PMI | Africa IRS (AIRS) Project
Indoor Residual Spraying (IRS 2) Task Order Six

PMI/SENEGAL
INDOOR RESIDUAL SPRAYING
SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT 2015-2020
KAOLACK, TAMBACOUNTA, KAFFRINE, KOLDA
PYRETHROIDS, CARBAMATES, ORGANOPHOSPHATES,
AND CHLORFENAPYR

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PMI/SENEGAL INDOOR RESIDUAL SPRAYING
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<th><strong>DESCRIPTION</strong></th>
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<td>AGHRYMET</td>
<td>Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Operationelle</td>
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<td>ACTs</td>
<td>Artemisinin-based combination therapies</td>
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<td>AIRS</td>
<td>Africa Indoor Residual Spraying</td>
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<tr>
<td>BCC</td>
<td>Behavior Change Communication</td>
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<td>BEO</td>
<td>Bureau Environmental Officer</td>
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<td>BMP</td>
<td>Best Management Practices</td>
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<td>CILSS</td>
<td>Comité Inter-États de Lutte contre la Sécheresse dans le Sahel (Interstate Committee for Drought Control in the Sahel)</td>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<td>CFR</td>
<td>U.S. Code of Federal Regulations</td>
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<tr>
<td>CNPG</td>
<td>Commission National de la Gestion des Produits Chimiques (National Commission on Pesticide Management)</td>
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<tr>
<td>CS</td>
<td>capsule suspension</td>
</tr>
<tr>
<td>CSP</td>
<td>Sahelian Pesticides Committee</td>
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<tr>
<td>DDT</td>
<td>dichloro-diphenyl-trichloroethane</td>
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<td>DEEC</td>
<td>Direction de l'Environnement et des Etablissements Classes (Directorate for the Environment and Classified Factories)</td>
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<td>District Health Management Team</td>
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<td>District Health Office</td>
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<td>DHS</td>
<td>Demographic and Health Survey</td>
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<tr>
<td>DIS</td>
<td>Department of Information</td>
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<td>DPV</td>
<td>Direction de la Protection des Végétaux (Directorate for Plant Protection)</td>
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<tr>
<td>DREEC</td>
<td>Direction Regionale de l'Environnement et des Etablissements Classes (Regional Branch of the Directorate for the Environment and Classified Establishments)</td>
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<td>EC</td>
<td>emulsifiable concentrate</td>
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<td>Environmental Compliance and Safety Manager</td>
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<td>Food and Agriculture Organization of the United Nations</td>
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<td>Global Fund</td>
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<td>Global Health Initiative</td>
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<td>GoS</td>
<td>Government of Senegal</td>
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<td>HIV/AIDS</td>
<td>Human immunodeficiency virus/acquired immune deficiency syndrome</td>
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<td>IEC</td>
<td>Information, Education, and Communication</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>IMVCS</td>
<td>Integrated Malaria Vector Control Strategy</td>
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<td>INS</td>
<td>National Institute of Health</td>
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<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
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<tr>
<td>IPT</td>
<td>Intermittent preventive treatment of pregnant women</td>
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<tr>
<td>IRD</td>
<td><em>Institut de Recherche pour le Développement</em> (Research Institute for Development)</td>
</tr>
<tr>
<td>IRS</td>
<td>Indoor Residual Spraying</td>
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<tr>
<td>IVM</td>
<td>Integrated Vector Management</td>
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<tr>
<td>LLIN</td>
<td>long-lasting insecticidal net</td>
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<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
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<tr>
<td>MCH</td>
<td>Maternal and Child Health</td>
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<tr>
<td>MoA</td>
<td>Ministry of Agriculture and Rural Equipment</td>
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<tr>
<td>MoE</td>
<td>Ministry of Environment and Sustainable Development</td>
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<td>MOH</td>
<td>Ministry of Health and Social Action</td>
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<tr>
<td>MOP</td>
<td>PMI’s Malaria Operational Plan</td>
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<td>MSDS</td>
<td>Material safety data sheet</td>
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<td>MSP</td>
<td>Mobile Soak Pit</td>
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<td>NEMP</td>
<td>National Environmental Management Program</td>
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<tr>
<td>NGO</td>
<td>Non governmental organization</td>
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<td>NMCP</td>
<td>National Malaria Control Program</td>
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<td>NHS</td>
<td>National Hygiene Service</td>
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<td></td>
<td><em>Service Nationale d’Hygiene</em></td>
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<td>OPs</td>
<td>organophosphates</td>
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<tr>
<td>PEA</td>
<td>Programmatic Environmental Assessment</td>
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<td>PMI</td>
<td>President’s Malaria Initiative</td>
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<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
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<tr>
<td>RDT</td>
<td>Rapid diagnostic tests</td>
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<tr>
<td>SEA</td>
<td>Supplemental Environmental Assessment</td>
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<td>SNEIPS</td>
<td><em>Service National de l’Education et l’information pour la Santé</em> (National Health Education and Information Service)</td>
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<td>SNH</td>
<td><em>Service National de l’Hygiene</em></td>
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<tr>
<td>SOP</td>
<td>Spray Operator</td>
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<td>SPIA</td>
<td><em>Societe de Produits Industriels et Agricoles</em></td>
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<td><em>Universite Cheikh Anta Diop de Dakar</em></td>
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<td>USAID</td>
<td>U.S. Agency for International Development</td>
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<td>USEPA</td>
<td>U.S. Environmental Protection Agency</td>
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<tr>
<td>USG</td>
<td>U.S. Government</td>
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<td>WHO</td>
<td>World Health Organization</td>
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<td>WHOPES</td>
<td>WHO Pesticide Evaluation Scheme</td>
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The authors of this report gratefully acknowledge the support given to this activity by the staff of Abt Associates who are involved in the project in Senegal. Specific acknowledgement is given to Dr. Adama Kone, COP of AIRS Senegal, Dr. Abdoulaye Diop, Senior Operations Manager for Abt Associates and Mrs. Sana Diop Dieng, Environmental Compliance Officer for Abt Associates for their guidance and assistance.
I. SUMMARY OF FINDINGS

1.1 MALARIA BURDEN IN SENEGAL

Malaria is endemic throughout Senegal and 100% of the 14.1 million population is at risk of the disease. The three ecological zones, based on annual rainfall, are the northern Sahelian zone with < 400 mm of rainfall occurring between July and September, the central Sahelian zone with 400 – 1,000 mm of rainfall occurring between July and October, and the southern tropical zone with 1,000 – 1,250 mm of rainfall occurring between June and October. The country can also be divided into two epidemiological zones: the tropical zone, with year-round transmission peaking during the rainy season and lower transmission during the rest of the year; and the Sahelian zone, with high transmission toward the end of and immediately after the rainy season and very low transmission during the rest of the year. Transmission in the Sahelian zone may occur throughout the year, often as small outbreaks, in areas close to rivers or other water sources that persist through the dry season. In peri-urban areas, persistent flooding during and after the rainy season has led to higher peaks in transmission during the rainy season and a longer transmission season.

While the South of Senegal is hyper-endemic, the Northern part of the country is hypo-endemic, with a low rate of malaria transmission. Plasmodium falciparum is the major malaria parasite species, accounting for more than 90% of all infections. The main vector species are Anopheles gambiae sensu strictu, An. arabiensis, An. funestus, and An. melas.

The Senegalese Ministry of Health and Social Action (now the Ministere de la Sante et d’Actions Sociales) created the National Malaria Control Program (NMCP) in 1995. The NMCP underwent a major reorganization in 2005 after cancellation of the Global Fund Round 1 grant. By 2005, Senegal had established an effective malaria control program based on strong management and well-defined plans and has attracted increased donor funding to date.

The vulnerable groups in Senegal comprise an estimated 2.7 million children under five and 561,000 pregnant women. According to routine data collected by the NMCP between 2001 and 2006, malaria was responsible for just over one-third of all outpatient consultations. Incidence of confirmed malaria per thousand increased from 14 in 2009 to 27 in 2013, with malaria representing 5.4% of all consultations and 7.5% of all deaths in 2013. Incidence ranged from 1/1,000 in five northern districts to over 200/1,000 in two south-eastern districts.

Indoor residual spraying remains a high priority vector control intervention for the NMCP in Senegal with the objective to ensure that 90% of the population has access to at least one method of malaria prevention: indoor residual spraying (IRS) or long lasting insecticide treated bednets (LLINs).

1.2 PMI SUPPORT IN SENEGAL

Senegal was selected as a PMI country in 2006, for the first year of the initiative’s launch. IRS as an intervention through the support of PMI in Senegal began in 2007 with three districts and by 2010 was expanded to six districts. Since 2010, IRS coverage as fluctuated between 4 and 6 districts. For 2015, PMI/NMCP plans to conduct focal IRS in “hot spot” districts (Koungheul, Koumpentoum, Malem Hoddar, and Nioro).
Since the NMCP had little experience with IRS before 2007, PMI has been training and equipping locally recruited spraying agents with help from and supervision by the Service National de l’Hygiène, SNH (the environmental public health division of the Ministry of Health), the Directorate of the Environment and Classed Factories, DEEC/DREEC.

Presently, PMI support to Senegal is in line with the Government of Senegal’s (GoS) 2014-2018 National Malaria Control Strategic Framework. Senegal has now adopted all the WHO-recommended interventions and remains a leader in piloting and scaling up new recommendations and innovative strategies to increase the reach and effectiveness of interventions.

Supported activities continue to focus on achieving and maintaining high coverage of LLINs, particularly among the vulnerable populations of pregnant women and children under five, targeting IRS to complement national universal coverage campaigns, providing sulfadoxine pyrimethamine (SP) and support for intermittent preventive treatment of pregnant women (IPTp) scale-up, and improving case management, implementing chemo-prevention to children under 10 years old, along with supportive activities such as Behavior Change Communication (BCC), strengthening supply chain management, and Monitoring and Evaluation (M&E).

In 2015, PMI plans to devolve some of the implementation of the program to the NMCP. The objective of this approach is to improve implementation of malaria-related activities through the facilitation of supervision, distribution of commodities, and M&E. PMI will establish a district-level platform for BCC, Malaria in pregnancy (MIP) interventions, M&E, and case management in Senegal. In provinces where the USG has existing partners, efforts will be made to use these existing mechanisms, thereby following the GHI mandate and avoiding duplication of efforts.

In 2012, USAID prepared the Management Programs for Malaria Vector Control: Programmatic Environmental Assessment (PEA) that provides a broad view of the human health and environmental impacts that could result from implementation of malaria vector control interventions. Supplemental Environmental Assessments (SEAs) must be developed to describe in-country impacts of interventions and describe country-specific activities to minimize those impacts.

The PMI IRS program prepared the Supplemental Environmental Assessment for IRS to cover use of pyrethroids (specifically Lambda cyhalothrin) in Nioro, Richard Toll, and Velingara, approved in 2007. The 2007 PERSUAP limited the geographic coverage to three districts in three different regions. In 2009 when NMCP/PMI decided to expand to other areas and choose a different class of pesticide, (in the carbamates class (FICAM)), for IRS, an amendment to the SEA for the Senegal IRS program was prepared in March 2010 and provided an assessment of World Health Organization Pesticide Evaluation Scheme (WHOPES)- approved IRS insecticides, carbamates, pyrethroids and organophosphates for PMI IRS in five regions in Senegal.

This SEA covers 2015-2020, addresses changes in the PMI IRS program and updates the information that was provided in previous versions. This SEA assesses the use of WHOPEs recommended insecticides in the pyrethroid, carbamate, and organophosphate classes. It also includes chlorfenapyr, which is currently under WHOPEs review for IRS activities and is registered for similar use by USEPA (United States Environmental Protection Agency). Whereas the previous SEAs authorized PMI IRS activities in the 5 regions of Kaffrine, Saint Louis, Kolda, Kaolak, Kaffrine, Tambacounda, this SEA is applicable for IRS activities in the four regions of Kaolack, Tambacounda, Kaffrine, and Kolda.
1.3 **ADVERSE HEALTH AND ENVIRONMENTAL IMPACTS FROM IRS AND MITIGATION MEASURES**

1.3.1 **HEALTH IMPACTS**

Based on U.S. Agency’s for International Development (USAID) experience with implementation of IRS in 17 other sub-Saharan African countries under the PMI, the most likely potential adverse health impact of the IRS intervention is unintentional pesticide exposure, leading to acute but mostly transitory health impacts on beneficiaries and spray operators. The potential impacts from each of the WHO pesticide classes and specific formulations varieties have been assessed in the pesticide profiles section of the 2012 PEA.

Senegal will spray carbamates and organophosphates in 2015, including inventories left over from the previous campaign. Both carbamates and organophosphates cause cholinesterase depression in humans, through dermal contact and through inhalation. With carbamates, the effects subside in a few hours if exposure is discontinued. In contrast, cholinesterase depression from exposure to organophosphates is cumulative, and not as transitory, so exposure should be guarded against with greater vigilance.

For many of the campaign participants this is the second year of organophosphate use, but the newcomers must be trained and the veterans need refresher training. Therefore, additional efforts will be made to train and sensitize all IRS personnel to the risks involved, the symptoms of OP exposure, and the medical treatment protocol. WHO has determined that it is not necessary to implement a cholinesterase-monitoring program for spray operators and others in potential close contact with these pesticides. However, in 2015, PMI is conducting a bio-monitoring event in Ghana, as outlined in the PEA, measuring cholinesterase levels among a sample of operators, team leaders, and washers. The results of this testing may influence PMI policy going forward.

To mitigate risks of exposure, all individuals involved in the implementation of spraying – from spray operators to washpersons to storekeepers – will be provided with appropriate and adequate personal protective equipment (PPE), and will be trained in the best management practices contained in the PMI IRS Best Management Practices Manual (BMP). Community members will be informed on how to minimize direct and indirect exposure to insecticides (e.g., removing furniture and food from houses prior to spraying, keeping animals away, staying out of houses sprayed for two hours, sweeping dead bugs and properly disposing of them in pits or latrines, etc.). Finally, in order to prevent hazardous reuse of the insecticide bottles, they must be punctured upon return to the storehouse.

Exposure treatment for carbamates, pyrethroids, chlorfenapyr and OP-based pesticides are detailed in Annexes B and C.

1.3.2 **ENVIRONMENTAL IMPACTS**

Potential negative environmental impacts are summarized here and discussed in detail in the Environmental Impact section. The EMMP in Annex A of this SEA includes mitigation strategies for each of the risks.

Since all of the WHOPES recommended IRS insecticides except for malathion are hazardous for aquatic life, the highest risk to the environment is likely contamination to water resources, with subsequent die-off of fish and other aquatic life. The risk to bees, which are extremely sensitive to all these pesticides for malaria control, is also a consideration. Houses found within 30 meters of sensitive areas, including water bodies and bee-keeping activities, will be noted by mobilizers, marked (physically, as well as by the use of GPS if available), and not sprayed. Beekeepers should be advised to move their hives at least 30 meters from any home for the day of spraying, or their home will not be sprayed.
The PMI IRS BMP specifies that all washing areas, soak pits mobile soak pits and evaporation tanks must be constructed according to specifications in order to protect human and animal health as well as prevent environmental damage. Additional mitigation measures include utilization of PPE, best practices in pesticide storage and management, re-use/disposal of contaminated water from operations, and strong supervision and oversight at all levels.

Certain insecticides are packaged in plastic bottles. It is essential that spray operators perform a triple-rinse of the container while they are making up the spray solution in their tank, and that the rinsate is added to the tank as part of the final volume. If this rinse is not performed, not only is pesticide is wasted, but the bottle, which must be returned to stores for accounting purposes, will contain a significant amount of hazardous material, which will have to be removed and treated before the bottles can be recycled or otherwise disposed of. In addition, subsequent contamination or exposure may occur due to the residue that will otherwise remain in the bottle.

As required by USAID’s Automated Directives System 204.5.4, USAID will actively monitor ongoing activities for compliance with the recommendations in this Supplemental Environmental Assessment (SEA), and modify or end activities that are not in compliance.

1.4  APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:

The United States Agency for International Development’s Global Health Bureau has determined that the proposed indoor residual spraying effort for the President’s Malaria Initiative in Senegal, as described in this Supplemental Environmental Assessment 2015-2020, responds to the needs of the community and country as it relates to managing malaria in Senegal, as well as conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, documents the environmental planning and impact analysis executed by the IRS team in preparation for the proposed action. The design and standards of operation of the IRS program are established to avoid and reduce any potential impact. USAID has concluded that the proposed action, when executed as described in the Supplemental Environmental Assessment and the umbrella Programmatic Environmental Assessment (2012), is consistent with USAID’s goal of reducing malaria incidence in Senegal while minimizing negative impact to environmental and human health.

CLEARANCE:
Mission Director, USAID/Senegal ____________________________ Date: ____________

Susan Fine

CONCURRENCE:
Bureau Environmental Officer, Global Health: ____________________________ Date: ____________

Rachel Dagovitz
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CLEARANCE:
Mission Director, USAID/Senegal _______________ Date: 5/12/2015

Susan Fine

CONCURRENCE:
Bureau Environmental Officer, Global Health: _______________ Date: 5/14/2015

Rachel Dagovitz
ADDITIONAL CLEARANCES:

PMI / Senegal: _______________________________ Date: 5/11/15
Mame Birame Diouf

Mission Environmental Officer USAID/ Senegal: _______________________________ Date: 5/11/15
Abdourahmane Ndiaye

Regional Environmental Advisor, USAID/West Africa: _______________________________ Date: 5/11/15
Kalim Hanna

Africa Bureau Environmental Officer: _______________________________ Date: __________________
Brian Hirsch
2. PURPOSE OF THIS DOCUMENT

Under the U.S. Code of Federal Regulations (22 CFR §216), malaria vector control activities supported or planned by USAID must undergo environmental examination. To assist USAID missions in planning malaria vector control interventions, in 2012 USAID prepared the Management Programs for Malaria Vector Control: Programmatic Environmental Assessment (PEA) that provides a broad view of the human health and environmental impacts that could result from implementation of malaria vector control interventions. However, the PEA cannot account for inter-country and interregional variation regarding issues such as the capacity to manage pesticides used for vector control and the environment likely to be impacted. For this reason, Supplemental Environmental Assessments (SEAs) must be developed to describe in-country impacts of interventions and describe country specific activities to minimize those impacts.

Whenever an in-country malaria vector control activity involves “assistance for the procurement or use, or both, of pesticides,” SEAs supplementing the PEA must address the pesticide procedures found in 22 CFR 216.3(b). The pesticide procedures list 12 factors to address in SEAs which are described in the Pesticide Procedures section of this document.

The SEA should be looked upon as the overall representation of the country with regard to IRS. The SEA should address the human health and environmental impacts that may occur as a result of USAID support of malaria vector control activities.

The purpose of a malaria program is to save lives and reduce illness and suffering. The purpose of the SEA is to optimize these goals by ensuring malaria control programs use only safe and efficacious pesticides and use them in a way that will minimize inadvertent exposure and adverse health impacts; by ensuring the natural resources on which people depend for their daily food production and nutrition are not damaged; by ensuring that long term development is promoted by avoiding disruption of agricultural exports due to misuse of malaria pesticides on agricultural crops; and, by participating in international environmental agreements such as the Stockholm Convention on Persistent Organic Pollutants, among others.

The PMI IRS program prepared the original Supplemental Environmental Assessment for IRS, approved in 2007, to cover the use of pyrethroids (specifically lambda cyhalothrin) in Nioro, Richard Toll, and Velingara. The 2007 PERSUAP limited the geographic coverage to three districts in three different regions. In 2009 when PMI wanted to expand to other areas and choose a different class of pesticide for IRS, an amendment to the SEA was prepared that provided an assessment of WHOPES recommended IRS insecticides in the carbamate, pyrethroid and organophosphate classes for IRS in 5 regions in Senegal.

This SEA addresses changes in the PMI IRS program and updates the information that was provided in previous SEAs. This SEA assesses the use of WHOPES recommended pesticides for IRS in the pyrethroid, carbamate and organophosphate classes. It also includes chlorfenapyr (when approved), which is currently under WHOPES review for IRS and is registered for similar use by USEPA.

Finally, this SEA further stipulates that if Senegal does undertake small-scale hut trials, such as the chlorfenapyr one performed in Nigeria, additional review of the protocol and clearance are required from the Global Health BEO and the project COR.
Upon approval of this SEA, a Letter Report will be submitted to USAID annually that will discuss the IRS program for that particular year’s spray campaign. However, the preparation of this SEA update renders the preparation of a Letter Report unnecessary for 2015.
3. BACKGROUND

3.1 BACKGROUND TO THE PROPOSED ACTION

The PMI was launched in June 2005 as a 5-year, $1.2 billion inter-agency initiative to rapidly scale up malaria prevention and treatment interventions and to reduce malaria-related mortality by 50% in 15 high-burden countries in sub-Saharan Africa. Senegal was selected as a PMI country in fiscal year (FY) 2006. PMI’s primary goal in Senegal is to assist the Government of Senegal (GoS), in collaboration with other partners, to reduce malaria mortality by 50% by rapidly scaling-up coverage of vulnerable groups with four highly effective interventions: artemisinin-based combination therapy (ACT), intermittent preventive treatment of pregnant women (IPTp), insecticide-treated bed nets (ITNs), and indoor residual spraying (IRS).

With the passage of the Tom Lantos and Henry J. Hyde Global Leadership against HIV/AIDS, Tuberculosis, and Malaria Act in 2008, PMI developed a U.S. Government Malaria Strategy for 2009–2014. This strategy included a long-term vision for malaria control in which sustained high coverage with malaria prevention and treatment interventions would progressively lead to malaria-free zones in Africa, with the ultimate goal of worldwide malaria eradication by 2040–2050. Consistent with this strategy and the increase in annual appropriations supporting PMI, four new sub-Saharan African countries and one regional program in the Greater Mekong Sub-region of Southeast Asia were added in 2011. The contributions of PMI, together with those of other partners, have led to dramatic improvements in the coverage of malaria control interventions in 19 PMI-supported countries, 17 of which have documented substantial declines in all-cause mortality rates among children less than five years of age.

The updated President’s Malaria Initiative Strategy (2015–2020) takes into account the progress over the past decade and the new challenges that have arisen, setting forth a vision, goal, objectives, and strategic approach for PMI through 2020, while reaffirming the longer-term goal of worldwide malaria eradication. Malaria prevention and control remains a major U.S. foreign assistance objective, and this strategy fully aligns with the U.S. Government’s vision of ending preventable child and maternal deaths and ending extreme poverty. It is also in line with the goals articulated in the draft RBM Partnership’s second Global Malaria Action Plan and WHO’s draft Global Technical Strategy.

Within the USG, the U.S. Agency for International Development (USAID) Senegal Health Team has merged into one Integrated Health Office, maximizing the programmatic synergies among the President’s Emergency Plan for AIDS Relief (PEPFAR), PMI, and other health programs.

Senegal was selected as a PMI country in 2006. Large-scale implementation of artemisinin-based combination therapies (ACTs) and rapid diagnostic tests (RDTs) began in 2007 and progressed rapidly with support from PMI and other partners. ACTs and IPTp are now being used in all public health facilities nationwide, RDTs are used to confirm malaria cases at all levels of the health system (including the community level) and more than 7.3 million long-lasting insecticide-treated bed nets (LLINs) have been distributed using a universal coverage approach since 2010. Malaria is still a major cause of morbidity and mortality and a high priority for the government, even though the number of reported cases of malaria has dropped significantly since 2007-2008. While the decline in the first year can be partially ascribed to a change in the malaria case definition that now requires parasitological confirmation of all cases, the proportion of all outpatient visits due to confirmed malaria continued to fall, from 6% in 2008 to 3% in 2009. However, there has been an uptick of cases in recent years with malaria representing 5.4% of all consultations and 7.5% of all deaths in 2013. Forty-three of 76 health districts...
saw their incidence decrease or remain stable from 2010-2013, while 30 districts had increases (no data available for three districts). Eight districts in the southeastern part of the country carry the highest disease burden (more than 100 cases per 1,000 population).

### 3.2 Malaria Burden in Senegal

Senegal’s estimated population in 2016 will be approximately 14 million, based on the most recent census conducted in 2013. Although substantial improvements have been achieved since the 1960s, Senegal’s indicators of human development remain low, with the country ranked 154 out of 186 countries worldwide on the Human Development Index. The infant mortality rate is 43 deaths per 1,000 live births and the under-five mortality rate is 65 deaths per 1,000 live births. Maternal mortality is estimated to be 392 deaths per 100,000 live births and the mean life expectancy is 56 years. The adult HIV prevalence rate is estimated at 0.7% for adults 15-49 years of age, with 54,000 adults and 5,000 children estimated to be living with HIV/AIDS.

Malaria is endemic throughout Senegal and 100% of the population is at risk of the disease. The three ecological zones, based on annual rainfall, are the northern Sahelian zone with < 400 mm of rainfall occurring between July and September, the central Sahelian zone with 400 – 1,000 mm of rainfall occurring between July and October, and the southern tropical zone with 1,000 – 1,250 mm of rainfall occurring between June and October. The country can also be divided into two epidemiological zones: the tropical zone, with year-round transmission peaking during the rainy season and lower transmission during the rest of the year; and the Sahelian zone, with high transmission toward the end of and immediately after the rainy season and very low transmission during the rest of the year. Transmission in the Sahelian zone may occur throughout the year, often as small outbreaks, in areas close to rivers or other water sources that persist through the dry season. In peri-urban areas, persistent flooding during and after the rainy season has led to higher peaks in transmission during the rainy season and a longer transmission season.

Plasmodium falciparum is the major malaria parasite species, accounting for more than 90% of all infections. The main vector species are *Anopheles gambiae sensu strictu*, *An. arabiensis*, *An. funestus*, and *An. melas*. The species distribution depends on rainfall and the presence of permanent sources of water.

The vulnerable groups in Senegal comprise an estimated 2.7 million children under five and 561,000 pregnant women. According to routine data collected by the NMCP between 2001 and 2006, malaria was responsible for just over one-third of all outpatient consultations. In October 2007, the case definition of malaria changed from a purely clinical definition to one that relies on parasitological confirmation. From that point on, health workers were directed to test all suspected cases of malaria and to treat and report only those cases with positive results. Suspected cases of malaria are defined as those with fever who do not have signs or symptoms indicative of other illnesses. In 2013, 87% of suspected cases were tested.

As a result of these changes, the proportion of all outpatient visits due to malaria fell from 36% (clinically diagnosed) in 2001 to 6% (parasitologically confirmed) in 2008. The proportion of all deaths in children under five in health facilities that were attributed to malaria also fell from 30% to 7% over the same timeframe. Although the change in the case definition of malaria obscured assessment of the impact of program activities, this reduction continued between 2008 and 2009, with malaria representing only 3% of all outpatient visits and 4% of all deaths in 2009.

Morbidity and mortality data were not available between 2010 and 2012 because health worker unions were staging a nationwide data retention strike. This data strike was lifted in March 2013, and data have been backfilled, though data quality for 2010-2012 is not optimal. In 2013, the routine data system was functional once again. Incidence of confirmed malaria per thousand increased from 14 in 2009 to 27 in 2013, with malaria representing 5.4% of all consultations and 7.5% of all deaths in 2013. Incidence ranged from 1/1,000 in five northern districts to over 200/1,000 in two south-eastern districts.
3.2.1 MALARIA PREVALENCE

The epidemiological situation of malaria in Senegal is marked by two developments between 2008 and 2013:

- A decline in prevalence (the actual number of cases, living with the disease either during a period of time)
- An increased incidence (the rate of new (or newly diagnosed) cases of the disease.)

National parasite prevalence declined from 2008 to 2013, from 5.9% in 2008 to 2.8% in 2013. The prevalence of this disparity exists because the South zones (Ziguinchor, Tamba, Sédhiou, Kolda, Kédougou) have high numbers of up to 9.1%; For central regions (Diourbel, Kaolack, Fatick, Kaffrine) is 2.2%; for the west-north area (Dakar, Thies, Louga, St Louis, Matam), it was 0.7% (See Figure 1 below). In the rainy season, it was 4.3% on average while that from February to August, the average is 1.1%. In urban areas, parasite prevalence is 0.4% against 3.9 in rural areas. (PNLP, 2014)

FIGURE 1: THE EVOLUTION OF MALARIA PREVALENCE FROM 2008 TO 2013 (FROM NMCP STRATEGIC PLAN 2014-2018)

ENPS: Enquête Nationale sur le Paludisme au Sénégal (Senegal Malaria National Survey)
EDS: Enquête Démographique et de Santé (National Demographic and Health Survey)

Malaria incidence calculated from routine Health District data, has increased from 2009 to 2013 from 14% to 27%. This could be explained by several factors:

- There were difficulties between 2011 and 2012 in the overall management of malaria in Senegal mainly the monitoring activities and availability of inputs (ACTs and RDTs);
- The likely decline in the effectiveness of LLINs distributed in 2010 in the area. (IRD study).

The increase in supply through new health infrastructure creation and substantial recruitment Dispensateurs de Soins à Domicile (DSDOM) or home care providers in English by the NMCP which
increased reporting of cases. This correlates with the level of attendance of health structures increased in the same period with a number of visits for all causes steadily increasing.

