Operational Plan (MOP) FY 2015

# 3. AFFECTED ENVIRONMENT - GHANA

This section describes the environments and ecosystems that could be adversely affected in the implementation of the IRS program if adequate and necessary mitigation measures and monitoring are not put into place. These critical ecosystems or activities 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 application of pesticides.

## 3.1 OVERVIEW OF GHANA

### 3.1.1 POSITION AND SIZE

Ghana is located in West Africa with the Gulf of Guinea and the Atlantic Ocean as the coastline. It has a surface area of 238,535 sq. km., with 2,093 km of international land borders. Its coastline to the south is 560 km long and Ghana is bordered by Côte d'Ivoire to the west, Togo to the East, and Burkina Faso to the north.

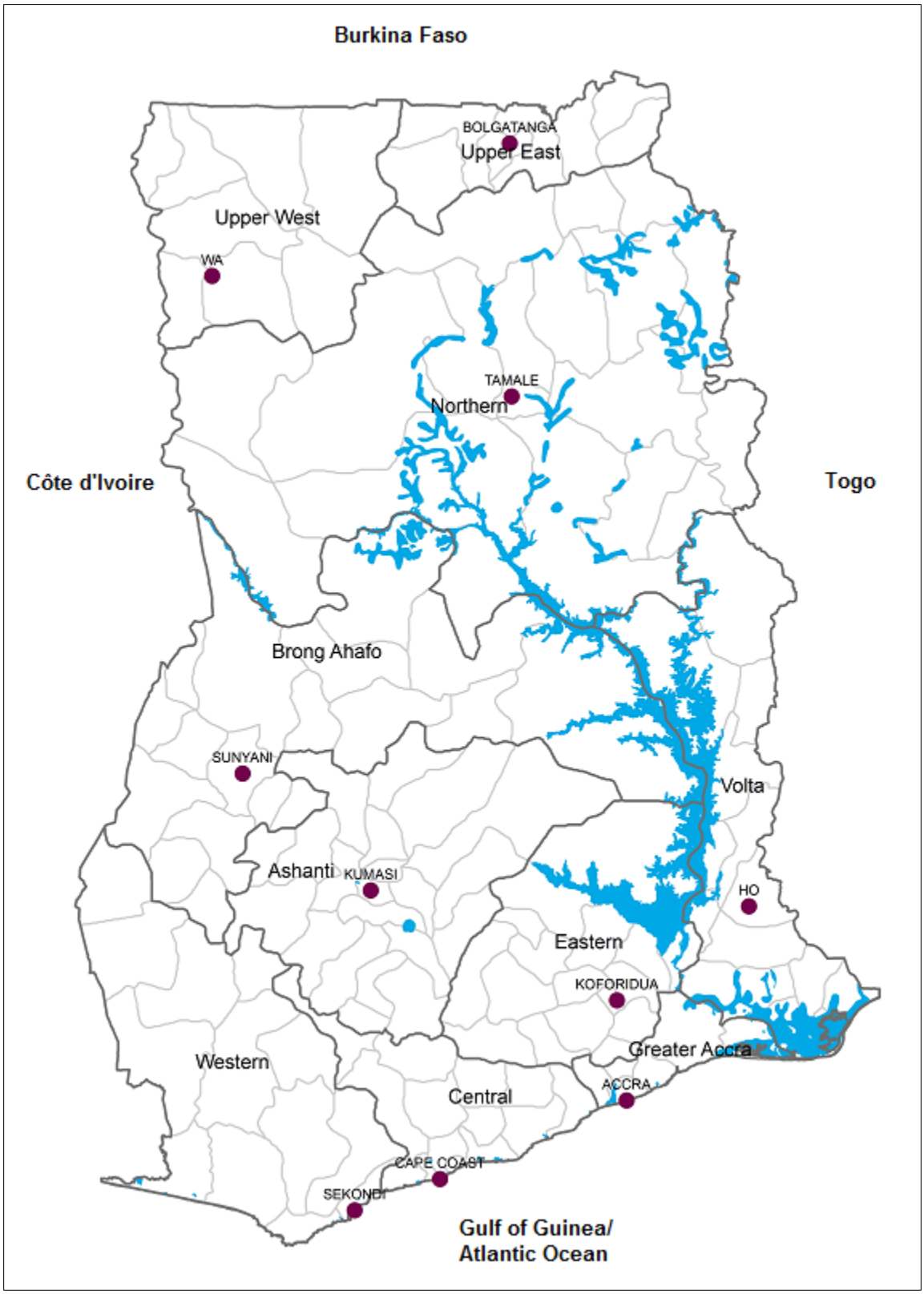
### 3.1.2 ADMINISTRATIVE AND POLITICAL UNITS

Ghana is divided into 10 regions that, since 2012, are sub-divided into 216 districts. Some of the districts are metropolitan (6) or municipal (46) areas. Each of the 216 districts is governed by a District Assembly with the District Chief Executive (DCE) responsible for the day-to-day running of the Assembly. The 216 districts are further divided into 275 constituencies with representation at the National Parliament. Table 2 presents the number of districts in regions and Figure 2 presents the 10 regions and 216 districts of Ghana.

**TABLE 2: REGIONS AND CORRESPONDING NUMBER OF METROPOLITAN, MUNICIPAL AND DISTRICT ASSEMBLIES IN GHANA**

| | Metropolitan Area | Municipal Area | Ordinary District |
|---|---|---|---|
| Ashanti (30) | 1 | 7 | 22 |
| Brong Ahafo (27) | | 8 | 19 |
| Central (20) | 1 | 6 | 13 |
| Eastern (26) | | 7 | 19 |
| Greater Accra (16) | 2 | 7 | 7 |
| Northern (26) | 1 | 1 | 24 |
| Upper East (13) | | 2 | 11 |
| Upper West (11) | | 1 | 10 |
| Volta (25) | | 5 | 20 |
| Western (22) | 1 | 2 | 19 |

**FIGURE 2: MAP OF REGIONS AND DISTRICTS**




Source: Ghana at a Glance, EPA

### 3.1.3 POPULATION

According to the World Bank, Ghana's population in 2013 was 25.9 million[5], with a decreasing average growth rate that has dropped from 2.6 percent per year in 2008 to 2.1 percent per year in 2013. Based on the 2010 Population and Housing Census of Ghana[6], the highest population density areas of Ghana are mainly the major urban areas with about 51 percent of the population. The most populous region is the Ashanti Region, with about 19 percent of the country's total population, followed by the Greater Accra Region, with about 16 percent.

## 3.2 PHYSICAL ENVIRONMENT

### 3.2.1 CLIMATE

Ghana lies between latitudes 4° and 12°N, and longitudes 4°W and 2°E in the tropics. There are two main wet seasons, although the northern parts of the country tend to experience only one wet season. Average temperature range between 82°F and 70°F with 90°F and 59°F record high and low temperatures respectively. Average humidity ranges between 79 percent and 85 percent.

### 3.2.2 RAINFALL PATTERNS IN GHANA

The southern part of Ghana is generally wetter that the northern parts. The bi-modal rain pattern has most of the rains between March and July with a second rainy season (which is generally not experienced in the northern part of the country) between September and November. The average annual rainfall measures about 79 cm with about 77 days of rain in a year.

Rainfall seasons of Ghana are controlled by the movement of the tropical rain belt – the Inter-Tropical Conversion Zone, ITCZ – which oscillates between the northern and southern tropics over the course of a year (McSweeney, New, Lizcano; 2010). The dominant wind direction in regions south of the ITCZ is south-westerly, blowing moist air from the Atlantic onto the continent, but north of the ITCZ the prevailing winds come from the north east, bringing hot and dusty air from the Sahara desert (known as the "Harmattan"). As the ITCZ migrates between its north and south positions over the course of the year, the regions between these those northern and southernmost positions of the ITCZ experience a shift between the two opposing prevailing wind directions. The northern parts of Ghana experience a single wet season that occurs between May and November, when the ITCZ is in its northern position and the prevailing wind is south-westerly – bring wind across the Sahara Desert – and a dry season between December and March when the "Harmattan" wind blows north-easterly. Northern and central parts of Ghana receive 15 - 25 cm per month in the peak months of the wet season (July to September). Southern parts of Ghana have two wet seasons, one from March to July, and a shorter wet season from September to November, corresponding to the northern and southern passages of the ITCZ across the region.

Seasonal variations in temperature in Ghana are greatest in the north, with highest temperatures in the hot, dry season at 81 - 86°F, and lowest in at 77 - 81°F. Further south, temperatures reach 77 - 81°F in the warmest season, and 72 - 77°F at their lowest.

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[5] http://data.worldbank.org/country/ghana accessed on 1/7/2015

[6] http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf accessed on1/7/2015

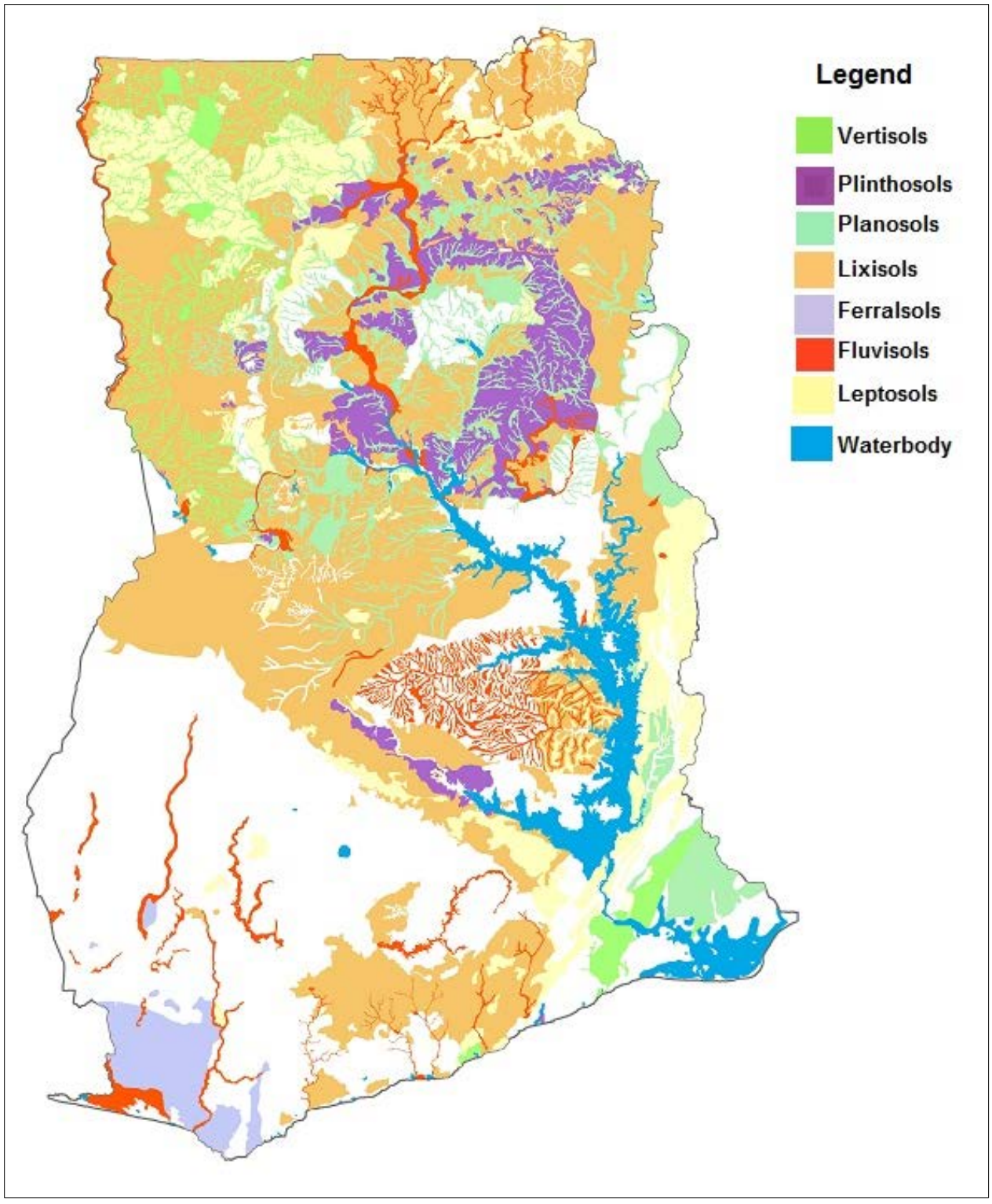
### 3.2.3 TOPOGRAPHY, GEOLOGY AND SOILS

Throughout Ghana, weathering, leaching, and the formation of laterite hardpans by capillary movement and evaporation are common processes that vary in importance according to the characteristics of each locality. Leaching is more pronounced in the wet south, while the formation of laterite is more widespread in the drier north. In general, most soils are formed in place from parent rock material that has been subjected to prolonged erosion and consequently has limited fertility. Figure 3 presents the distribution of some major soil categories in Ghana.

In the forest zones the soils are mostly lateritic. They are subdivided into relatively fertile and less-acidic ochrosols (red, brown, and yellow-brown, relatively well-drained soils) in areas of moderate precipitation and into more-acidic and less-fertile oxisols in the extreme southwest, where annual precipitation exceeds 65 inches. Ochrosols occur over considerable areas in the coastal and northern savanna zones. As in the forest zone, they are the best soils for agriculture.

The coastal savanna zone has an abundance of soil types, including tropical black earths, tropical gray earths, acid vleisols, and sodium vleisols. Except for the tropical black earths, known locally as Akuse clays, most of these soils are of little importance agriculturally. The Akuse clays fill a broad zone across the coastal savanna plains; although heavy and intractable, they respond well to cropping under irrigation and mechanical cultivation.

**FIGURE 3: MAJOR SOIL TYPES OF GHANA**



## 3.3 BIOLOGICAL ENVIRONMENT

### 3.3.1 PLANT LIFE

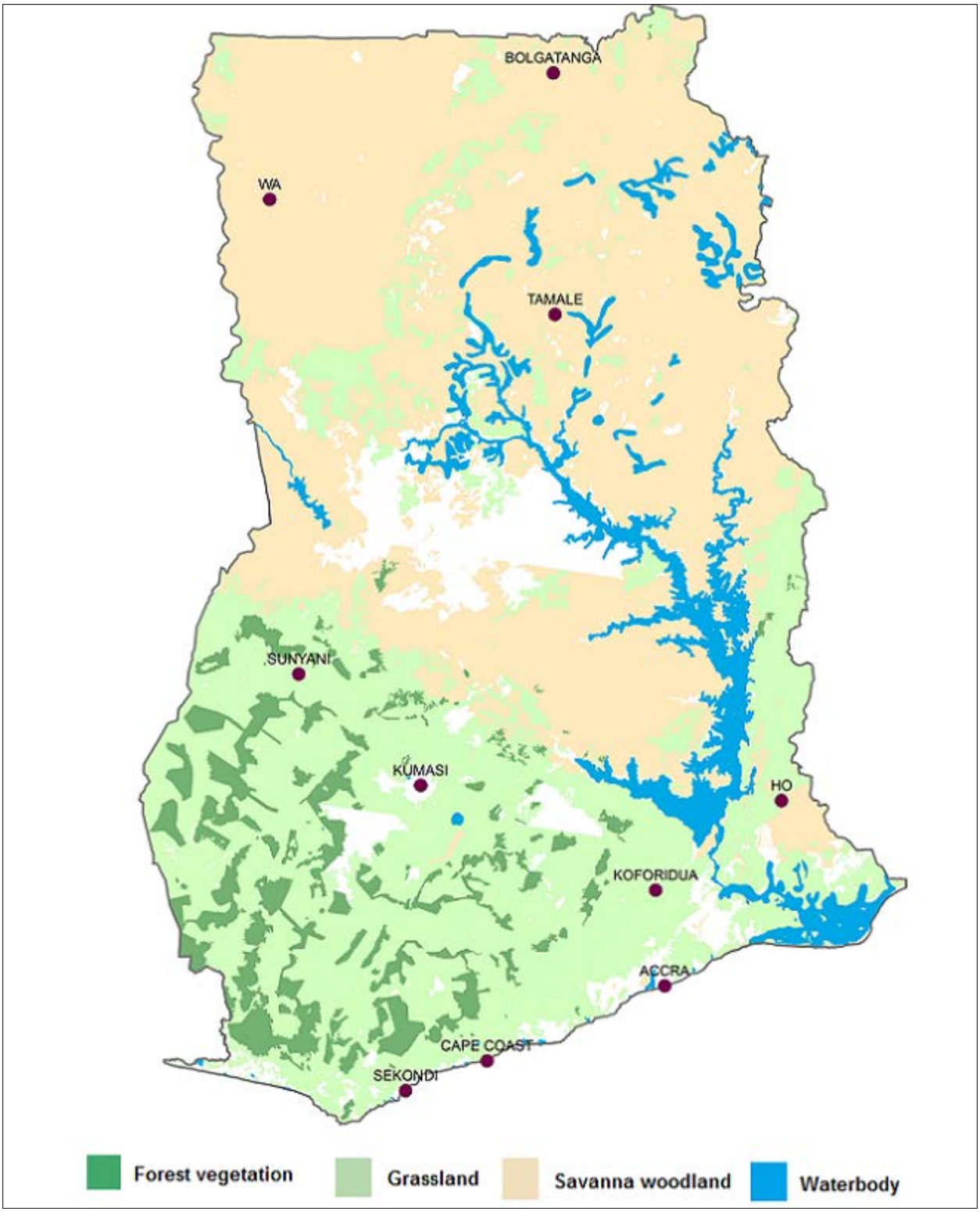
The vegetation of Ghana is dominated by grasslands mixed with south coastal shrub lands and forests. The forests extend northward from the south-west coast of Ghana 320 km and eastward for a maximum of about 270 km with the Kingdom of Ashanti or the southern part of Ghana being a primary location for mining of industrial minerals and timber. Savanna woodlands dominate the landscape towards the northern part of the country. Figure 4 presents the distribution of the major types of vegetation in Ghana.

The coastal savanna in the southeastern plains around Accra consists of a mixture of scrub and tall grass, with giant anthills, often 3 to 4 meters high, providing an anchorage for thicket clumps that often include Elaeophorbia (a fleshy-leaved plant containing caustic latex) and other drought- and fire-resistant species such as the baobab.

The forest zone covers about a third of the southern part of Ghana, with a mean annual precipitation exceeding 114 cm and is well distributed throughout the year without a pronounced dry season. The predominant vegetation within this zone is evergreen and tropical semi-deciduous forest. There are tall trees of varying heights, forming a closed canopy at the top, above which tower a few forest giants, such as the silk cotton tree, the wawa tree, and the African mahogany. The evergreen forest is in the extreme southwest, where the precipitation exceeds 165 cm a year, while there is a semi-deciduous forest farther north. The dense forest zone formerly covered an area of about 78,000 sq. km, but farming activities and timber exploitation have reduced it to less than 21,000 sq. km, including about 15,500 sq. km of reserved forest.

The third vegetation type, the northern savanna, is found in the northern two-thirds of the country, where the low annual precipitation, between 76 and 114 cm, occurs in a single season and is followed by a period of intense drought. The vegetation within this zone consists mostly of tall Guinea grass, together with a scattering of low trees, such as the shea butter tree, various species of acacia, and baobabs. Along the northern border the savanna gives way to a more open type of grassland that has developed largely as a result of prolonged human interference.

**FIGURE 4: MAJOR TYPES OF VEGETATION ZONES IN GHANA**




Source: Ghana at a Glance, EPA

### 3.3.2 ANIMAL LIFE

The development of human settlements and, as a result, human-related activities such as hunting has had the effect of reducing the relatively rich in animal life in Ghana. Large mammals that can be found in Ghana include lions, leopards, hyenas, antelope, elephants, buffalo, wild hogs, chimpanzees, and many other kinds of monkeys. Among the snakes are pythons, cobras, horned and puff adders, vipers, and green mambas.[7] Crocodiles, the endangered manatees, and otters are found in the rivers and lagoons, with hippopotamuses found in the Volta River. There are many species of lizards, tortoises, and giant snails.

Among the numerous birds are parrots, hornbills, kingfishers, eagles, kites, herons, cuckoos, nightjars, sunbirds, egrets, vultures, snakebirds, and plantain eaters.

The ocean, rivers, and inland lakes are rich in fish and other forms of life. Sardines, locally called herring, arrive seasonally in the coastal waters in large shoals; other fish include anchovy, tuna, mackerel, soles, skates, mullet, bonitos, flying fish, lungfish, elephant fish, sea bream, and sharks. Edible turtles, barracuda, and stingrays are fairly common; mussels, crabs, lobsters, and prawns also are found in the waters of Ghana.

Insect life is particularly abundant in Ghana. There are beetles, fireflies, ants, termites, butterflies, crickets, and bugs. Among the most dangerous insects are mosquitoes, tsetse flies, and blackflies, which are responsible for transmitting the endemic diseases of malaria and yellow fever, trypanosomiasis (sleeping sickness), and onchocerciasis (river blindness, a parasitic disease), respectively.

### 3.3.3 LAKES AND LAGOONS

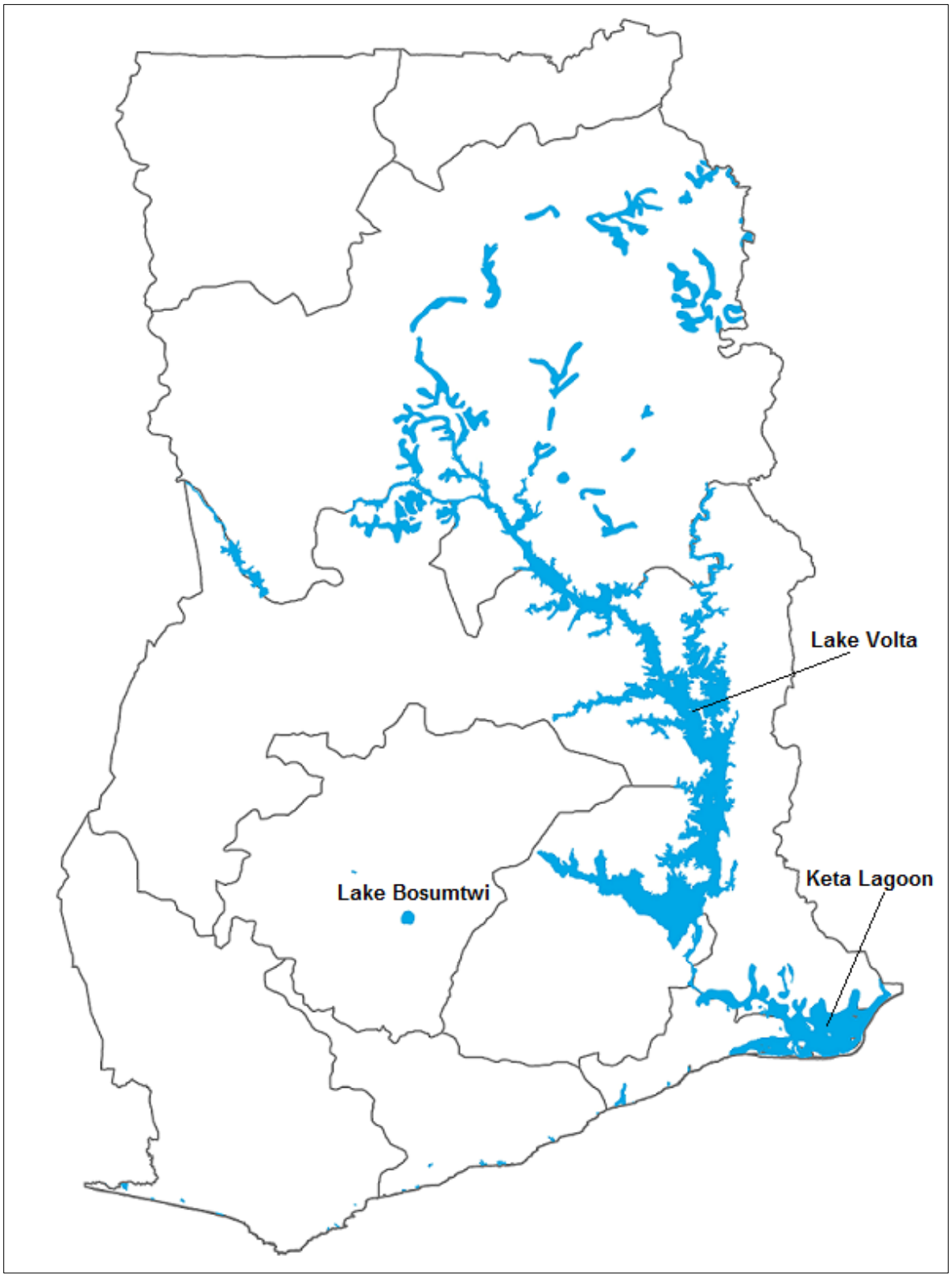
Ghana has two prominent lakes and many other smaller lakes. Ghana has the largest man-made lake in the world. Lake Volta, which is also the largest reservoir by surface area, was formed by damming the White Volta and the Black Volta to provide a hydro-electric power source for the country in 1965. The lake is 8,502 sq. km in surface area and is about 520 km long from north to south. The main islands within the lake are Dodi, Dwarf and Kporve and the Digya National Park lies on part of the lake's western shore. The lake completely submerged a forest after the construction of the dam and, in addition to the generation of electric power, provides other economic activities, such as fishing, transportation, and tourism. According to FAO statistics, inland capture fisheries contributed 27 percent of total Ghanaian fish production in 2009 (FAO FishStat Plus).

The other prominent lake in Ghana is Lake Bosumtwi in the Ashanti Region. Lake Bosumtwi is situated within an ancient meteorite impact crater, approximately 8 km across, and the only natural lake in Ghana. It is a popular recreational area with about 30 surrounding villages with a combined population of about 70,000 people. The people of the area regard the lake to be a sacred site, and as a result, fishing in the lake is only allowed from wooden planks. Fish species found in the lake are the endemic cichlid (*Hemichromis frempongi*), and the near-endemic cichlids (*Tilapia busumana*).

Besides Lake Volta and Lake Bosumtwi, the only standing, inland, large waterbodies are lagoons, such as the Keta Lagoon and Korle Lagoon. Figure 5 presents the distribution of lakes and lagoons in Ghana.

[7] Reptile Database. 2011. http://reptile-database.reptarium.cz/ Searched 1/9/2015

**FIGURE 5: LAKE AND LAGOON FEATURES OF GHANA**




Source: Ghana at a Glance, EPA

### 3.3.4 RIVERS

Ghana is drained by a large number of streams and rivers. In the wetter south and southwest areas of Ghana, the river and stream pattern is denser, but in the area north of the Kwahu Plateau, the pattern is much more open, making access to water more difficult. Several streams and rivers also dry up or experience reduced flow during the dry seasons of the year, while flooding during the rainy seasons is common.