This increase was more pronounced in the South and Southeast regions of the country, mirrored with an increase in the proportionate malaria morbidity over the same period from 5.37% in 2009 to 5.41% in 2013.

Similarly, the incidence in five southern regions increased from 25.36% (2009) to 35.03% (2012).

The map on the variation of malaria incidences show that the southern areas have increased significantly in recent years. These regions were the first to benefited universal coverage of LLINs in 2010, which became less effective over the course of the next few years. In 2013, a second universal coverage campaign was to be conducted in light of this loss of effectiveness (which is known after 3 years of use), but there were problems with the mobilization of resources, prevented its implementation.

**FIGURE 2: EVOLUTION OF MALARIA INCIDENCE PER 1000 INHABITANTS FROM 2010-2013**
3.3 **HISTORY OF MALARIA CONTROL IN SENEGAL**

The National Malaria Control Program, NMCP, was created in 1995 under the Ministry of Health, or Ministère de la Santé et de l’Action Sociale. Although it is known that dichloro-diphenyl-trichloroethane (DDT) was sprayed in the country in the 1960’s and 1970’s, along with other interventions, not much literature is published about this. However, it is known that the main vector species, *Anopheles gambiae sensu strictu*, *An. arabiensis* and *An. Melas*, are resistant to organochlorines, i.e. DDT.

Senegal has benefitted from IRS since PMI began work in the country in 2007, and will receive its 9th spray round in 2015. The first three districts sprayed with PMI support - Richard Toll, Nioro, and Vélingara - each represented different ecological zones. One spray round was carried out just before the high transmission season in each district, while in Richard Toll, a district along the Senegal River, another round was done immediately prior to the second seasonal peak in April. After entomological monitoring demonstrated that the insecticidal activity persisted long enough to cover the second peak, this second round was eliminated in 2010. Also in 2010, IRS operations were expanded to Guinguinéo, Malem Hoddar, and Koumpentoum, districts that were among the 16 health districts prioritized for IRS by the NMCP. In 2011, because malaria rates were low and insecticide resistance was high in Richard Toll, spray operations ceased in this district and Koungheul was selected as a replacement. In early 2013, the IRS Steering Committee made the decision to cease IRS operations in the districts of Guinguinéo and Nioro because data indicated that malaria rates had become very low. A plan for post-withdrawal action was prepared, including communications at both administrative and community levels and enhanced surveillance.

The population protected during the seven years of IRS ranged from around 650,000 in 2007 to more than 1 million in 2012, with high coverage rates being achieved in most years (see Table 1 for last 8 years).

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Districts Sprayed</th>
<th>Insecticide Used (# districts)</th>
<th>Number of Structures Sprayed</th>
<th>Coverage Rate</th>
<th>Population Protected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>3</td>
<td>Lamdacyalothrine</td>
<td>76,279</td>
<td>98%</td>
<td>678,971</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>Lamdacyalothrine</td>
<td>153,942</td>
<td>95%</td>
<td>663,407</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>Lamdacyalothrine</td>
<td>176,279</td>
<td>95%</td>
<td>661,814</td>
</tr>
<tr>
<td>2010</td>
<td>6</td>
<td>Lamdacyalothrine (1)</td>
<td>254,559</td>
<td>98%</td>
<td>971,187</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deltamethrin (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>5</td>
<td>Bendiocarb (4)</td>
<td>240,770</td>
<td>98%</td>
<td>887,315</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deltamethrin (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>6</td>
<td>Bendiocarb</td>
<td>306,916</td>
<td>98%</td>
<td>1,095,093</td>
</tr>
<tr>
<td>2013</td>
<td>4</td>
<td>Bendiocarb</td>
<td>206,704</td>
<td>98%</td>
<td>690,090</td>
</tr>
<tr>
<td>2014</td>
<td>4</td>
<td>Bendiocarb (2)</td>
<td>204,159</td>
<td>97%</td>
<td>708,999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organophosphate (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015*</td>
<td>4 (focalized)</td>
<td>Organophosphate</td>
<td>215,000*</td>
<td>740,000*</td>
<td></td>
</tr>
</tbody>
</table>

*Represents projected targets
Pyrethroids were used during the first four years of spray operations, from 2007-2011, but a significant drop in insecticide susceptibility of mosquitoes to pyrethroids was observed and the decision was made to switch to a carbamate for the 2011 operations. Insecticide susceptibility to pyrethroids increased after this rotation and remained high in 2012. Insecticide susceptibility of mosquitoes also dropped with carbamates and then the program switched to organophosphates in 2014. Please see the Entomological section of this SEA for more elaboration.

Spray operations have been organized by PMI implementing partners under the direction of the NMCP, the National Hygiene Service (SNH), UCAD, and district health management teams. PMI support includes training and equipping locally-recruited spraying agents with help from the NMCP and its vector-control partners, with supervision by the SHN. All spray rounds were followed by post-spray evaluation meetings to identify lessons learned and opportunities for improving the next round.

To maintain good cooperation and synchronicity between all partners involved in IRS activities, an IRS Steering Committee was established including members from the DEEC, SNH, SNEIPS (Service Nationale de l’Education et de l’Information pour la Santé), DPV, SLAP (Service Lutte Anti-Parasite) a local laboratory, PMI Implementing Partner, PMI, NMCP and the UCAD (Universite Cheikh Anta Diop de Dakar). This Committee meets several times a year to discuss upcoming spray rounds, analyze the entomological data on vector resistance and malaria incidence data to determine which insecticide should be used and in what districts. The Committee makes all levels of decision making a shared effort and discussion among the different partners.

### 3.4 PMI STRATEGIC APPROACH

The President’s Malaria Initiative (PMI) is a core component of the USG Foreign Assistance Strategy, along with human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), maternal and child health, reproductive health, and tuberculosis. PMI was launched in June 2005 as a five-year, $1.2 billion initiative to rapidly scale up malaria prevention and treatment interventions and reduce malaria-related mortality by 50% in 15 high-burden countries in sub-Saharan Africa. With passage of the 2008 Lantos-Hyde Act, PMI was extended and the position and role of the USG Global Malaria Coordinator was formalized. As required by Lantos-Hyde, a US Global Malaria Strategy was developed covering 2009-2014 and the original goal of the PMI was expanded in 2015. The new six-year US Global Malaria Strategy for 2015-2020 goal is now to reduce malaria-related mortality by 30% from 2015 levels in PMI supported countries, achieving a greater than 80% reduction from PMI’s original 2000 baseline levels. This will be achieved by reaching 85% coverage of the most vulnerable groups — children under five years of age and pregnant women — with proven preventive and therapeutic interventions, including ACTs, ITNs, IPTp, and IRS.

This FY 2015 Malaria Operational Plan (MOP) presents a detailed implementation plan for Senegal, based on the PMI Multi-Year Strategy and Plan and the National Malaria Control Program’s (NMCP’s) 2014-2018 Strategic Framework. It was developed in consultation with the NMCP, with participation of national and international partners involved with malaria prevention and control in the country. Proposed activities build on investments made by PMI and other partners to improve and expand malaria-related services, including the Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund) malaria grants. This document briefly reviews the current status of malaria control policies and interventions in Senegal, describes progress to date, identifies challenges and unmet needs, and describes planned activities for FY 2015 funding.

### 3.5 PMI PROGRAM OBJECTIVES

By the end of 2015, PMI will assist Senegal to achieve the following targets in populations at risk for malaria:
>90% of households with a pregnant woman and/or children under five will own at least one ITN;
85% of children under five will have slept under an ITN the previous night;
85% of pregnant women will have slept under an ITN the previous night;
85% of houses in geographic areas targeted for IRS will have been sprayed;
85% of pregnant women and children under five will have slept under an ITN the previous night or in a house that has been protected by IRS;
85% of women who have completed a pregnancy in the last two years will have received two or more doses of IPTp during that pregnancy;
85% of government health facilities have ACTs available for treatment of uncomplicated malaria; and
85% of children under five with suspected or confirmed malaria will have received treatment with ACTs within 24 hours of onset of their symptoms.

The U.S. Government shares the long-term vision of affected countries and global partners of a world without malaria. This vision will require sustained, long-term efforts to drive down malaria transmission and reduce malaria deaths and illnesses, leading to country-by-country elimination and eventual eradication by 2040–2050. The U.S. Government’s goal is to work with PMI-supported countries and partners to further reduce malaria deaths and substantially decrease malaria morbidity, toward the long-term goal of elimination. Building upon the progress to date in PMI-supported countries, PMI will work with NMCPs and partners to accomplish the following objectives by 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 pre-elimination.

To achieve these objectives, PMI will take a strategic approach which emphasizes the following five areas:

- Achieving and sustaining scale of proven interventions
- Adapting to changing epidemiology and incorporating new tools
- Improving countries’ capacity to collect and use information
- Mitigating risk against the current malaria control gains
- Building capacity and health systems.

These areas of focus are informed by PMI’s experiences to date, which include building on the successes that countries have achieved with the support of PMI and other partners, incorporating the lessons learned from implementation thus far, and addressing directly the ongoing and new challenges that could prevent further progress toward malaria control and elimination.

### 3.6 Institutional Framework for Malaria Control

#### 3.6.1 National Malaria Control Program

**NMCP strategy by malaria control intervention**

Senegal has now adopted all the WHO-recommended interventions and remains a leader in piloting and scaling up new recommendations and innovative strategies to increase the reach and effectiveness of interventions.
• **LLINs:** Mass distribution for universal coverage transitioning to a nationwide campaign in 2016, with scale-up of multi-channel routine distribution.

• **IRS:** Focal spraying to target hotspots at the level of the health post in districts with incidence greater than 15/1,000 of incidences of malaria per inhabitant.

• **Larval source management:** Bio-larvicides applied in areas where larval sources are few, fixed, and findable, such as the suburbs of Dakar that are prone to flooding. (This is done without PMI support, and is not therefore addressed in this SEA.)

• **Seasonal malaria chemoprevention:** One treatment of sulfadoxine-pyrimethamine (SP) and amodiaquine (AQ) monthly during the transmission season, up to four months, for children 3-120 months in regions that meet WHO criteria. Presently in the regions of Kolda, Kédougou, Sédhiou and Tambacounda.

• **Malaria in pregnancy:** IPTp with SP under directly observed therapy, beginning during the second trimester, at every contact with the health facility, at intervals of at least one month. Every pregnant woman is to receive a free LLIN during her first ANC visit. Pregnant women with confirmed malaria are treated with quinine in the first trimester and with ACTs thereafter, unless signs of severe disease, when IV quinine or artesunate is used.

• **Case management:**
  - **Uncomplicated malaria:** All suspected cases are to be confirmed with RDT, and patients with positive tests treated with an ACT. Artemether-lumefantrine, artesunate- amodiaquine, and dihydroartemisinin-piperaquine are co-first line therapies.
  - **Severe disease:** Pre-referral treatment with rectal artesunate if identified at community or health post level. Definitive treatment at the health center or hospital level with IV quinine or artesunate, to be followed with a course of oral ACT. Hospitalized patients should have malaria confirmed by blood smear.
  - **Community level:** All patients with fever are tested with an RDT and patients with positive tests receive an ACT. Both health hut and home-based care programs are integrated with diarrhea and pneumonia.

• **Health promotion:** Evidence-based behavior change campaigns and activities accompanied by M&E to measure impact, increasing role of communities and private sector.

• **Epidemic surveillance and response:** Epidemic surveillance sites in 20 sentinel sites report all data weekly and data are analyzed to identify hotspots. They are distributed in 10 health districts and 7 medical regions. Case notification and reactive case investigation in pre-elimination zones.

• **Monitoring and evaluation/research:**
  - Integration of NMCP data into DHIS2 adopted by the MoH, with quarterly data reviews.
  - Introduction of mobile health (mHealth) system to facilitate reporting of data at community level and reporting of weekly case counts.
  - Health facility supervision using tablet computers to streamline analysis and feedback.
  - Reinforce pharmacovigilance.
  - Operational research on the introduction of low-dose primaquine for transmission reduction in elimination settings.

• **Supply chain management:** Improve storage and transport capacity, strengthen coordination between the NMCP and the Central Medical Stores, strengthen capacity for supply chain management at all levels, monitor drug quality and efficacy.
Program management and coordination: Improve managerial and operational capacity, increase resource mobilization and coordination efforts, and strengthen partnerships.

FIGURE 3: INTERVENTIONS TARGETED TO INCIDENCE, BY DISTRICT (STRATEGIC FRAMEWORK 2014-2018 OF NMCP)

Key Abbreviations: MSAT – mass screen and treat; FSAT - focal screen and treat; SUFI – scale up for impact (LLINs, IPTp, RDTs, ACTs, PECADOM); MDA – mass drug administration; SMC – seasonal malaria chemoprevention

3.6.2 INTEGRATION, COLLABORATION, AND COORDINATION

A new coordination body was created in 2011, called the Cadre de Concertation des Partenaires de Lutte contre le Paludisme (CCPLP), which brings together funding, technical, and non-governmental partners. The president is selected on a rotating basis from among the partners, with the NMCP functioning as the secretariat. This group meets several times each year to exchange information and has been instrumental in helping resolve challenges and coordinate efforts.

Funding and technical partnerships

Senegal currently has one active Global Fund malaria grant for approximately $88 million, awarded to two principal recipients, the NMCP and IntraHealth International.

Phase 1 of the grant has been extended to the end of 2014 and the NMCP submitted a concept note in June 2014 under the new funding model for additional resources to cover the period 2015 to 2017. The NMCP, PMI, and Global Fund Senegal teams enjoy frequent communication and close collaboration.
The **World Bank** continues to provide support for malaria through the Senegal River Basin Development Organization and the Nutrition Enhancement Project. Activities include LLIN distribution and communication/education.

The **World Health Organization** (WHO) continues to provide technical and some financial support for the implementation of treatment and prevention policies, planning, M&E, research, surveillance, and management of the NMCP.

The **United Nations Children’s Fund** (UNICEF) provides support for district-level health plans in the regions of Kolda, Sédhiou, Kédougou, Tambacounda, and Matam. UNICEF collaborates with the United States Agency for International Development (USAID) funded Community Health Program Component to support various community health interventions in more than 500 health huts. They also contributed to the scale-up of integrated PECADOM in four regions, and supported operational costs for the 2013 SMC campaign.

The **Islamic Development Bank** (IDB) provided $8 million in loans in 2009-2010 for the procurement of LLINs and RDTs, health personnel training, and supervision. They are finalizing a new $10 million loan to be disbursed beginning in 2015.

In addition to multilateral institutions, Senegal benefits from the support of various bilateral donors. The **French Cooperation** contributes significantly to research activities through the **Institut Pasteur** and the **Institut de Recherche pour le Développement** (IRD) and places a technical advisor at the MOH. The **Japan International Cooperation Agency** (JICA) and **USAID** have developed a joint partnership in Tambacounda and Kédougou regions; JICA donated $1 million for malaria activities in these regions through UNICEF in 2013. The **Chinese Cooperation** makes periodic donations of drugs for the treatment of uncomplicated and severe malaria, and the **Embassy of Thailand** has supported the participation of health personnel at malaria training courses in Thailand. The Belgian Technical Cooperation is supporting the overall development of the health sector primarily in Fatick and Kaolack regions.

Senegal’s non-governmental and faith-based partners are also numerous. **Médicos del Mundo** and several Spanish non-governmental organizations are active in Sédhiou and Kolda regions. They have supported outreach activities by health post staff, rehabilitation of health huts, and LLIN distribution campaign operations.

**Speak Up Africa** is a local non-governmental organization dedicated to mobilizing African leadership, resources and individual action against malaria, diarrhea, and pneumonia in several countries. In Senegal, the group has supported various communications/advocacy activities and helps to draw in national celebrities to support the malaria control cause.

The **International Committee of the Red Cross** supports outreach activities and LLIN distribution campaign operations in conflict zones in Ziguinchor and Sédhiou regions, as well as in the mining areas of Kédougou Region.

The **Malaria Control and Evaluation Partnership for Africa** (MACEPA), which began work in Senegal in 2009, has implemented a pre-elimination project in one northern district, including enhanced and integrated surveillance and case investigation, and a mass screen and treat program in hotspots in three additional districts.

Senegal is fortunate to have strong academic and research capacities in epidemiology, parasitology and entomology at the NMCP, **Université Cheikh Anta Diop** (UCAD), the **Parasite Control Service** (**Service de Lutte Anti-Parasitaire** - SLAP), IRD, and the **Institut Pasteur**.

These groups have strong collaborative relationships and together have published much of the recent literature on malaria in Senegal.
**Private sector**

In recent years the NMCP has been working with an increasing number of private enterprises on outreach and sensitization programs, LLIN distributions, and malaria case management. For example, collaboration with the **Senegalese Sugar Company** in the northern city of Richard Toll led the company to introduce RDTs in their clinic, to screen all seasonal workers for malaria, and to provide them with LLINs. The company continues to be active in pre-elimination activities in the district, which was highlighted during 2014 World Malaria Day events. **BICIS Bank** (BNP/Paribas) has become more active in the past year, supporting the printing of a popular children’s comic book on malaria and airing spots/messages on the video screens in their branches. The fuel company **Total** has supported communications activities and will sell socially marketed LLINs in their stations’ shops. Nevertheless, meaningful, longer-term partnerships have proven to be challenging due to the time commitment and skills required to develop them.

**Within United States Government (USG)**

The **United States Peace Corps** and PMI embarked on a new partnership in 2011. In Senegal, PMI staff and implementing partners continue to regularly participate in pre-service and in-service training sessions and over the past year supported one third-year malaria volunteer to oversee malaria PCV malaria activities and liaise with PMI and one third-year volunteer to support the entomology laboratory at UCAD. Peace Corps volunteers also support PMI and the NMCP through information, education and communication (IEC) activities and by participating in M&E and operational research (OR) activities. Two innovative strategies piloted by Peace Corps, universal coverage distribution of LLINs targeting every sleeping space, and PECADOM Plus, a community-based active fever detection program, have been adopted by the NMCP.

**Global Health Initiative**

Through the GHI, the United States will help partner countries improve health outcomes with a particular focus on improving the health of women, newborns and children. The GHI is a global commitment to invest in healthy and productive lives, building upon and expanding the USG’s successes in addressing specific diseases and issues. (MOP 2015)

**3.6.3 Senegal Ministry of Environment and Sustainable Development**

The Ministry of Environment and Sustainable Development’s **Direction de l’Environnement et Etablissements Classes**, DEEC, is responsible for natural resource management activities (forests, wildlife) and environmental protection in all sectors of activity (pollution and nuisance control, ecosystem preservation and so on.). The Ministry is responsible for insuring that all other ministries comply with the environmental code.

The Ministry includes four sub directorates that are responsible for the implementation of environmental policy; the Directorate of National Parks (DPN), the Directorate of Environment and Classified Establishments (DEEC), the Directorate of Water, Forests, Hunting and Soil Conservation (DEFCCGS), and the Directorate of water retention basins and artificial lakes (DBRLA).
Environmental Code

The Senegalese Environmental Code is the main regulatory framework dealing with the environmental aspects of the IRS Program. According to the code (articles L44 – L47) an Environmental Assessment is required prior to the implementation of any project that is likely to have negative environmental effects. The procedure of the Assessment as well as the format and the content of the assessment report are well defined in a set of regulatory documents related to the enforcement of the Code. The DEEC is responsible for the enforcement of the Code.

The IRS project has potential negative/adverse effects on human health and environment and hence there is a requirement by DEEC to have an EA report prepared and submitted to them for review and analysis to determine if the mitigation measures proposed are satisfactory before approval. This National Environmental Impact Assessment was conducted in 2011, and was approved in the same year. Up to this date, this National Environmental Impact Assessment has not been required to be updated, per the DEEC. From recent discussions occurring in March 2015, according to the Division Head of DEEC, this project is considered a “community” project, or a project which works in collaboration with the same human health goals as the Government of Senegal, no country EIA is required, at present. However, the implementing partner’s recommendation is that the Environmental Mitigation and Monitoring Plan and Report be updated and be submitted to the DEEC for review and approval every year.

This is a list of pertinent Environmental Laws within the Code de L’Environnement (Loi N° 2001 - 01 du 15 January 2001) to the proposed activities of this SEA:

- **Chapter III: Waste Management**

  **Article L3:** Waste must be disposed of or recycled in an environmentally sound manner in order to remove or reduce harmful effects on human health, natural resources, fauna and flora or the quality of the environment. The provisions of this chapter apply to all categories of waste, including medical waste.

  **Article L34:** The conditions under which must be made for the collection, sorting, storage, transport, recovery, reuse, recycling or any other form of treatment and final disposal of waste to avoid overproduction, waste of recoverable waste and pollution of the environment in general, are fixed by order of the Minister of the Environment in collaboration with other Ministers concerned.

  A ministerial decree regulates and sets:

  - The information to be provided by manufacturers and importers of chemical substances for marketing and for the chemical compositions to be placed on the market, the volume marketed and their potential effects vis-à-vis the man and his environment;
  - The list of substances the production, import, transit and traffic on the national territory are prohibited or subject to prior approval of the commission for the control and monitoring of chemicals, harmful and dangerous;
  - The conditions, method, route and transport schedule, as well as all requirements for packaging and marketing of the substances;
  - The terms of issue of the prior authorization.

  **Article L 46:** Harmful and dangerous chemicals manufactured, imported or offered for sale in violation of the provisions of this Act shall be seized by authorized officials of relevant departments.

  When danger warrants, these substances must be destroyed or neutralized as soon as possible by the care services for the administration raised the expense of the offender. Industrial companies may be asked to provide technical assistance to the environmentally sound disposal of these substances.

  **Article L 47:** Prohibits the importation, manufacture, possession, sale and distribution of chemicals
that have not been subject to the approval of the National Committee on Chemicals Management in accordance the provisions of Article L 46 of this Act.

- **Chapter IV: Hazardous materials and dangerous chemicals**

  **Article L44:** Noxious and dangerous chemicals which, because of their toxicity, radioactivity, their destructive nature in the environment or their concentration in biological terms, present or may present a danger to humans, natural environment or the environment when they are produced, imported in the country or discharged into the environment, are subject to the control and supervision of relevant departments. The provisions of this chapter are supplemented by other relevant regulatory legislation.

  **Article 45:** A National Commission on Chemicals Management is ordered by decree of the Minister for the Environment the task to control and monitor the import, use and transport of chemicals, harmful and dangerous to maintain.

  A ministerial decree regulates and sets:

  - The information to be provided by manufacturers and importers of chemical substances for marketing and for the composition of preparations placed on the market, the volume marketed and their potential effects vis-à-vis the man and his environment;
  - The list of substances the production, import, transit and traffic on the national territory are prohibited or subject to prior approval of the commission for the control and monitoring of chemicals, harmful and dangerous;
  - The conditions, method, route and transport schedule, as well as all requirements for packaging and marketing of the substances;
  - The terms of issue of the prior authorization.

- **Title III: Protection of Affected Environments Act**

  - **Chapter I: Water Pollution**

    **Article L 59:** Are subject to the provisions of this Act including spills, runoff, discharges, deposits, direct or indirect of any kind that may cause or increase water degradation by modifying their physical, chemical biological or bacteriological, whether surface water, groundwater or sea water within territorial waters. Special protection areas, subject to special measures shall, if necessary, be formed by order of the Ministers of the Environment, Public Health, Water, Merchant Marine and Fisheries according to the observed levels of pollution and taking into account certain specific circumstances worsen the negative impacts.

  - **Chapter II: Air Pollution and unpleasant odors**

    **Article L 76:** The provisions of this Act and the regulations thereunder air pollution or odors that bother people, endanger the health or public safety, damage to agricultural production, conservation buildings and monuments and the character of sites and natural ecosystems.

    As part of the implementation of international conventions relating thereto, the Government of Senegal can take general actions to prevent air pollution.

  - **Chapter III: Pollution and degradation of soils**

    **Article L 81:** The protection of soil, subsoil and wealth they contain, as limited resources, renewable or not, against all forms of degradation is provided by the State and Local Government.

    **Article L 82:** A joint order, issued by the relevant Ministers, under this Act, sets:
• The specific terms of protection to preserve the elements of biodiversity, fight against
desertification, erosion, loss of arable land and soil pollution and its resources by chemicals,
pesticides and fertilizers;
• The list of fertilizers, pesticides and other chemicals whose use is allowed or promoted in
agricultural work;
• Authorized amounts and terms of use so that the substances do not affect the quality of the
soil or other receiving environments;
• Decree No. 2001 - 282 of 12 April 2001 on the implementation of the Environmental Code
Title I installations classified for environmental protection;
Title II environmental impact study;
Title III water pollution;
Title IV water police;
Title V air pollution;
Title VI noise pollution;

• **Chapter VI Establishing an Emergency Plan**

  Emergency plans must be elaborated to deal with critical situations that may generate severe
environmental impacts and pollution are prepared by the Minister for the Environment in
collaboration with the Ministries and other public administrations and / or private parties concerned.
Consultation is required for this and will be organized in a specialized technical committee set up
under the Permanent Secretariat of the Supreme Council of Natural Resources and Environment.

  The provisions of this Article shall be integrated into the National Emergency Response Plan that is
approved by decree.

3.6.4 **PESTICIDE REGULATIONS AND CONTROL**

Senegal has ratified all international conventions relating to the management of chemicals and
implemented them at the institutional level through the National Commission for Chemicals
Management or the *Commission National de la Gestion des Produits Chimiques* (CNGP).

Senegal has signed the Stockholm Convention on Persistent Organic Pollutants, Rotterdam Convention
on Hazardous Chemicals and Pesticides, the Basel Convention on the trans-boundary movement of
hazardous materials, and the Bamako Convention on trans-boundary movements of hazardous wastes in
Africa. Most importantly, Senegal is a member country of the CILSS (Permanent Interstate Committee
for Drought Control in the Sahel), which consists of a "Common Regulation for the Registration of
Pesticides within CILSS member countries" in March 1994. Senegal, like the CILSS member countries
within the framework of sub-regional integration, joined the Sahelian Pesticides Committee (CSP)
responsible to register pesticides.

The National Committee on Pesticides Management (CNGP) manages pesticides in Senegal. Approval
and registration is exclusively the responsibility of the Sahelian Pesticides Committee (CSP) in Bamako,
Mali. This Commission was established by Order No. 000825/MJEHP 8 February 2001.

Provisional Sale Authorization (VPA) or HOMO of the Sahelian Pesticides Committee (CSP) is given for
authorized vendors. In the case of Senegal, many of the pesticides are sold through the *Societe de Produits
Industriels et Agricoles* (SPIA), which are storefront shops can be found in all regions in Senegal.
The institutional framework for pesticide management relies on three main Ministries in the Senegalese government: Ministry of Agriculture and Rural Equipments, Ministry of Health and Social Action, and the Ministry of Environment and Sustainable Development (DEEC).

The Ministry of Agriculture and Rural Equipments organizes two levels of intervention for pesticide management:

- at the national level: the Directorate of Plant Protection (DPV)
- at the regional level: the Rural Development Regional Directorates (DRDR)

Plant Protection Directorate (DPV) is responsible for the overall protection of crops throughout the extent of the national territory and this, together with the different services that are Customs, Research, Universities, Agricultural Training Schools and security forces, etc. The DPV provides technical and material support to regional rural development companies in generalized invasion of their cotton farms, tomato, rice, sugar cane, etc.

The primary mission of the DPV is to prevent the introduction of new pests in the country putting in place at land borders, sea and air checkpoints. They also have Phytosanitary responsibilities for inspecting and controlling all plant inputs and plant parts from other states. Secondly, the DPV has the responsibility to ensure that the pesticides used in country are used following effective and safe chemical means respecting the environment and human health.

Ministry of Environment and Sustainable Development (MoE) in Senegal or the DEEC is in charge of control and environmental monitoring, application of pesticides; evaluate, appreciate and advises or recommends a pesticide after the latter have already Permitted (APV) or registered by the CSP/CILSS for its use in the country.

Ministry of Health and Social Action: The National Health Service (SNH) is operational including the fight against vectors and diseases (malaria, schistosomiasis); regional services are operational in the regions.
<table>
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<tr>
<th>Legal instrument (type, reference year)</th>
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<tr>
<td>Law No. 84-14 of 2 February 1984</td>
<td>Ministry of Agriculture and Rural Equipment</td>
<td>supervision of agro-pharmaceutical specialties and assimilated specialties MAH approval, pesticide control and sanctions</td>
<td>Articles 2, 4, 6, 7, 10, 15</td>
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<tr>
<td>Law No. 2001-01 Of 15 January 2001</td>
<td>Ministry of Environment and Sustainable Development (DEEC)</td>
<td>Streamline the management of the environment</td>
<td>Chapter IV Articles L44, L45, L46, L47</td>
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<tr>
<td>Decree No. 84-503 of 2 May 1984</td>
<td>Ministry of Agriculture and Rural Equipment</td>
<td>Control agro-pharmaceutical products</td>
<td>Articles 1, 2, 5</td>
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<tr>
<td>Décret N° 2001-282 du 12 avril 2001</td>
<td>Ministry of Environment and Sustainable</td>
<td>Streamline the management of the environment</td>
<td></td>
</tr>
<tr>
<td>Decree No. 09415 du 06-11-2008 restricting importation, production and utilization of pesticides and chemicals listed in the Stockholm Convention on POPs</td>
<td>Ministry of Environment and Sustainable Development Ministry of Agriculture and Rural Equipments Ministry of Livestock Ministry of Trade</td>
<td></td>
<td>Articles 1, 2, 3, 4</td>
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<tr>
<td>Order No. 5381 of 20 May 1985 laying composition and rules of organization of the National Commission of Accreditation</td>
<td>Ministry of Agriculture and Rural Equipment</td>
<td>Examine applications for approval of pesticides and select users with effective and safe pesticides</td>
<td>Articles 1, 2</td>
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<td>Decree No. 005161 primatorial of 26 May 1995</td>
<td>Ministry of Agriculture and Rural Equipment and CSP</td>
<td>Initiate a sustainable management strategy for chemicals</td>
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<td>Ministerial Order No. 000852 of February 8, 2002</td>
<td>National Commission for Chemicals Management CNGP</td>
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<tr>
<td>Circular No. 01307 of February 1990 of</td>
<td>Ministry of Agriculture and Rural Equipment</td>
<td>Agricultural Pesticide Management</td>
<td></td>
</tr>
</tbody>
</table>
The following is a summary of the relevant aspects of the Pesticide Regulation:

**Procedures for obtaining registration**

All substances containing pesticides or plant growth regulators to be imported, produced, marketed and used in the country are subject to a prior registration with the CILSS (Committee on Drought Control in the Sahel) and with the GoS’s Ministry of Agriculture and Rural Equipment. At the international level, Senegal is a Member state of the Committee on Drought Control in the Sahel (known by its French acronym CILSS) which share a common Regulation for Pesticide Registration. Established in 1973, CILSS includes nine Member States: Burkina Faso, Cape Verde, Chad, Guinea Bissau, The Gambia, Mali, Mauritania and Senegal. These regulations provide for the registration of all pesticides entering the Sahel region to be performed by a central committee of experts, called the Sahelian Pesticide Committee. Harmonized tests and field trials have been established, and regional laboratories for conducting various analyses relating to pesticides also exist. The technical and scientific data needed for the evaluation of pesticides includes the physical-chemical, toxicological, eco-toxicological properties and biological metabolism and residues. Label requirements, packaging characteristics and criteria for toxic classification and its impact on the environment, are contained in the rules for the registration and handling of pesticides. On delivery of the request, the applicant must pay a fee set by the registration authority.

**Evaluation**

The pesticide registration is carried out based on the evaluation of the efficacy and safety of the product, to ensure that under normal conditions of use, it is within the acceptable toxicological standards for human, animal and environmental health. During the evaluation product samples for testing purposes or technical formulations of the active ingredient may be required.

In Senegal, there are a number of laboratories equipped and suitable for quality control of residual analysis, training and research. However, at the state level, no appropriate laboratory for analysis and control of the quality of distributed pesticides exists. Otherwise, the DPV should be in charge of doing the quality control.

The Laboratory of Analytical Chemistry and Toxicology, Faculty of Medicine and Pharmacy of the University Cheikh Anta Diop of Dakar conducts microbiology analyzes, pesticide residues of heavy metals in drinking water, food, and soil; mycotoxin and industrial waste.

The Toxicological Pharmacy Laboratory of the Inter-State School of Veterinary Sciences and Medicine of Dakar conducts the same activities as the Laboratory Analytical Chemistry and Toxicology of the University Cheikh Anta Diop of Dakar but in the veterinary field.

**Composition and specifications**

The composition and physical-chemical properties of pesticides proposed for registration shall conform to the specifications of the World Health Organization (WHO) or the United Nations Food and Agriculture Organization (FAO).
Organization (FAO) and must appear on the label. Since Senegal is francophone, the labels should be in French. When these specifications do not exist, the registration authority may consider the specifications provided by the manufacturer. The specifications label on the active substances must match those contained in the pesticide and comply with international standards.

**Toxicological classification**

The toxicological classification of pesticides is based on the 50% lethal dose (LD$_{50}$) for oral or dermal, and 50% lethal concentration (LC$_{50}$) for inhalation exposures. Pesticides are placed into one of three classes: class I - highly toxic (label with red stripes); class II - moderately toxic (label with yellow stripes); and class III - slightly toxic (label with green stripes).

**Authorization of pesticides for Public Health activities**

Public health pesticides are broken down into 2 groups: a) pesticides for domestic (homeowner) use b) pesticides for professional use in vector control. Pesticides for domestic use are subject to registration, import, distribution and application requirements defined by the registration authority, as laid down in the rules for the registration and handling of pesticides. Pesticides for professional use in vector control are subject to the normal registration procedures and should also be tested by the DPV. In the case of the AIRS project, the pesticide will be tested through an internationally qualified laboratory.

Public health pesticides labels must be written in French and include the registrant, product identification and active substance, purpose and mode of application, safe use and disposal of packaging after use, as well as the procedures for first aid in case of poisoning.

**Importation of Pesticides**

The entity intending to import pesticides, whatever their amount, is required to obtain a certificate of registration as an importer of pesticides.

**Pesticide storage**

The store manager shall, in coordination with DPV or the DRDR regionally, follow all technical standards concerning storage conditions for pesticides based on the FAO directives. The pesticides should be stored in isolated compartments and locked, properly ventilated, out of reach of children and unauthorized persons, and always properly separated from food and animals, medicines.

**Application of pesticides**

Only pesticides that are registered, or authorized for emergency or experimental, use can be used. The pesticides should always be applied in accordance with the particulars given on the label, bearing in mind proper protection practices and, whenever possible, the principles of integrated pest management of pests and diseases. These practices must minimize the risk to the applicator, consumers, non-target organisms, the general population and the environment.

**Transport of pesticides**

All vehicles must be authorized to carry pesticides based on quantities greater than or equal to the following: i) 200 pounds or liters of pesticides of class I; ii) 1,000 pounds or liters of pesticides of Class II; iii) 2,500 liters of pesticides Class III. Only drivers approved by the registration authority or his representative shall transport pesticides on public roads as per the quantities listed above. For the PMI/NMCP IRS project, vehicles will be certified with BMPs on emergency spills and inspected by the implementing partner's Environmental Compliance Officer, DREEC, SNH and.

**Disposal of pesticides**

The disposal of pesticides or their relocation to approved locations can only be undertaken after prior authorization from the central or DPV with consensus from the Ministry of Agriculture and Rural Equipments. Registration authority CSP, will establish the procedures for pesticide disposal. In the case
of the AIRS project, the NMCP and the DEEC worked together to select a qualified facility for disposal of IRS wastes. An appropriate incineration facility at SOCOCIM, the Societe Ouest Africaine de Ciments (West African Cement Factory) at Rufisque was used in 2013/2014. In 2015, during the scoping visit for this SEA, discussions were held with SODEFITEX, cotton manufacturing factories, in Tambacounda and in Velingara about pesticide waste disposal. During the meeting the General Manager shared with the PMI team that they would be procuring an incinerator for their waste disposal needs and would be willing to share the facility with the PMI/NMCP IRS project. This is described in more detail in section 8.2.

Training

Companies or entities that employ people to store, handle, transport or apply pesticides are responsible for training on the following: rules for transport, storage, application, fire safety, intoxications, spills, disposal and safe handling practices. These rules comply with WHO and FAO standard procedure. In the case of the IRS project, as local capacity building has been strengthened in terms of IRS activities and proper use and management, the National Hygiene Service (SHN) will conduct the spray operator training and supervise the spray techniques. The SHN has undergone rigorous Training of Trainers workshops and demonstrated full knowledge of the Best Management Practices for IRS and expertise.

Obsolete pesticides

It is prohibited to distribute obsolete pesticides. Organizations, users, companies or other entities that have obsolete pesticides shall communicate in writing to the registration authority, detailing the type of active substance, the trade name, quantity, type of packaging, the location of the product as well as reasons of obsolescence.

Supervision

The supervision of the importation, storage conditions, application, production, distribution, disposal and quality control of pesticides will be made by technical personnel accredited by DPV or who legally represents it. The inspection team should include SNH/DREEC staff. The DEEC supervises, monitors and conducts the environmental compliance inspections of the IRS activities.

Competence to oversee

Technical staff authorized and indicated by the registration authority to carry out the inspection has a right of access to all establishments or places of production, storage, distribution and application of pesticides.

3.6.5 INTERNATIONAL CONVENTIONS

The following are the many Multilateral Environmental Agreements to which Senegal is a party:

- Basel Convention on the Trans boundary Movement of Hazardous Wastes and their Disposal
- Bamako Convention on the ban of Import into Africa and the Control of Trans boundary Movement and Management of Hazardous Wastes within Africa
- Common Regulation of CILSS on the registration of pesticides signed in 1990 and ratified in 2002
- Comprehensive Test Ban Treaty
- Convention on Biological Diversity
- Convention on Fishing and Conservation of Living Resources of the High Seas
3.7 **SeneGAL MalarIa CoNtRolv AcTIVITIES**

3.7.1 **VeCToR CoNtRolv AcTIVITIES**

Malaria prevention Integrated Vector Management (IVM) incorporates various vector control interventions, selected on the basis of the local factors that determine malaria transmission include the following:
• IRS - most effective method in controlling adult mosquitoes, the vector of malaria, by spraying pesticide on the walls of homes, which can result in reducing the level of malaria transmission.

• LLINs - effective and preventive method that provides a physical barrier between mosquitoes and home owners, and also is toxic to mosquitoes.

• Environmental management/larval control (includes all physical, chemical and biological methods) - larval mosquito vector control of malaria has the potential to be effective whenever the breeding targets are well defined and are limited in number, particularly in the sub and peri-urban areas.

• Entomological monitoring - ensures the assessment of density, the vector of malaria susceptibility and residual efficacy of pesticides used on IRS and LLINs. This is currently conducted by the UCAD in 24 entomological sites.

The NMCP’s 2014-2018 Strategic Framework includes IRS as a key component of malaria prevention along with other vector control interventions, such as LLINs and larval source management. Senegal has only benefitted from IRS since PMI began work in the country in 2007. The NMCP has adopted a targeted approach for IRS: a) districts with a yearly incidence of less than 30 per 1,000 will not receive IRS, b) districts with an incidence between 30 and 50 per 1,000 may have targeted IRS in the health post zones where malaria incidence is greater than 50 per 1,000 (hot spots) and c) districts with an incidence greater than 50 per 1,000 will receive IRS over the whole district. Entomological parameters such as indoor biting and resting rates also will be used to assist in determination of where IRS may be appropriate. The goal for IRS is to protect at least 90% of the population in targeted areas. The program has used pyrethroids and is using carbamates and organophosphates, which are insecticide classes approved by the World Health Organization.

Universal coverage of LLIN distributions targeting every sleeping space began in 2010 and were completed in early 2013, with 6.9 million LLINs distributed. In 2013, PMI piloted free distribution to primary school students in two regions, with 75,710 LLINs distributed in classes CI and CE2 (six- and nine-year olds) once during the school year.

The Senegal NMCP 2014-2018 Strategic Framework includes one overarching strategy for malaria prevention related to LLINs, which is to strengthen distribution mechanisms. It describes two distinct approaches: 1) mass distribution of LLINs to achieve/maintain UC, defined as one treated net per sleeping space; and 2) routine distribution to allow ongoing access to LLINs. The objective is for 80% of the total population of Senegal to sleep under an LLIN.

3.7.2 ENTOMOLOGICAL MONITORING

Insecticide resistance threatens both LLIN and IRS programs in Senegal, as it does in many PMI countries. Only three of the 15 surveillance sites showed sensitivity to pyrethroids in 2010 and none were in districts targeted for IRS. While pyrethroid sensitivity has increased in many of the entomologically monitored districts, both in those sprayed with carbamates and those not, a return to pyrethroids for IRS is not foreseen given the strategy of universal coverage with LLINs. Carbamates were used in all IRS districts from 2011-2013, their short residual life (two months) has necessitated a switch to organophosphates in 2014 in the higher transmission districts with longer rainy seasons. The 2015 spray season will see a majority of the spray districts sprayed with organophosphates, and some with carbamates.

During the eight months following the end of the 2013 PMI IRS spray round, entomologists from UCAD, the Parasite Control Service, Institut Pasteur, and IRD conducted entomologic monitoring in five villages in each of the four IRS districts and three villages in two neighboring districts, Kolda and Kaffrine (24 sites total). The monitoring included cone bioassays on walls to test for insecticidal activity (not in the non-IRS districts), knockdown spray catches, and human landing catches. Because susceptibility to carbamate was still high at the end of the 2012 spray round, this class of insecticide was selected for the
2013 spray season. On average the results of cone bioassays on carbamate-sprayed walls were similar in all districts with the mortality between 90% -100% in the first month and between 75 and 80% in the second month. By the third month the results were variable but all except Koumpentoum were well below 70%. Thus, as in previous years, the insecticidal activity of bendiocarb appeared to endure at most two months. In three districts, cone bioassays were also done with mosquitoes raised from locally collected larvae. Mortality rates were generally even lower, although Anopheles gambiae from these districts were 99% to 100% susceptible to bendiocarb in resistance assays. As was observed in 2011 and 2012, an apparent increase of insecticidal activity was noted in cone bioassays in all the districts in the five to eight months after spraying, a phenomenon that may be related to decreases in ambient temperature. For the two months following spraying in 2013, parity rates of mosquitoes collected in the IRS district of Vélingara were lower (4% in September and 30% in October) than those collected in the neighboring non-IRS district of Kolda (18% and 83%, respectively) suggesting that insecticide was still reducing vector longevity. Mosquitoes continue to bite indoors as well as outdoors but at lower rates both indoors and outdoors in the IRS districts than in the comparison districts.

Insecticide resistance assays were conducted in 16 geographically dispersed districts of Senegal, in a total of 24 sites. Assays were performed with insecticides of all four classes but not all insecticides were tested in all districts. The insecticides used for the assays are as follows:

- **Pyrethroids:**
  - Deltamethrin 0.05%
  - Lambda-cyhalothrin 0.05%
  - Permethrin 0.75%
  - Cyfluthrin 0.15%
  - Alpha-cypermethrin 0.1%

- **Organo-chlorine:**
  - DDT 4%
  - Dieldrin 4%

- **Organophosphates:**
  - 5% Malathion
  - Fenitrothion 1%
  - Pirimiphos-Methyl 1%

- **Carbamates:**
  - Bendiocarb 0.1%

The data showed that vector susceptibility to bendiocarb remained high in most of the country (99%-100% in the IRS districts) but was fairly low in the three districts without IRS (Kaffrine, 83%; Ndoffane, 78%; and Richard Toll, 86%). Pyrethroid resistance varied greatly but improved in both IRS and non-IRS districts whereas DDT resistance was evident in almost all sites.

During the 2014 rainy season, the determination of the sensitivity of malaria vectors to insecticides was made in 24 health districts in all natural regions.

For pyrethroids, the few cases of sensitivity obtained were noted with Deltamethrin (Koungheul, Kaffrine and Kanel), Permethrin (Fatick and Linguère) and Cyfluthrin (Koungheul and Richard-Toll) and Lambda-cyhalothrin (Richard Toll). In most districts, the specimens were resistant to at least four of the
five molecules pyrethroids tested. In Maleme, Tambacounda, Kédougou, Dakar and Guédiawaye, the samples were resistant to all tested pyrethroids.

The sensitivity of the samples to Malathion and especially Pirimiphos-methyl was general in all the districts where they have been tested with more than 99% mortality of exposed specimens. A general trend in sensitivity was also noted with Fenitrothion, but with resistance in the district of Kédougou. Anopheles gambiae strains were resistant to organochlorines in all districts.

The status vis-à-vis Bendiocarb samples varies depending on the districts. Generally in the districts of Centre strains are sensitive unlike those tested in the South (Tambacounda, Kolda, Kédougou and Velingara), in the Niayes, Thies (Ndioukhane) and Dakar and its suburbs. This is likely related to a high insecticidal pressure related to the cultivation of cotton (South) and market gardening (Center - West).

Capacity building in entomological monitoring has been carried out since before the AIRS project started in 2007. Senegal is a beneficiary of a WHO/Gates Foundation grant to improve insecticide resistance monitoring capacity. Entomologists from UCAD, the Institut Pasteur de Dakar, the Institut de Recherche pour le Développement (IRD), and the Parasite Control Service in Thiès, together with members of SNH, detailed 12-day course to train district and Regional Hygiene Service staff on entomologic control and surveillance methods. The training included but was not limited to mosquito sampling methods, species identification, insecticide resistance testing that include insecticide resistance intensity, assessment of the contribution of metabolic detoxification enzymes to phenotypic resistance using CDC bottle bioassays with synergists, ovary dissection, and preservation, storage and shipment of mosquito samples for advanced laboratory work.

In 2008, 42 staff of the Hygiene Service from 11 of Senegal’s 63 districts were trained. At present, it is unclear whether Hygiene Service staff will carry out these methods independently or will assist trained entomologists in the studies. Every year to date, the PMI IRS project has trained new personnel in entomological methods.

To provide more consistent support for the entomology personnel and activities in Senegal, in 2015, two entomologists one from the PMI AIRS/Senegal project and the other from NMCP will participate in six days of intensive regional entomology training.

Collection of data on insecticide resistance intensity, resistance mechanisms (metabolic detoxification enzymes) using CDC bottle bioassay with synergists and some secondary PMI entomological indicators like parity rates was not part of the PMI AIRS project routine work across all project countries for the past three years. Going forward there is a plan to include these indicators as part of routine entomological monitoring data collection across all the project countries. The regional entomology training is intended to provide skills to help this happen and provide an opportunity for sharing of best practices and experiences among countries.

With the possibility of emerging insecticide resistance in Senegal and the transition/change of certain IRS and areas to universal LLIN coverage, epidemiologic and entomologic monitoring in IRS districts has expanded and will most likely expand.

Other Resistance Management studies: Currently, the NMCP is conducting an ongoing three year durability testing of ITNs/LLINs with PMI. This testing is done to compare the quality and durability of less than ten different types/brands of LLINs.

3.7.3 Food and Agriculture Organization of the United Nations (FAO)
Prevention and Disposal of Obsolete Pesticides

FAO’s Program on the Prevention and Disposal of Obsolete Pesticides is working to inform the world about the dangers of obsolete pesticide stocks. It collaborates with developing countries to prevent more obsolete pesticides from accumulating and assists them dispose of their existing stockpiles. In
Senegal, obsolete pesticides do exist and there are hefty fines associated with being in possession of such stocks. Information on what quantities or what types of obsolete pesticides in Senegal is not available.
4. **Description of Proposed and Alternative Actions**

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:

- **Preferred action**: Establish annual IRS campaigns that spray pesticides of the pyrethroid, carbamate, and organophosphate (and the chlorfenapyr, pyrrol, when approved by WHOPES) 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.

- **No action alternative**: This action would discontinue PMI support for IRS activities in Senegal.

- **Spraying in alternative geographic regions**: This alternative would use different criteria to select alternative districts and sectors to spray.

- **Using alternative pesticides**: This alternative would consider pesticides other than those recommended by WHOPES.

- **Alternative technologies**: This alternative would consider methods other than IRS to achieve the stated goals of reduction in malaria mortality and morbidity.

### 4.1 Proposed Action - Indoor Residual Spraying

The preferred action is to implement an IRS program in selected communities as guided by the National Malaria Control Strategic Plan and the IRS Steering Committee for choosing among the pyrethroid, carbamate, and organophosphate classes (and chlorfenapyr, when recommended by WHOPES), considering current entomological, epidemiological, logistical, environmental, and economic conditions. The Safe Use Action Plan (SUAP, Chapter 8) and the Environmental Mitigation and Monitoring Plan (Annex A) will be followed to ensure environmental compliance and safe operations.

The NMCP 2014-18 Strategic Plan and the Senegal's IRS Steering Committee have identified several needs to improve the efficiency of operations. The NMCP Strategic Plan calls for a more targeted approach to IRS, switching from blanket approach to focal IRS spraying. It lays out a number of criteria for selecting IRS areas (i.e. areas of high incidence over 15/1000 inhabitants, high population but not highly urbanized centers, and feasibility in terms of the nature of habitat and behavior of the population). The Plan also addresses the need for more capacity building at the District level, even with the anticipation of establishing IRS management units that will improve coordination and management between the different partners. In keeping with the goals set forth in the Malaria Strategic Plan, PMI aims to support the following goals in the next five years:

- An integrated, evidence-based approach to IRS that results in a more cost-effective and efficient targeted strategy for the country.

- Implementation and improvement based on continually collected data, in a way that results in an integrated approach to vector control in Senegal.
• Strengthening of the IRS program, by improving managerial and operational capacity, increase resource mobilization and transferring of responsibilities to the NMCP, and to the District level.

The criteria outlined in this strategy was used by the NMCP, which is part of the IRS Steering Committee, to develop the chosen "hot spot" districts that should be prioritized for IRS this upcoming spray season. The IRS Steering Committee plan to review the epidemiologic and entomologic data collected every year and make adjustments to the target areas.

PMI will work as a team with its Senegalese counterparts and will lead, finance, and be ultimately responsible for the implementation of the spray campaign for its 9th round in Senegal in 2015. The IRS "hot spot" zones were picked in 4 target districts, i.e. Malem Hoddar, Koundheul, Koumpentoum and Nioro. The IRS Steering Committee proposed the following dates for the 2015 spray rounds: all eligible health posts in Koumpentoum, Malem Hoddar and Koundheul will begin spraying with organophosphates on May 2015 for 20 days. However, to ensure optimal coverage of the transmission season given the limited residual efficacy of the carbamates, bendiocarb spraying will start in eligible health posts of non-selected hot spots in Nioro.

Exact health posts within these districts will be determined by Senegal's IRS Steering Committee and will be determined by HMIS data on malaria incidence. PMI plans to support one round of spray operations in malaria "hot spots" as defined epidemiologically by health post zones with malaria incidence in excess of 15 cases per 1,000 residents. In this context, this year 120,553 structures are targeted to be sprayed and approximatively 450,000 people protected.

In support of the spray campaign, NMCP will conduct Information, Education & Communication (IEC), also known as Behavior Change Communication (BCC), mobilization activities in all four districts with direct funding from PMI/Senegal and the PMI AIRS project. Additionally, AIRS Senegal will continue to work in close collaboration with NMCP and will be responsible for conducting monitoring and evaluation (M&E) and environmental inspections in collaboration with DEEC and its Regional Directorate of Environment and Classified Establishments (DREEC). The project will also be responsible for the distribution and transport of IRS commodities and personnel. As in previous years, NMCP will continue to organize the supervision of operations with support from AIRS Senegal in collaboration with SNH in all selected districts.

PMI will continue to support the epidemiologic and entomologic surveillance by the UCAD to lead the in-country activities and contribute data and results in support of the vector control work of the NMCP. Their specific tasks include determining the residual life of the sprayed insecticide in the local context; monitor the level of insecticide resistance to all four classes of insecticides annually, and determine the mechanism of resistance if resistance is detected; gather data on vector feeding time and location; identify vector species found in the intervention areas, including using molecular identification methods. Insecticide resistance assays were conducted in 24 geographically dispersed districts of Senegal, in 2014. Assays were performed with insecticides of all four WHO recommended classes but not all insecticides were tested in all districts.

PMI will also support the NMCP in their national Malaria control program by strengthening each district's capacity to manage IRS activities occurring in its district and by improving the quality of NMCP IRS operations. PMI will assist with the IRS training of trainers in a cascade approach for the central level NMCP team, district malaria managers, and key malaria staff. These personnel will then be responsible for conducting the training of the spray operators in the districts. In addition, the NMCP will lead the national planning meeting, national evaluation meeting, TOTs, and IEC trainings in all districts. AIRS Senegal will work together with MOH/NMCP to ensure supervision of spray performance during the campaign.
4.1.1 Proposed Activities for FY 2015:

(PMI identifies activities for the Malaria Control Program annually, and activities for subsequent yearly programs may vary).

- IRS Implementation in four districts: PMI plans to support one round of spray operations in malaria hot spots in selected districts based on malaria incidence and entomological data. Eligible areas include districts and/or health post zones with an incidence greater than 15/1,000 in the previous year and with indoor resting and biting malaria vectors and are generally located in the four southeastern regions. Number of structures sprayed and people protected will be estimated after districts or health zones have been chosen but will be similar to those covered in 2014 (215,000 and 740,000 inhabitants respectively).

- Purchase equipment and supplies for the IRS operations in four districts: Procure adequate quantities of personal protective equipment and spare parts for spray pumps, etc. (excluding insecticides)

- Support of NMCP IRS activities for training of trainers through a cascade approach and supervision of IRS activities

- Support ongoing entomologic monitoring activities in the IRS districts and non IRS districts to support insecticide resistance testing and vector species monitoring.

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). As an example, the following is the approach PMI used to study chlorfenapyr in Nigeria, and may be used to guide activities in Senegal.¹

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:

a. Assess the insecticidal bio-efficacy of key disease vectors to chlorfenapyr in comparison with other insecticides.

   In order to assess insecticidal bio-efficacy, 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.

b. Compare the efficacy and residual life of chlorfenapyr applied as an indoor residual spray on relevant substrates with that of other WHOPE-recommended pesticides at recommended doses.

   The second activity will be carried out in experimental huts (four or five) located in a high endemic location.

   Bendiocarb will serve as a comparison insecticide from the carbamate class, alpha-cypermethrin for the pyrethroid, and Actellic CS for the OP classes of insecticides. The walls, windows, ceiling, and

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¹. Abt/USAID PMI AIRS Project IRS2 Task Order Four. Supplemental Environmental Assessment Addendum, Nigeria. 2014
door of the huts will be treated with the specified insecticides per the WHOPEs recommended dosages using a compression sprayer. One trained spray operator will be used, and it will take one day to complete the spray operation.

To mimic residential life in the huts and attract mosquitoes, volunteers will sleep inside a hut for up to seven nights on a monthly basis, for up to six months total. Six adult male volunteers (ages 20-30 years) will be recruited for the study among the inhabitants of the village close to the hut site. Sleepers will be rotated randomly among the huts. Sleepers shall enter the hut at night (9 pm) to sleep on the mattresses provided and remain inside until dawn (6 am).

At specified intervals, data will be collected on blood feeding rates, death rates, and entry versus exit rates using window traps. Bioassays will be conducted to determine residual efficacy of all insecticides. In addition, the pH and sand/silt/clay content will be recorded for each wall surface. Both have been known to impact the results of bio-efficacy.

If Senegal does undertake small scale hut trials under this project, additional review of the protocol and clearance are required from the Global Health BEO and the project COR.

4.1.2 PREFERRED INSECTICIDE CLASSES

Due to the issues of resistance in Senegal, preferred insecticides will change in response to the results of the annual entomology reports. Generally, pyrethroids have been the preferred insecticide of choice for PMI programs, but due to increase of resistance to pyrethroids, and also carbamates, organophosphates will be used in Senegal.

4.1.3 REJECTED INSECTICIDE CLASSES

All of the WHOPEs-recommended insecticides for IRS with the exception of DDT will be considered for use on the PMI IRS program, as well as chlorfenapyr when approved by WHOPEs. All other pesticide classes are rejected.

4.1.4 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, groundwater resources, protected habitat, aquacultural activities, etc.) to maintain a 30 meter buffer distance 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 responsibilities, including site managers, team leaders, spray operators, overalls washers, site attendants, security guards, and water fetchers.
- Procure, transport, and store all necessary spray and personnel protective equipment (PPE),
• Implement the Environmental Mitigation and Monitoring Plan (EMMP) in Annex A of this SEA throughout all processes.²

4.2 **NO PROJECT ALTERNATIVE**

IRS is one of the critical interventions in the control of the spread of malaria. The highly prioritized districts, also known as hotspots, are those that have an incidence of malaria higher than 15 per 1000 inhabitants. A no project alternative will result in rising rates of infections, transmissions, mortality and morbidity due to the increased prevalence of malaria infected vectors. Therefore, the no action alternative does not meet the overall goal of the Senegal National Malaria Control Program (to reduce malaria mortality by 2018 by 75%) and President’s Malaria Initiative, which is to reduce malaria mortality by 50% in up to 15 countries (total population: 175 million) in sub-Saharan African by 2020.

4.3 **ALTERNATIVE IRS GEOGRAPHICAL SITES**

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

4.4 **USE OF ALTERNATIVE INSECTICIDE(S)**

For IRS to be supported by PMI, a pesticide approved by World Health Organizations (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 approved the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines and organophosphates. Currently, there are no other pesticides eligible for use in PMI-funded IRS, but deliberations included chlorfenapyr in addition to the WHO-approved pesticides. This proposed action for Senegal includes the use of organophosphates, carbamates, chlorfenapyr (when WHO approved and registered in Senegal), and pyrethroid formulations. DDT is banned in Senegal.

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² USAID. President’s Malaria Initiative. Senegal. *Malaria Operational Plan FY 2015*. 
4.5 **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. The specific focus of this PMI effort and the role that PMI plays in Senegal includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays the National Malaria Control Program, PMI and its partners would evaluate them and proceed accordingly.