The major drainage divide runs from the southwest part of the Akwapim-Togo Ranges northwest through the Kwahu Plateau and then irregularly westward to the Côte d'Ivoire border. Almost all the rivers and streams north of this divide form part of the Volta system. Extending about 1,600 km in length and draining an area of about 388,000 sq. km, of which about 158,000 sq. km lie within Ghana, the Volta and its tributaries, such as the Afram River and the Oti River, drain more than two-thirds of the country. To the south of the divide are several smaller, independent rivers. The most important of these are the Pra River, the Tano River, the Ankobra River, the Birim River, and the Densu River. With the exception of smaller streams that dry up in the dry seasons or rivers that empty into inland lakes, all the major rivers in the country flow into the Gulf of Guinea directly or as tributaries to other major rivers. Figure 6 presents the distribution of some major rivers in Ghana.

#### *3.3.4.1 THE DENSU RIVER BASIN*

The Densu River Basin has an area of 2,490 sq. km and spans 11 districts in 3 regions (i.e. Central Region, Eastern Region and the Greater Accra Region). There are about 200 settlements in the Basin and the total population is over 600,000, equivalent to 240 persons per sq. km. This figure is visibly far higher than the national average of about 100 persons per sq. km. The vegetation in the Densu river basin consists of coastal savannah, thicket and grassland in the south, and moist semi-deciduous forest in the north. The river takes its source from the Atewa Range and flows into the Weija Reservoir before entering the Gulf of Guinea through the Densu Delta Ramsar Site. The Densu River is includes the Weija Reservoir which supplies water for approximately half of the Accra Metropolitan Area.

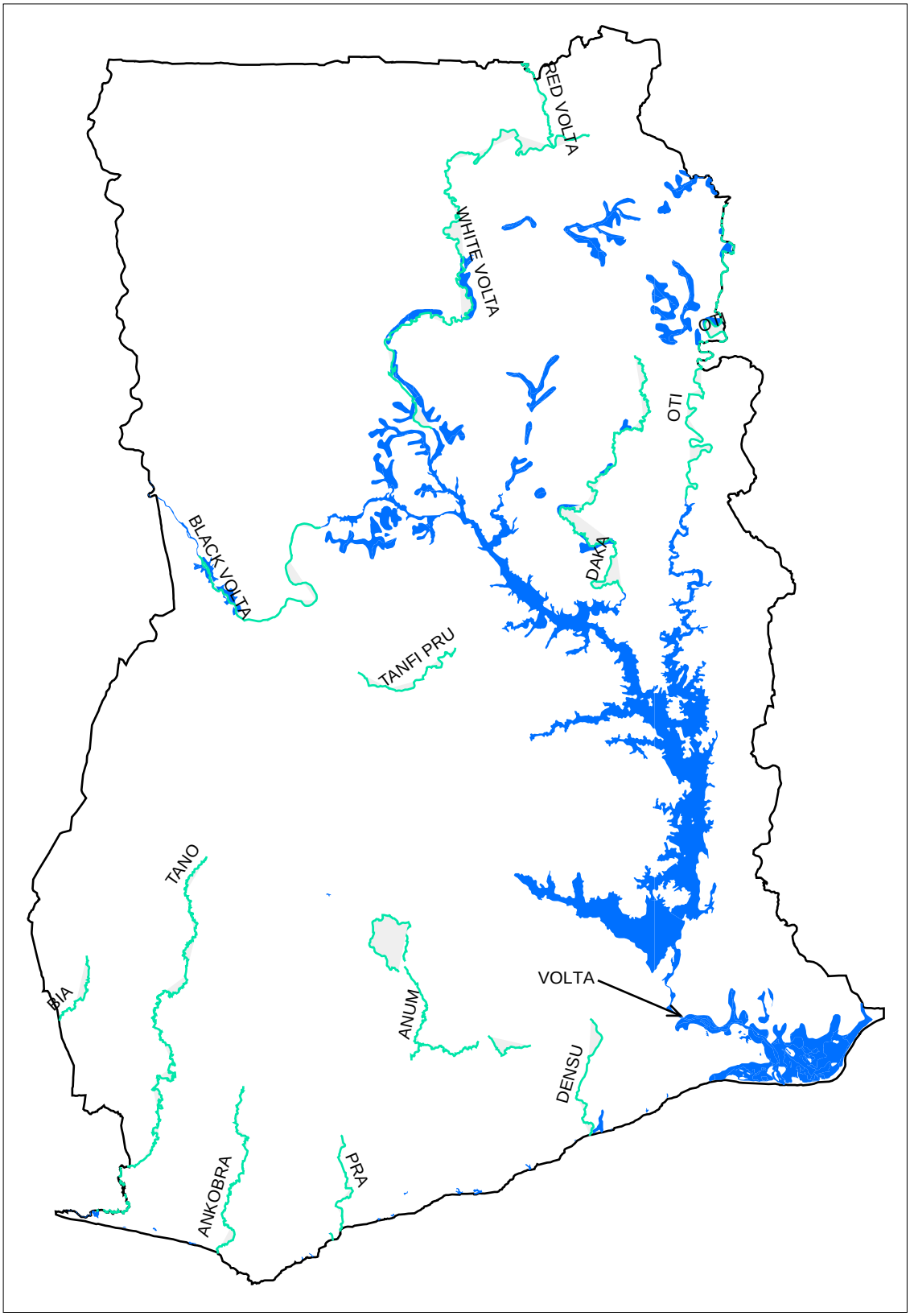
From the source to the Gulf of Guinea, the Densu River traverses upper Birimian rocks in the upper reaches, middle Birimian rocks in the middle segments and Togo series in the lower portions. The Densu Basin is generally low lying with undulating topography and isolated ridges forming the characteristic landscape features in many places. The soils are mainly well drained, friable, porous, loamy savanna ochrosols mostly red or reddish brown in color. The northern parts of the Basin include forest Ochrosol that are red or reddish brown, orange brown, or brown in color. Animals found in the basin grasscutters and rats. There are about 18 fish species in the Densu including the Weija Reservoir, with the most commonly fished species being Tilapia and Mud-fish.

#### *3.3.4.2 THE TANO RIVER BASIN*

The Tano Basin is one of the principal south-western river basins systems of Ghana. It has a total catchment area of about 15,000 sq. km, which spans almost 35% of Brong-Ahafo, 15% of Ashanti, and 50% Western Regions. The river basin drains a region of intensive gold mining activities. Its total catchment area is split between Côte d'Ivoire (7%) and Ghana (93%). The major tributaries include the rivers Abu, Amama, Boin, Disue, Gaw, Kwasa, Sumre, Suraw, and Totua.

The Tano basin lies within the wet evergreen (south-east) and the moist-semi-deciduous agro-ecological zones (AEZ) of Ghana. The Tano River Basin is underlain by alternate formations with lower Birimian greywacke making up 54% and Granitoids (43%) with minor Volta system at the extreme north, and a narrow unit of Eocene to Cretaceous sediments in the southernmost part of the basin, which stretches towards the coast (Water Resources Commission, 2012).

**FIGURE 6: MAJOR RIVERS OF GHANA**




Source: Ghana at a Glance, EPA

#### 3.3.4.3 THE PRA RIVER BASIN

The Pra River Basin's drainage network comprises the main Pra and its major tributaries of Birim, Anum, and Offin rivers and their tributaries. The drainage area is about 22,106 sq. km, with an average elevation of about 300m and generally less than 600m above sea level. It features the Lake Bosomtwi, which is a natural lake that stands out as a prominent protected area.

The Pra Basin is one of the most extensively and intensively used river basin areas in Ghana in terms of settlement, agriculture, logging and mining. The basin contains most of the large cocoa growing areas in the Eastern, Ashanti, and Central regions. Tree cash crop cultivation other than cocoa includes mainly oil palm. Food cropping is more commercialized especially around the medium and large settlements and along the major road axes. The basin contains the highest density of settlements (both rural and urban) in Ghana. It also has a high concentration of mining activities, mainly concerned with gold and other ground minerals.

#### 3.3.4.4 THE ANKOBRA RIVER BASIN

The Ankobra Basin is one of the south-western basins of Ghana. It is bounded to the East; West and South by the Pra Basin, Tano Basin and the Gulf of Guinea respectively. The basin has an area of 8,403 sq. km spanning 11 districts in three regions with Wassa Amenfi, Wassa West, and Nzema East Districts making 81% of the total area. The basin falls under the South-Western Equatorial and the Wet Semi-Equatorial climatic regions. The South-Western Equatorial is the wettest climatic region in Ghana with mean annual rainfall above 190 cm. The vegetation of the basin comprises the Rain forest as well as the Moist-semi deciduous forest.

#### 3.3.4.5 THE WHITE VOLTA BASIN

The White Volta sub-basin covers about 49,210 sq. km in Ghana, representing 46% of its total catchment area of 10,742 sq. km distributed in Ghana, Burkina and Togo. Its main tributaries are Morago and Tamne. The Morago has a total area of 1,608 sq. km with an area of 596 sq. km in Ghana and 912 sq. km in Togo. The Tamne lies entirely in Ghana with an area of 855 sq. km. The White Volta covers mainly the north-central Ghana and some parts of the Upper East and Northern Regions. It is located within the Interior Savanna Ecological Zone and is underlain by the Voltaian and granite geologic formations.

#### 3.3.4.6 THE AFRAM PLAINS

The Afram Plains are located in the southeastern corner of the Volta Reservoir. The terrain is low, averaging 60 to 150 meters in elevation, and annual rainfall is between 114 and about 140 cm, with much of the surrounding countryside is flooded or swampy during the rainy seasons. With the creation of Lake Volta in the mid-1960s, much of the Afram Plains was submerged. Despite the construction of roads to connect communities displaced by the lake, road transportation in the region remains poor. Renewed efforts to improve communications, to enhance agricultural production, and to improve standards of living began in earnest only in the mid-1980s.

#### 3.3.4.7 THE BLACK VOLTA BASIN

The Black Volta has a total catchment area of 142,056 sq. km including areas outside Ghana. Only 33,302 sq. km (23.5%) of the catchment area is located in Ghana. Its main tributaries are Kamba, Kuon, Bekpong, Kule Dagare, Aruba, Pale, San, Gbalon, Chridi, Oyoko, Benchi, Chuco and Laboni. The catchment areas are all within Ghana. The Black Volta basin is primarily located in northern-western Ghana. The basin includes portions of the Upper, Northern and Brong Ahafo Regions.

#### 3.3.4.8 OTI BASIN

The Oti River Basin has a surface area of 16,801 sq. km in northeastern Ghana. The basin includes portions of the Northern and Volta Regions. It also expands to Togo where it covers more than 40% of the land. The relief varies considerably from 150 m to 450 m in Ghana and much more in Togo. Annual rainfall in the basin varies from 101 cm in the north to 140 cm in the south. The Oti River Basin is entirely within the Interior Savanna Ecological Zone and is underlain by the Voltaian and Buem geologic formations. Current surface water usage in the basin is negligible and there have been no irrigation development potentials identified in the basin.

#### 3.3.4.9 DAKA BASIN

The Daka Basin covers an area of 7,424 sq. km located almost entirely in eastern part of northern Ghana. The annual rainfall on the basin varies between 112 cm and 134 cm and most of the biophysical characteristics found in the basin are similar to those of the Oti River Basin. The predominant land use is bush fallow cultivation of yam, maize, and guinea corn with free grazing animals. A recent land use problem within the greater part of the Volta basin especially in the Black Volta, White Volta, Afram, Daka, and Oti sub-basins is the activity of alien herdsmen who graze their large herds of cattle indiscriminately, leading to widespread destruction of vegetation and even crop farms. In some cases, bushfires are set to hasten the re-growth of fresh vegetation leading to high rates of soil erosion and loss of soil productivity.