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3 The NMCP malaria prevention plan incorporates Integrated Vector Management (IVM) using various vector control interventions, which are selected on the basis of the local factors that determine malaria transmission. Environmental management/larval control is an IVM intervention that includes all physical, chemical and biological methods. Larval mosquito vector control of malaria has the potential to be effective whenever the breeding target are well defined and are limited in number, particularly in the sub and peri-urban areas. Currently, larval control and the reduction of potential breeding grounds are not common practices, and only are implemented in specific geographic locations, such as in flood prone zone near Dakar. To be successful, this activity requires multi-sectoral and community involvement.
5. Affected Environment

5.1 Country Overview

Senegal is located on the west of the African continent. It lies between latitudes 12° and 17°N, and longitudes 11° and 18°W. The country’s total area is 196,190 km², of which 192,000 km² is land, and 4,190 km² is water. Senegal is bordered to the west by the North Atlantic Ocean. On land, the nation’s longest border is with Mauritania to the north, an 813 km border along the Senegal River. To the east is the 419 km border with Mali. In the southeast is Guinea (330 km border) and to the southwest is Guinea-Bissau (338 km), both borders running along the Casamance River. Senegal is one of only a handful of countries to have a near-enclave within its borders—the small nation of the Gambia in the interior, which has a 740 km border with Senegal.

The Gambia penetrates more than 320 km into Senegal, from the Atlantic coast to the center of Senegal along the Gambia River, which bisects Senegal’s territory. In total, Senegal has 2,640 km of land borders, and 531 km of coastline and shoreline. Senegal makes maritime claims of a 24 nmi (44.4 km; 27.6 mi) contiguous zone, a 12 nmi (22.2 km; 13.8 mi) territorial sea, and a 370 km (200 nmi; 230 mi) exclusive economic zone. It also claims a 200 nmi (370.4 km; 230.2 mi) continental shelf, or to the edge of the continental margin.

The lowest point in Senegal is the Atlantic Ocean, at sea level. The highest point is an unnamed feature near Nepen Diakha in the Fouta Djallon foothills at 581 m (1,906 ft)).
5.2 Climate

Senegal’s climate is conditioned by the tropical latitude of the country and by the seasonal migration of the Intertropical Convergence Zone (ITCZ)—the line, or front, of low pressure at which hot, dry continental air meets moist oceanic air and produces heavy rainfall. The prevailing winds are also characterized by their origin: the dry winds that originate in the continental interior and the moist maritime winds that bring the rains.

The dry winds, sometimes called the dry monsoon, consist of the northeast trade winds. In winter and spring, when they are strongest, they are known as the ‘Harmattan.’ They bring no precipitation apart from a very light rain, which the Wolof people of Senegal call the heug. The moist rain-bearing winds blow primarily from the west and northwest. Beginning in June with the northward passage of the ITCZ, these winds usher in the summer monsoon. As the ITCZ returns southward beginning in September, the rainy season draws to a close. The slow north-south migration of the ITCZ results in a longer, heavier rainy season in the southern part of the country. From the combination of these factors, three principal climate zones may be distinguished: coastal, Sahelian, and Sudanic.

The Sahelian climate occurs in an area bounded to the north border with Mauritania by the Sénégal River and to the south by a line running from Thiès (a town on Cape Verde Peninsula) to Kayes in the neighboring country of Mali. The weather there in January is also cool, especially in the mornings before sunrise, when the temperature drops to about 57 °F (14 °C); afternoon temperatures, however, may top 95 °F (35 °C) by mid afternoon. In May minimum temperatures are no lower than about 72 °F (22 °C), and maximums often rise above 104 °F (40 °C). The dry season is quite distinct and lasts from November to May. Certain places, such as Podor and Matam on the border of Mauritania, are particularly noted for their dryness and heat. Between July and October the rainfall averages about 14 inches (360 mm), moderating the temperature somewhat, while maximum temperatures reach about 95 °F (35 °C).

The Sudanic zone in the southern half of the country is generally hot, humid, and uncomfortable. Annual precipitation varies from north to south. In the Kaolack-Tambacounda vicinity, rainfall averages between 29 inches (740 mm) and 39 inches (990 mm), occurring on about 60 days between June and October. Cultivation without irrigation is possible here. Annual rainfall in the Gambian area frequently amounts to 50 inches (1,270 mm), resulting in the growth of a continuous belt of light forest and patches of herbaceous undergrowth. In the southern Casamance area it exceeds 50 inches, falling on 90 days of the year. The forest there is dense, green, and continuous, without undergrowth, and oil palms, mangroves, and rice fields are characteristic.

- **The coastal region:** the Atlantic coastal strip is cooler than inland, partly due to brisk onshore winds. Winter temperatures range from 18-26°C in January. In summer; maximum temperatures average around 31°C. Rains arrive in July, peak in August and tail off by October, bringing around 550mm of rainfall annually.

- **The Sahel region:** the northern half of the country falls within the ‘Sahel belt’, a region of semi-arid land which spans across the African continent. Here, temperatures can be cool at night (dropping to around 14°C), but often reach 40°C by day. Rainfall is below 400mm.

- **The Southern region (in Casamance/Zinguinchor):** the southern half of the country is hot and humid, with average maximum temperatures above 30°C throughout the year. Rainfall is usually over 1,500mm to the far south from June to October.

4 [http://www.britannica.com/EBchecked/topic/534445/Senegal/55044/Climate]
The zones correspond roughly to isohyètes for rainfall through 1960
5.3 **TOPOGRAPHY**

The topography of Senegal is generally quite flat (elevations below 50 m on nearly 75% of the territory). The highest altitudes (highest point 581 m) are found in the far south-east of the foothills of the Fouta.

Intense geomorphologic, soil and climate activities experienced by the West African region for millions of years have led to a wide variety of soils. In the north, there are dry sandy soils, while in the central and southern regions are respectively located ferruginous and lateritic soils (CSE, 2005).

Senegal is the westernmost part of a broad savannah extending across the Sahel. Most of the country lies upon a low sedimentary basin characterized by an expanse of flat and undulating plains with sparse grasses and woody shrubs. There are no significant natural landmarks or major changes in elevation. Broken terrain and steep slopes are found only in the extreme southeast.

Extensive riverine areas have been converted to farmland, especially in the Siné and Saloum River basins; the lowlands between Thiès and Kaolack yield significant peanut and other food crops. Beyond these areas, most of the land has little potential except as pasturage. Volcanic action created the Cap Vert promontory, which is the westernmost point in Africa, and the nearby islets. Senegal lies on the African Tectonic Plate.\(^5\)

\(^5\) [http://www.nationsencyclopedia.com/geography/Morocco-to-Slovakia/Senegal.html#ixzz3V4tkdX8Q](http://www.nationsencyclopedia.com/geography/Morocco-to-Slovakia/Senegal.html#ixzz3V4tkdX8Q)
5.4 SOILS

The soils of Senegal range from dry sandy soils in the north, to tropical ferruginous soils in the central region, and to ferralitic soils in the South. Overall, soil fertility is low and soils are mostly fragile, making them highly susceptible to water and wind erosion (USGS/EROS, op. cit.). The soil texture of most fresh water river valleys tends to be high in clay and silt content. Soils in these valleys are classified as "generally good soils", i.e., they do not have serious limitations and are able to produce good yields of suitable, climatically adapted crops. Most cultivated soils located in the Peanut Basin are "generally poor to moderate soils". These soils have one or more limitations that restrict their use, are usually of fairly low natural fertility, and generally give low to moderate yields of climatically adapted crops under traditional systems of management.

FIGURE 7: MAP SHOWING MAJOR SOIL DIVISIONS OF SENEGAL (USGS/EROS, 2006)
5.5 HYDROLOGY

There are four major river systems in Senegal. The country is drained by the Sénégal, Saloum, Gambia (Gambie), and Casamance rivers, all of which are subjected to a monsoonal climatic regime—i.e., a dry season and a rainy season. Of these rivers, the Sénégal—which was long the main route to the interior—is the most important. The river rises in the Fouta Djallon highlands of Guinea and, after traversing the old massifs, rapidly drops downward before reaching Senegalese territory. At Dagana it forms the so-called False Delta (or Oualo), which supplies Lake Guier on the south (left) bank. At the head of the delta is the town of Richard-Toll (the “Garden of Richard”), named for a 19th-century French nursery gardener. The slope of the land is so gentle on this stretch of the river that, at times of low water, salty seawater flows about 125 miles (200 km) upstream. The island on which the town of Saint-Louis stands, near the mouth of the river, is situated about 300 yards (270 meters) from the sea in the False Delta; the river’s true mouth lies 10 miles (16 km) to the south. In the southern half of the country, estuaries are muddy and salty, with marshy saline depressions known as tannes occurring occasionally. 6

FIGURE 8. MAP OF MAJOR BASINS IN SENEGAL

6 http://www.britannica.com/EBchecked/topic/534445/Senegal#toc55042
The Senegal River is located in part of Saint Louis and rises in the Fouta Djallon Mountains, but the principal tributary, the Bafing River, rises much farther south on the Guinean Dorsale. Because of the great seasonality of the precipitation over the entire catchment area, the river is very prone to flooding, and this is exacerbated by the fact that most of its course is very flat. Indeed, along the entire Senegal border the river descends less than 200 m, and over its last 1000 km it falls only 100 m, thus having the very shallow mean gradient.

From this place the river describes a great arc, northwestwards, westwards and finally southwestwards, to reach its delta at Saint Louis. The middle floodplain is approximately 410 km long between Bakel and Richard-Toll and has a mean width of 16 km, and provides a seasonally inundated area of 656,000 ha above the delta. Over much of the floodplain the river flows in more than one channel and there are many ananaties and numerous lakes in abandoned sections of channel.

The Saloum River rises about 105 km east of Kaolack, Senegal, and flows into the Atlantic Ocean. The significant Saloum Delta is located at its mouth, which is protected as Saloum Delta National Park. The river basin lies within the Serer pre-colonial Kingdom of Saloum. Mangrove forests occupy a five-kilometer belt on either side of the river almost 70 kms upstream.

The Gambia River (formerly known as the River Gambra) is a major river in West Africa, running 1,130 km (700 mi) from the Fouta Djallon plateau in north Guinea westward through Senegal and the Gambia to the Atlantic Ocean at the city of Banjul. It is navigable for about half that length. The river is strongly associated with the Gambia, the smallest country in mainland Africa, which consists of little more than the downstream half of the river and its two banks. From the Fouta Djallon, the river runs northwest into the Tambacounda Region of Senegal, where it flows through the Parc National du Niokolo Koba, then is joined by the Nieri Ko and Koulountou before entering the Gambia at Fatoto. At this point the river runs generally west, but in a meandering course with a number of oxbows, and about 100 km from its mouth it gradually widens, to over 10km wide where it meets the sea. Near the mouth of the river, near Juffure, is Kunta Kinteh Island, a place used in the slave trade which is now a UNESCO World Heritage Site.

The Casamance River flows westward for the most part into the Atlantic Ocean along a path about 320 km (200 miles) in length. However, only 130 km (80 miles) of it are navigable. The Casamance is the principal river of the Kolda, Sédhiou, and Ziguinchor Regions in the southern portion of Senegal between the Gambia and Guinea-Bissau. The three regions are also collectively known as Casamance after the river. There is a ferry at Ziguinchor in Senegal, one of the most important towns on the river. Other important towns/villages on its banks include Goudomp, Sedhiou, Diattakounda, Tanae, and Kolda.
5.6 **Vegetation**

The vegetation of Senegal can be divided into three major ecological regions. From north to south, they are: the Sahelian Region, the Sudanian Region, and the Guinean Region. The Sahelian Region occurs between rainfall isohyets of 150 and 700 mm/yr. The core area lies between the 300 and 500 mm/yr isohyets. It is located in northern Senegal. The early seasonal rains, which usually begin in July, transform the landscapes into green, lush rangelands, drying out quickly after the last rains in late September. During the long dry season of 8 to 10 months, the herbaceous cover disappears as livestock and termites tend to take over, exposing bare soil to wind erosion. The primary land use is raising animals, which has been a traditional activity for centuries. Woody plants are usually associated with the vast expanses of seasonal grass cover, together forming the dominant vegetation types of the Sahelian Region. The most common types are shrub savannas, shrub and tree savannas, and bushlands.

**FIGURE 9: MAP OF DIFFERENT VEGETATION ZONES IN SENEGAL**

![Vegetation and Land Use of Senegal](image)

- **Vegetation and Land Use of Senegal**
  - Shrub Steppe
  - Shrub Savanna
  - Shrub-Temperate Savanna
  - Tree-Woodland Savanna
  - Savannah
  - Woodland
  - Mangrove
  - Agricultural Land
  - Urban Areas
  - Quarries
  - Salt Flat
  - Marshes
  - Water
5.6.1 Sahelian Zone

Vegetation found in the Sahelian zone are shrubby steppe (sandy part of the Ferlo) and shrubby savannah (lateritic part of the Ferlo). These forests consist essentially of *Dalbergia melanoxylon*, *Pterocarpus lucens*, *Acacia tortilis*, *Acacia raddiana*, *Acacia senegalensis*, *Acacia seyal*, *Acacia albida*, *Balanites aegyptiaca*, *Grewia bicolor*, *Commiphora africana*, *Ziziphus mauritiana*, *Sclerocarya birrea*, *Pterocarpus erinaceus*, *Hyphaene thebaica*, and grasses such as *Eragrostis*, *Aristida* and *Cenchrus*. *Dalbergia melanoxylon* and *Hyphaene thebaica* are fully protected by the Senegal Forest Code, and *Dalbergia melanoxylon* is on the IUCN Red List (2007). *Acacia senegalensis* and *Ziziphus mauritiana*, both of great economic value, as well as *Acacia albida* and *Acacia raddiana*, whose value is mainly ecological, are partly protected by the Forest Code. In contrast, *Pterocarpus lucens*, a source of fodder for livestock, which has high mortality in the area, is not protected. *Crotalaria sphaerocarpa* is the only endemic species reported in this area.

During the last decades, forests of this area have suffered a sharp drop in their potential productivity and diversity. Apart from the protected areas, the woody cover is spontaneous and limited to park-like forests dominated by a few acacias.

5.6.2 Sudanian Zone

The Sudanian zone, located at the central and western part of the country, covers nearly 40% of the national territory. Rainfall exceeds 600 mm/year and can last 4 months or more. Natural forests are therefore more diversified and productive. Plant cover is currently characterized by a mosaic composed of shrub lands, wooded savannahs, woodlands and a few remnants of open forests. The western and central part of this zone (traditional groundnut basin), once characterized by relatively dense vegetation, is now characterized by wooded man-made parks dominated by acacias (*Acacia albida* and *Acacia raddiana*). Vegetation of the southern and eastern part (Saloum and New lands) is heterogeneous - the result of colonization of this area for agriculture. Today, there is essentially a park of planted trees, characterized by an abundance of *Cordyla pinnata*, a forest relic species that used to cover this area. Only a few remnants of woodlands characterized by low numbers of species constitute the diversity that remains. Woody species of these woodlands are *Combretum glutinosum*, *Pterocarpus erinaceus*, *Bombax costatum*, *Sterculia setigera*, *Cassia sieberiana*, *Daniellia oliveri*, *Terminalia macroptera*, *Lannea acida*, *Sclerocarya birrea*, *Lonchocarpus laxiflorus*, *Stereospermum kunthianum*, *Celtis integrifolia*, *Diospyros mespiliformis*, and *Detarium senegalensis*. The economic potential of the most exploited species has declined, leaving room for perennial species, such as *Combretum*.

The most threatened species are *Pterocarpus erinaceus*, *Bombax costatum*, *Sterculia setigera*, *Cassia sieberiana*, *Daniellia oliveri*, *Celtis integrifolia*, *Diospyros mespiliformis*, and *Detarium senegalensis*. Among these species, three are protected by the Forest Code. They are *Celtis integrifolia* and *Diospyros mespiliformis* (protected) and *Pterocarpus erinaceus* (partially protected). There are five endemic plant species reported in the area, including *Ceropegia praetermissa*, *Ficus dichranostyla*, *Bolboschoenus grandispicus*, *Rhynchosia albae pauli* and *Urginea salmonea*.

5.6.3 Sub Guinean Zone

This zone is confined to the southern part of the Tambacounda region and the regions of Ziguinchor and Kolda, where the annual rainfall is above 1000 mm. Vegetation is similar to the Guinean zone, and it is comprised of small relics of massive dry forests on sandy plateaus growing with deep soils and gallery forests found all along the rivers. Fish found in the waters of these dry forests are *Parinari excelsa*, *Erythroleium guineense*, *Detarium senegalensis* and *Elaeis guineensis*.

Forests located in the eastern part of this area have long been a refuge for wildlife in Senegal, particularly for big mammals found in Niokolo Koba National Park, the last significant sanctuary that has been reserved for them. These are characterized by woodlands, open forests, degraded dry forests in the
woody savannah areas, gallery forests and riparian forests located along the rivers, such as the Gambia River and the Niokolo River.

Species diversity remains relatively high, and the protection of these forests allows for conservation of a large part of the genetic resources threatened by extinction in Senegal. Protected areas of this zone are part of the last ecosystems pertaining to the Sudanese zone that are legally protected in Africa. In recent years, many of the marshes occurring in Niokolo Koba National Park have been invaded by two introduced species, *Mimosa pigra* and *Mitragyna inermis*. Invasion of marshes leads to the obstruction and drying up of these very important water sources for the wildlife. The level of obstruction of some marshes now poses a problem for wildlife to access water. The dry forests of this area are also disappearing because of climate change and pressures from human activities.


The eleven species listed below are among those partially protected by the Forest Code: *Adansonia digitata*, *Afzelia africana*, *Borassus aethiopum*, *Cordyla pinnata*, *Acacia albida*, *Prosopis africana*, *Pterocarpus erinaceus*, *Khaya senegalensis*, *Sclerocarya birrea*, *Tamarindus indica* and *Grewia bicolor*. Some species such as *Khaya senegalensis*, *Afzelia africana*, *Vitellaria paradoxa*, and *Albizia ferruginea* are on the IUCN Red List (2007). *Albizia ferruginea* was also mentioned on the World List of Endangered Trees. *Azadirachta indica*, a species introduced in the 1960’s, has completely invaded the valleys of small islands located in of the Saloum Delta Biosphere Reserve, at the expense of some threatened species found in these valleys.

The western part of this zone (Casamance) hosts dry forests that are characterized by dominant trees with more or less contiguous crowns and a dense herbaceous layer. These forests are the habitats of many scarce and endangered plant and animal species. Among the fully protected plant species found here are *Anthocephala nobilis*, *Anthocephala procera*, *Anthocephala djalonensis*, *Calamus deereatus*, *Pandanus candelabrum*, and *Raffia sudanica* (Appendix F). Plant species protected under the Forest Code in this area include: *Abizia adianthifolia*, *Alstonia boonei*, *Daniellia ogea*, *Mitragyna stipulosa*, *Piptadeniastrum africanum* and *Holarrhena floribunda*. *Ceiba pentandra*, *Chlorophora regia* and *Khaya senegalensis* are partially protected.

There are 17 endemic plant species that have been inventoried in this area. These are *Acalypha senensis*, *Alectra bassirei*, *Andropogon gambiensis*, *Berhautia senegalensis*, *Boisbokia grandispicous*, *Ceropogia praetermissa*, *Cyperus lateriticus*, *Digitaria gentilis*, *Cissus gambiana*, *Cissus okoutensis*, *Lipocarpha prieuriana*, *Nasaea dodecandra*, *Panicum calocarpum*, *Polycarpea linearifolia* var. *Racemosa*, *Rhynchosia albae pauli*, *Scleria chevaleri* and *Spermacoe phyllocephala*.

### 5.6.4 Fresh Water Vegetation

Consisting mainly of riparian forests, these ecosystems have a high plant and animal species diversity due primarily to high levels of available moisture. Scarce and or endangered species, as well as endemic terrestrial and marine plants and animals, are reported. These ecosystems are located in the Senegal, Saloum, Gambia and Casamance River basins, as well as watercourses such as the Kayanga, lakes such as Guiers Lake, and some ponds. Under the effects of the droughts and human activities in recent decades, *Acacia nilotica* trees, which used to form huge riparian forests extending along the Senegal River, have suffered high mortality.
Fisheries resources of the rivers have also suffered severe degradation. Endemic species reported include: *Abutilon macrophyllum*, *Acalypha senensis*, *Andropogon gambiensis*, *Crotalaria sphaerocarpa*, *Cyperus lateriticus*, *Digitaria gentilis*, *Najas velutina*, *Nesaea dodecandra*, *Panicum calocarpum*, *Polycarpon prostratum var. Coastal*, *Salicornia senegalensis*, *Spermacoce galeopsisdis* and *Urginea salmonea*).

Numerous vegetative species, particularly those with Guinean affinity, are threatened with extinction. Within the Senegal River estuary, vegetation occurring on dry ground characterized by *Acacia tortilis* and *Acacia senegalensis* is also threatened. On the Saloum Delta, mangroves and vegetation occurring on sandy islands are subjected to drought and strong pressures caused by human activities.

### 5.6.5 Marine Ecosystems

Marine ecosystems occurring on a vast continental plateau of 31,000 km² are equally affected by the high exploitation of saltwater resources. These are mainly located along the “Big Coast” (Niayes zone) and in delta and estuarine areas (Senegal, Saloum and Casamance rivers) that are characterized by wetlands with a large diversity of species having Guinean traits, and in the Niayes zone by mangroves consisting of *Rhizophora*, *Avicennia*, *Conocarpus* species plus *Laguncularia* occurring in the estuaries. The Niayes zone is home to some 419 plant species of which 80 are woody or sub-woody. This diversity represents nearly 20% of all the flora of Senegal and cannot be found anywhere else in Senegal north of 13° latitude. The richness of the bird populations and fisheries resources has been the basis for creation of many protected areas in the estuaries (i.e., Djoudj, Langue de Barbarie, the Saloum Delta). Endemic species reported here are: *Ceropegia praetermissa*, *Ceropegia senegalensis*, *Crotalaria sphaerocarpa*, *Digitaria gentilis*, *Salicornia senegalensis*, *Scleria chevalieri*, *Bolboschoenus grandispicus* and *Ficus dicranostyla*. In recent decades, these ecosystems have suffered an accelerated degradation under the pressure of multiple factors that undermine their future. Recurrent droughts, rapid urban growth and multiple uses that do not take into account ecological and population thresholds seriously threaten these ecosystems. Not a single estuarine depression has been found in its natural state since the 1970's drought.

### 5.7 Agriculture

Most of Senegal lies within the drought-prone Sahel region, with irregular rainfall and generally poor soils. With only about 5% of the land irrigated, Senegal continues to rely on rain-fed agriculture, which occupies about 75% of its workforce. The sector is inhibited due to low output and limited investments. Although this sector was impacted by a locust invasion in 2004, it has recovered and gross agricultural production is expected to increase by 6.1% in 2006 and 5.1% in 2007. Reforms of the agricultural sector have suppressed direct government support and engaged the privatization of state holdings. The main agricultural crops are peanuts and cotton both being important sources of foreign exchange income as well as millet, rice, corn, sugarcane, and livestock.

Peanuts are the engine of the rural economy and their production accounts for around 40% of cultivated land, taking up 2 million hectares. The peanut sector provides employment for as many as 1 million people in Senegal. In recent years, the reported average annual peanut production lies around 828,000 tons (95% for oil). 

Cotton accounts for about 3% of total exports and the third source of export earnings for Senegal. Cotton is grown in nearly every region and covers almost one third of cultivated acreage. However, production is concentrated in the South-Eastern part of the country (South of the Kahone–Tambacounda belt, as well as in the Casamance and Kédougou regions).

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7 USDA Foreign Agricultural Service; Senegal Agricultural Situation Report, 2007.
Production of food crops does not meet Senegal's needs, which makes Senegal a net importer. The production of major staple food crops covers barely 30% of consumption needs. Only in years of favorable rainfall does the country approach self-sufficiency in millet and sorghum, the basic staples with rice.

FIGURE 10. MAP FROM 1988 DRAWN BY INSTITUT REGIONAL DE DEVELOPPEMENT

5.8 LIVESTOCK

The livestock population includes approximately 3.1 million cattle and 8.7 million sheep and goats. Cattle are reared extensively and on a small-scale basis. Despite a significant livestock population, Senegal remains a net importer of meat, especially sheep (live) during major holidays and religious events.

5.9 FISHERIES

Fish is a major source of protein for the Senegalese population. Fishing plays a dominant role in the Government of Senegal’s policy towards employment. The Government estimates that the sector employs more than 200,000 people and generates significant temporary employment in the informal sector, in particular through the artisanal fishing, using lines, traps, and nets with small-scale traditional fishing canoes. (2013)

The fishing sector benefits from a long coastline (approximately 448 miles or 720 km) and a productive continental shelf area of approximately 15,535 km2 (9,653 miles2). Industrial fishing consists of sardine, tuna and trawler harvesting (shrimp, mullet, sole, cuttlefish, etc.). "Artisanal" catches are mainly for the local market with a large proportion purchased by local factories for processing. Senegal's fishing sector has historically been one of the country's largest sources of foreign currency.8

8 (Ndiaye, Mbalo. "Senegal agricultural situation country report". U.S. Foreign Agricultural Service (January 17, 2007).)
In 2005, seafood products represented 22% of Senegal's total exports and generated more than $366 million in national income from an annual catch of approximately 400,000 tons, against approximately $374 million for a catch of approximately 430,000 tons in 2004.

5.10 **DEMOGRAPHICS**

As of July 2014, the population of Senegal is estimated to be 13.9 million inhabitants, growing at a rate of 2.7% a year and is expected to keep growing⁹, that is higher than the world average (1.14%), but is comparable to other countries in the region (2.5%).

Wealth income disparity is pronounced. From 2001-2002, 48.7% of the population remained below the poverty line (below $1.50/ a day), between 2005-2006 was at 55.2%, it fell to 48.7% in 2005-2006, it marginally fell to to 46.7% in 2011.

About 70% of Senegal's population is rural. In rural areas, density varies from about 77 inhabitants per km² (or 200 inhabitants/mile²) in the west-central region to 2 inhabitants per km² (5 inhabitants /mile²) in the arid eastern section. About 50,000 Europeans (mostly French) and Lebanese and Vietnamese reside in Senegal, mainly in the cities.

Life expectancy figures for Senegal, averaging about 56 years for both men and women, are among the highest in sub-Saharan Africa. The population is heavily weighted toward the young, as are most African populations, with more than two-fifths under 15 years of age. Urban unemployment and underemployment remain high. (Britannica, 2014)

French is the official language but is used regularly only by the literate minority. Almost all Senegalese speak an indigenous language, of which Wolof has the largest usage. Many Senegalese live in Europe, particularly in France, Italy and Spain.

The Wolof comprise almost one-half of the total population, and their language is the most widely used in the republic. Under the traditional Wolof social structure, similar to those of other groups in the region, people were divided into the categories of freeborn (including nobles, clerics, and peasants), caste (including artisans, griots, and blacksmiths), and slaves. The Serer, numbering slightly more than one-tenth of the population, are closely related to the Wolof. The Fulani and the Tukulor combined make up about 1/5th of the population. The Diola and the Malinke constitute a small portion of the population. Other small groups consist of such peoples as the Soninke, rulers of the ancient state of Ghana; the Mauri, who live primarily in the north of the country; the Lebu of Cape Verde, who are fishermen and often wealthy landowners; and the Basari, an ancient people who are found in the rocky highlands of Fouta Djallon.

In rural areas dwellings are usually well constructed and roofed with straw, with walls made of either earth or straw. In more-prosperous villages roofs may be made of corrugated iron; the walls may be made of cement brick. Houses in towns are constructed of cement and have roofs either of tile or of corrugated iron; typically, many families are crowded together in these dwellings. Migration from the countryside has expanded the population of urban areas and resulted in the proliferation of shantytowns.

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⁹ PNLP, Plan strategique, Agence Nationale de la Statistique et Demographie (ANSD), 2014
Wolof villages, which are small, contain about a hundred households. The houses are built of locally obtained materials. Harvests are kept in straw granaries, located far from the housing compounds for fear of fire. In the area around the Saloum River, each Wolof village is surrounded by three concentric zones of vegetation. The first of these—the inner zone—consists of fields and vegetable gardens. The second circle consists of land that has been exhausted, except for peanut cultivation. The third, the farthest from the village, is where cereal crops are cultivated.

The typical Malinke village has between 200 and 300 inhabitants living in enclosed compounds and crowded together in geometrically aligned rectangular huts. Agriculture and stock raising are the principal economic activities. Each village is usually headed by a chief or a Muslim marabout, who, like most traditional leaders, is conservative in outlook. (Britanica, 2014)

Unlike Wolof and Malinke villages, Serer family compounds are more dispersed, and each one is autonomous. On the islands at the mouth of the Saloum River, each Nyiominka Serer compound contains solidly built houses and a granary.