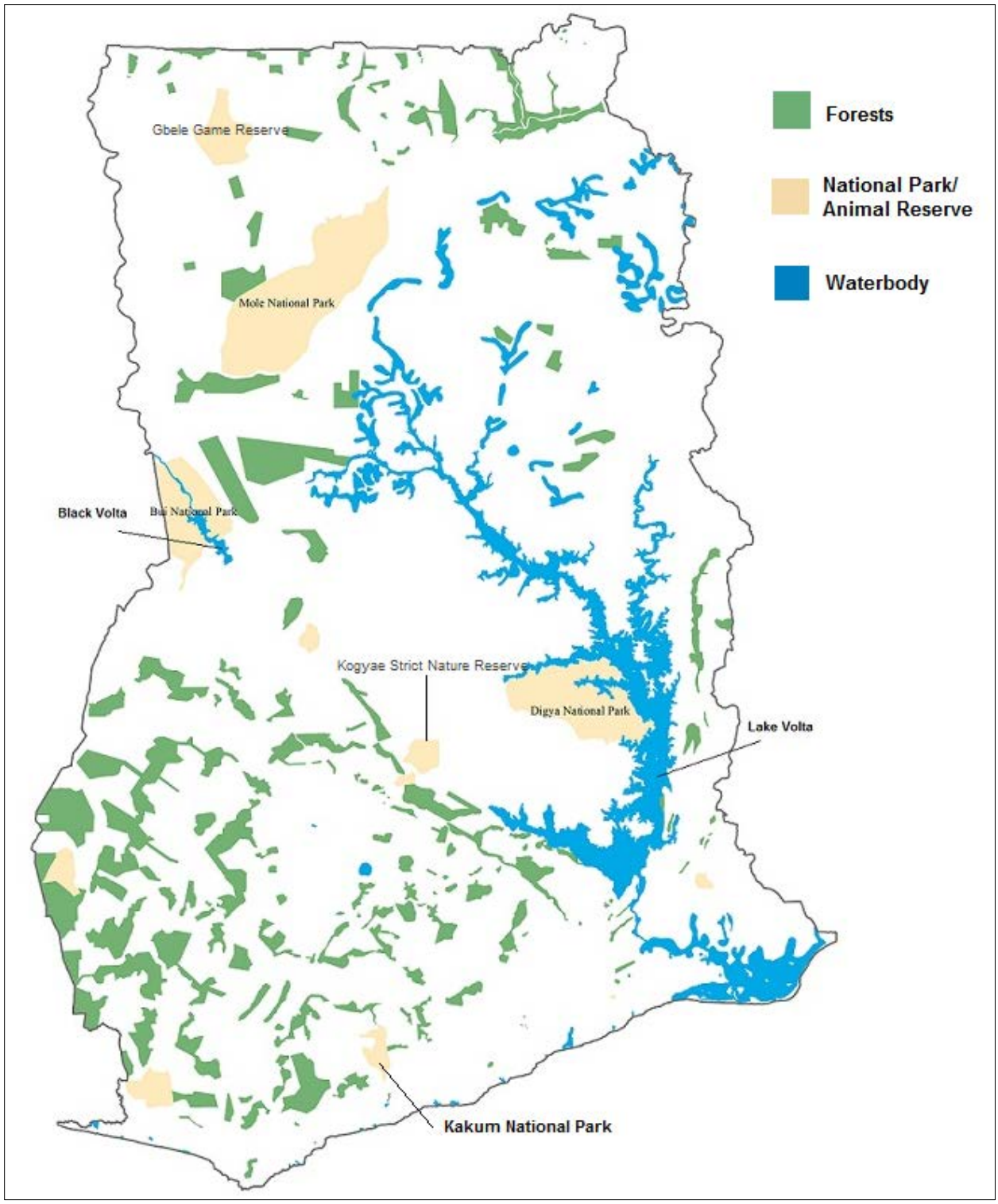
### 3.3.5 NATIONAL FORESTS AND ANIMAL RESERVES

About 22 percent (or about 49,400 sq. km) of Ghana is forested. Of this, 8 percent is classified as primary forest, the most biodiverse and carbon-dense form of forest, with about 2,600 sq. km of planted forest. Ghana's forests contain 381 million metric tons of carbon in living forest biomass. The forests of Ghana contain some 1,185 known species of amphibians, birds, mammals and reptiles according to figures from the World Conservation Monitoring Centre. About 1 percent of these known species exist in no other country, and 3 percent are threatened. Ghana is home to at least 3,725 species of vascular plants, of which about 1 percent exists in no other country. Some of the national forests in Ghana also serve as national parks or animal reserves. Figure 7 displays the national forests and game reserves (or national parks) in Ghana.

The Mole National Park near Damongo is about 4,900 sq. km in extent and has an abundant game population. The park is home to over 93 mammal species, and the large mammals of the park include an elephant population, hippos, buffalo, and warthogs. The park is considered a primary African preserve for antelope species including kob, defassa waterbuck, roan, hartebeest, oribi, the bushbuck, red duiker, and yellow-backed duiker. Olive baboons, black-and-white colobus monkeys, the green vervet, and patas monkeys are the known species of monkeys resident in the park. Of the 33 known species of reptiles, slender-snouted and dwarf crocodile are found in the park. Among the 344 listed bird species are the martial eagle, the white-headed and palm-nut vultures, saddle-billed storks, herons, egrets, the Abyssinian roller, the violet turaco, various shrikes and the red-throated bee-eater.

The newer Kakum National Park, which is located about 22 km north of Cape Coast and opened to the public in 1994, had originally been established as a timber reserve in 1932. It comprises about 360 sq. km of tropical rainforest. The most notable endangered species of fauna in the park are Diana monkey, giant bongo antelope, yellow-backed duiker and African elephant. It is also an Important Bird Area recognized by the Bird Life International with the bird area fully overlapping the park area. The bird inventory confirmed 266 species in the park, including eight species of global conservation concern. One of these species of concern is the white-breasted guinea fowl. Nine species of hornbill and the African grey parrot have been recorded. It is very rich in butterflies as well, and a new species was discovered in 1993. As of 2012, the densest population of forest elephants in Ghana was located in Kakum.

**FIGURE 7: GHANA FORESTS AND WILDLIFE GAME RESERVES**



The Digya National Park was gazetted in 1971 and covers an area of 3,478 sq. km. It is situated on the western shores of the Volta Lake. Guinea savanna woodland predominates with gallery forest along the major lines. The Park supports at least six primate species including black and white colobus, elephants and a variety of antelopes. Manatee and clawless otter are also reported to be present in the Park.

The Bui National Park was established in 1971. The site covers an area of 1,820 sq. km. The reserve is notable for its hippopotamus population in the Black Volta. The endangered black and white colobus monkey and a variety of antelopes and birds are also present.

The Gbele Game Reserve is situated in the Upper West Region of Ghana. It was created in 1975 to protect the many animal and plant species located within the Gbele catchment area. Gbele is closest to Burkina Faso on a trans-boundary migratory route for elephants and other mammals to and from the Naziga Game Ranch. It is 565 sq. km. The Gbele resource reserve is endowed with a wide range of birds in the wooded savannah forest along Kulpawn River such as raucous pied, long tailed parakeet, Senegal parrot, beaded barbet, kingfisher, hornbill and pygmy goose, purple heron, and Vieillot barbet. It also supports a number of larger mammals such as waterbucks, bushbucks, petas, baboons, and warthogs.

## 3.4 SOCIOECONOMIC ENVIRONMENT

Ghana's economy is a mixture of private and public enterprise. In 2013, the GDP was about $48 billion with a per capita GDP of $1,858.

National income is derived primarily from agricultural and mineral output and only to a limited extent from manufacturing and services. Most of the cash crops and mineral products are for export. The top-5 exports by value for Ghana are gold (44%), crude petroleum (18%), cocoa beans (15%), cocoa paste (2.3%), and manganese ore (1.3%). In terms of categories, precious metals (including, gold, precious metal scraps, and diamonds) account for about 44 percent, minerals (including, crude petroleum, manganese ore, and refined petroleum) accounting for 23 percent, and foodstuff (including, cocoa beans, cocoa paste, and processed fish) accounting for 20 percent of all exports (Observatory of Economic Complexity statistics).

### 3.4.1 AGRICULTURE AND ORGANIC FARMING

Although agriculture accounts for about 21.5% of Ghana's GDP – behind industry (28.7%) and services (49.8%) – it employs about 56% of the population (mainly small landholders). Major crops produced are cocoa, rice, cassava (manioc, tapioca), peanuts, corn, shea nuts, bananas, and timber. There is extensive use of chemicals in the cultivation of many cash and food crops in Ghana. Unfortunately, much of the use of agro-chemicals is not regulated and not as per label requirements. This unregulated use of agro-chemicals poses a serious risk to the growing organic farming sector in Ghana.

#### *3.4.1.1 ORGANIC FARMING*

In the past, much of the non-cash crop farming done in Ghana did not involve the use of pesticides. This was a result of the high cost of agro-chemicals, and to some extent, the lack of information on the part of the growers. Pesticide use for cash-crops was encouraged to improve the productivity, and thus export-earning capabilities of the crops. Over time, as farmers recognized the benefits of using chemicals to control pests and improve productivity, there was a large increase in the use of agro-chemicals. This increase in agro-chemical use also resulted in the use of chemicals for food crops such as vegetables. Ghana's organic farming sector started as a response to the export market for certified organic food products. Urban consumers also increased their demand for fresh organic produce. However, the majority of the organic products grown in Ghana are export commodities such as palm oil, fresh fruits, cocoa, bananas, cashew nuts, shea nuts, cotton, and vegetables.

Very little government support exists for organic agriculture in Ghana. However, some domestic and international non-government organizations have filled the void by providing technical support to enhance the organic production capacity and promote export.

#### *3.4.1.2 BEE KEEPING*

Beekeeping in Ghana is, to a large extent, a supplementary economic activity. Very little attention is paid to the use of bees as pollinators for the agricultural sector. There are an estimated total of about 22,063 beekeepers in Ghana, 7,085 (32%) of whom are women. Some 4,413 people are estimated to be employed by beekeepers on beekeeping activities, bringing the total number employed in this economic activity to about 26, 476.

Since the 1970s, a number of non-governmental organizations have been making significant strides in the introduction of modern beekeeping technologies, training, and the provision of beekeeping equipment in the sub-sector. In spite of these efforts, traditional honey production (e.g. use of clay pots and tree barks) and wild honey hunting still dominate the sub-sector (Akangaamkum, Agbenorhevi, and Okudzeto; 2010). Much of the beekeeping in Ghana is conducted away from homesteads: on farms and within forests. However, some of the bees (including those in the wild) may be found around homesteads during periods of the day.

## 3.5 SUMMARY

Ghana still has high prevalence and transmission rates of malaria and IRS has been demonstrated to help reduce these rates in the areas where it has been employed. Ghana also has a rich and diverse natural environment that needs to be preserved for future generations. The people are part of this environment, and they must be cared for as well. PMI has a strong record of IRS execution without environmental degradation, and it is highly likely that with continued adherence to the environmental mitigation and monitoring plan, which is key to this history of success, that implementing contractors will continue to deliver life-saving IRS with insignificant environmental impact. Therefore, it is recommended that IRS be permitted to continue in the areas identified by the NMCP.

# 4. PESTICIDE PROCEDURES

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 Implementing Partner in Ghana 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 Ghana.

## 4.1 A. THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S REGISTRATION STATUS OF THE REQUESTED PESTICIDE

Pesticides recommended by WHOPES and registered for IRS or a similar use in the United States and the host country government will be preferred in this IRS project. However, some of the pesticides on the WHOPES list are not registered with the USEPA, for economic reasons rather than technical ones. Because this is an economic issue rather than a technical one, US regulations permit the use of these insecticides, conditioned on the performance of the proper environmental assessments, as well as notification to and authorization from the host country government. There is widespread acceptance and use of these chemicals around the world, with a good database attesting to the safety of the chemicals when used as directed. PMI/USAID works closely with host country governments, with full and clear disclosure, as well as providing 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 Ghana EPA and MOH, provide the notification and mitigation requirements of US regulations. PMI/USAID is therefore empowered, upon the receipt of formal authorization from a competent Ghana entity, to allow the use of all WHOPES-recommended pesticides in the pyrethroid, carbamate, and organophosphate classes, and chlorfenapyr when recommended.

## 4.2 B. THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

In addition to the above criteria, insecticide selection for any PMI supported program is subject to international procurement requirements of the US Federal laws. Requests to purchase public health insecticides used in IRS must be initiated at class level, rather than for a particular insecticide (compound). The insecticide class to be used in IRS is selected each season based on a number of considerations.

### 4.2.1 PRIMARY CRITERIA FOR CHOOSING PESTICIDES

**Recommendation by the World Health Organization Pesticide Evaluation Scheme:** Only insecticides recommended by WHO can be used in IRS. Certain pesticides in the organophosphate, carbamate, pyrethroid, pyrrole, and organochlorine classes are WHOPES-recommended for use in IRS. Table 3 shows the list of WHO-recommended pesticides.

**TABLE 3: WHOPES RECOMMENDED PESTICIDES WITH EFFECTIVE DURATION, MARCH 2, 2015**

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

(1) CS = capsule suspension; EC = emulsifiable concentrate; SC = suspension concentrate; SC-PE = polymer enhanced suspension concentrate; WG = water dispersible granules; WG-SB = water dispersible granules packaged in water soluble bags; WP = wettable powder.
(2) 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 the country:** In the case where the insecticide proposed to be used for IRS is not registered in Ghana, PMI will work with the Ministry of Health and the EPA to obtain special authorization for the use of the pesticide.

**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 figure 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 make 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. The duration of effectiveness on the primary wall surface types will continue to be researched and considered when selecting insecticide class and active ingredient.

**Pesticide must be appropriate for use on the wall surfaces of the selected location:** Structures in Ghana are mainly of 3 different types: plastered and painted; plastered and not painted; and mud. Mud brick (or earth) and cement (or concrete) make up about 89 percent of materials used for outer walls. With regards to ceiling or roofing materials, corrugated metal sheets (60%), thatch (19%), and slate (13%) are the main materials used. Pyrethroids, carbamates, and

organophosphates are known to function well on mud and cement walled houses and are therefore appropriate for use.

A few villages also have structures made of woven grass (which seem like temporary structures) and wooden structures (in some communities living over water like Nzulezo in the Western Region). The current PMI IRS Project in Ghana does not operate in areas with these structures. However, if such structures are found in a target spray area, we will investigate whether the structures are sprayable before any determination is made to spray.

**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 Ghana, vector susceptibility studies are conducted by the PMI Implementing Partner in collaboration with the NMIMR. Recent entomology suggests some degree of resistance to DDT and the pyrethroid class in many geographical areas. The PMI Implementing Partner has confirmed the effectiveness of pirimiphos methyl in these districts. Pirimiphos methyl is now being used for IRS in the current spray districts to manage resistance and to take advantage of the long residual effect.

**Ecological impact:** Ghana boasts a diverse wildlife throughout the country, but especially in the National Parks and protected areas, it is extremely important that IRS does not in any way diminish this biodiversity. The ecological impact of the WHO 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 4.5 and 4.7 below, as well as other sections of this document.

**Human health impact:** The 2012 IVM PEA also 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).

### 4.2.2 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

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

IPM is defined[8] as:

[8] http://www.ipm.ucdavis.edu/IPMPROJECT/about.html

"...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."

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:

- *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 four primary interventions, insecticide-treated nets, indoor residual spray, larviciding, and wall lining. Other malaria prevention and treatment measures used are artemisinin-based combination therapies, and intermittent preventive treatment for pregnant women.

PMI strategy has been that IRS will be implemented as a component of IVM for malaria control, along with ITNs and preventative and curative drugs. PMI supports an evidence-based approach and will continue to review health management information systems ,entomologic data, as well as national and special surveys to determine where best to deploy IRS.

## 4.4 D. The Proposed Method or Methods of Application, Including Availability of Appropriate Application and Safety Equipment

IRS involves spraying a liquid insecticide with long lasting residual activity on indoor wall 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, 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 shoulder-hung 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 clean the sprayer following PMI BMPs to guard against release and/or exposure, and the manufacturer's recommendations to ensure their proper operation and calibration.

## 4.5 E. 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. A brief summary is given here for each insecticide, with the pesticide class in parentheses. P is for insecticides in the pyrethroid class, C for carbamates, OP for organophosphates, OC for organochlorines, and PR for pyrroles. The reader is referred to Annex E of the 2012 IVM PEA for greater detail about toxicity. Table 4 below provides information about the relative toxicity of the WHO-approved pesticides on various receptors.

**TABLE 4: PESTICIDE TOXICITY**

| IRS Insecticide | Mammal | Bird | Fish | Other Aquatic | Bee | Persistence | Bioaccumulate |
|---|---|---|---|---|---|---|---|
| **Alpha-cypermethrin (P)** | | | | | | | |
| **Bendiocarb ( C)** | | | | | | | |
| **Bifenthrin (P)** | | | | | | | |
| **Cyfluthrin (P)** | | | | | | | |
| **DDT (OC)** | | | | | | | |
| **Deltamethrin (P)** | | | | | | | |
| **Etofenprox (P)** | | | | | | | |
| **Fenitrothion (OP)** | | | | | | | |
| **Lambda-cyhalothrin (P)** | | | | | | | |
| **Malathion (OP)** | | | | | | | |
| **Pirimiphos-methyl (OP)** | | | | | | | |
| **Propoxur ( C)** | | | | | | | |
| **Chlorfenapyr (PR)** | | | | | | | |

Source: IVM PEA 2012

**Key**

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

### 4.5.1 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, 2000b). 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.

In the environment, most of the insecticides are highly toxic to fish and other aquatic organisms. Similarly, apart from pirimiphos-methyl all the approved insecticides are highly toxic to bees. In mammals, all the insecticides approved by WHO for IRS carry low-to medium toxicity, with the exception of lambda cyhalothrin and propoxur, which are categorized as highly toxic to mammals. In avi-fauna, only propoxur, fenitrothion, and chlorfenapyr are categorized as highly toxic with the rest categorized as low-medium in toxicity.

Specific hazards include exposure during handling (transporting or spraying), environmental release through vehicular accidents during transportation, and the possibility of fire causing combustion of pesticides, in storage or in transportation. These hazards are discussed in more detail, along with the mitigation measures to be employed, in the Environmental Mitigation and Monitoring Plan (Annex A)

### 4.5.2 Mitigation of Health Impacts

Training for supervisors, spray team leaders, spray operators, washpersons, store managers, and health officials include recognition of the symptoms of poisoning, incident response elevation protocol, and, for the medical professionals, the treatment protocols for each pesticide. In addition, for 2015, PMI will conduct a limited bio-monitoring of spray teams in Ghana aimed at detecting any inadequacies in PPE use when OPs are sprayed. Results of the limited bio-monitoring will inform any needed update to the training for spray teams in successive years. Exposure treatment for the proposed carbamate-, organophosphate-, pyrethroid-, and chlorfenapyr-based pesticides is detailed in Annexes B & C.

Specific measures to mitigate transportation-related exposure will include:

- Training drivers before they transport insecticides from the customs warehouse or central storage facility to the local storage facility.
- Ensuring that drivers are thoroughly knowledgeable about the toxicity of insecticides, and that training includes information for drivers to respond to scenarios related to the transport of specified insecticides.
- Preventing pesticide contamination in vehicles rented for the project in order to avoid negative consequences when the vehicles are used for other purposes, such as food transport. To prevent pesticide runoff from vehicle washing, drivers are responsible for wiping the vehicle bed with a damp cloth before washing the exterior of the vehicle

Other than transporters, storage area personnel, and spray teams, the people at risk of exposure are primarily the beneficiary population in the targeted communities. Acceptance of the pesticide and indeed of the IRS intervention among the targeted households is a primary external factor, and is critical for the overall safety of the program and environmental compliance. The Information, Education, and Communication (IEC) program is the primary tool for gaining this acceptance. It is important that the targeted community and households are adequately educated on safety, including procedures for removing personal belongings prior to spraying, observing the required exclusion period, and avoiding contact with sprayed surfaces on an indefinite basis.

IEC programs have been and continue to be implemented in targeted communities under the IRS operation. The campaign includes radio spots for mass media announcements and also direct communication through mobilizers, and through the spray operators themselves. Communities are mobilized by local governments and administrations. Clear instructions are provided on what to do before and after the house is sprayed, including the removal of all foodstuffs and cooking utensils during spraying, barring of entry into the sprayed rooms for at least two hours, ventilation of the structure for an additional half hour, and preventing the re-entry of children and animals until the floors have been swept clean or washed. Targeted training of selected health care providers is provided at the region, district, and community levels on the management of pesticide poisoning.

### 4.5.3 Mitigation of Environmental Impacts

Environmental impacts are mitigated through extensive training for all personnel and all aspects related to IRS. Potential impacts have been evaluated, and methods developed to eliminate or reduce these impacts. In particular, proper methods of pesticide storage, transportation, preparation and application and waste disposal are well-documented and enforced. For more information on the risks of IRS and the measures for mitigation, refer to the EMMP (Annex A).

## 4.6 F. 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. Selection criteria have been expounded upon in Section 4.2. 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 the PMI Implementing Partner, 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). The major vectors are *Anopheles gambiae* and *An. funestus*. These species generally bite late in the night, will rest both indoors and outdoors, and are most common in the rural and peri-urban areas. This makes them suitable targets for IRS. Outdoor biting is common in the northern savannah. *Anopheles melas* is also found in the mangrove swamps of the southwest and *An. arabiensis* in savannah areas of northern Ghana. These species have been found to rest outdoors after feeding.

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.[9] 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 operational criterion for suspecting vector resistance is having 2% or more survival rate in the number of mosquitoes tested using standardized methods of the WHO.[10]

The residual efficacy of the pesticide being used for IRS is crucial to evaluating the implication of vector resistance. Generally, a positive correlation between observed vector resistance and a decline in pesticide efficacy is an important criterion in determining the need for a change of the pesticide in a local area. It is important that wall bioassays 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 are taken prior to shipment, 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

## 4.7 G. 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 4). 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. 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 in a municipal landfill as per the IRS BMPs, or contaminated solid wastes are incinerated in an incinerator capable of destroying the pesticide and

[9] WHO. (2012) Global plan for insecticide resistance management in malaria vectors. World Health Organization, Geneva.

[10] WHO. (2013) Test procedures for insecticide resistance monitoring in malaria vectors. World Health Organization, Geneva.

preventing environmental contamination. The Environmental Mitigation and Monitoring Plan (Annex A) details the measures that have been and will be enacted to prevent contamination of ecosystems.

## 4.8 H. The Conditions under Which the Pesticide is to be Used

Chapter 3 of this document provides a detailed account of the environmental conditions in Ghana under which the pesticide is to be used. IRS is scheduled to be performed prior to the rainy season in each location 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 habitat will be protected, and all insecticides will be kept away from all water habitats and resources. IRS will be prohibited within 30 meters of protected ecosystems, such as the core areas of national forests. Prior to spraying, the implementing contractor will identify non-eligible structures in sensitive areas, and train sprayers to identify houses that should not be sprayed. The contractor will consult with EPA and the Forestry Commission of Ghana 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.

## 4.9 I. The Availability and Effectiveness of Other Pesticides or Non-Chemical Control Methods

This IRS program is limited to using those pesticides that are on the WHO list of recommended pesticides. WHO currently recommends 15 insecticides from four chemical groups for IRS, each with a specific dosage regime, duration of effectiveness, and safety rating.[11],[12] Each of these agents has been evaluated for effectiveness within the program, and continuing monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign.

The recommended insecticides (see Table 4), are effective for differing periods, generally categorized as 2-3 months, 3-6 or 4-6 months, and >6 months. Within this range, the effective period depends on local circumstances, including dosage actually applied, wall type, climate (temperature and humidity), and resistance to that chemical in the mosquito population.

[11] Najera JA, Zaim M (2002). Malaria vector control – Decision-making criteria and procedures for judicious use of insecticides. WHO, Geneva, WHO/CDS/ WHOPES/2002.5. (Document available at: www.who.int/ctd/whopes/docs/JudiciousUseRev.pdf)

[12] Chlorfenapyr is currently under consideration to be included. The 17th WHOPES Working Group (2014) recommended that, considering the potential efficacy of chlorfenapyr to kill pyrethroid-resistant Anopheles, further evidence be gathered in Phase II to assess the efficacy of indoor residual application of chlorfenapyr 240 SC against malaria vectors, following the WHO guidelines for IRS. It is recommended that the trials should be conducted at a minimum of three study sites, the applied doses should comply with target doses, the vectors are susceptible to chlorfenapyr, and use should be made of appropriate positive controls (i.e. WHO-recommended insecticides for IRS) to which local vectors are susceptible (control 1) and resistant (control 2). If, in a specific situation, local vectors are not susceptible to the positive controls, in at least the two other study sites the local vectors should be susceptible to the positive controls.

For IRS to be effective, the NMCP must either use a chemical that lasts longer than the average malaria transmission season or conduct multiple rounds of spraying to achieve continuous control with a shorter-lived chemical. Thus, current formulations of carbamates that are effective for 3-6 or 4-6 months may be sufficiently effective with one application per year in an area with a short transmission season zone, but would require two applications per year if used in zones with perennial transmission.

Non-chemical means of malaria vector control are examined and discussed under section 4.3, 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. However, wherever possible, non-chemical means will be employed.

## 4.10 J. The Requesting Country's Ability to Regulate or Control the Distribution, Storage, Use, and Disposal of the Requested Pesticide

### 4.10.1 Environmental Protection Act (Act 490), 1994

Environmental Assessment Regulations

Part I of the Legislative Instrument deals with registration and permitting procedures before a project is provided with a go ahead. These procedures were derived from the main Environmental Legislation, Environmental Protection Agency Act, 490.

Specifically, these regulations specify that any new developments are to register with the EPA, conduct an environmental assessment of their proposals and submit an environmental assessment report to the EPA for review. Environment Permit is granted for the development to start when EPA is satisfied with the assessment conducted and the mitigation measures proposed for any environmental impact likely to be associated with the project. This SEA report will be submitted to EPA for review and approval as required before the spray operations commence. This IRS must therefore fulfill the requirement for ensuring that all investments are subjected to environmental assessment as represented by this SEA report.

### 4.10.2 Pesticides Control and Management Act, 1996

The third statute of the EPA, but not a very well-known one, is the Pesticides Control and Management Act, 1996, (Act 528). This law deals with pesticide importation licensing and permitting procedures, sale among others. Under the Chemicals Control and Management Centre (CCMC) of the EPA the mission of CCMC is to ensure the proper labelling, distribution, storage, transportation, use, application, and disposal of chemicals and associated hazardous waste within Ghana through fair and equitable implementation and enforcement of the Act.

CCMC provides the regulation on the use of pesticides for agriculture, horticulture, forestry, gardening and public health and other pesticides related uses as well as monitoring the use of pesticides and take enforcement action against illegal use. It also provides permitting of chemical imports and exports as well as Pesticides Registration & Licensing.

This Act is significant to the IRS program in the sense that all the pesticides proposed for use must be registered for use under the Act including importation licenses. Pyrethroids, organophosphates, and carbamates have been registered for use in public health under this Act. If chlorfenapyr is proposed for use for IRS in Ghana, PMI will work with the MOH and EPA to get it registered before purchasing and using it as an IRS pesticide.

### 4.10.3 INSTITUTIONS

The Ghana Environmental Protection Agency was established in 1994. Its functions include advising the Minister for the Environment on policies on all aspects of the environment (Section 2 of the EPA Act 1994, Act 490). The Agency is also supposed to co-ordinate activities of all bodies concerned with the environment and to be the link between such bodies and the Ministry of the Environment. It has responsibility to co-ordinate the activities of bodies that generate waste with the aim of controlling the generation, treatment, storage and transportation of industrial waste. It must protect and improve the quality of the environment. It has power to issue environmental permits and pollution abatement notices to control waste discharges and emissions and to prevent or reduce noise pollution. It is supposed to provide standards and guidelines in relation to air, water and other forms of environmental pollution. It also has authority to ensure that developers comply with environmental impact assessments of their development plans before they begin development.

The EPA by virtue of its mandate and functions is one of the institutions that are involved in all aspects of pesticide application and management. It ensures, through the concept of Environmental Impact Assessments (EIA) that the negative impact of development projects are reduced through the monitoring of the proponents mitigation plans.