Diola villages contain 5,000 or more people. Like those of the Serer, the compounds are not grouped in any distinguishable hierarchy. These villages are characteristically built on the edge of a plateau or on ground overlooking the rice fields, which are associated with Diola life. These houses are considered the best-built and most-permanent village dwellings in Senegal. On occasion they constitute veritable fortifications, as in Thionck-Essil and Oussouye. The villages near Essil also can be quite sophisticated, with many of them equipped with rainwater-catchment systems. Diola and Serer villages have no chiefs with authority or prestige comparable to those of Wolof or Malinke villages.

5.11 HEALTH

Although Senegal has a considerable range of medical facilities, most of them are concentrated in Dakar. They include hospitals, clinics, maternity homes, and various services specializing in diseases such as tuberculosis, syphilis, and leprosy. The Senegalese Red Cross, the Research Institute for Development, and the World Health Organization are active. Most of the population, however, continues to utilize traditional African and Islamic forms of healing because they are more accessible and affordable.

5.11.1 SENEGAL HEALTH SYSTEM

Senegal’s health system is pyramidal, with three main parts: a National level, a regional level, and a peripheral level.

Administratively, the country is divided into 14 regions and 45 departments. The health system functions at the level of the regions (each with a Regional Chief Medical Officer) and is further decentralized into 76 health districts that may be all or part of an administrative department. Health districts are led by the District Chief Medical Officer who, together with the District Health Management Team, oversees care and treatment activities at the District Health Center and at peripheral facilities, as well as prevention activities. Health districts have at least one health center and a number of health posts that are staffed by chief nurses and sometimes midwives. There are approximately 1,247 health posts in Senegal.
Although not a formal part of the health system, Senegal’s health care pyramid rests on a foundation of approximately 2,162 functional health huts that are established and managed by local communities and cover approximately 50% of the country’s population. A functional health hut is defined as one that has a trained community health worker (literacy is preferred but not required), regular supervision by the chief nurse of the health post, and the basic structure and equipment needed to provide services. The community health workers (CHWs) offer an integrated package of preventive and curative services or referral for more advanced medical care. Additional community health staff includes matrones, who are trained birth attendants; and relais, who are health educators and communicators.

### 5.11.2 Population Health Status

After years of investments family planning and reproductive health; maternal, neonatal, and child health; malaria and HIV prevention; health systems; and community-based services, the government of Senegal has made enormous strides in reducing child mortality and malaria-related mortality, and it has stabilized a low incidence of HIV.

Today, more than one-third of Senegalese women report an unmet need for family planning services, and many communities, particularly the urban poor, need better reproductive health services

### 5.12 Education

Western education has existed in Senegal since the 19th century, which was predominantly taught in the French language. Since independence in 1960, Senegal has made particular efforts to increase school enrollment in rural areas, although with limited success; the literacy rate remains one of the lowest in the world, at 66%. (2011)

Attendance rates in Senegalese schools vary widely from as much as 93% of school-age children in urban areas to as low as 10% in some rural areas. Drop out incidences remain high in primary school, with

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10 [IntraHealth.org](http://www.intrahealth.org/page/senegal)
only about 50% of students who start out in first grade making it through to the end of the school year. A recent report from United Nations Educational, Scientific and Cultural Organization’s (UNESCO) regional office in Dakar showed that Senegal is near the bottom of countries in Africa in terms of the percentage of students who enroll in primary school compared to those who complete the cycle. With a gross enrollment rate of 90%, but an achievement rate of only around 50%, Senegal fares considerably worse than neighboring countries, such as Guinea, Mali, Benin, Ghana, and Gambia.

Among the secondary schools, the Faidherbe Lycée at Saint-Louis and the Van Vollenhoven Lycée at Dakar are the oldest and most renowned. Technical education is expanding and is provided by institutions in Dakar, Saint-Louis, Diourbel, Kaolack, and Louga.

Senegal has diverse options of institutes for higher education with private and public universities. University-level instruction is only in French. In 2012 the Ministry of Higher Education in Senegal in cooperation with UNESCO’S Regional Office in Dakar launched a project to improve the quality of higher education in Senegal. This project established training opportunities, prepared guides for foreign students, researched on existing systems of quality assurance, and assess employment needs.

Higher education started and was developed in 1918 at the School of Medicine of Dakar. It achieved full status as a university in the French system in 1957 and became known as the University of Dakar. The name was changed in 1987 to University Cheikh Anta Diop to honour a prominent Senegalese scholar and politician. Following disturbances in 1968, Senegal concluded an agreement with France that emphasized a more African-based curriculum. The College of Sciences and Veterinary Medicine for French-speaking Africa is also located in Dakar, and a polytechnic college opened at Thiès in 1973. The University of Saint-Louis, founded in 1990, was renamed University Gaston-Berger in 1996 for a Senegalese philosopher who was born in Saint-Louis. Approximately one-fifth of the students attending these schools are foreign, mostly from the French-speaking countries of Guinea, Mali, and Burkina Faso.

5.13 INFRASTRUCTURE

The transport network in Senegal has developed primarily in the western part of the country within the area bounded by Saint-Louis, Kaolack, and Dakar. About half of Senegal’s extensive road network is travelable year-round.

The rail system, which is being rehabilitated and expanded, includes a line from Saint-Louis to Dakar, with a branch line running from Louga inland to Linguère, and a line from Dakar to the Niger River at Koulikoro, Mali. Locomotives are run entirely on diesel fuel. Phosphates represent the great bulk of freight carried by rail.

Senegal’s three seaports are Kaolack, Ziguinchor, and Dakar. Only Dakar is an international port; the others are limited to handling local traffic. Dakar is one of the busiest ports in Western Africa and accommodates ships up to 100,000 tons along 6 miles (10 km) of quay. The quays provide refrigerated facilities that serve 1,000 fishing boats each year.

Historically, Senegal’s rivers, especially the Sénégal, were important transportation arteries, despite limited navigability. However, their significance has diminished since the end of the 19th century, with the construction of rail lines. Navigation of the Sénégal was facilitated by the completion of the Diama and Manantali dams in the late 20th century. Activity on the Saloum River centres on peanut shipping from Kaolack, and traffic on the Casamance is to and from the port of Ziguinchor.

Senegal has a strong, reliable telephone system, especially in urban areas. Sonatel, the national telecommunications company, provides telephone service. Senegal became wired for Internet use in 1996, providing the opportunity for many technology-based services to develop in the country. Internet and mobile phone services are presently provided by a small number of private companies, as well as Sonatel. Both services have grown in popularity in Senegal.
5.14 **Senegal Regions**

Senegal is subdivided into 14 regions, each of which is administered by a Conseil Régional, or Regional Counsel, elected by population weight at the arrondissement level. Senegal is further subdivided into 45 departments, 103 arrondissements. Three of these regions were created on September 10, 2008, when Kaffrine Region separated from Kaolack; Kédougou region separated from Tambacounda, and Sédhiou region was separated from Kolda. To date, all Regions in Senegal take their name from their regional capitals.

**FIGURE 12: CURRENT REGIONS OF SENEGAL**
TABLE 3: SENEGAL REGIONS

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<th>Region</th>
<th>Capital</th>
<th>Area</th>
<th>Population (2013 census)</th>
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<td>Sédiou</td>
<td>Sédiou</td>
<td>7,341</td>
<td>452,944</td>
</tr>
<tr>
<td>Tambacounda</td>
<td>Tambacounda</td>
<td>42,364</td>
<td>681,310</td>
</tr>
<tr>
<td>Thiès</td>
<td>Thiès</td>
<td>6,670</td>
<td>1,788,864</td>
</tr>
<tr>
<td>Ziguinchor</td>
<td>Ziguinchor</td>
<td>7,352</td>
<td>549,151</td>
</tr>
</tbody>
</table>

Source: Agence de l'informatique de l'État (ADIE), 2013

5.14.1 DAKAR REGION

Dakar region is the smallest and most populated region of Senegal, encompassing the capital city of the country, Dakar, and all its suburbs along the Cap–Vert Peninsula, Africa’s most westerly point. The Dakar region is divided into four departments: Dakar Guédiawaye, Pikine and Rufisque.

Economically, Dakar Region generates 68% of Senegal's GDP. 80% of the country's industries are located in the metropolitan region. In water resources consumption, Dakar consumes three-quarters of Senegal’s piped water and 40% of its charcoal.

Spatially, urban development is characterized by many recent informal settlements with limited access and poor transportation, and inadequate infrastructure and services. Unplanned settlements have made it difficult to gain access to and to connect neighborhoods, and have put additional strain on the existing transportation network. Low-income districts tend to be the most unplanned and mismanaged; for example, in the central city 61% of households have piped water but this figure drops to 16% in the poor district of Rufisque.12

5.14.2 DIOURBEL REGION

The region is located at 14° 30 and 15° N and 15° 40 west longitude. Without access to the sea, it is bordered to the North by the Thiès and Louga Regions, to the south by the Thiès and Fatick, to the east by the Fatick and Louga and west by the Thiès region. It is the smallest region in the country after Dakar.

12 http://ww2.unhabitat.org/programmes/uef/cities/summary/dakar.htm
Diourbel is to the east of its national capital, Dakar, by the National Road No. 3, the asphalt coating is generally in good condition, and the railroad Dakar-Kidira is operational.

The climate of the region is of type Sudano Sahelian in Sahelian predominance. It is defined by the alternation of a long dry season (ranging from October to June months) and a rainy season (from June to October).

The temperatures are still high and fluctuating with a minimum of 24 ° Celsius in January and a maximum of 35 ° Celsius in June average. The climate is characterized by low rainfall and high evaporation. The area does not have maritime fringe, nor a coastline and nor does it reside over perennial water.

The rainfall, the region is between isohyets 400 and 500 mm. Between the years 2000 and 2006, the recorded average annual rainfall is 465 mm with a minimum of 303.6 mm and a maximum of 622.8 mm. In the last 30 years, the inter-annual variability has increased and a strong tendency to decline.

Diourbel Region belongs to the sedimentary basin of secondary and tertiary nature. Water resources exist mostly underground. Groundwater is the only source of supply for its inhabitants and livestock, since they are obtained at a varying degree of depth and quality.

There are mainly three ground water sources in the region:

- **Luthétien**: it is accessible in the depths of 20-95 m. It is found in the district of Lambaye;
- **Paleocene**: is accessible between 104 and 280 m in depth. The quality of its water diminishes from mediocre to unacceptable with a salt content exceeding 1.5 g / l and more than 1 mg / l for fluoride. It is unsuitable for use. This is located in the district of Ngoye (Bambey).
- **Maastrichtian**: captured between 240 and 349 m in depth, interested in the entire region. The water quality is generally good for the consumption of humans and animals. It particularly interested boroughs Ndindy, Kael and Ndame. The fluorine content of such water may sometimes exceed 1.5 mg / liter. (WHO standard)

The region has no perennial surface water and fossil valleys of Sine and Car-Car no longer able to store rainwater. Surface water resources consist of temporary pools or bassins that collect water during the rainy season.

5.14.3 **FATICK REGION**

The Fatick Region, which is located south east of Dakar Region, shares a border with the Gambia, from the southern eastern corner. The regional capital is the city of Fatick. This region had 24,243 inhabitants in 2013. It is surrounded on the north and northeast by the Thiès, Diourbel and Louga Regions, to the south by the Republic of Gambia, to the east by the region of Kaolack and west by the Atlantic Ocean.

Fatick is home to many Sereer people; whom are one of the one of the major ethnic groups in Senegal and there are four Sereer dialects. Fatick is a major urban center for the region and it houses many resources such as post offices, markets and the departments of education, arboriculture and agriculture for the region.

The Fatick Region is located within the Sudano-Sahelian climate region, and in normal years rainfall varies between 600 and 900 mm. In recent years it was more irregular, varying between 400 and 600 mm (2013).

Third of the territory is composed of saline land (0.5 to 3 g / l) and high in fluorine (2 mg / l), which makes it unsuitable for cultivation. Agriculture, livestock and fishing are the main resources for livelihood, but although underused, the tourism potential in the Fatick region is rich and diverse.

5.14.4 KAFFRINE REGION

The Kaffrine Region covers an area of 11,492 km² with a population of approximately 600,000 inhabitants. From the North, it is bordered by the Diourbel and Louga Regions; to the East by the Tambacounda Region; to the South by the Republic of the Gambia; and to the West by the Kaolack Region.

The regional capital of this Region is the city of Kaffrine. Following the administrative reforms undertaken in 2008, Kaffrine was established as one of the 2 newly created districts.¹⁴

The Kaffrine Department is on the southernmost edge of the Sahel. Its climate is semi-arid, with annual rainfall between 500-800 mm. There are three distinct seasons: the rainy season (June-October), the cool dry season (October-March), and the hot-dry season (March-June). Absolute temperatures range from 55 degrees F in the cool season to 110 degrees F in the hot season. Most soils are clays or sandy soils, although some areas with loamy soils are also found in the region. Soils are significantly depleted and the region has been seriously deforested. Savanna-type vegetation characterizes the region. The water table typically sits at 20-30 meters.

The economy of Kaffrine relies almost exclusively on rainy season agriculture activities. The primary crops are peanuts, millet, and corn. No large scale food processing is done in the region. Surpluses, particularly of peanuts, are sold to the government and processed elsewhere¹⁵.

5.14.5 KAOLACK REGION

The Region of Kaolack extends over 2,068 mi² (5,357 km²) and is located in the center-west, it shares a border with Gambia, straddling the southern Sahelian and North Sudanian zone. To the north, it borders the Region of Fatick, to the East, Kaffrine, and to the west, again Fatick. The Kaolack Region is located at the heart of the peanut basin. The area is richly agricultural, but anchored by the vibrant urban marketplace of Kaolack city. Kaolack is located just four hours southeast of Dakar, on the road to Mali and the Gambia.

There is approximately 395,400 ha of land devoted to agricultural farming. Kaolack Region is the 3rd largest producer of peanuts in Senegal, and fifth largest producer of millet and other cereals.

Part of Kaolack is in the Sine Saloum region, which mostly consists of mangrove swamps. The upper reaches of the rivers adjoin the Sahel region and are affected by its desertification. The salinity of the water increased during the 1970s instance of the Sahel drought and mismanagement of the rivers upstream has been described as a factor. Mangroves are disappearing, and freshwater fish are disappearing with them. The villagers have difficulty obtaining freshwater. Sometimes water pumps are donated by international organizations, but spare parts are difficult to find when the pumps fail. The change in water salinity is affecting the ecosystem as much as it is changing the lifestyle of the inhabitants of the region. It is in this region that the Saloum Delta National Park is located. 145,811 hectares of the Delta were designated a UNESCO Heritage Site in 2011. Because it flows so slowly, this delta allows saltwater to travel deep inland. For this reason, a lot of salt flats are found here and salt production exists.

¹⁴ [http://yenkasa-africa.amarc.org/en/node/545]
¹⁵ [http://peacecorpssenegal.org/kafrine/]
5.14.6 KOLDA REGION

The Kolda Region (5,317 mi² (13,771 km²)) is located in the South Center of Senegal, in what is considered Haute-Casamance. Both vegetation and rainfall are abundant in Kolda. The wet season lasts for five months, from June through October. The dry season begins in November and ends in May. According to the 2013 census, Kolda region has 633,652 inhabitants.

The annual average temperature is 28°C with a maximum of 35°C in April, May and October, and a minimum of 20°C in January and August.

Natural conditions are favorable to diverse agricultural activities, including rice, millet, corn, peanuts, and cotton, as well as animal rearing and tree crops, particularly mango and cashew. Agricultural production has been boosted in recent years by the expansion of cotton production in the Kolda Region and rice growing in the Anambe Basin.

Part of the Niokolo-Koba National Park, a UNESCO world heritage site lies in the Kolda Region, in the eastern border.

5.14.7 KEDOUGOU REGION

At the time of Senegalese independence in 1960, the region was part of the eastern Senegal, one of the seven regions at that time. Later it was integrated in the new region of Tambacounda, then in 2008, Kedougou became its own region at the same time as at Sédiou and Kaffrine.

Local attractions in Kedougou Region include the Dindefelo Falls and Niokolo-Koba National Park, both of which are UNESCO world heritage sites. The Niokolo-Koba National Park is a refuge for many endangered species. The last elephants in Senegal have found refuge in this sanctuary and the giant eland (the largest antelope in the world). It is the most mountainous region in the country, culminating in the south to 581 m and bordered to the west by the hills of Bassari country and Mount Assirik inside the Niokolo-Koba National Park at 311 m.

The main sources of income in this region are agriculture, small-scale commerce, construction, and gold mining. The Gold mining industry has brought several large scale foreign mining companies to the Kédougou area. This has been a source of tension with some local residents who point to a lack of jobs available to locals. In late 2008, protests over the practices of Gold mines in the region turned violent.

The most commonly spoken languages are Pulaar, Bassari, Bedik, Diaxanké, Malinké and French.

The Gambia River provides water to the area, as its source Fouta Djallon (Guinea) is nearby, and tributaries such As Niokolo Koba, provide more water.

5.14.8 LOUGA REGION

The Louga Region covers an area of 2,918,800 ha, or 29,188 km² and hosts approximately 677,533 inhabitants.

The Region is located in northwestern Senegal. The region provides a passage between the port cities of Dakar and St. Louis. The area surrounding Louga is at the northern limits of Senegal's peanut-(groundnut-) growing area and is inhabited by the Fulani, who are generally pastoral nomads, and the Wolof, who are sedentary farmers.

This region has a Sahelian almost dry desert climate, steppe vegetation characterized by a short season and unstable rainfall and a long dry season of nine months or more. The harmattan, hot and dry, very active from January to May, is the prevailing wind in this area. It carries dust which sometimes causes real sandstorms, and above all, it favors wind erosion and water loss through evaporation.
5.14.9  MATAM REGION

The Matam Region is spread across 29,445 km² (11,369 sq mi) and is home to approximately 541,032 inhabitants (2013). It is located to the far north east of Senegal, bordering Mauritania.

It is a stark, flat, arid zone bounded on the north by the Sénégal River and the south by the Sahelian plain studded with baobab trees. Matam is populated by the tall Pulaar-speaking Toucouleur people who brought Islam to Senegal in the 11th century and gave us the music of Baaba Maal in the 21st century.

Matam has a potential phosphate mines. There are nearby deposits at Bofal in southern Mauritania. Many of the people living in this region are nomadic herders. The majority of this population consists of rural households practicing agriculture, livestock production and, less often, river fishing. Over the last three decades, a dramatic decline in rainfall (from 496 mm to 250 mm/year) and changes in the flood pattern of the Senegal River caused by the Manantali Dam had pushed the families living in this area into a situation of increasing economic insecurity and poverty. Conditions got even worse following the events of 1989 and the repatriation of 7 000 refugees, who settled in the region.

5.14.10  ST. LOUIS REGION

St Louis Region covers approximately 1,904,400 ha or 19,044 km² and is home to approximately 688,767 inhabitants in 2013. The region runs along the Mauritanian border to the mouth of the Senegal River. The regional capital is the city of St. Louis.

Saint-Louis only has two seasons, the rainy season from June to October, characterized by heat, humidity and storms, and the dry season from November to May, characterized by cool ocean breeze and dust from the Harmattan winds.

The Senegal River is the second longest river in West Africa. It flows through a broad valley that cuts through the semiarid Sahelian landscapes of Senegal, Mali, and Mauritania, creating a unique, complex environment determined largely by the hydrological, soil, and topographic conditions of the floodplain.

Among Saint-Louis' numerous protected sites include the the National Park of the Langue de Barbarie, the National Park of the Birds of Djoudj, the Fauna Reserve of Gueumbeul, the colonial waterworks at Makhana, the Diama Dam, and various hunting areas on the south side of the Senegal River.

National Park of the Langue de Barbarie is 20 kms², occupies the southern point of the Langue de Barbarie, the estuary of the Senegal River and part of the continent. It hosts thousands of water birds like cormorants, brushes, pink flamingos, pelicans, herons and ducks each year.

National Park of the Birds of Djoudj is the world's third largest ornithological park, it is located 60 km north of Saint-Louis. This park occupies over 120 km² and includes part of the river, and many lakes, basins, and marshes. About 3 million migrating birds of 400 species visit it each year.

Fauna Reserve of Gueumbeul is located at a dozen kilometers south of the city of Saint-Louis, this reserve has an area of 7 kms² and shelters birds and endangered species such as the Dama Gazelle, the Patas monkey and the African Spurred Tortoise.

5.14.11  SEDHIOU REGION

The Sedhiou Region is located in the center of Casamance, in the South West of Senegal. It covers 7,341 km² (2,834 sq mi) and has a population of 434,877 as of 2013.

It is one of the last regions created in Senegal in 2008. Tourists come to Sédhiou for mainly one reason: hunting. There are the venison, such as the wild pig and the wild rabbit. Many birds such as: la Poule de roche, la Tourterelle Cap, la Pintade, le Pigeon Vert, la Tourterelle Collier, la Tourterelle Mallier, le Pigeon Ronier, le Gangas, le Francolin Commun.
Most of the Region is covered by various forms of vegetation ranging from dense forest to open arboreal formations, or shrubby and grassy savannas. Agricultural areas cover approximately 25% of the total surface with a strong predominance of the rain-fed herbaceous crops.

5.14.12 **TAMBACOUNDA REGION**

The Tambacounda Region covers the area of 42,364 km² (16,357 sq mi), and has an approximate population of 649,854 (2011).

Tambacounda region used to be part of the Mali Empire before the borders were created to separate Mali from Senegal. Tambacounda is physically the largest of Senegal’s 14 regions, but is sparsely populated and its economy lags behind the rest of the country. The department of Kédougou was separated from Tambacounda in 2008, and became a separate region.

Tambacounda is situated on the sparsely populated sahélien plains of eastern Senegal. Like most of West Africa, the area has two seasons, the rainy season from June to October, characterized by heat, humidity and storms, and the dry season from November to May. The economy of Tambacounda is based primarily on agriculture, with cash crops including cotton and peanuts. Tambacounda region is also a center for agricultural processing, with millet, sorghum, maize and cotton grown in the dry plains of the region. Sodefitex operates a large cotton processing plant in the town of Tambacounda.

5.14.13 **THIES REGION**

Thies Region has a surface area of 6,670 km² (2,580 sq mi) and has a population of approximately 1,709,112 (2013). It has two coastlines, one in the north with the Grande Côte housing the Niayes vegetable market, one to the south with the Petite Côte, one of the tourist areas of Senegal.

Thies region is principally the main passageway between the Dakar peninsula and the rest of the country and has had recent infrastructure investments such as creating a new railroad track and newly paved highways.

Relatively small, yet it is the most populous region after the Dakar. The coastal communities whom are dependent on fishing, growing crops and coastal tourism for subsistence. Phosphates are also mined here.

The Thiès Region has always been occupied by the Serer people since the ancient Serers and their ancestors. However in the pre-colonial period, more so around the 16th century, the Wolof immigrants among others have settled in. Like the Fatick Region, the entire Thiès Region is strongly Serer and one of the most important of Serer country. It is also where many of the Serer sacred and historical sites are found. The area is well represented by the Cangin, a sub-group of the Serers, who had a fierce reputation for protecting their country from outsiders in precolonial times as well as during the colonial-era.

About 62% of the surface area of the region of Thiès is dedicated to agricultural activities and the most common rainfed crops are millet, groundnuts, sorghum, beans and cassava. Millet is the most common crop and it is mainly used on subsistence bases, followed by groundnuts, which is more than a cash crop. The average cereal production is 0.6t/ha.

Horticulture is the main dry season activity and it is meant both for family consumption and commercialization. The common horticultural crops are: green beans, pepper, onion, cabbage, aubergine (*Solanum melongena*), bitter tomatoes, potatoes, carrot, turnip, parley, sorrel, sweet potatoes etc. French beans are primarily produced for exportation to Europe. The horticultural crops depend on irrigation and the yields are fairly good.

Arboriculture is wide spread; it was generally adopted as a mean of mitigating the effects of annual crop failure. Most of the orchards are fenced with live fencing materials. Plot size varies from 0.5 to 2
hectares with mango, cashew (*Anacardium occidentale*) and rum-palm (*Borassus aethiopum*) as the principal species.

The main livestock in the region of Thiès are large ruminants (cattle, horse and donkey), small ruminants (sheep, goats and swine) and poultry which forms the majority of the livestock population because of the distribution of chicken in most of the households. Ducks are also very popular in the area. Cattle are mainly reared for prestige while sheep and goats are easily raised for revenue.¹⁶

### 5.14.14 ZIGUINCHOR REGION

The Ziguinchor Region covers 7,352 km² (2,839 sq mi) and has a population of approximately 523,840 (2013). This region is also referred to historically and popularly as Basse Casamance.

The climate is low-lying and hot, with some hills to the southeast. The Region has average rainfall greater than the rest of Senegal, with most areas receiving over 50in/1270mm annually, and as high as 70in/1780mm in some places. The entire Casamance region experiences a tropical savanna climate.

The Casamance was subject to both French and Portuguese colonial efforts before a border was negotiated in 1888 between the French colony of Senegal and Portuguese Guinea (now Guinea-Bissau) to the south. Portugal lost possession of Casamance, then the commercial hub of its colony. Casamance, to this day, has preserved the local variant of Kriol known as Ziguinchor Creole, and the members of the deep-rooted Creole community carry Portuguese surnames like Da Silva, Carvalho and Fonseca. Interest in Portuguese colonial heritage has been revived in order to exert a distinct identity particularly in Baixa Casamança.

Bissau-Guinean people are also present in the region, as expatriates, immigrants, and refugees from the poverty and instability that since long affects the neighbouring country, including a recent civil war.

### 5.15 PROTECTED AREAS

At present, Senegal’s wild fauna can only be found in national parks and reserves. The Niokolo Koba National Park alone holds 330 species of birds, 80 species of mammals, 60 species of fish, 36 species of reptiles, and 2 species of amphibians. In total, 10% of the country’s territory is currently under protection. The Senegal River Delta, another highly interesting site with respect to biodiversity, is the only ecosystem affected by invasive alien species issues. In addition, mangroves, niayes, and the Djoudj area are of particular interest because of their important biodiversity, ecological role and fragility.

Senegal comprises 2,500 species of flower plants. Insects account for the greatest number of animals with 2,000 species, followed by mollusks, which, combined with fish species, amount to more than 1,000 species. This illustrates the significance of a marine biodiversity that remains largely unknown. In Senegal, some species benefit from strict protection, such as elephants, sea turtles, Derby élans, and bamboo.

¹⁶ [http://www.ioo.florence.it/training/geomatics/Thies/Senegal_23linkedp8.htm](http://www.ioo.florence.it/training/geomatics/Thies/Senegal_23linkedp8.htm)
5.15.1 National Parks

The **Djoudj National Bird Sanctuary** (French: *Parc national des oiseaux du Djoudj*) lies on the southeast bank of the Senegal River in Senegal, in northern Biffeche, north east of St-Louis.

It provides a range of wetland habitats which prove very popular with migrating birds, many of which have just crossed the Sahara. Of almost 400 species of birds, the most visible are pelicans and flamingos. Less conspicuous are the Aquatic Warblers migrating here from Europe; for these, the park is the single most important wintering site yet discovered. A wide range of wildlife also inhabits the park, which is designated a World Heritage Site. The site was added to the list of World Heritage in Danger in 2000 due to the introduction of the invasive giant salvinia plant, which threatens to choke out the park’s native vegetation. However it was removed from the list in 2006.

Since operation of the Diama Dam on the Senegal River began in 1988, experts have observed a lowering of the water level, desalinization, and silting. The changes pose a threat to the fauna and flora. There has been in particular a proliferation of typhas and phragmites.

In 2006, though no cases of avian flu had been reported in Senegal, a monitoring program was put into effect.
Isles de la Madeleine National Park

Le Parc National des Îles de la Madeleine is the smallest national park in the world, and a UNESCO World Heritage Tentative List site. Because of its apparent barrenness and the past inability to cultivate the land of the island, local lore dictates that evil spirits inhabit it which prevent its being populated. Sarpan (Île aux Serpents), the largest of the islands, is also home to an extremely rare subspecies of Phaeton, a marine bird found only on the Îles de la Madeleine and the Galápagos Islands. These Isles are located off the coast of Dakar.

Niokolo Koba National Park

The Niokolo Koba National Park in Tambacounda covers over 900,000 ha and is the most valuable and extensive conservation park in Senegal. Although registered as both a UNESCO World Heritage site and a Man and the Biosphere (MAB) Reserve it has been heavily poached in the past and has suffered from the great droughts of the 1970’s.

The southern forest zone in the Tambacounda region has six protected areas comprised of four classified forests, one national park and one hunting reserve. The gallery forests in the Niokolo Koba system represents 78% of the gallery forests in Senegal and consists of palms, raphias as well as marsh prairies. Of the 31 plant species considered endemic to Senegal, 12 are present in this zone and 8 are considered endangered. This zone contains 80 species of mammals, around 330 bird species, 36 reptiles, 60 fish species, 2 amphibians and about 1,500 plant species. Because of the diversity of habitats and the large size of this park, species richness is high, although the number of endemic species is not exceptional.

This ecosystem houses the only viable population of the rare Eland de Derby (Tragelaphus derbianus derbianus) in the sub-region. The park is equally the last refuge for the elephant (Loxodonta africana) in Senegal and around 150 chimpanzees (Pan Troglodytes) live in the gallery forest in and around the park.

Many of the remaining large mammals are protected because they are close to extinction locally (including elephants, leopard, cheetah, hippopotamus, red-fronted gazelle, giant eland, chimpanzee, ostrich, marabou stork, crocodiles and lions).

Saloum Delta National Park or Parc National du Delta du Saloum in Senegal, is a 76,000-hectare national park. Established in 1976, it is situated within the Saloum Delta at the juncture of the Saloum River and the North Atlantic.

The park, which forms part of a UNESCO World Heritage Site and a Ramsar Convention site, lies within the 180,000 ha biosphere reserve. Water comprises 61,000 ha (of the park, intertidal mangroves and saltwater vegetation cover 7,000 ha, and savannah and forest cover 8,000 ha. It lies on the East Atlantic Flyway. The bird species that breed or winter in the area include royal tern, greater flamingo, Eurasian spoonbill, curlew sandpiper, ruddy turnstone, and little stint.

Sine Saloum National Park

The Sine-Saloum National Park occupies a large part of the delta, covering 73,000 ha, and is itself situated within the larger Biosphere Reserve of 180,000 ha. The Biosphere reserve includes 23,000 ha of seasonally flooded lands, 72,000 ha of land under marine influence, i.e. tidal swamps, sand-bars, lagoons etc., and 85,000 ha of dry land. It is planned that the park shall become part of an international park with a new section to be added in the south, across the Gambian border to include the mangroves at the mouth of Karenti Bolon. The Saloum Delta National Park with its 73,000 ha has a village within its small forest and has practically no remaining large wildlife, yet the delta itself is rich in marine life.
5.15.2 Natural Reserves:

Guembeul Natural Reserve (fr. Réserve spéciale de faune de Guembeul) is a natural reserve located about 10 km south of Saint-Louis, Senegal, in the Gandiol region. It covers an area of 720 hectares, and was designated an IUCN category IV Faunal Reserve in 1983.

The park is home to many species of birds, reptiles and mammals. The site is also the center for reintroduction programs of three species of gazelles and is home to the African Spurred Tortoise. This is an IUCN category IV (habitat/species management area) area.

Kalissaye Avifaunal Reserve

’Kalissaye Avifaunal Reserve’ (KAR) is a small nature reserve in Senegal, located at the mouth of Kalissaye Pond in the middle of the Casamance River.

Like Basse Casamance National Park 35 km away, KOR is currently closed due to the Casamance Conflict.

5.15.3 Marine Protected Areas in Senegal

The issue of Marine Protected Areas has become a part of all discussions concerning the sustainable management of marine and coastal environments and of fishing in Senegal, often under the impetus of development partners. The creation and development of MPAs, which are supposed to bring numerous answers to fisheries management problems, especially in coastal zones, have thus become a primary challenge for both the fisheries and the environment authorities.

In practice, however, Senegal is still in the initial stages of MPA development, so that very few lessons can be learned about MPA management methods and their impact on fisheries management. Furthermore, their purpose lacks clarity, and the imprecision in the legal and institutional framework for their management has resulted in numerous conflicts over competency, leading to strategies where actors often lack a common line of action and favour different approaches depending on the donor agency.

### TABLE 4: OVERVIEW OF THE SENEGALESE MARINE PROTECTED AREAS NETWORK

<table>
<thead>
<tr>
<th>Protected areas</th>
<th>Surface area</th>
<th>Interest from biodiversity perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somone Nature Reserve of Community Interest (RNICS), created in 1999.</td>
<td>700 ha</td>
<td>Highly diversified avifauna including: spoonbill, pelican, cormorant, egret, curlew, sandpiper, etc.</td>
</tr>
<tr>
<td>Palmarin Community Nature Reserve (RCP), created in 2003.</td>
<td>10,430 ha</td>
<td>Reproduction site for sea turtles, striped hyena, jackals, monkeys, very important avifauna.</td>
</tr>
<tr>
<td>Bamboung Community-Managed Marine Protected Area, created in 2004.</td>
<td>7,000 ha</td>
<td>Spawning and feeding grounds for ichthyofauna, manatees, dolphins and sea turtles.</td>
</tr>
<tr>
<td>Saint Louis Marine Protected Area, created in 2004.</td>
<td>49,600 ha</td>
<td>Sustainable protection and conservation of fisheries.</td>
</tr>
<tr>
<td>Cayar Marine Protected Area, created in 2004.</td>
<td>17,100 ha</td>
<td>Protection of sites of special interest for maintaining and renewing fishery stocks in and around the conservation area.</td>
</tr>
<tr>
<td>Joal Fadiouth Marine Protected Area, created in 2004.</td>
<td>17,400 ha</td>
<td>Spawning ground and reproduction site for sea turtles.</td>
</tr>
<tr>
<td>Abene Marine Protected Area, created in 2004.</td>
<td>11,900 ha</td>
<td>Sustainable protection and conservation of fisheries.</td>
</tr>
</tbody>
</table>

### Table 5: List of Legally Recognized MPAs in Senegal

<table>
<thead>
<tr>
<th>MPA</th>
<th>Status</th>
<th>MPA Objectives</th>
<th>Area</th>
<th>Line Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langue de Barbarie National Park</td>
<td>Decree (1976)</td>
<td>biodiversity conservation in the lower delta, protection of marine turtles</td>
<td>Sandy point + maritime zone: 20 km² in total</td>
<td>DPN</td>
</tr>
<tr>
<td>Iles de la Madeleine National Park</td>
<td>Decree (1976)</td>
<td>Conservation of the environment and of biodiversity</td>
<td>15 ha of islands + maritime zone of 30 ha</td>
<td>DPN</td>
</tr>
<tr>
<td>Natural Reserve of Popenguine</td>
<td>Decree (1986)</td>
<td>Restoration of damaged environment</td>
<td>Terrestrial part 10 km² + maritime border (1/2 nautical mile)</td>
<td>DPN</td>
</tr>
<tr>
<td>National Park and Biosphere Reserve of the Saloum Delta</td>
<td>Decree (1976)</td>
<td>Conservation of delta ecosystems, conservation of biodiversity, restoration of ecosystems</td>
<td>Park: 730 km² Rb: 4 500 km²</td>
<td>DPN</td>
</tr>
<tr>
<td>Saint-Louis MPA</td>
<td>Listed as bR in 1981</td>
<td>Protection of natural and cultural resources</td>
<td>496 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td>kayar MPA</td>
<td>Listed as a Ramsar site in 1984</td>
<td>Conservation of delta ecosystems, conservation of biodiversity, restoration of ecosystems</td>
<td>Park: 730 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td>Joal-Fadiouth MPA</td>
<td>bR: 4,500 km²</td>
<td>DPN (National Park Directorate)</td>
<td>174 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td>Abene MPA (Casamance)</td>
<td>Decree (2004)</td>
<td>Protection of natural and cultural resources</td>
<td>496 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td>Bamboung MPA (Saloum delta)</td>
<td>Decree (2004)</td>
<td>Protection of natural and cultural resources</td>
<td>171 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td></td>
<td>Decree (2004)</td>
<td>Protection of natural and cultural resources</td>
<td>174 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td></td>
<td>Decree (2004)</td>
<td>Protection of natural and cultural resources</td>
<td>119 km²</td>
<td>DPN/DPM</td>
</tr>
<tr>
<td></td>
<td>Decree (2004)</td>
<td>Protection of natural and cultural resources</td>
<td>70 km² (30 km² of which are bolong)</td>
<td>DPN/DPM</td>
</tr>
</tbody>
</table>

Note: bR = biosphere reserve, DPN = National Park Directorate, DPM = Directorate of Maritime Fisheries.
5.16 **SENEGAL ECOREGIONS**

The following are descriptions of the ecoregions found in Senegal as identified by the AGHRYMENT, Sahelian Regional Center for Climate, Drought Control and Water Management.

**FIGURE 14**: MAP SHOWING ECO-GEOLOGICAL REGIONS OF SENEGAL

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### 5.16.1 WEST CENTRAL AGRICULTURAL ECOREGION, OR PEANUT BASIN

Of all of Senegal’s ecological regions, the Peanut Basin has been the most fundamentally altered by centuries of human activity. In particular, the last 150 years have witnessed a nearly complete transformation of its landscape. In the mid 1800s, small farming communities were scattered throughout a mosaic of wooded savannas and open woodlands. Today, continuous cultivation under an acacia tree parkland has replaced all vestiges of the natural vegetation the Peanut Basin was cultivated, with most of the remainder (31%). In 1965, approximately 67% of the Peanut Basin was cultivated with most of the remainder in large blocks of grazing land and grassy fallow. The cultivated area is presumed to have peaked sometime in the mid-1980s, when farmers still benefited from agricultural subsidies. This trend then reversed itself, declining to about 67% under cultivation in 2000.

Throughout the West-Central Agricultural Region, or ‘Peanut Basin’, there is considerable evidence of the negative effects of drought on the woody resources. It is, however, not as apparent as in the pastoral regions because there are few vestiges, if any, of the original vegetation cover. Beginning in the mid 1800’s, the French colonialists introduced peanuts, encouraging Wolof and Serer farmers to methodically clear major areas of ‘dior’ soil areas for cultivation, resulting in a completely agricultural landscape. By 1900, pseudo-climax woodland characterized the area dominated by such Sudanian Zone tree species as *Combretum glutinosum* (rat), *Anogeissus leiocarpus* (ngejan), *Cordyla pinnata* (dimb), *Khaya senegalensis* (xaay), *Bombax costatum* (garabu lawbe), *Pterocarpus erinaceus* (win), and *Sterculia setigera*.
While many of these species are uncommon or rare in the region today, a number of Sahelian and Sudanian zone species do survive in the fields of village terroirs. At least 69 woody species can still be found in the central Peanut Basin (Seyler, 1993). In addition to the relict species, several introduced species have become widespread, of which \textit{Acacia albida} (\textit{kad}) stands out, owing to its dominance in much of the central Peanut Basin.\textsuperscript{17}

5.16.2 \textbf{THE SENEGAL RIVER VALLEY}

The Senegal River is the second longest river in West Africa. It flows through a broad valley that carves through the semiarid Sahelian landscapes of Senegal, Mali, and Mauritania, creating a unique, complex environment determined largely by the hydrological, soil, and topographic conditions of the floodplain. Remnants of a once extensive riverine woodland dominated by \textit{Acacia nilotica}, or the gum Arabica tree, are today restricted to shallow depressions and levees along the river. Twenty-eight of these woodlands were designated as forest reserves. Most of the floodplain, known as the \textit{Walo}, has been cleared gradually by local peoples over the centuries for traditional subsistence agriculture, and in recent decades, for vast hydro-agricultural projects designed to make Senegal self-sufficient in food production and to boost cash crop production for export (rice and sugarcane). Flood recession agriculture is practiced on the heavy alluvial soils on the banks of the river and its numerous channels. Vast expanses of the alluvial plain remain relatively barren.

Owing to the unique and highly threatened status of the riverine woodlands, there has been a sharp decrease in the area of woodlands, despite the numerous reserves that ‘protect’ them from cutting. Clear evidence of the devastation has resulted from charcoal production and clearing for irrigation agriculture. The loss of the riverine forests has destroyed a rich and diverse habitat for wildlife, food for livestock (the pods provide valuable browse material), and termite-resistant wood used in construction.

5.16.3 \textbf{NORTHERN SANDY PASTORAL ECOREGION}

This region, also known as the sandy Ferlo, constitutes the heart of Senegal’s sylvo-pastoral zone. It has the typical characteristics of the central Sahelian climatic zone: a short, irregular rainy season, open grasslands with scattered shrubs and trees, a relatively limited number of woody species, and a predominance of the genus acacia. Generally too dry for crop production, the region is primarily used for grazing. The gently undulating to flat eolian sands are remnants of an erg deposited during the middle to recent Quaternary Period, approximately 0.5-2.5 million years ago.

During the course of the 20th century, drought has had a moderate but not a severe impact on the woody cover. The deep, sandy soils, with their large water storage capacity, have helped temper the effects of drought on the woody vegetation. Nevertheless, the woody cover has declined over the past half century. Today, annual grasses flourish during a short 2–3 month rainy season, while the woody vegetation cover has become quite open and floristically poor. In 1965, before the severe droughts that followed, the woody cover in the central sandy Ferlo typically ranged from 10 to 15 %. This range does not appear to have changed significantly since 1942. The woody cover to range from less than 1–5%, except within the small interdune depressions where the density is often 10–40%.

The primary change is the significant incursion of rain-fed agriculture (mainly millet and peanuts). In 1965, cultivated area was limited to about 1%; in 1984, cultivation had increased to over 13%, and in 1999 it grew to over 16 %. Reasons for the expansion into this climatically marginal region are complex, but some of the driving factors include mounting land pressure, soils that are deep, light, and workable, and national policies on land laws that encourage \textit{mise en valeur}—maintaining land in production, which

strengthens farmers’ claims to the land. Traditional subsistence crops cultivated by the semi-nomadic Fulbe pastoralists have not significantly contributed to rise in cultivated area. The trend of agricultural expansion in the Ferlo is expected to continue as population pressure and the demand for land increases in the Senegal’s western and southern regions.

5.16.4 Ferruginous Pastoral Ecoregion (or Lateritic Ferlo)

The shallow, loamy, gravelly soils of the ‘Lateritic Ferlo’ set this Sahelian and Sahelo–Sudanian region apart from the sandy pastoral regions to the west. Underlying the shallow plateau soils is an often-impenetrable laterite crust. The local relief is also more pronounced between plateaus and valleys. At fewer than 5 people per km², it is the least populated ecological region of Senegal, because of its poor agricultural potential and difficult access to water. The region constitutes a vast grazing land, with scattered settlements and temporary camps of the Fulbe semi-nomadic pastoralists, primarily along the fossil valleys. The vegetation can be described as a ‘dry bush formation.’

Overgrazing, browsing, and trampling led to loss of herbaceous and woody cover and soil compaction. Exposed soils became susceptible to water erosion, and the upper horizon was washed into the valley bottoms. A badland effect has spread quickly over recent decades, and can be monitored nationally using time-series satellite images.

5.16.5 Southern Sandy Ecopastoral Region

This region shares many of the geomorphological and pedological characteristics of the Northern Sandy Pastoral Region but is distinguished from it by significantly higher rainfall. Human settlement has been limited, mainly because the soils are shallower and less workable than those in the Peanut Basin, and because ground-water is generally much deeper. The Southern Sandy Pastoral Region is part of Senegal’s extensive sylvo-pastoral region, with more reliable and more productive grasslands than ecoregions to the north and east. Large sylvo-pastoral reserves and forest reserves were established in the 1930s by the colonial authorities. Many considered the vegetation to be a ‘fire-climax,’ its woody cover kept open by centuries of burning. The predominant formation today is that of a shrub and tree savanna, with floristic composition characteristic of the transition from Sahelian to Sudanian types. Trees are taller than they are in the Sahelian zone (6–8 m), with fewer acacia species and a predominance of the combretaceae family. Despite the higher rainfall, the woody cover remains very open, typically ranging from 5–15 % (mainly bushes) in continuous grassland.

5.16.6 The Niaves or North Coast

A narrow strip of land along Senegal’s northern coast forms a unique ecological region owing to the combined influences of a humid maritime air mass, a Sahelian rainfall regime, and a geomorphology of active littoral and stabilized continental sand dunes that create special microenvironments. The microenvironments consist of inter-dune depressions, called niayes. The niayes are a biological crossroads, harboring a complex and rich flora, with many relic species of the Sudanian and Guinean regions. The region includes a wide range of humid to arid habitats, ranging from hydromorphic depressions to the sandy soils of the sand dune formations. Many species of plants from the higher rainfall zones to the south are able to survive by tapping into the near-surface ground-water. Temporary lakes can form during the rainy season, especially during the wetter periods.

Since the 1970s, drought and human pressure have taken their toll on this unique ecological zone. Many species of Guinean affinity, including the oil palms, have succumbed to the effects of drought. The moist, fertile soils of the niayes are good for market gardening. The surrounding red-colored continental sand dunes support a shrub savanna, used for centuries by Fulbe pastoralists as important grazing lands.
5.16.7 Saloum Agricultural Ecoregion

The land use and land cover of the Saloum Agricultural Region was dominated by an agricultural parkland until recently when it was nearly completely transformed by agriculture. Although generally included by many authors in the ‘Peanut Basin,’ it can be distinguished from the latter by its higher rainfall and greater floristic and agricultural diversity. Before the rapid changes of the 20th century, the climax was at a total of 89 woody species from numerous sites in the protected Fathala Forest. Today, most tree species found in farmers’ fields are relics of the ancient woodland. Today, only a few protected wooded savannas remain, and tree cover in these areas has fallen to 10–20%.

The agricultural expansion into the former woodlands is quite recent. Peanut production began to make inroads between 1900 and 1940, but the area under cultivation was small and scattered. Expansion increased dramatically in the 1950s and 1960s. By the 1990s, the transformation was complete, leaving only a few patches of protected woodlands. Mounting population pressures, drought, and national policies that encouraged peanut production have resulted in the demise of the centuries-old bushland-fallow agricultural system. By the 1990s, virtually all arable land was under cultivation, with little use of fallow or other soil conservation practices. Furthermore, most rural people are no longer within walking distance of the few remaining woodlands—traditional sources of food, fiber, firewood, and medicine.18

5.16.8 Agricultural Expansion Ecoregion

In the past half-century, winds of change have swept across this ecoregion, driven almost exclusively by human activity. In the deeper soils of the broad valleys, its wooded savannas have been replaced by agriculture, and the thin soil uplands have been transformed into a degraded shub and tree savanna. As land constraints and declining soil fertility in the Peanut Basin became more acute, the most logical direction for expanding production was to the south-east. Wedged between The Gambia to the south and the syrto-pastoral regions to the north, the Agricultural Expansion Region has higher rainfall and a longer rainy season than most of the Peanut Basin. Its broad valleys with deep, sandy to loamy soils are suitable for many crop varieties.

Wolof and Serer farmers from the Peanut Basin, driven by harsh economic and environmental conditions, settled in the region, and by the 1980s, most of the wide valleys were under cultivation. However, unlike the Peanut Basin, more than half of the region is composed of low, lateritic plateaus, with a thin veneer of gravelly and loamy soils. Far less suited to agriculture than the valleys, the plateaus have remained mostly unfarmed. Wooded savannas with flora characteristic of the northern Sudanian bioclimatic region remained relatively intact until a wave of charcoal production swept across the region from the 1960s to about 1990. Tree mortality from drought in the 1970s and 1980s also exacerbated the situation. Today, patches of degraded, biologically poor shrub and tree savannas are all that remain.

Agriculture has clearly been the primary agent of change, expanding from 35.4 % of the area to 64.6 % from 1965 to 2000 . The rate of expansion will slow considerably, because most of the soils suitable for cultivation have been used. Consequently, the predominant vegetation cover has changed from a wooded savanna to a shrub and tree savanna.

5.16.9 **EASTERN TRANSITION ECOREGION**

Biophysically, the Eastern Transition Region is similar to the Agricultural Expansion Region. However, its distance from Senegal’s densely populated agricultural region, and the predominance of lateritic plateaus have spared the region from the anthropogenic pressures of the western regions. Spared, that is, until the 1980s when the wave of charcoal production began to sweep through its wooded savannas and forest reserves. This region has become Senegal’s primary source for fuelwood, mainly in the form of charcoal. By 1995, approximately half of the wooded savannas had been degraded by charcoal production, leaving behind a biologically poor tree savanna and woody cover typically ranging from 5 to 20%. Thus, the woody cover is significantly reduced following logging for charcoal production; the impact on the biology and habitat quality may be much greater.

Agricultural expansion, driven by Wolof and Serer settlers from the west, is a secondary force of change. It is beginning to chip away at the wooded savannas and grazing lands. Cotton and peanuts have become significant cash crops. Farmers carve new fields out of the wooded savannas and systematically clear stumps, shrubs, and trees to facilitate animal traction. Tragically, this example causes the loss of one of the largest and densest gallery forests in the region. Gallery forests are unique niches that preserve rich communities of Guinean and Sudanian flora and fauna.

5.16.10 **SHIELD ECOREGION**

Geology is the primary feature that sets this region apart. Ophiolitic, granitized, and tightly folded volcanic and sedimentary rocks make up a Precambrian shield. The surface geomorphology of low plateaus and hills, terraces, and valleys only hints at the complexity of the underlying geology. Until recently, the great distance from Senegal’s population centers and the very limited agricultural potential of the region has deterred migration to the region. Population and human pressure have been low (4 people km²), with widely scattered villages lining up along the fossil valleys.

A Sudanian deciduous wooded savanna constitutes the main vegetation type of the region. Based on his detailed field observations the 1930s, dry woody formations that cover the region form heterogeneous communities, with no one tree species dominating the floristic composition. The communities are floristically rich.

A mosaic of several other vegetation formations occurs as a function of the geomorphology, soils, rainfall, fire, and to a smaller degree, grazing and shifting cultivation. Annual fires that sweep across most of the region are such an important component of the ecosystem that these wooded savannas are referred to as fire-climax formations. The wide range of habitats explains the rich flora, with species from both the Sudanian and the Guinean bioclimatic zones. A unique but common formation is the grassy bowe!, which are marked by outcrops of impermeable laterite that restricts root penetration and results in open, often treeless meadows. Evergreen, closed-canopy gallery forests still occur along some fossil valleys, but they are being fragmented and destroyed by agricultural expansion.

A large part of this region falls under the protection of the Niokolo-Koba National Park. The park covers some 913,000 ha and contains some of the most pristine Sudanian-type flora and fauna left in Africa. The floristic diversity remains high, preserving many of the genetic resources that are being lost in other parts of Senegal.

Agriculture in the region enjoys relatively high rainfall, and farmers grow responsive crops, such as maize, sorghum, peanuts, cotton and, even rice. Bush fallows of up to 5 years are still practiced. When the fragile soils are laid bare by cultivation, however, they are quite vulnerable to water erosion. The vast areas of non-tillable terraces and plateaus ensure the availability of extensive rangelands for cattle and a corresponding potential for internal transport of nutrients to fields.
5.16.11  THE CASAMANCE

‘La Verte Casamance,’ as it is fondly referred to, is well known for its tropical greenery, lush forested landscapes, valleys fringed with oil palm groves, and rice paddies. These traits give it a unique personality, markedly different from the semi-arid regions to the north. Geographically, the region can be distinguished from other regions by the combination of high seasonal rainfall, a well-developed drainage system, ferrallitic soils, relatively dense and floristically rich Sudanian and Guinean vegetation types, diverse agrarian ethnic groups, and its relative isolation from the rest of Senegal.

The Casamance is showing signs of a major, potentially irreversible transformation in land use and land cover, comparable to the dramatic evolution that reconfigured the Saloum Agricultural Region from the 1930s to the 1990s. Senegalese ecologists are already referring to parts of eastern and central Casamance as ‘la région compromise,’ whose biological resources are quickly succumbing to the extreme pressures of expanding cultivation and charcoal production. Today tracts of agricultural parkland closely resemble the open, degraded landscapes of the Saloum Agricultural Region.

As in the Shield Region to the east, annual rainfall amounts of over 1000 mm support a Sudanian-type deciduous wooded savanna and woodland over much of the region. In the numerous forest reserves and areas of minimal human activity, these floristically rich and heterogeneous formations maintain woody cover levels of 20–50%. The highest woody densities occur in the extreme east (Department of Velingara) and extreme west (Department of Ziguinchor).

Natural conditions are favorable to diverse agricultural activities, including rice, millet, corn, peanuts, and cotton, as well as animal rearing and tree crops, particularly mango and cashew. Agricultural production has been boosted in recent years by the expansion of cotton production in the Kolda Region and rice growing in the Anambe Basin.

5.16.12  THE ESTUARIES

Two major complexes of low tidal flats and estuaries produce another distinct ecoregion. These coastal wetlands are flooded twice daily by the ocean tide and have historically been occupied by mangroves of the genus *rhizophora* and *avicennia*. The mangrove forest cover is quite dense, ranging from 50 to 100%. Ancient mud flats called *tannes* occur on slightly higher ground between the channels. The Saloum and Casamance Rivers, which constitute the main arteries of the two estuary regions, receive only minimal water flow from upstream, and only in the rainy season 3–4 m³ s⁻¹ at Kolda. Consequently, the water remains brackish from the intrusion of seawater.

Since the 1970s and 1980s, some of the mangrove forest has perished, particularly in the northern third of the Saloum estuary complex, as well as along the Casamance River. We see direct evidence of the loss of mangrove forest from comparisons of Corona, Landsat, and aerial images.

The disappearance of the mangrove is related to a modification of physical–chemical conditions of the river water and ground-water (increased salinity and acidity) because of the decline in rainfall in recent decades. Drought is cited as the primary cause. Salinity has reached three to five times that of seawater. On a positive note, the villagers of Faoye (south of Fatick) have noticed regeneration of mangrove plants in the mud flats since 1994. They attribute this to somewhat higher rainfall. Regeneration is also occurring along the lower Casamance River. ¹⁹

FIGURE 15: AERIAL VIEW THE SENEGAL RIVER.

FIGURE 16: SALOUM RIVER IN KOALAS REGION.
**TABLE 6: PROTECTED AREAS IN SENEGAL.**

<table>
<thead>
<tr>
<th>Protected Area</th>
<th>Date Created</th>
<th>Size (hectares)</th>
<th>International Conventions</th>
</tr>
</thead>
<tbody>
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<td>913,000</td>
<td>Man and Biosphere Reserve</td>
</tr>
<tr>
<td>Lower Casamance National Park</td>
<td>970</td>
<td>5,000</td>
<td>World Heritage Site</td>
</tr>
<tr>
<td>Djoudj Bird National Park</td>
<td>1971, 1975</td>
<td>16,000</td>
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</tr>
<tr>
<td>Saloum Delta National Park</td>
<td>1976</td>
<td>76,000</td>
<td>World Heritage Site, Ramsar Site</td>
</tr>
<tr>
<td>Biosphere Reserve of the Saloum Delta</td>
<td>1981</td>
<td>180,000</td>
<td>Man and Biosphere Reserve</td>
</tr>
<tr>
<td>Langue de Barbarie National Park</td>
<td>1976</td>
<td>2,000</td>
<td>Ramsar site, REDBIOS site</td>
</tr>
<tr>
<td>Iles de la Madeleine National Park</td>
<td>1976</td>
<td>45</td>
<td></td>
</tr>
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<td>Ornithological Reserve of Kalissaye</td>
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<td>Special Wildlife Reserve of Guembeul</td>
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<td>Popenguine Natural Reserve</td>
<td>1986</td>
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<td>South Ferlo Wildlife Reserve</td>
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<td>Samba Dia Biosphere Reserve</td>
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<td>763</td>
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<td>Ndiael Special Wildlife Reserve</td>
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</tr>
</tbody>
</table>

Source: Direction des Parcs Nationaux, modifiée par Centre de Suivi Ecologique avec la collaboration de l’SE
FIGURE 19: MAP OF PROTECTED AREAS (DPN, 1998)

Source: Direction des Parcs Nationaux, modifiée par Centre de Suivi Ecologique avec la collaboration de l'ISE
6. PESTICIDE PROCEDURES

Regulation 22 CFR 216.3(b) mandates the consideration of twelve factors when a project includes “assistance for the procurement or use, or both, of pesticides”. This section addresses each of those twelve factors for the Malaria Control Program in Senegal.

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

Pesticides registered for IRS in Senegal and the United States, and recommended by WHO, will be preferred for use in this IRS project. However, some of the pesticides on the WHOPES list are not registered with the U.S. Environmental Protection Agency (USEPA), for economic reasons rather than health and safety or technical ones. Because this is an economic issue rather than a technical one, and because there is widespread use of these chemicals around the world, with a good database attesting to the safety of the chemicals, USAID and USEPA has chosen to allow the use of all WHO-recommended pesticides under the Africa IRS program. Currently, chlorfenapyr is under review by WHOPES and is currently registered by the USEPA for some agricultural uses, but has not yet been registered for public health use.

The pesticide regulating body in Senegal is under the Ministry of Agriculture and Rural Equipment, the National Committee on Pesticide Management (CNGP) and the DPV (La Direction de la Protection des Vegetaux). Currently, the three out of the four class groups recommended by WHO for IRS activities, pyrethroids, carabmates, and organophosphates, are registered by the National Commission on Pesticide Management for use in public health. This national commission is also subsidiary to the CSP, Comite Sahelien des Pesticides, which governs 9 countries in West Africa. Chlorfenapyr is currently not registered for public health, and will need to go through the approval process before it can be used in IRS activities. All applicable Senegalese laws and regulations regarding the public health use of the WHOPES recommended pesticides will be followed.