**TABLE 5: SUMMARY OF LEGISLATIVE REQUIREMENTS**

| Legislation | Significance | License/Permit | Responsibility | Action |
|---|---|---|---|---|
| EPA Act | Require EIA report before approval for commencement of project. | Issues EIA license after which project can commence | PMI IRS Implementing Partner is responsible for preparing and submitting the EIA report. | EIA report was prepared and submitted before operations began. |
| Pesticide Control and Management Act | All pesticides to be procured must be reviewed by the Chemicals Control and Management Centre | Permit for importation and licenses given | PMI IRS Implementing Partner will present the list of pesticides it intends to procure the center to get necessary permits. | |

## 4.11 K. 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. USAID has developed guidelines for IRS operations (*"Best Management Practices (BMP) for Indoor Residual Spraying (IRS) in Vector Control Interventions", updated 2015*), and Were (2014) provides a training manual *"Spray Operator Pocket Guide"*. Other resources include the *WHO-UNEP Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning,*[13] USAID PMI's IVM PEA

[13] WHO-UNEP Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning: A Resource Tool. World Health Organization, Geneva. 332 Pages. Document also accessible at: http://www.who.int/whopes/recommendations/IPCSPesticide_ok.pdf

(USAID, 2012 Update), as well as this SEA, all provide precautions and recommendations on many aspects of IRS operations. The IRS BMP manual and the PMI IVM PEA mitigation measures are used as a starting point for developing country-specific mitigation measures, but other documents may be used for reference. It is not incumbent upon the implementing partner to comply with non-PMI documentation except where required by law and as outlined in the EMMP (Annex A).

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Ghana. 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[14] 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 identification of temporary workers recruited from local areas and trained as spray operators and wash persons. New operators will receive five to seven days of training prior to the spray operations. Priority areas of training will include:
  - How to properly mix the pesticide, including for liquid organophosphate, triple-rinsing the pesticide container while filling the sprayer,
  - Correct spraying (maintaining 35-55 psi pressure, spray nozzle at 45 cm from the sprayable surface, swath overlap, etc.),
  - The correct use of protective materials and related safety precautions,
  - Support to households on safety issues,
  - Personal safety relating to the different pesticides used for IRS (carbamate and organophosphate-based pesticides, as well as the pyrethroids which are currently in use),
  - Environmental safety in relation to pesticides, including management of the empty pesticide sachets, disposal of any leftover pesticide, and proper clean-up equipment and techniques, and,
  - The use of daily spray cards and data entry.

## 4.12 L. 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. The immediate (output) level relates to the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors, and involves direct entomological evaluations on pesticide contact bioassays and related pesticide resistance methodologies as recommended by WHO.[15] The second broad level of measuring the effectiveness of the pesticides relates to the general goal of reducing the local disease burden. This will require

[14] These are usually health-related government staff within the targeted district (health assistants/educators/ inspectors, nursing assistants, and community development assistants).

[15] WHO (2103) Test procedures for insecticide resistance monitoring in malaria vectors. WHO/HQ, Geneva, World Health Organization.

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) composition. This area is ripe for research, and any contributions that could be made towards increasing the knowledge of the relationship between these variables and the resultant effectiveness of the pesticide would be very valuable.

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 Ghana, this characteristic may be critical to the success of IRS. Therefore, the CS formulation of pirimiphos methyl has been used for PMI spraying in the Northern Region of Ghana since 2013.

# 5. ENVIRONMENTAL AND HEALTH IMPACTS

This section addresses the risks and hazards of the IRS program in Ghana.

## 5.1 POTENTIAL POSITIVE EFFECTS OF THE IRS PROGRAM

### 5.1.1 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.

### 5.1.2 INDIRECT POSITIVE EFFECTS

The IRS program will also indirectly contribute in the enhancement of the local economy in the following indirect ways: spray operators, washers, mobilizers, supervisors will all receive a daily payment for their work. There will also be human and institutional capacity building in the form of training of a large number of people associated with IRS operations. A reduction in household pests may result in a reduction in other diseases carried by the pests. By reducing the malaria burden, the IRS program will improve the education level amongst children of school going 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.

## 5.2 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.

### 5.2.1 DIRECT POTENTIAL ADVERSE EFFECTS

#### *5.2.1.1 CONTAMINATION OF SURFACE WATERCOURSES AND UNDERGROUND WATER*

During IRS implementation, it is possible to accidently 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 deliberate 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 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 the sites for soak pits are carefully chosen according to

criteria in the PMI BMPs, and secondarily because pyrethroids, OPs, and carbamates degrade very quickly when exposed to sunlight and in the soil. If wash areas and soak pits are properly constructed and used, liquid pesticide waste will be captured in the charcoal layer of the soak pit and held until it breaks down by natural processes.

#### *5.2.1.2 Impacts to Birds, Fishes, and other organisms from pesticides*

The degree of toxicity of the four WHOPES-recommended pesticide classes and chlorfenapyr to birdlife, aquatic life and insects especially bees including the degree of persistence and bio-accumulation is well-documented and very important to remember. See Table 4 in Section 4.5 of this SEA for details.

#### *5.2.1.3 Impacts on Bees*

Bee keeping in Ghana is mainly conducted away from the household and the sale of honey provides some income to the residents. 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. The project will make conscientious efforts to identify locations where beehives are kept, and observe a 30 meter no-spray buffer zone around them.

## 5.3 Indirect Adverse Effects

After completion of the IRS program, USAID will properly dispose of the IRS equipment in the hands of the District Health Offices and with the communities; and will no longer supervise its use. IRS equipment left to district health officials includes backpack compression sprayers, used, clean boots, wash basins, progressive rinse barrels, etc. that are still in operable condition. The conduct of IRS by District Health Officers with communities, using properly working equipment left behind by USAID 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 through the on-going PMI capacity building activities among the District Health Officers, the total pesticide load on the environment is expected to be less than if the donation is not made

### 5.3.1 Summary of Toxicity of pesticides to Avifauna, Aquatic life, Mammals and Insects by Class

#### *5.3.1.1 Pyrethroids:*

- All pyrethroids are highly toxic to bees and highly toxic to fish and other aquatic organisms except Deltamethrin, which has low toxicity to other aquatic organisms[16].
- Birds, if exposed, are most affected by bifenthrin (low to medium toxicity). All other pyrethroids have very low toxicity to birds.
- In the pyrethroid class, only lambda cyhalothrin is highly toxic to mammals. Alpha-cypermethrin and etofenprox have very low toxicity to mammals while bifenthrin, cyfluthrin and deltamethrin have low to medium toxicity.
- In terms of persistency in the environment, only cyfluthrin is considered persistent. The rest of the pyrethroids have low to medium persistence.

[16] USAID's IVM PEA

- Bifenthrin does not accumulate in the environment. Potential for bio-accumulation in aquatic organisms for deltamethrin and cyfluthrin is relatively low while lambda-cyhalothrin is medium and alpha-cypermethrin is high.

#### 5.3.1.2 CARBAMATES (BENDIOCARB AND PROPOXUR)

- Carbamates are highly toxic to bees, and have the potential to cause cholinesterase depression in humans. Care must be taken to avoid skin contact with carbamates, especially by spray operators. All spray personnel should be trained to recognize the symptoms of cholinesterase depression, and know the protocol for obtaining medical assistance.
- In addition to other aquatic organisms propoxur is also highly toxic to mammals and birds. Acute symptoms of propoxur poisoning in birds include eye tearing, salivation, muscle incoordination, diarrhea, and trembling. Depending on the type of bird, poisoning signs can appear within 5 minutes of exposure, with deaths occurring between 5 and 45 minutes, or overnight. On the other hand this insecticide has very low toxic properties on fish.
- Bendiocarb has low to medium toxicity on mammals and birds.
- In general both carbamates have low to medium indications for persistency in the environment and bioaccumulation in organisms

#### 5.3.1.3 ORGANOPHOSPHATES (OPS)

- OPs have different characteristics and impacts on different organisms depending on the type of insecticide. However, all three WHO-approved OPs have the potential to cause cholinesterase depression in humans and other organisms, and *skin contact with these pesticides must be strictly avoided, especially by spray personnel*. All spray personnel should be trained to recognize the symptoms of cholinesterase depression, and know the protocol for obtaining medical assistance.
- Fenitrothion has low toxicity on mammals and fish and is not persistent in the environment. However it is highly toxic to bees, birds and other aquatic organisms, like crustaceans and aquatic insects and has a medium toxicity to aquatic worms. It has moderate to medium potential to bioaccumulate in organisms.
- Malathion is only highly toxic to bees. It has very low impacts on fish and other aquatic organisms, and has a very low potential to bioaccumulate in organisms or persist in the environment. Its toxicity on mammals and birds is low to medium.
- Pirimiphos-methyl is highly toxic to fish and other aquatic organisms and has a high potential to persist in the environment. It has low to medium toxic effects on mammals and bees. It does not bioaccumulate in organisms.

#### 5.3.1.4 CHLORFENAPYR

- Chlorfenapyr has high acute, sub-acute, and chronic (reproductive) toxicity in birds. The acute toxicity of chlorfenapyr to birds is high to very high. The subchronic toxicity to birds is also very high. Although (lab) results suggest that there is a considerable potential for the use of chlorfenapyr to cause acute and reproductive toxicity in wild birds, there appear to be no reports of detectable impacts on birds or other wildlife when these have been closely monitored in areas where chlorfenapyr has been used.
- Chlorfenapyr poses an acute poisoning hazard to aquatic organisms
- Chlorfenapyr is very toxic to honeybees and very highly toxic to mosquitoes

## 5.4 HUMAN EXPOSURE RISKS/IMPACTS

Exposure risks of all WHO approved pesticides in relation to cancer and non-cancer endpoints, and with respect to exposure dosage, Hazard Quotient and the Life Time Average Daily Dose 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.

### 5.4.1 INHALATION EXPOSURE AND RISK DURING MIXING

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

### 5.4.2 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.

### 5.4.3 INHALATION EXPOSURE AND RISK DURING SPRAYING

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

### 5.4.4 DERMAL EXPOSURE AND RISK DURING SPRAYING

- Of the proposed pesticides, fenitrothion and pirimiphos-methyl have non-cancer risks due to dermal exposure.

### 5.4.5 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.

### 5.4.6 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.

### 5.4.7 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.

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

- Only deltamethrin is registered 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 recycle 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.

### 5.4.9 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.

### 5.4.10 WORKER AND RESIDENT EXPOSURE PATHWAY

During the IRS spraying process, spray personnel are at risk of un-intentional 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.

#### *5.4.10.1 PRE SPRAYING EXPOSURE PATHWAY*

Preparing pesticide solutions during the IRS requires pouring the pesticide in the spray pump to ensure ample mix with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, mostly from releases of pesticide vapors, and solutions. Vapor releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapors or 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.

#### *5.4.10.2 EXPOSURE DURING SPRAYING*

Inhalation of aerosol vapors 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.

#### *5.4.10.3 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. Ingestion exposure can occur from drinking contaminated surface water. Once the excess formulation gets into the soil, the pesticide can reach the groundwater, which may be used as a water supply via household wells. Residents may then be exposed to this contaminated water by ingestion or by dermal contact when it is used for cleaning or drinking purposes.

#### *5.4.10.4 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.

## 5.5 CUMULATIVE IMPACT

The combined, incremental effects of human activity, referred to as cumulative impacts, pose a serious threat to the environment. Cumulative impacts develop over time, from one or more sources, and can result in the degradation of important resources.

The critical resources or ecosystems that can be affected by the IRS program over a period of time especially with regards to pesticide application include water supply, food supply, waste assimilation/disposal capacity, river, lake, and stream quality, agriculture, aquaculture, apiculture, human and animal health, biodiversity resources, environmental services, and others. Pesticide run-off and accumulation in the rivers, streams and other water bodies, can lead to the progressive contamination of the water resources and reduction of aquatic biodiversity. However, using the IRS BMPs reduces the likelihood of releases, and the chances of a series of releases within the pesticides half-life are extremely unlikely, except in the case of willful malfeasance.

Continuous human exposure to pesticides over time can lead to health risks or complications, especially among spray operators and others in close contact with pesticides. This is particularly true in the case of OPs. However, the risk assessment performed in the IVM PEA indicates minimal exposure with the use of proper technique and appropriate PPE, i.e. dust masks, helmet, face shield, gloves, overalls and boots that minimize exposure by dermal absorption or inhalation, and a great reduction in the potential for harm. In order to confirm that spray operator use of PPE, as per the BMP, is sufficient for preventing significant health risks or complications among the spray team, PMI will perform limited bio-monitoring in 2015 in Ghana. Results of the limited bio-monitoring will inform any needed update to the training for spray teams in successive years.

The sprayed pesticides solidify on the walls, ceilings, and eaves of the structures, and become largely immobile and significantly less harmful. Exposure to the occupants will be further reduced by the procedures and safety measures described in the EMMP.

Pyrethroids, OPs and carbamates degrade very quickly when exposed to light and to the external environment, thus the cumulative and residual adverse impacts of their use will be insignificant. The soak pits used for waste disposal are designed to break down influent pesticides wastes within about three months, while the pesticides are held by the charcoal used in pit construction.

The long-term use of any pesticide could lead to insecticide resistance. To minimize this cumulative impact, insecticide resistance is actively monitored. The proposed action is designed with the concept of vector monitoring, insecticide rotation and mosaicking which will reduce the future incidence of vector resistance.

# 6. SAFER USE ACTION PLAN

This section outlines the safer use action plan proposed for the potential adverse impacts outlined above. 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. The mitigation measures, along with monitoring and reporting information, are compiled in the EMMP found in Annex A and in Annex D.