6.2 THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

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 for each campaign based on a number of considerations. The insecticide selection and the timing of the spray cycle are dictated by the consortium that is made up of NMCP, PMI/GoS/ the IRS Steering Committee and are based on the results of annual entomological studies conducted by the UCAD. The current organophosphate insecticide will be supplied by PMI, which is procuring the national need for IRS insecticides. While no formal Integrated Vector Control Plan exists for the PMI program, the basis for the selection of the requested pesticides will rely upon the results from the entomological studies done by the UCAD on four pesticide classes done that same year. There is no strict cycle of pesticide class rotation in Senegal, rather it is based on immediate manifestations of pesticide resistance of the vectors.
Primary Criteria for choosing pesticides:

a. **Approval by the World Health Organization Pesticide Evaluation Scheme**: Only insecticides approved by WHO can be used in IRS. Organophosphates, carbamates, pyrethroids and organochlorines are WHOPES approved classes of pesticides for use in IRS and thus any can be chosen for use based on entomological data and host country registration status. Chlorfenapyr belongs to the pyrroles class of chemicals, which are not included in the WHOPES-approved classes for IRS; however, it is currently under consideration and could be considered at a later date for Senegal.

b. **Registration for use in the country**: The pesticides recommended by WHO for IRS are registered for use in public health by the CSP, Comite Sahelien des Pesticides, and the regulated by the DPV. Chlorfenapyr is currently not registered for public health, and will need to go through the approval process before it can be used in IRS activities.

c. **Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area**: According to WHO, all pyrethroids, carbamates, OPs and DDT are expected to have duration of 3 to 6 months in terms of effectiveness; however, the duration of effectiveness varies under different climatic conditions. In most of the country, the peak periods of malaria incidence occurs during the peak rainy season from May to August. The PMI implementing partner have used pyrethroids in the past and then switched to carbamates and now organophosphates. Recent entomological testing has shown that the organophosphates have an appropriate longevity of 6-8 months after being sprayed.

d. **Pesticide must be appropriate for use on the wall surfaces of the selected location**: In rural areas dwellings are usually well constructed and roofed with straw, with walls made of either earth or straw. In more-prosperous villages roofs may be made of corrugated iron; the walls may be made of cement brick, called banco. The majority of the structures in the targeted regions are of this nature. Structures made of corrugated metal are not sprayed, as the pesticides don’t adhere sufficiently to the surface to be effective. In Senegal, the inside of the walls are sprayed, part of the ceilings (if not metal) and eves are sprayed.

e. **Local vector susceptibility to the insecticide**: One of the major concerns when implementing IRS campaign is to prevent resistance to insecticide among vectors. Resistance to insecticide develops when a hereditary feature is selected in an insect population that reduces the population’s sensitiveness to a given insecticide. PMI has provided a significant amount of support to build Senegal’s entomological capacity both at the central level and regionally, working closely with the UCAD. The PMI supported central entomology laboratory and insectary at the UCAD is operational and serves as the reference laboratory for in country processing of mosquito material. The PMI supported entomology laboratory and insectary in Thies, serves as a regional center for entomologic monitoring and surveillance for IRS and LLIN activities in the rural parts of Senegal. The NMCP/PMI is supporting the development of a vector control strategy and an insecticide resistance monitoring plan to guide vector control efforts in a coordinated, evidence-based manner, due to be released in 2015.

Insecticide resistance to pyrethroids has been well documented in Senegal recently and in other sub-Saharan African countries; it can have a devastating impact on the effectiveness of both IRS and LLINs, which are treated with pyrethroids. WHO approved pesticides resistance tests were conducted with bendiocarb, deltamethrin, DDT, and lambdacyhalothrin. Insecticide resistance varied between the different sites. Insecticide resistance assays were conducted in 16 geographically dispersed districts of Senegal. Assays were performed with insecticides of all four classes but not all insecticides were tested in all districts. The data showed that vector susceptibility to bendiocarb remained high in most of the country (99%-100% in the IRS districts) but was fairly low in the three districts without IRS (Kaffrine, 83%; Ndoffane, 78%; and Richard...
Toll, 86%). Pyrethroid resistance varied greatly but improved in both IRS and non-IRS districts whereas DDT resistance was evident in almost all sites. Organophosphates showed low levels of resistance in all sites.

As part of the insecticide resistance management plan, the PMI IRS Steering Committee recommends that the specific selection of insecticides for a rotation cycle will be determined based on insecticide susceptibility data collected each year. However, both insecticide choice and rotation cycle may vary based on the results of annual resistance testing. In areas where pyrethroid and carbamate insecticide resistance has been documented, organophosphate insecticides will be used instead.

Chlorfenapyr has a unique mode of action and is believed to be highly improbable that mosquitoes can develop resistance to it. It is also not cross-resistant to DDT, pyrethroids, carbamates, or organophosphates.

f. **Ecological impact:** The 2012 PEA for Integrated Vector Management (IVM) assessed the toxicity of IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and ‘other aquatic’ organisms. In summary, pyrethroids and carbamates are similar in toxicity to non-target organisms as shown in the Table below. Apart from propoxur, the rest of the insecticides are all highly toxic to fish and other aquatic organisms. Similarly all the insecticides from the approved classes are highly toxic to bees, apart from pirimiphos methyl. 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. There has been much concern over chronic exposure of bird species to DDT and its effects on reproduction, especially eggshell thinning and embryo deaths. In avi-fauna, only propoxur is categorized as highly toxic with the rest categorized as low/medium in toxicity.

<table>
<thead>
<tr>
<th>IRS Insecticide</th>
<th>Mammal</th>
<th>Bird</th>
<th>Fish</th>
<th>Other Aquatic</th>
<th>Bee</th>
<th>Persistence</th>
<th>Bioaccumulate</th>
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<td>Alpha-cypermethrin (P)</td>
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<td>Lambda-cyhalothrin (P)</td>
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<td>Pirimiphos-methyl (OP)</td>
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<td>Propoxur (OP)</td>
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<td>Chlorfenapyr</td>
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**Key**

- High Toxicity
- Medium to High Toxicity
- Medium Toxicity
- Low to Medium Toxicity
- Low Toxicity
- Data Not Found
g. Human health impact: The 2012 PEA for IVM also assessed cancer and non-cancer risks associated with all WHOPES approved 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 than OPs when risks are assessed via any pathway. If OPs are used, then decisions on insecticide type should be informed in part by the human health toxicity and risk associated with each compound and formulation. Occupational exposures to OP insecticides are measurable using blood cholinesterases and urinary excretion of chemical biomarkers. An investigation will need to be conducted to determine if Senegal has the capability to conduct biomonitoring and what level of capacity building would be required. All of the IRS facilities are located at health centers; therefore, biomonitoring could in theory be completed at some of these centers.

Secondary Selection Criteria:

Once the NMCP/Global Fund and PMI approve the analysis of these factors, then the criteria is updated to include international procurement language in which the criteria is clearly stipulated and then tendered out in accordance with international open competitive procurement rules.

Once there are responses to the call for bids, the resulting proposals are subjected to secondary criteria 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

6.3 THE EXTENT TO WHICH THE PROPOSED PESTICIDE USE IS PART OF AN INTEGRATED PEST MANAGEMENT PROGRAM

Integrated Pest Management (IPM) is defined\(^\text{20}\) as:

“…an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties [agricultural products]. 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.”

\(^\text{20}\) http://www.ipm.ucdavis.edu/IPMPROJECT/about.html
Senegal is in the process of preparing an Integrated Malaria Vector Control Strategy (IMVCS) which is
due to be released in 2015. IMVCS was developed to reorient and better coordinate vector control
interventions and has been essentially referred to in the NMCP Strategic Plan of 2014-2018.

IPM is often used in an agricultural context, but similar in nature is the concept of 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.
- USAID strategy has been that IRS will be implemented as a component of IVM for malaria control,
  along with LLINs, larviciding and environmental management. These other interventions are
  described in a preceding section on Proposed Action and Alternatives.

6.4 PROPOSED METHODS OF APPLICATION

IRS involves spraying a liquid insecticide with long lasting residual activity on the 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,
and the mosquito is killed.

Pesticide will only be applied using pressurized spray equipment approved for the pesticide in use, by
trained spray operators wearing full PPE (face mask, gloves, overalls, hard hats with face shields, boots,
neck protection and goggles). Experienced program operators will train spray operators in the correct
spray procedures per PMI IRS BMPs. These procedures have been proven to be effective for providing
long-lasting effectiveness toward controlling the malaria vector mosquito.

The following IRS equipment will be used:

- **Spray Nozzles**
  The program in Senegal will procure 8002E nozzles for the spray pumps, which are the standard size
  recommended by WHO for mud and brick walls.

- **Spray pumps**
  The spray operators who implement IRS use HUDSON X-PERT or Goizper backpack compression
  sprayers to apply a measured amount of insecticide on the interior walls of houses and structures. A
  water-soluble insecticide is added to the sprayer containing a pre- measured amount of water, the
  sprayer is pressurized, and the material is then applied to the interior walls of targeted house
  (structure). After the day’s spraying is complete, spray operators must clean the sprayer following
  the manufacturer’s recommendations to ensure their proper operation and calibration.
6.5 **Acute and Long-Term Toxicological Hazards and Measures to Minimize Them**

The two broad categories of hazard are exposure to humans and domestic animals, and release into the environment causing environmental damage. These may occur at any point, from the production or importation of the pesticide through transportation, storage, distribution, pesticide preparation, spray application, cleanup, and final disposal. Post-spray activity may cause exposure as well through improper behavior of beneficiaries regarding sprayed surfaces and cleanup and disposal of residue and any insects killed with the insecticides from the household after spraying. Hazards are discussed in the Environmental Impact section and addressed in the EMMP in Annex A. The EMMP includes mitigation strategies for each of the risks. The consequences of release and exposure are found in Table 7. The acute and long-term toxicological hazards of pyrethroids, carbamate and OP-based pesticides are detailed in Annex E: Pesticide Profiles of the PMI IVM PEA.

Major hazards include exposure during handling (transporting or spraying), environmental release through vehicular accidents during transportation, and widespread airborne release of pesticide combustion byproducts in the event of a fire at the storage facility or in transport.

Although the PMI IRS BMP manual is the operative document, the Pesticide Storage and Stock Control by FAO provides detailed guidance on proper storage management practices, as well as remedial measures in case of spillage and incidents brought on by natural disasters including flooding. These guidelines therefore provide a sound basis for minimizing the risk of human, animal, or environmental exposure. It is not incumbent on the PMI Senegal implementing partner to observe all recommendations from the FAO manual.

Exposure treatment for carbamates, pyrethroids, chlorfenapyr and OP-based pesticides are detailed in Table 2, 3, 4, 5, and 6, and Annexes B and C. Training for supervisors, spray team leaders, spray operators, washpersons, storeroom 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.

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 opportunities for drivers to respond to scenarios related to the transport of specified insecticides, and have certifications for transport.
- Knowing the routes that must be negotiated to transport the pesticide to its destination, and the hazards that exist along those routes. The drivers will also be trained on mitigation of those hazards, and driving after sundown is prohibited.

Drivers must remove any 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. All cloths used in wiping down the interior and bed of the vehicle should be washed with spray operator overalls. All cloths can only be used for IRS.

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 IRS intervention among the targeted households are primary external factors critical for compliance. The IEC program is of critical importance toward gaining beneficiary 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, also referred as Behavior Change Communication (BCC) programs, are currently being implemented in targeted communities under the ongoing IRS operation.

The main purpose of mobilization is to remind beneficiaries about the positive benefits of IRS in controlling and preventing malaria and malaria-related deaths, and to remind them of their roles and responsibilities before, during, and after spray operations in the elimination or mitigation of any possible negative impacts.

The PMI IRS implementing partner finances and puts the NMCP in charge at all levels to mobilize communities. The NMCP will continue providing overall guidance to the districts on the Ministry of Health’s communication policy while they develop IEC mobilization implementation plans. The NMCP will work with the district and local authorities to encourage higher acceptance of IRS and to build a sense of ownership and responsibility. Additionally, NMCP and DHMTs will work with district authorities on strategies aiming to reduce refusal rates in specific areas identified during the last campaign. The project will continue to work closely with the NMCP’s IEC/communication unit, National Service for Health Education and Information (SNEIPS), and district and regional IEC/communication units.

District supervisors work in close contact with the team leaders to inform the population about the spraying schedule. The project develops, prints, and distributes household IRS cards as well as IRS fliers, brochures and posters with key IRS messages. In 2015 a particular focus will be in advocacy toward the local authorities as well as health posts enrolled or not to give the justifications that have guided the choice of spray areas. The PMI AIRS Project in collaboration with the NMCP will conduct the first level of advocacy by going to meet health, administrative, and local authorities in all districts. Then, the district team will continue the advocacy work with local leaders and care providers in both hot spots and non-hot spot areas. In the selected hot spots areas community meetings will be strongly encouraged. Also, a combination of mass and proximity communication strategies will be implemented to reach beneficiaries. Thus, the three door-to-door visits (before, during, and after spraying) will be maintained and community radio will be used for mass communication.

6.6 THE EFFECTIVENESS OF THE REQUESTED PESTICIDE FOR THE PROPOSED USE

Pesticides are selected by NMCP/IRS Steering Committee for IRS based on efficacy in the intended use, and other extrinsic variables. Selection criteria have been expounded in the Description of Alternative and Proposed Actions section, and in Section 6.2 of this Pesticide Procedures section.

Once the program is established, it is necessary to monitor vector resistance prior to the initiation of spray activities, to ensure that acceptable kill levels will be achieved. A resistance monitoring program has been established and is operating, and the results from this ongoing program will be a primary determinant 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 either compromised if the vector exits after feeding without resting on the wall, or absent if the vector feeds outdoors (exophagic) and rests outdoors (exophilic). Overall human landing catch collection results showed that vector biting was consistently higher indoors than outdoors, indicating a tendency of endophagic habits. This is characteristic of *Anopheles gambiae s.l.* and *Anopheles funestus s.l.*, which are the dominant vectors in Senegal.
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 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.

The operational criterion for vector resistance is having 20% or more survival rate in the number of mosquitoes tested using standardized methods of the WHO.21

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.22,23 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 will cover).

Irrespective of the pesticides used for IRS, national capacity is being strengthened to enable systematic evaluation of the mechanisms for resistance development and the gene frequencies among the local malaria vector populations. There is also a need to evaluate other pesticides and non-chemical alternatives to facilitate the evolution of a full-fledged IVM for malaria.

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.

The third major factor affecting the effectiveness of the pesticides is their quality (strength and other factors). 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 should be taken prior to use, and analyzed for the concentration of the active ingredient.

6.7 **Compatibility of the Proposed Pesticide with Target and Non-Target Ecosystems**

The WHOPES recommended pesticides are compatible with the target environment (indoor walls) in that they dry on these surfaces, and are not released to any great extent. The dried pesticide remains on the sprayed surfaces, and performs as designed, killing vector mosquitoes that rest on those surfaces. In fact, there is a high potential for a positive impact on the target environment because of corollary reduction of other household pests.

The proposed pesticides are incompatible with the non-target ecosystems (humans, animals, and the environment), in that if they are released to the non-target environment in large quantities, they would have negative effects on humans, as well as land and water based flora and fauna.

The IRS implementation process is carefully designed to ensure that pesticides are deliberately and carefully applied via strict protocols to the interior surfaces of dwellings, and do not come in significant contact with humans, animals, or the environment. IRS implementation protocols minimize and responsibly manage IRS liquid wastes, through the next day reuse of mixed but unused pesticides drained from operators’ spray tanks at the end of the day, and the triple rinsing process. At the end of the spray season, contaminated solid wastes are incinerated in approved incinerators that comply with FAO/WHO specifications (outlined in section 8.2.3) that destroy the pesticide and prevent environmental contamination. The EMMP in Annex A details the steps and measures that will be taken to prevent negative impacts on the non-target ecosystems.

6.8 **The Conditions Under Which the Pesticide Is To Be Used**

Chapter 5, Affected Environment of this SEA discusses in detail the environmental background conditions that exist in Senegal relative to the implementation of IRS. Malaria is endemic throughout Senegal, and most of the country has year round malaria transmission with a seasonal peak during the rainy season, from April to August.

In general, carbamates, pyrethroids, OPs and chlorfenapyr have the potential to cause harm to bees, birds, fish, and other aquatic organisms. Prior to spraying, IEC and reconnaissance personnel will work to identify areas where bee-keeping or natural bee habitats are established, and ensure that they are located at least 30 m from any habitation.

Senegal contains a rich network of rivers and water bodies, and established National Parks. The PMI IRS implementing partner will consult with DEEC and the DPN (Direction de la Protection de la Nature), who is responsible for managing all protected areas, regarding the application of pesticides near ecologically sensitive areas, such as wetlands, lakeshores, river edges, protected areas and National Parks, and follow their policies and guidelines. At a minimum, no IRS activities will take place within 30 meters of any sensitive sites. To protect groundwater resources, IRS will only be conducted outside of potential flood zones, areas where the groundwater is close to the ground surface, wells and other water supplies for domestic or cattle use. In addition, soak pits and storerooms will be carefully sited to avoid these sensitive areas.

The PMI IRS implementing partner will identify households within sensitive areas, and train sprayers to also identify houses that should not be sprayed. In addition to spraying precautions, pesticide storage areas should be curbed (bermed) if necessary to contain any spills and provide an extra layer of protection for down gradient natural or developed resources.

Strict supervisory control will be established to prevent contamination of Senegal’s economic resources, such as agricultural, aquacultural, horticultural, or apiary production, due to authorized or unauthorized outdoor spraying, or disposal of wastes.
6.9 **The Availability and Effectiveness of Other Pesticides or Non-Chemical Control Methods**

This IRS program is limited to using those pesticides that WHO currently recommends, comprising 14 insecticides (WHO 2013) from four chemical groups, each with a specific dosage regime, duration of effectiveness, and safety rating. A relatively new pesticide, chlorfenapyr, which is a pyrrole class, will also be considered for the IRS program, when approved by WHOPES. Each of these agents has been evaluated for effectiveness within the program, and continued monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign. PMI programs in other countries (Nigeria) are assessing the efficacy of chlorfenapyr. PMI Senegal may also decide to conduct similar studies. The goal of this SEA is to broaden the options for pesticide use to combat periodic resistance development. Non-chemical control methods include behavior modification and use of untreated bednets. While the IEC program includes certain types of behavior modification to avoid or reduce the probability of beneficiaries contracting malaria, untreated nets are not used, in favor of treated nets. Luring and trapping of vector mosquitoes remains a possibility, but in general, luring is accomplished by the use of some type of chemical, which may or may not have toxicity characteristics. The PMI IRS implementing partner will remain alert to the possibilities for other non-chemical control methods, and will continuously evaluate the utility and practicality of these methods.

6.10 **The Requesting Country’s Ability to Regulate or Control the Distribution, Storage, Use, and Disposal of the Requested Pesticide**

The CSP, CNGP and the DPV within the Ministry of Agriculture and Rural Equipments are responsible for regulating the registration, importation and use of agricultural pesticides. The CSP has a list of registered public health pesticides. In keeping with following all country regulations, PMI program will follow the CSP Pesticides Regulations in the IRS program.

Senegal’s DEEC is the principal authority for the management of environmental issues. DEEC sets national environmental policy and enforces environmental regulations at the national level. The DREEC oversees activities at the regional level. In general, the DREEC heavily involved with overseeing the environmental aspects of NMCP activities, as they do partner with the PMI implementing partner in all spray districts.

In 2015, in the context of transferring IRS responsibilities to the government, AIRS Senegal intends to devolve more responsibility to DEEC and DREEC throughout pre, mid and post spray operations. Working with DEEC and PMI AIRS Senegal will carry out the pre-season environmental compliance assessments (PSECA) at least three months before the spray round begins. The purpose of the pre-spray assessments will be to:

- Access the warehouse/storage facilities to ascertain their compliance with the PMI Best Management Practices Manual as well as the requirements spelled out in the SEA;

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• Ensure that needed EC equipment and supplies have been or will be ordered in sufficient quantity, and will arrive before the beginning of the spray campaign;

• Inspect soak pits at operational sites to determine if there is a need for any rehabilitation and, if so, to determine and secure the materials and labor needed. For any new sites contemplated, this assessment will also identify acceptable soak pit locations, and secondary stores that can meet EC requirements; and

• Propose mechanisms and measures for correcting non-compliance issues noted before the launch of spray activities.

For the PSECA assessments, the project will use a smart-phone based tool that allows for comprehensive data collection (checklist questionnaire, location coordinates and pictures) to be collected and uploaded through the internet to a project-wide database that could be accessed by the country and Home Office staff.

Once all of the items on the work list are reported as complete, a follow-up pre-spray inspection will take place 1-2 weeks before the start of spray activities to ensure that the needs identified by the pre-season EC assessment have been met, and the facilities are ready for IRS in an environmentally responsible manner.

The mid-spray inspections will be coordinated by the ECO and DEEC/DREEC. The objectives of the mid-spray environmental inspection will be to:

• Ensure that issues identified in the pre-spray assessment have been adequately addressed, and that facilities are being maintained appropriately;

• Support the spray teams in all matters of EC in order to successfully complete each spray round;

• Observe IRS environmental activities in progress (soak pits, use of PPE, triple rinsing of Actellic bottles by spray operators, stock management of insecticide), and assess whether the malaria program is in full compliance with USAID requirements as specified in the approved SEA;

• Continue gathering data on current compliance activities for the purpose of evaluating improvements and trends in IRS activities;

• In case of non-compliance, take steps to immediately comply with the country SEA and IRS standards; and

• Determine the training and other support required to improve and ensure future compliance with SEA requirements.
6.11 THE PROVISIONS MADE FOR TRAINING OF USERS AND APPLICATORS

The effectiveness of the IRS program depends on the availability of adequately trained spraying personnel, well-maintained equipment, and competent supervision, as well as end-user acceptability and compliance. USAID has developed guidelines for IRS operations (“PMI IRS Best Management Practices”), and WHO provides a training manual Manual for Indoor Residual Spraying\(^{25}\). Although PMI-produced documentation has precedence over other guidance, information from other sources may be useful and may be followed if the recommendations do not conflict with PMI sources. Other resources include the WHO-UNEP Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning,\(^{26}\) the 2012 PEA and this SEA, all of which provide precise precautions and recommendations on many aspects of IRS operations.

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Senegal. The PMI IRS implementing partner 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:

- In order to reduce training costs, AIRS Senegal will work with NMCP and SNH to use core trainers who will be trained in one day (replacing TOT). In addition, former operators who have been working for more than two campaigns will receive two to three days refresher training and some of these operators will be used as hands-on trainers for new operators. NMCP will be responsible for funding and organizing trainings on IEC. In addition NMCP/SNH will organize the trainings on IRS supervision with AIRS Senegal’s support.

- 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 communities 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 wettable powder or liquid pesticides, and filling of the sprayer. If liquid pesticides are used, the sprayers will be trained to triple-rinse containers during the filling of 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 OP-based pesticides, as well as the pyrethroids).


• Environmental safety in relation to pesticides, including management of the empty pesticide sachets.
• The use of daily spray cards and data entry.

6.12 **THE PROVISIONS MADE FOR MONITORING THE USE AND EFFECTIVENESS OF THE PESTICIDE**

Two kinds of measurements are needed to provide a complete understanding of the effectiveness of pesticide that is being used for IRS. 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.\(^{27}\) 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 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). These are usually health-related government staff within the targeted district (health assistants/educators/inspectors, nursing assistants, and community development assistants).

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.

7. Potential Health and Environmental Consequences

This section addresses the potential direct and indirect impacts of the IRS program in Senegal, and briefly discusses mitigation and monitoring measures. The EMMP, in Annex A, presents the best management practices and mitigation measures identified for the project, responsibilities for the implementation of the Plan, and monitoring and reporting measures. This EMMP is the guiding document for IRS management and implementing team in Senegal, and will be used as the tool for ensuring environment compliance for the program. The EMMP Annual Reporting Form and Certification will be completed and submitted to the COR as part of the annual end-of-spray report (EOSR).

7.1 Potential Positive Effects of the IRS Program

Direct Positive Effects

The direct positive impacts of the IRS program are generally 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.

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 in IRS operations. A reduction in household pests may result in a reduction in other diseases carried by the pests.

7.2 Potential Adverse Impacts

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

7.2.1 Direct Potential Adverse Effects

Pesticides such as etofenprox, fenitrothion, pirimiphos-methyl, propoxur and chlorfenapyr have a moderate to high risk for human and environmental impacts and should be used with caution and with strict best management practices.

Contamination of surface watercourses and underground water

During IRS implementation, it is possible to accidentally release insecticides into water bodies during the transportation and storage of pesticides, application of insecticides to walls, and cleanup 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 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 in well-chosen areas, and used properly, liquid pesticide waste will be captured in the charcoal layer of the soak pit and held until broken down by natural processes.

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

The degree of toxicity of the four WHO approved pesticide classes 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 7 for details.

**Impacts on Bees**

Bee keeping is done at a household level 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 except for DDT. In addition, spraying near hives can lead to contamination of edible honey and possible economic loss from rejection of the product. 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.

### 7.2.2 INDIRECT ADVERSE EFFECTS

When the PMI IRS program is discontinued, USAID will leave remaining IRS equipment in the hands of the DHMTs and will no longer supervise its use. IRS equipment left to district health officials includes backpack compression sprayers, unexpired unused chemicals, and used, clean boots that are still in operable condition. USAID and/or the implementing partner will ensure that appropriate environmental compliance training on IRS BMPs has been conducted. The action of leaving behind IRS equipment may temporarily, and in a minor way increase the total pesticide load on the environment.

### 7.2.3 SUMMARY OF TOXICITY OF PESTICIDES TO AVIFAUNA, AQUATIC LIFE, MAMMALS AND INSECTS BY CLASS

**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\(^\text{28}\).

- 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.

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\(^{28}\) USAID’s IVM PEA 2012
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.

**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

**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.

**Pyrrole (Chlofenapyr)**

- Chlofenapyr has a high to very high acute toxicity to birds. It also poses an acute poisoning hazard to aquatic organisms, and is very toxic to honeybees. Chlofenapyr has low volatility and water solubility; is lipophilic; binds strongly to soil particles; and degrades slowly in soil (avg. half-life of 1 yr), sediment (avg. half-life of 1.1 yr), and water (avg. half-life of 0.8 yr). Chlofenapyr is rapidly metabolized and excreted by mammals, birds, and fish; hence, unlikely to bioaccumulate in individual organisms or biomagnify between trophic levels.
7.3 **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 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.

**Inhalation exposure and risk during mixing**
- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

**Dermal exposure and risk during mixing**
- From the WHOPES approved 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.

**Inhalation exposure and risk during spraying**
- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

**Dermal exposure and risk during spraying**
- Of the proposed pesticides, fenitrothion and pirimiphos-methyl have non-cancer risks due to dermal exposure.

**Fetal Exposure (Pregnancy Testing)**
- All female candidates for spray operators or washers will be tested for pregnancy before being recruited and every thirty days thereafter 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, touching or moving pesticide stock, or washing contaminated items.

**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.

**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.
- 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.

**Resident exposure and risk due to reuse of pesticide containers**
- Only deltamethrin is registered to have potential for acute ingestion from using pesticide containers. However, residents will have no access to pesticide containers used in IRS. The pesticide containers are only available in IRS storage facilities which are securely double locked and must be disposed by incineration at high temperature.
Worker exposure and risk due to inhalation during spillage

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

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.

a. 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.

b. 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.

c. 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.

d. 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.
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, implementing the EMMPs provided in this SEA 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 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.

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 effluent 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.

Spray Operator Exposure

Each spray operator will be provided with safety equipment in accordance with WHO and FAO 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 PMI IRS implementing partner Operations Director.

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 day 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 PMI IRS BMP. Potential spray operators must also pass written and practical tests at the end of training.

Occupational exposures to OP insecticides are measurable using blood cholinesterase and urinary excretion of chemical biomarkers. In 2015, PMI is conducting a bio-monitoring event in Ghana, as outlined in the PEA, measuring cholinesterase levels among a sample of operators, team leaders, and washers. PMI will use the results to guide the implementation of the OP spraying programs.

**Conclusion**

Table 8 below is a somewhat subjective but useful decision criteria matrix showing that if all the factors are considered in combination i.e. (diseases management effect, environmental effect, health risk and cost effectiveness etc.), pyrethroids are the most cost effective, have beneficiary and government preference, and are considered less detrimental to human health and the environment, though studies show an increase in mosquito resistance. OPs have the disadvantage of higher human health risk and higher cost, with lower beneficiary preference, and may require urine or blood biomonitoring. At the same time, it is important to note that all four pesticide classes, when used with all the compliance and mitigation measures, have acceptable risk to human health and the environment and therefore are considered part of the proposed action.

**TABLE 8: DECISION CRITERIA MATRIX**

<table>
<thead>
<tr>
<th>Choice</th>
<th>Susceptibility</th>
<th>Socio-economic impact</th>
<th>Cost</th>
<th>Country Preference</th>
<th>Human and Ecological Impacts</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT</td>
<td>+</td>
<td>+++</td>
<td>++</td>
<td>---</td>
<td>---</td>
<td>5</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>--</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Carbamates</td>
<td>--</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Organophosphates</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>--</td>
<td>6</td>
</tr>
<tr>
<td>Chlorfenapyr</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>-</td>
<td>--</td>
<td>4</td>
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<td>0</td>
<td>---</td>
<td>--</td>
<td>---</td>
<td>0</td>
<td>-8</td>
</tr>
</tbody>
</table>

Key/Legend
0= net zero effect
-=net negative effect  +=positive effect
--=moderate negative effect  +++=moderate positive effect
---=significant negative effect ++++=significant positive effect
8. SAFER USE ACTION PLAN

8.1 IMPLEMENTATION CONDITIONS

During implementation, USAID/PMI/Senegal and its PMI IRS implementing partners will adhere to the conditions detailed in this SEA, which are summarized below, and in more detail in the Environmental Monitoring and Mitigation Plan (EMMP), Annex A of this report.