### 6.1.1 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. It is assumed that all pesticides procured from reputable manufactures are of good quality and testing in country is not required. PMI and the IRS Implementing Partner will have a certified laboratory do quality assurance tests on all batches of insecticide from the manufacturer before they are used for IRS.

### 6.1.2 PESTICIDE TRANSPORT

After the procurement of the insecticides for use during the current IRS campaign, insecticides are expected to move to the district warehouses by road. During transportation, there is a risk of vehicle accidents and consequently insecticide spillage. The transport must comply with Ghana's environment management regulation, Act 490, the Environmental Protection Act of 1994, regarding hazardous substances, pesticides and other toxic substances and the guidelines of EPA on transport of pesticides.

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

- Purpose of the insecticide.
- Toxicity of the insecticide.
- Security issues, including implications of the insecticide getting into the public.
- Hazardous places along the routes to be taken, and mitigation measures.
- Steps to take in case of an accident or emergency (according to FAO standards).
- Combustibility and toxicity of combustion byproducts of insecticide.

Drivers hired specifically for the spray campaign period will receive:

- Training in operator transportation best practices and vehicle requirements from PMI BMP #2, Worker and Resident Health and Safety.
- Training provided to spray operators (with the exception of sprayer operation and spray practice).
- Handling an accident or emergency (according to FAO standards).
- Handling vehicle contamination.

The vehicles to transport insecticides must be in good condition and preferably a lockable box truck. Insecticides must be kept locked at all times during transportation. If the pesticides are to be left unattended for any period of time, including lunch breaks or overnight stops, a lockable box truck is required.

**FIGURE 8: EMERGENCY RESPONSE TO INSECTICIDE SPILLS**

**IN CASE OF INSECTICIDE SPILLS**

- Control, contain and clean up the spill
- Protective clothing should be donned prior to attempting to clean the spills.
- It is imperative to avoid fire as a result of the accident and a fire extinguisher should be deployed just in case. The engine should be shut off and smoking in the area strictly prohibited.
- Onlookers and bystanders should be cautioned against approaching the accident site.
- If the crew has come in contact with the pesticides, they should remove contaminated clothing immediately and wash the pesticide off their skin.
- For major spills send for help immediately; drivers should have cell phones and an emergency number for use in such cases.
- People should 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.
- Vehicles that are used for transporting large quantities of pesticides should 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, including food, it is important to ensure that vehicles are decontaminated. 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.

### 6.1.3 WAREHOUSE/STORAGE RISK MANAGEMENT

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

- All primary pesticide storage facilities will be double-padlocked and guarded on a 24 hour basis.
- All the storage facilities will be located away from nearby watercourses, domestic wells, markets, schools, hospitals, etc.
- Soap and clean water will be available at all times in all the facilities.
- A trained storekeeper will be hired to manage each facility.
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed.
- All the warehouses will have at least two exit access routes in case of fire outbreak.
- A fire extinguisher will be available in the storage facilities and all workers will be trained on how to use this device.

- Warning notices will be placed outside of the store with skull and crossbones and the local language.
- All pesticides waiting to be used and any remnants will be stored under lock and key until the next rounds of spraying.

#### ACCIDENTAL WAREHOUSE FIRES

Human inhalation of toxic fumes in the event of a storehouse fire is also an unavoidable risk. 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.

### 6.1.4 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. Females 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.

### 6.1.5 SPRAY OPERATOR EXPOSURE

Each spray operator will be provided with safety equipment in accordance with PMI BMP specifications.

Workers will be closely monitored for acute symptoms, because there will always be some level of exposure. In addition, workday duration should be monitored to limit exposure as required by safety recommendations.

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 district coordinator, who will forward the report to the Implementing Partner's Operations Director within 24 hours. The report will then be forwarded to the PMI Contract Officer Representative (COR) Team and the PMI IRS Activity Manager in Ghana upon receipt.

Similarly, residential exposure will be monitored. 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 exposure incidents.

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps and practical exercises during a five-days training period prior to the beginning of the spraying campaign. They will also receive training 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 2002 WHO's *Manual for Indoor Residual Spraying* and the 2015 BMP manual. Potential spray operators must also pass written and practical tests at the end of training.

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. PMI has evaluated various approaches for monitoring sprayer exposure to OPs, and has developed protocols based on these evaluations. However, the WHOPES Working Group meeting recommendations stated that, "provided that operational guidelines are followed, routine cholinesterase monitoring of spray men during indoor residual spraying programs is not required" for Actellic CS. Therefore, PMI will perform

limited bio-monitoring in 2015 to confirm the sufficiency of protective measures and protocols used in Ghana in preventing significant cholinesterase depression among spray team members.

### 6.1.6 RESIDENTIAL EXPOSURE

District Directors Disease Control Officers, Environmental Health Officers (of the MOH), , implementing partners, and IRS staff will work with relevant institutions at all levels to carry out an IEC campaign to sensitize residents to IRS activities, in accordance with WHO guidelines and PMI Malaria Operational Plan. The IEC campaign (as well as IRS Project team leaders and MOH officers) 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 outside the home during spraying for two hours after spraying.
- Move and keep all animals outside 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.
- Sweep floors free of any residual insecticide that may remain from the spraying and dispose of in pits or latrines.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using bed-nets for protection against malaria.
- If skin itches after re-entrance into home, wash with soap and water; for eye irritation, flush eyes with water; for respiratory irritation, leave the home for fresh air; for ingestion 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 follow 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 not removed from the houses.
- Adopt a system of moving household effects to the center of the room and covering them with impermeable material before spraying.
- Materials can also be moved into structures that are not targeted to be sprayed, e.g., an isolated kitchen or other 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 mid of spraying:

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

### 6.1.7 PESTICIDE EXPOSURE AND TREATMENT

The project will confirm that all the health facilities around the spray sites have in their store these recommended drugs and that all the staff responsible receive appropriate training on administering

emergency treatment to pesticide exposure. Annexes B and C provide additional information on symptoms and treatment protocols.

All the 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, eye or dermal contact with the chemical. This training will be conducted by the District and Sector Coordinators and will include drills to test knowledge of the operators. However, most interventions will have to be provided by medical professionals at the nearest health clinic.

### 6.1.8 Solid and Liquid Contaminated Wastes

Liquid wastes will be disposed of on a daily basis in soak pits that are carefully sited according to criteria in the PMI BMP manual. The soak pit is designed so that pesticides are adsorbed by the charcoal layer, and held until environmental processes result in the degradation of the pesticide.

At the end of the spray season, non-contaminated wastes, or those that are cleaned thoroughly with soap and water will be recycled whenever possible, and disposed of in a municipal landfill if there is no appropriate recycling outlet. Contaminated solid wastes are incinerated in incinerators that are capable of destroying the pesticide and preventing environmental contamination. In Ghana, the incineration will take place at the Zoil Service Limited incinerator in Takoradi, which meets PMI criteria for destruction of non-chlorinated pesticide waste. The EMMP in Annex A details 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.

# 7. EMMP IMPLEMENTATION

The PMI implementing partner will implement the EMMP, with guidance from EPA, MOH, and the 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 spray operation. The District Coordinators will monitor environmental compliance during the IRS campaign. The implementing partner will complete the annual EMMR Form in Annex D and certification form in Annex E, and submit them to USAID along with the annual end-of-spray report.

The implementing partner's Environmental Compliance Officer will conduct environmental compliance assessments and inspections during pre-spray activities, during spray operations and at the completion of the spray campaign. These inspections will endeavor to ensure that all of the critical facilities are in place, that mitigation measures in the EMMP are implemented, and to propose measures for current improvements (if necessary) and/or for the next IRS campaign. These compliance inspections achieve the following objectives:

- Create a knowledge base for evaluating the need for improvement in future IRS programs.
- Observe IRS activities in progress to determine and document whether the intervention is in full compliance with USAID requirements.
- Determine, in consultation with NMCP officials, the training and support required to improve and ensure future compliance with the SEA.
- Ensure adherence to relevant international rules and regulations, including USA regulations.
- Ensure accurate record keeping and daily collection of empty sachets.
- Ensure that progressive rinsing methods are used in all spray sites and ensure that leftover insecticide solution is re-used for spraying the next day to prevent environmental contamination.
- Ensure that SOPs, washers, team leaders and supervisors are knowledgeable of the correct way to handle and apply insecticides.
- Ensure that all persons in potential contact with pesticides use PPE at all times.

As required by USAID's Automated Directives System 204.3.4, USAID will actively monitor ongoing activities for compliance with the recommendations in this SEA, and modify or end activities that are not in compliance. PMI has biennial-programmed funds to conduct an independent environment compliance audit to ensure that all the mitigation measures are implemented during the spray campaign.

After the year in which the SEA is prepared and approved, the implementing partner will submit an annual Letter Report two months before the initiation of spray activities that describes the plans and preparations for the upcoming spray season. This Letter Report will be distributed to the MEO, REA, and the BEOs, as well as to Mission personnel.

# ANNEX A: ENVIRONMENTAL MITIGATION AND MONITORING PLAN

| 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 | 1. Occupational risks for workers involved in IRS campaigns (e.g., risks from insecticide exposure and vehicular accidents), especially women of child-bearing age | a. Inspect and certify vehicles used for pesticide or spray team transport prior to contract.<br><br>b. Train drivers<br><br>c. Provide cell phone, personal protective equipment (PPE) and spill kits during pesticide transportation.<br><br>d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.<br><br>e. Health test all spray team members for duty fitness.<br><br>f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE.<br><br>g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps.<br><br>h. Provide adequate facilities and supplies for end-of-day cleanup.<br><br>i. Enforce spray and clean-up procedures. | a-d. Environmental Compliance Officer (ECO).<br><br>e-g. Operations Manager (OM).<br><br>h. ECO<br><br>i. Chief of Party (COP), Technical Project Managers (TPM) and headquarters environmental staff. | a. Transport vehicles have a valid inspection certificate on-board.<br><br>b. Drivers have a certificate of training completion.<br><br>c. Transport vehicles are equipped with cell phone, spill kit, and PPE.<br><br>d. Storekeeper has records of pregnancy testing for all female team members.<br><br>e. Storekeeper has medical exam results for all team members.<br><br>f. Spray operators wear complete PPE during spraying and clean-up.<br><br>g. Operators mix pesticide properly, and the pump does not leak.<br><br>h. All facilities are compliant, and materials required for clean-up are present.<br><br>i. Inspections are performed as scheduled, corrective action is taken as needed. | a-c. ECO inspection of vehicles in the field.<br><br>d-e. ECO inspection of health records at IRS operational sites.<br><br>f-h. ECO performs pre-spray inspections of inventories and training records, and mid-spray inspections of PPE use and spray operator performance.<br><br>i. Monitoring of on-line database for submission of inspection reports. | a-c. 2 inspections per week.<br><br>d-e. One inspection per campaign, additional inspection if new hires or more than 30 spray days.<br><br>f-h. ECO pre-spray inspections 2/campaign, ECO mid-spray inspections 5 times/week.<br><br>i.Weekly |

| 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) | a. IEC campaigns to inform homeowners of responsibilities and precautions.<br>b. Prohibit spraying houses that are not properly prepared.<br>c. Two-hour exclusion from house after spraying<br>d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside. | a-b. IEC officers, OM, ECO<br>c. ECO<br>d. Spray operators (SO) and Team Leaders (TL) | a. Pre-spray IEC campaigns were executed. Homeowners know responsibilities.<br>b. All houses being sprayed are properly prepared.<br>c. Homeowners observe 2 hour exclusion.<br>d. Lack of incident reports, or incident reports with proper response noted. | a. OM- IEC work records,<br>ECO- mid-spray inspections.<br>b-d. ECO mid-spray inspections | a. Inspect work records 1/campaign,<br>b-d. ECO mid-spray inspections 3/wk. |
| | 3. Ecological risk to non-target species and water bodies from use of insecticides (during mixing and spraying) | a. Spray indoors only.<br>b. Train operators on proper spray technique.<br>c. Maintain pumps. | a-c. TL, District Coordinator (DC), OM, ECO | a. Operators spray only inside of houses.<br>b. Operators are trained and know and use proper spray techniques.<br>c. Pumps are maintained and operated to eliminate leaks and erratic spraying. | a. ECO mid-spray inspections.<br>b-c. Training records, ECO mid-spray inspections | a. ECO inspections 3/wk.<br>b. ECO inspection of training records 1/campaign.<br>b-c. ECO mid-spray inspections 5/wk. |

| 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) | a. Choose sites for disposal of liquid wastes according to PMI BMPs.<br>b. Construct soak pits with charcoal to adsorb pesticide from rinse water.<br>c. Maintain soak pits as necessary during season.<br>d. Inspect and certify solid waste disposal sites before spray campaign.<br>e. Monitor waste storage and management during campaign.<br>f. Monitor disposal procedures post-campaign. | a-c. Abt OM, ECO, DC<br>d-f. Abt ECO | a. Operations sites meet PMI BMPs.<br>b. Soak pits are constructed according to the PMI BMP manual.<br>c. Soak pits perform properly throughout the spray season.<br>d. Disposal sites have the capacity and policies to properly dispose of wastes.<br>e. Wastes are stored and managed according to PMI BMPs.<br>f. Waste disposal sites has taken place as agreed and certificates of disposal received. | a-b. ECO Pre-spray inspections<br>c-f. ECO mid- and post-spray inspections and monitoring. | a.2/campaign<br>b.1/campaign<br>c. 5/week<br>d. 1/campaign<br>e. 3/week<br>f. Continuous during disposal |
| | 5. Risk of diversion of insecticides for unintended or uncontrolled use | a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.<br>b. Reconcile number of houses sprayed vs. number of sachets/bottles used.<br>c. Examine houses sprayed to confirm spray application.<br>d. Perform physical inventory counts during the spray season. | a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO | a-d. All pesticide management records are reconciled. | a-b, d. Inspection of pesticide management records. Storekeeper performance checklists.<br>c. ECO mid-spray inspections. | a-b, d. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District Coordinators<br>c. 1/campaign by country headquarters. 2/campaign by ECO<br>d. 2/campaign/ store-room |

# ANNEX B: GENERAL PRINCIPLES IN THE MANAGEMENT OF ACUTE POISONING

**Skin Decontamination**

Decontamination must proceed concurrently with whatever resuscitative and antidotal measures are necessary to preserve life. Shower patient with soap and water, and shampoo hair to remove chemicals from skin and hair. If there are any indications of weakness, ataxia, or other neurologic impairment, remove the victim's clothing, have the victim lie down, and give the victim a complete bath and shampoo using copious amounts of soap and water. Check for pesticide sequestered under fingernails or in skin folds and wash these areas.

Flush contaminating chemicals from eyes with copious amounts of clean water for 10-15 minutes. If eye irritation is present after decontamination, ophthalmologic consultation is appropriate.

Persons attending the victim should avoid direct contact with heavily contaminated clothing and vomitus. Contaminated clothing should be promptly removed, bagged, and laundered before returning to the patient. Shoes and other leather items cannot usually be decontaminated and should be discarded. Note that pesticides can contaminate the inside surfaces of gloves, boots, and headgear. Decontamination should especially be considered for emergency personnel (such as ambulance drivers) at the site of a spill or contamination. Wear rubber gloves while washing pesticide from skin and hair of patient. Latex and other surgical or precautionary gloves usually do not provide adequate protection from pesticide contamination.

**Airway Protection**

Ensure that a clear airway exists. Suction any oral secretions using a large bore suction device if necessary. Intubate the trachea if the patient has respiratory depression or if the patient appears obtunded or otherwise neurologically impaired. Administer oxygen as necessary to maintain adequate tissue oxygenation. In severe poisonings, mechanically supporting pulmonary ventilation for several days may be necessary.

**Note on Specific Pesticides:** There are several special considerations with regard to certain pesticides. In **OP** and **carbamate** poisoning, adequate tissue oxygenation is essential prior to administering atropine.

**Gastrointestinal Decontamination**

A joint position statement has recently been released by the American Academy of Clinical Toxicology and the European Association of Poisons Centres and Clinical Toxicologists on various methods of gastrointestinal decontamination. A summary of the position statement accompanies the description of each procedure.

1. **Gastric Lavage.** If the patient presents within 60 minutes of ingestion, lavage may be **considered**. Insert an orogastric tube and follow with fluid, usually normal saline. Aspirate back the fluid in an attempt to remove any toxicant. If the patient is neurologically impaired, airway protection with a cuffed endotracheal tube is indicated prior to gastric lavage. Lavage performed

more than 60 minutes after ingestion has not proven to be beneficial and runs the risk of inducing bleeding, perforation, or scarring due to additional trauma to already traumatized tissues. It is almost always necessary first to control seizures before attempting gastric lavage or any other method of GI decontamination. Studies of poison recovery have been performed mainly with solid material such as pills. There are no controlled studies of pesticide recovery by these methods. Reported recovery of material at 60 minutes in several studies was 8 percent to 32 percent. There is further evidence that lavage may propel the material into the small bowel, thus increasing absorption.

**Note on Specific Pesticides:** Lavage is contraindicated in hydrocarbon ingestion, a common vehicle in many pesticide formulations.

**Position Statement**: Gastric lavage should not be routinely used in the management of poisons. Lavage is indicated only when a patient has ingested a potentially life-threatening amount of poison and the procedure can be done within 60 minutes of ingestion. Even then, clinical benefit has not been confirmed in controlled studies.

2. **Activated Charcoal Adsorption**. Activated charcoal is an effective absorbent for many poisonings. Volunteer studies suggest that it will reduce the amount of poison absorbed if given within 60 minutes. There are insufficient data to support or exclude its use if time from ingestion is prolonged, although some poisons that are less soluble may be absorbed beyond 60 minutes. Clinical trials with charcoal have been done with poisons other than pesticides. There is some evidence that paraquat is well absorbed by activated charcoal. Charcoal has been anecdotally successful with other pesticides.

**DOSAGE OF ACTIVATED CHARCOAL:**

- Adults and children over 12 years: 25-100 g in 300-800 mL water.
- Children under 12 years: 25-50 g per dose.
- Infants and toddlers under 20 kg: 1 g per kg body weight.

Many activated charcoal formulations come premixed with sorbitol. Avoid giving more than one dose of sorbitol as a cathartic in infants and children due to the risk of rapid shifts of intravascular fluid. Encourage the victim to swallow the adsorbent even though spontaneous vomiting continues. Antiemetic therapy may help control vomiting in adults or older children. As an alternative, activated charcoal may be administered through an orogastric tube or diluted with water and administered slowly through a nasogastric tube. Repeated administration of charcoal or other absorbent every 2-4 hours may be beneficial in both children and adults, but use of a cathartic such as sorbitol should be avoided after the first dose. Repeated doses of activated charcoal should not be administered if the gut is atonic. The use of charcoal without airway protection is contraindicated in the neurologically impaired patient.

**Note on Specific Pesticides:** The use of charcoal without airway protection should be used with caution in poisons such as OPs, carbamates, and organochlorines if they are prepared in a hydrocarbon solution.

**Position Statement:** Single-dose activated charcoal should not be used routinely in the management of poisoned patients. Charcoal appears to be most effective within 60 minutes of ingestion and may be considered for use for this time period. Although it may be considered 60 minutes after ingestion, there is insufficient evidence to support or deny its use for this time period. Despite improved binding of poisons within 60 minutes, only one study suggests that there is improved clinical outcome. Activated charcoal is contraindicated in an unprotected airway, a GI tract not anatomically intact, and when charcoal therapy may increase the risk of **aspiration** of a hydrocarbon-based pesticide.

**Seizures:** Lorazepam is increasingly being recognized as the drug of choice for status epilepticus, although there are few reports of its use with certain pesticides. Emergency personnel must be prepared to assist ventilation with lorazepam and any other medication used to control seizures. See dosage table below. For organochlorine compounds, use of lorazepam has not been reported in the literature. Diazepam is often used for this, and is still used in other pesticide poisonings.

**DOSAGE OF DIAZEPAM:**

- *Adults*: 5-10 mg IV and repeat every 5-10 minutes to maximum of 30 mg.
- *Children*: 0.2 to 0.5 mg/kg every 5 minutes to maximum of 10 mg in children over 5 years, and maximum of 5 mg in children under 5 years.

**DOSAGE OF LORAZEPAM:**

- Adults: 2-4 mg/dose given IV over 2-5 minutes. Repeat if necessary to a maximum of 8 mg in a 12 hour period.
- Adolescents: Same as adult dose, except maximum dose is 4 mg.
- Children under 12 years: 0.05-0.10 mg/kg IV over 2-5 minutes. Repeat if necessary .05 mg/kg 10-15 minutes after first dose, with a maximum dose of 4 mg.

Caution: Be prepared to assist pulmonary ventilation mechanically if respiration is depressed, to intubate the trachea if laryngospasm occurs, and to counteract hypotensive reactions.

Phenobarbital is an additional treatment option for seizure control. Dosage for **infants, children, and adults** is 15-20 mg/kg as an IV loading dose. An additional 5 mg/kg IV may be given every 15-30 minutes to a maximum of 30 mg/kg. The drug should be pushed no faster than 1 mg/kg/minute.

For seizure management, most patients respond well to usual management consisting of benzodiazepines, or phenytoin and phenobarbital.

# ANNEX C: SUMMARY OF ACUTE EXPOSURE SYMPTOMS AND TREATMENT OF WHO PESTICIDES

**Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Carbamates**

| 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-phosphates | Human side effects | Treatment |
|---|---|---|
| Malathion | Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase in the blood and brain. Exposure to high levels can result in difficulty breathing, vomiting, blurred vision, increased salivation and perspiration, headaches, and dizziness. Loss of consciousness and death may follow very high exposures to malathion. | Oral exposure to malathion should be treated with rapid gastric lavage unless the patient is vomiting. Dermal exposures should be treated by washing the affected area with soap and water. If the eyes have been exposed to malathion, flush them with saline or water. People exposed to malathion who exhibit respiratory inefficiency with peripheral symptoms should be treated via slow intravenous injection with 2–4 mg atropine sulfate and 1,000–2,000 mg pralidoxime chloride or 250 mg toxogonin (adult dose).<br><br>Exposure to high levels of malathion that result in respiratory distress, convulsions, and unconsciousness should be treated with atropine and a re-activator. Morphine, barbiturates, phenothiazine, tranquillizers, and central stimulants are all contraindicated. |
| Fenitrothion | Fenitrothion is the most toxic to man of the insecticides approved for residual house spraying, and has a relatively low margin of safety.<br><br>Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor. | Dermal exposure to fenitrothion should be treated by removing contaminated clothing, rinsing the skin with water, washing the exposed areas with soap and water, then seeking medical attention. If fenitrothion gets into the eyes, they should be rinsed with water for several minutes.<br><br>Contact lenses should be removed if possible and medical attention should be sought. Ingestion of fenitrothion should be treated by rinsing the mouth and inducing vomiting if the person is conscious. Inhalation exposures require removal to fresh air and rest in a half-upright position. Artificial respiration should be administered if indicated and medical attention should be sought. |

| Organo-phosphates | Human side effects | Treatment |
|---|---|---|
| Pirimiphos-methyl | 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.<br><br>Later there may be convulsions, coma, loss of reflexes, and loss of sphincter control. | OP poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spraymen (in the case of dispersed operations) should be trained in first-aid and emergency treatment of OP intoxication.<br>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.<br><br>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.<br><br>Atropine sulfate. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible.<br>Glycopyrolate has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion. |

**Summary of Acute Exposure Symptoms and Treatment for Pyrethroids**

| Pyrethroids | Human side effects | Treatment |
|---|---|---|
| Bifenthrin | Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness.<br>No skin inflammation or irritation observed; however can cause a reversible tingling sensation.<br>Incoordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses. | Depends on the symptoms of the exposed person. Casual exposures require decontamination and supportive care. Wash affected skin areas promptly with soap and warm water.<br>Medical attention should be sought if irritation or paresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline. |
| Deltamethrin | 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. | If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.<br>Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate.<br>Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed. |
| Lambda-Cyhalothrin | Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning.<br>Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions.<br>Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis. | Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest. |

| Pyrethroids | Human side effects | Treatment |
|---|---|---|
| Alpha-cypermethrin | Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia.<br><br>Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful | 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. |
| Cyfluthrin | Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma. | If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.<br>Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed. |
| Etofenprox | Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma. | If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water.<br><br>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. |

## Summary of Acute Exposure Symptoms and Treatment for Chlorfenapyr

| Human side effects | Treatment |
|---|---|
| As chlorfenapyr is a rather new product there are not many cases of poisonings where the symptoms were described. One patient first exhibited general fatigue, hyperperspiration, nausea and vomiting. He was initially diagnosed as being dehydrated. Another patient initially presented diaphoresis, headache and cough. Symptomatic management is initiated, but after seven days she presents neurological and respiratory deterioration, causing her death. | Symptoms following exposure should be observed in a controlled setting until all signs and symptoms have fully resolved.<br>If ingested, control any seizures first. Chlorfenapyr can produce abnormalities of the hematopoietic system, liver, and kidneys. Do not use emetics.<br>Monitoring complete blood count, urinalysis, and liver and kidney function tests is suggested for patients with significant exposure.<br>If respiratory tract irritation or respiratory depression is evident from inhalation, monitor arterial blood gases, chest x-ray, and pulmonary function tests.<br>Significant esophageal or gastro-intestinal tract irritation or burns may occur following ingestion.<br>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).<br>Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation.<br>Activated charcoal binds most toxic agents and can decrease their systemic absorption if administered soon after ingestion.<br>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.<br>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.<br>Carefully observe patients with inhalation exposure for the development of any systemic signs or symptoms and administer symptomatic treatment as necessary.<br>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 persist, the patient should be seen in a health care facility.<br>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. |

# ANNEX D: EMMR FORM

**Please see Annual Environmental Mitigation and Monitoring Report (EMMR) Form next page**

**PMI IRS GHANA**

**ENVIRONMENTAL MITIGATION AND MONITORING REPORT (EMMR)**

**ANNUAL REPORTING 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 |
|---|---|---|---|
| 1a. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport. | | | |
| 1b. Driver training | | | |
| 1c. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation. | | | |
| 1d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact. | | | |

| Mitigation Measure | Status of Mitigation Measures | Outstanding issues relating to required conditions | Remarks |
|---|---|---|---|
| 1e. Health fitness testing for all operators | | | |
| 1f. Procurement of, distribution to, and training on the use of PPE for all workers with potential pesticide contact. | | | |
| 1g. Training on mixing pesticides and the proper use and maintenance of spray pumps. | | | |
| 1h. Provision of adequate facilities and supplies for end-of-day cleanup, | | | |
| 1i. 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 according to PMI BMPs. | | | |
| 4b. Construct 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. | | | |
| 4e. Monitoring waste storage and management during campaign. | | | |

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

# ANNEX E: REFERENCES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