8.1.1 IMPLEMENTING PARTNER REQUIREMENTS:

1. The prime contractor for the project (“the contractor”, or “the PMI IRS implementing partner”) or his designee will develop this SEA that specifies the conditions under which IRS may be implemented.

2. The PMI IRS implementing partner(s) will follow the prescriptions of the EMMP contained herein, including monitoring and reporting to assure appropriate implementation and the sufficiency of environmental compliance measures.

3. The PMI IRS implementing partner(s) shall integrate these environmental compliance measures into the project work plan and report on them in the normal basis of project reporting, including the EMMR Annual Reporting Form and Certification, which will be included in the end-of-spray report (EOSR). The PMI IRS team shall assure that this integration occurs.

4. The PMI IRS implementing partner(s) will ensure that training is provided to all IRS staff and workers as prescribed by the EMMP and USAID’s Automated Directives System (ADS) 204.5.4.

5. The PMI IRS implementing partner(s) will notify PMI/IRS of any work plan activities outside the scope of the SEA, and the PMI unit will independently audit the work plan against the requirements of the SEA.

6. Any activities not addressed within the SEA must be addressed with an SEA amendment that must be approved by the Global Health and Africa Bureau Environmental Officers (BEO) before the activities in question can go forward.

7. The PMI IRS team shall ensure that the contractor’s or PMI IRS implementing partner’s responsibilities with respect to environmental mitigation and monitoring will be incorporated into contracts, grants or any other sub-agreement and scopes of work.

8. For projects currently in implementation, PMI/Senegal, with the assistance of the Mission Environmental Officer (MEO) and/or the Regional Environmental Officer (REO) as necessary, will discuss SEA conditions with the contractor; and where necessary, come to appropriate agreement regarding the process for implementing these conditions as a mid-project adjustment.

9. As devising and implementing environmental compliance approaches should be an integral part of work plan development, these procedures place this responsibility principally on prime contractors. PMI IRS team’s primary role is thus to review and monitor, as with the execution of any other part of the work plan. Where such review and monitoring indicates unforeseen environmental impacts or that mitigation and control measures are insufficient, the PMI IRS unit will consult promptly with the Regional Environmental Advisor, to revise and adapt the environmental mitigation measures as necessary.
8.1.2 POLICY, PLANNING AND INSTITUTIONAL REQUIREMENTS

- Prohibit IRS in sensitive ecosystems (i.e. within 30 meters of flood zones, wetlands, National Parks, National Reserves, rivers, dams, lakes, fish farms, beekeeping areas, etc.); IRS uses insecticides that could negatively impact such sites. In line with the established best practices for IRS, and relevant national and USAID policies, the PMI IRS implementing partner will establish and implement mitigation measures to assure adequate protection of these sensitive ecosystems.

- Develop and implement a vector resistance management plan. Appropriate measures will be undertaken to prevent/manage resistance and to ensure the continued effectiveness of insecticides used for IRS.

- Promote inter-sectoral collaboration frameworks and institutional arrangements to facilitate a comprehensive approach to vector control and associated pesticides management. Coordination between the Ministry of Health and major stakeholders will be strengthened. This will include collaboration with:
  - Ministry of Health and Social Action is responsible for activities pertaining to the protection and improvement of public health and social welfare. NMCP and Regional Health Department have the mandate to plan, implement and coordinate malaria control activities in Senegal. The District Health Management Teams (DHMTs) address all diseases including malaria at the district level.
  - Ministry of Environment and Sustainable Development is the principle authority for implementing the Framework Environmental Act which provides a legal framework for the use and correct management of the environment and its components and to assure the sustainable development of Senegal. The DEEC coordinates environmental management activities for the IRS project at the National level. The DREEC coordinates environmental management activities at the regional and district level.
  - Ministry of Agriculture and Rural Equipment, The CNGP and the CSP are responsible for regulating the importation and use of pesticides. It issues permits for the importation of pesticides and implements international conventions governing such pesticides. The DPV has the responsibility to ensure that the pesticides used in country are used following effective and safe chemical means, respecting the environment and human health.

8.1.3 OPERATIONAL REQUIREMENTS

PMI and the PMI IRS implementing partner will work with DEEC, NMCP and DPV to access relevant country level authorization and support needed for successful IRS implementation. PMI IRS implementing partner will work closely with the NMCP, DREEC, SNH to coordinate and implement the IRS program at the field level. PMI will work with all government partners in the following areas:

- Quality assurance for commodity procurement and IRS operations, to minimize risks to human health and the environment. This will include ensuring legitimate procurement sources, verifiable chain of custody of commodities, and representative sampling and analysis of pesticide, as well as effective quality compliance inspections of IRS activities in the field.

- Ensure compliance with national regulations on pesticides and this SEA EMMP for registering, importing, transporting, labeling, handling, use, storage, and disposal of pesticides. If there is a conflict, this SEA's EMMP normally has precedence, as it is based on the USAID PMI IRS BMP that was prepared specifically for PMI IRS programs and includes international regulations. USAID compliance requirements are usually more strict than country requirements, however, if country
Train relevant categories of workers involved in IRS operations (e.g. district program managers/coordinators, team leaders, spray operators, porters, storekeepers, pesticide transporters/drivers, washpersons, and guards) on best practices in accordance with national pesticides regulations and this SEA (which includes recommendations/guidelines of World Health Organization (WHO)). Criteria for reprimanding or punishing non-observance of best practices by these workers will be established.

Ensure use of appropriate PPE and best practices, including effective field supervision of spray operations, for adequate protection of spray operators and other handlers of pesticides or pesticide-contaminated waste.

Train health workers in the management of insecticide poisoning. This will include pesticide-specific guidelines on poison treatment; designation of district hospitals or health centers within the target areas for appropriate treatment of insecticide poisoning; training of IRS workers to recognize early danger signs of poisoning and taking appropriate action.

Enforce protection of fetuses and suckling children against exposure in spray operations. Exclude pregnant women and breast-feeding mothers from direct handling of pesticides (e.g. sprayers or washers). Before each spray season, and every thirty days thereafter during operations, pregnancy testing will be established for potential female handlers of pesticides.

Work with NMCP to carry out Information, Education, and Communication (IEC) activities for targeted communities and households to reduce exposure. Provide information on the removal of food, cooking and water utensils, covering of unmovable furniture with impermeable plastic prior to spraying; exclusion of spraying homes inhabited by pregnant women or sick individuals who are unable to leave the structure to be sprayed; preventing the reentry of sprayed rooms for at least two hours after spraying; sweeping of floor residues before reentry of children or animals and disposal cleaning wastes including dead insects in pits or latrines.

Establish strict practices to reduce environmental contamination from pesticides used in this program. This will include comprehensive pesticide chain of custody, auditing of pesticide stocks and pesticide usage, as well as enforcing best practices related to the handling, washing and disposal of containers; progressive use of waste/wash water and ablution blocks, and training on proper maintenance of spray pumps to prevent leakages.

Establish best practice for the transport of spray operators. This includes providing trucks with benches for transport of spray operators, and ensuring that insecticides are not transported in the same compartment as spray operators. Contract specific insurance for covering spray operators during spray operation. Strengthen training of drivers to limit risk of traffic accidents.

Provide IRS Training of Trainers (ToT) and training of spray operators on potential negative impacts of environmental contamination and the appropriate PMI IRS BMPs to avoid or minimize these impacts.

Provide training support, as necessary, to strengthen the supervisory capacity of DEEC/DREEC at National, Regional and District level for day-to-day monitoring environmental compliance of IRS activities.

8.1.3.1 **SUPERVISORY STRUCTURE**

In coordination with the PMI IRS contractor, DREEC with the NMCP/DHMTs will carry out routine compliance inspections of all IRS districts, including unannounced spot inspections, to verify compliance
with all relevant national regulations. The PMI IRS contractor will also conduct inspections, including unannounced spot inspections, of IRS activities and facilities in the IRS districts.

The District Health Management Team or DHMT is composed of the Regional Chief Medical Officer, District Chief Medical Officer, and the District Health Supervisor. The DHMT has a strong supervisory role throughout the duration of the spray round. Each district authority supervises the field activities in his/her district to help ensure quality and performance of the spray teams.

AIRS Senegal will take the lead on implementation of IRS activities in the spray districts while the NMCP will continue to lead IEC efforts, or BCC efforts, in all districts with direct funding from PMI. In addition, the NMCP with the SNH will lead the national planning meeting, national evaluation meeting, TOTs, and IEC trainings in all districts. AIRS Senegal will work together with the NMCP and SNH to ensure supervision of spray performance during the campaign.

The District Coordinator ensures the quality of the spray operations and administrative duties. He/she also works in collaboration with the Health Supervisor to manage the planning and coordination of IRS activities. The DC supervises all logistical operations such as store keeping and transportation. And he/she ensures all risk preventions and environmental compliance measures are fully implemented. The District Coordinator and Health Supervisor coordinate all activities. An operational spray plan (progress calendar), produced during the micro-planning and validated by the health team at the district level, indicating all communities to be sprayed during the spray operations will be maintained by the DC. The District Coordinators will hold weekly meetings with SNH and the DHMTs to discuss operational issues and their solutions. During these meetings, the partners will assess the progress of spray operations, ensure that the planned work schedule is strictly adhered to, and make recommendations as necessary to the IRS project or IEC implementers.

The District Supervisor evaluates the work of the spray teams and IEC activities in the field. He/she also inspects structures that have been sprayed to check quality of spraying and that proper protocols have been fully followed. Base Supervisors will monitor the effectiveness on beneficiary populations of IEC campaigns by visiting sprayed houses to discuss beneficiary impressions, and visiting unsprayed houses to discuss with heads of families why spraying is important. Regarding spray technique and spray operator discipline, monitoring will involve visiting the sprayed compounds and interviewing beneficiaries to ensure that spray operators respect household members, spray all eligible rooms, record the essential data in the relevant form, mix and apply insecticides at the right dosage, and pass the relevant health information to the household. Base Supervisors will provide oversight to ensure the goal of day-to-day achievement of environmental compliance. At the end of each day, team leaders at each operational site will meet with the Base Supervisor to discuss the day’s events, challenges faced, and recommendations for resolving problems.

The Team Leaders oversee spray operators to ensure spraying occurs according to best practices. They will also ensure sprayer equipment and PPE are properly cleaned daily, as well as review data collection for accuracy. They are also responsible for tracking insecticide sachets.

The Environmental Compliance Officer will visit each base during the spray operations and complete the Environmental Compliance Checklists. The Environmental Compliance Checklists are versions of those found in the PMI IRS BMP Manual for use in the field. The checklists ensure that all best management practices are being implemented and are effective, or that immediate action is taken to correct non-compliances.

The PMI IRS implementing partner will maintain records of program performance reports which will be able to demonstrate adherence to PMI IRS BMP, quality of training and supervision, procurement activities, and environmental compliance. Such reports include the pre- and mid- spray environmental compliance report (checklist), reports on core IRS indicators and end-of-spray evaluation reports.
Good supervision will also require observing each spray team during implementation to ensure best practices for insecticide storage and solid waste management. Since the reports of the operators are the basis for all reporting and data collection, supervisors will ensure that they are completed accurately and promptly at the end of the spraying day.

The districts are divided into geographical bases to facilitate operation and implementation. Base teams develop their operational plans with support from the DCs and Health Supervisors. To ensure that IRS operations are running smoothly, in each district, AIRS Senegal will have a district operations team made up of:

- District coordinator (full-time);
- Three to five data clerks (seasonal);
- Four finance assistant (seasonal); and
- Four logistic Assistants (seasonal).

In an effort to transfer more responsibilities to the NMCP and government entities the team will continue to work with DREEC and the DHMTs. However, the AIRS Senegal Environmental Compliance Officer (ECO) will remain responsible for the pre-spray assessments of every operational site (storeroom and wash areas) two months before spraying.

Prior to spray operations, the district teams will develop spray progress plans, in collaboration with health posts, health committee chairs, and other local officials who have greater knowledge of the villages and settlements targeted for spraying. To quantify the number of structures to be sprayed in 2015 (or any upcoming year), the project will use 2014 (the previous year’s) data for structures/rooms found by SOPs (spray operators).

Each site will have two to five teams, each comprised up of four to five SOPs and other staff as listed below:

Site managers, to support spray operations in their respective site (22);

Hygiene agent supervising spray techniques in each site (22);

Team leaders (one for each team; four to five teams, 88);

- SOPs (four to five in each spray team, 435);
- IEC mobilizers (763);
- IEC supervisors (77);
- Storekeepers (26);
- Pump technicians (38);
- Washers (45);
- Guards (48);
- Districts office cleaners (3);
- Logistics Assistants (3);
- Finance Assistants (4); and
- Data clerks (17).

The SOPs will work six days per week with average hours of operation from 7 AM to 2 PM. The project will ensure SOPs transportation to and from spray villages with traditional vehicle transportation while exploring new ways to reduce higher operational cost and increased environmental risk. Examples
include: organizing camp sites to reduce considerable transportation costs in remote areas. Every
morning, spray personnel will receive PPE, insecticide for the day, spray pumps, and data collection
materials.

To track daily results and promote competitive performance, the districts will be using the spray
performance tracking sheet that was successfully introduced in 2013 as well as the Mobile-based
performance tracker (MPT) introduced in 2014 in partnership with Dimagi. Additionally, this year the
PMI AIRS Project will work with the PMI implementation partner’s Client Technology Center (CTC) to
develop a simple SMS platform, called TextIt, designed to send helpful job reminders to hired seasonal
workers. The objective of these job-aid text messages is to reinforce key behaviors for high-quality and
environmentally sound spray implementation (i.e. proper use of PPE, proper data collection tips, etc.).
CTC costs associated with this and limited database support have been included in the country budget.

The AIRS Senegal operations manager will review the performance tracking sheet weekly (at least) for
all operational sites. Spray teams’ performance will be shared periodically with DMOs and the NMCP.
The use of the MPT will allow DMO, DHMTs, NMDP, and PMI to have daily access to spray data
(including number of structures sprayed, number of people protected, insecticide use, and SOP
attendance).

Logistics assistants and district storekeepers will be responsible for regular supervision of secondary site
stores to ensure appropriate stock and waste recordkeeping.

In 2015, the AIRS PMI project will continue enhancing efforts to increase women’s participation in IRS
operations. Specifically, AIRS Senegal will use planning meetings and meetings with local leaders as a
venue to advocate for recruitment of women as SOPs, team leaders, store keepers, and data entry
clerks. The project will also work with existing female SOPs and community-based organizations
including women and youth associations to promote this job to other women. AIRS Senegal will work
with the DHMTs to ensure the IRS program creates a safe working environment for female workers in
securing toilet and dressing rooms for them. In 2015, the project will review conditions of camps sites
for operators to ensure the safety and protection of women. The project will also plan to advocate
communities’ participation for free sites. AIRS Senegal will offer SOPs tarpaulins or mattresses for
better sleeping conditions in camping sites.

8.1.3.2  **INSECTICIDE SELECTION**

The insecticide selection and the timing of the spray cycle is dictated by the NMCP and IRS Steering
Committee and are based on the results of annual entomological studies. The insecticide will be supplied
by PMI. However, the table below provides somewhat subjective criteria ratings to approximate the
relative merits of each class of pesticide.

8.1.3.3  **QUANTIFICATION OF PESTICIDE REQUIREMENTS**

PMI IRS implementing partner will conduct an annual logistics assessment for planning and procurement
of materials (insecticides, pumps, PPE, etc.) for all Districts that have been selected by NMCP where PMI
support has been requested.

USAID PMI program will procure the insecticide from a reputable supplier. Delivery of all insecticide to
the central warehouse in Kaolack Region will be supervised by PMI, DPV and DREEC before being
dispatched to the districts where spray operations will be concentrated.

Transportation of insecticides will be done in compliance with program and national environmental
compliance requirements.
8.1.3.4 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. Senegal does not currently have a certified laboratory to do quality assurance tests. All pesticides procured from reputable manufacturers are required to supply data from their own laboratory testing from facilities, and additional in-country testing is not required.

8.1.3.5 QUALIFICATION OF WAREHOUSES (STORAGE FACILITIES)

During the geographical reconnaissance and logistics assessments, the need for rehabilitation of principal warehouses at district level to meet PMI IRS BMP requirements for pesticide storage will be assessed. Existing storage facilities that meet PMI IRS BMP requirements will be re-evaluated between spray campaigns by the ECO and the DREEC.

The procured pesticides are categorized as hazardous and toxic and can potentially cause adverse impacts to human health, animals, and the natural environment if not properly stored according to the EMMP in this SEA (which is based on PMI IRS BMPs (2015)). Before insecticides are procured or transported to the spray areas, suitable warehouse(s) must be assessed to ensure that they meet EMMP standards in this SEA. The standards include among others:

- Spacious enough to store insecticides in bulk and to store other materials separately
- Located as far as feasible from flood plains, wetlands, markets, schools and residential areas
- Well ventilated and allowing for air circulation
- Built of concrete or other solid material
- Adequate roofing that is not susceptible to leaks
- Adequately secured with double-locked doors and barred windows
- At least 2 exits for emergency purposes
- Fire extinguisher

During the logistical needs assessment, the PMI IRS implementing partner working with DHMTs will identify appropriate warehouses at the districts level that can meet the above-mentioned requirements. PMI cannot provide funds for the construction of new buildings, but can assist in the modification or renovation of existing facilities. In Senegal, IRS is implemented in partnership with the MoH/NMCP, therefore, some warehouses are located on Health Department property and rented for free for logistic and security purposes.

All facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of Senegal CNGP/CSP Pesticide Regulation, and any other relevant Senegal standards on pesticides use and management.

8.1.3.6 QUALIFICATION OF LIQUID WASTE DISPOSAL FACILITIES (WASH AREAS AND SOAK PITS)

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

- Soak pits must be located at least 30 meters from any sensitive areas such as water supplies, habitat, schools, etc. They should be located on relatively high ground to increase the vertical distance to groundwater. The general area should be level, but the wash area must slope gently toward the soak pit or toward the collection point that is piped to the soak pit.

- Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or micro-biological degradation. Clay soils have a high capacity to absorb many pesticides, while sandy soils have a much lower capacity to absorb. Where possible, locate facilities on fine textured soils with good absorptive properties. Hard packed clay or rocky soils are not appropriate.

- Pesticides may move in water runoff as compounds dissolve in water or attach to soil particles. Facilities should be located on high, level ground to minimize exposure to runoff. Avoid steep slopes or natural runoff flow lines. Where feasible, construct curbs or berms to divert runoff away from the soak pit, and to contain any spills. In very rainy areas or seasons, it may be necessary to cover the soak pit and wash area when not in use with a tarpaulin, to prevent flooding of the soak pit and subsequent runoff of pesticide-contaminated water.

### 8.1.3.7 Supply Chain and Disposal Options

The PMI IRS implementing partner will work with the relevant authorities and will employ the pesticide chain management as shown in Figure one in its Senegal IRS programs to ensure control. The chain of custody procedures are based on PMI IRS BMPs (and as previously mentioned, these BMPs include WHO, FAO and other international guidelines).

#### FIGURE 20: PESTICIDE CHAIN OF CUSTODY AND MANAGEMENT

| **Manufacture:** PMI procures all pesticides for the IRS program, PMI IRS implementing partner supplements pesticides for PMI program as needed |
| **Imported pesticides:** Pesticide samples will be tested for chemical properties and efficacy internationally. Pesticides from an established manufacturer with appropriate laboratory results will not require further tests. |
| **Port of entry:** Pesticides will be collected by PMI staff and DPV representative |
| **Transportation:** All drivers must be trained in proper pesticide handling and transportation safety measures as per the PMI IRS BMP. All vehicles must meet BMPs requirements. A PMI and DPV representative will escort the pesticide to the central storage facility. |
| **Central Storage:** Pesticide will be stored in warehouses that meet the specifications detail in the FAO manual for storage and transport of pesticides |
| **Spray Operators** must sign out all pesticides received daily and return empty sachets |
at the end of the day as per the Insecticide Distribution Section below

**District Storage:** Empty containers will be stored in warehouses that meet the specification detailed in the FAO manual for storage and transport of pesticides.

**Disposal:** All empty pesticide sachets will be incinerated in an approved incinerator. All plastic containers will be triple washed and recycled at an approved facility.

### 8.1.3.8 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. Accidents have occurred in the past, but no pesticide spillage has occurred to date in PMI Senegal implementation.

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 the 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 IRS 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. If the pesticides are to be left unattended for any period of time, including lunch breaks or overnight stops, a lockable box truck is essential. Figure 28 below provides a list of key responses to mitigate the impact of the insecticide spills.
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. For accidental spills, there is a collaboration between the DREEC, the Sapeurs Pompiers (fire dept), SOS, and DPV. SOS Sapeurs Pompiers have the materials, like sand, for accidental spills and are aware of the appropriate procedures. The Emergency number for an accidental spill is 12.21 “Numero Vert” and they are well equipped to handle an emergency situation.

8.1.3.9 **Health and Safety in the Warehouse**

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

- Guarded 24 hrs/day
- Warehouse must be double-padlocked.
- All the storage facilities must have thermometers installed for temperature recording.
- Soap and clean water for washing must be available at all times.
- Trained storekeepers must be present and wear appropriate PPE when in the pesticide area of storage.
- Pallets are available for proper storage of insecticides and must be used
• Pesticide stacking position and height in the warehouses must not be above 2 meters in height.
• Fire extinguishers must be available in the storage facilities and all workers trained on how to use them.
• Hazard warning notices must be placed in the outside of the store in pictorial form (skull and crossbones).
• First-aid kits must be available in all the central warehouses and secondary stores.

8.1.3.10 Insecticide Distribution and Management Process at District and Community Levels

The PMI IRS implementing partner will use, or develop if necessary, standard requisition, tracking, and monitoring forms to be used for inventory, and record and track all the insecticides distributed and returned. These forms will be used in the program at all levels, and the store managers will receive training on how to use these forms. The steps below highlight the insecticide distribution process proposed including recording and tracking methods:

• Upon reception of the pesticide at the central warehouse currently in Kaolack (the import company is responsible to deliver the pesticide to a determined location) lot numbers and quantities of insecticide are registered on shelf inventory card by the PMI IRS implementing partner storekeeper. All copies are kept at the warehouse.
• District requisitions are approved at the PMI IRS implementing partner program office, where copies are maintained.
• Requisition then proceeds to district warehouses where distribution takes place. All pesticide inventories are signed for based on sachet numbers. Insecticides are distributed on a “first-in, first-out” system, so the insecticide that arrived first is distributed first. This avoids accumulation of expired stock.
• All sachets are counted and stamped with the relevant stamp and registered on a stock card. Boxes are then resealed with the correct original quantity of sachets inside until the sachets are issued.
• Every morning before the spray operations begin, store managers distribute only enough sachets for the day’s work to the team operators. The team operator must sign for all pesticides received daily in a logbook.
• At the end of the day, empty and full sachets are returned and numbers checked against what was signed out. Returned empty and full sachets are logged into the logbook by the storekeeper or supervisor.
• Supervisor and team leaders examine spray operators’ performance by comparing number of structures sprayed to sachets used to determine whether there is an over or under application.
• Storekeeper must submit the following to the program office for data entry on a daily basis: 1) insecticide stock balances; 2) sign-in/sign-out results; and 3) structures sprayed per spray operator.
• The next day, all previously signed for but unused sachets are reissued and signed for by the relevant spray operator.
• At the end of each day and at the end of the spray round, stock remaining must equal the stock at start of the day minus the number of sachets distributed. Number of sachets distributed should be equal to number of sachets used if there is no returned full sachet.
8.1.3.11 PERSONAL PROTECTIVE EQUIPMENT

In accordance with PMI IRS BMP, all persons working on IRS must be adequately protected against potential harm due to exposure from pesticides. All persons with potential direct contact or exposure to pesticides during handling, transportation, storage, use and cleaning of pesticides or pesticide contaminated materials must wear appropriate personal protective clothing in accordance with the safety instructions on the pesticide label or material safety data sheet (MSDS).

Each team leader, spray operator, and washer for both the district based and community based implementation models will be provided with the following safety equipment to be used during the spraying, in accordance with the PMI IRS BMPs specifications:

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

For spray operators, safety precautions will depend on the proper use of PPE, and personal hygiene, including washing and daily changing of spray clothes. A schedule for carrying out and supervising personal hygiene, regular washing of protective clothes and cleaning of equipment will be organized along the following lines:

- Spraying staff will be provided with at least two uniforms to allow for frequent changes.
- Washing facilities with sufficient water and soap will be made available in the field at appropriate locations.
- All working clothes must be removed at the end of each day’s operations and a shower or bath taken—in circumstances where a full-body shower or bath is not feasible, face/neck and hands must be washed with soap and water.
- Working clothes will be washed daily by the wash-persons hired by the project.
- Particular attention will be paid to washing gloves, helmets, face-shields, and boots, and to avoiding contamination of the inside of these items.
- Spray operators will wash before eating, drinking or smoking at the end of the daily spray operation.
- Eating, drinking and smoking during work will be strictly forbidden at all times during operations. If spray operators need to drink water in the course of the operation, they must receive assistance from the homeowner, such that they do not need to handle water containers with gloves or other PPE that has been exposed to pesticides during spray or mixing activities. Because in the field there are no proper disposal facilities for water contaminated by washing gloves and hands, it is recommended that homeowners assist the operator if hydration is needed.
8.1.3.12 PROCUREMENT OF OTHER IRS EQUIPMENT

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

- **Spray Nozzles.** The program in Senegal will procure 8002E nozzles for the spray pumps, which are the standard size recommended by WHO for mud and brick walls.

- **Spray pumps.** Spray operators use Hudson X-PERT and Goizper compression sprayers and with shoulder- suspended tanks to apply a measured amount of insecticide on the interior walls of houses and structures. A water-soluble insecticide is added to the sprayer containing a pre- measured amount of water, the sprayer is pressurized, and the material is then applied to the interior walls of targeted house (structure). After the day’s spraying is complete, spray operators must clean the sprayer following the manufacturer’s recommendations to ensure their proper operation and calibration.

8.1.3.13 TRAINING

The objective of the trainings is to build the capacity of the host government at the national and district levels to implement, monitor and evaluate a well-organized IRS program.

Training in IRS implementation will be a key element of the PMI IRS program. The planning process for trainings will be carried out in coordination with the NMCP, and all SNH, DREEC malaria officers will be actively engaged from inception. The recruitment and training of spray operators are key elements in this process, and require vigorous involvement of Implementing Partner Staff to ensure that when these activities are transferred to NMCP/DHMTs, there will be sufficient local capacity to continue IRS activities.

**Drivers**

Drivers are recruited by a local community lead by the Prefet (mayor), the District Coordinator and the SNH at the district level. Drivers that will transport insecticide will be trained on methods and protocol for safe driving, handling insecticides, and what to do in an emergency situation when transporting insecticides. Drivers will also be trained on insecticide-related security issues, handling vehicle contamination, methods for cleaning vehicles after transporting insecticide, and handling insecticide run-off. They will also be provided with Emergency contact cards in the case of an accident.

**TOT Training for IRS supervisors:**

Participants include representatives from MoH/NMCP/SNH and former trainers from past spray campaigns. Key topics that will be covered include the following:

- Malaria epidemiology
- IRS
- Storage of IRS commodities
- Environmental and Safety issues concerning IRS campaigns
- IEC
- Spray pump use and maintenance
- Spray technique
- Data management and quality (correct use of forms)
- Basic entomological information
Supervision, performance monitoring and auditing of spray activities

Graduates of the TOT training for supervisors then conduct the spray operator training with the support of the PMI IRS implementing partner. The training has both theoretical and practical sessions.

Training in IRS implementation and supervision is crucial to the overall capacity building strategy of the IRS program. In order to reduce training costs, AIRS Senegal will work with NMCP and SNH to use core trainers who will be trained in one day (replacing ToT). In addition, former operators who have been working for more than two campaigns will receive two to three days refresher training and some of these operators will be used as hands-on trainers for new operators. NMCP will be responsible for funding and organizing trainings on IEC. In addition NMCP/SNH will organize the trainings on IRS supervision with AIRS Senegal’s support.

Training for District Staff on Environmental Compliance

Participants will include district health staff identified by the District Coordinator and the Environmental Compliance Officer (ECO). District health staff will be trained on measures taken during IRS operations to meet environmental compliance rules and regulations, based on the EMMP (Annex A). This will include best practices in Environmental Compliance, including pre- and post-spray season inspections/reporting.

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps, including practical exercises during a 5-day 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 is conducted in accordance with PMI IRS BMP (which includes WHO IRS guidelines).

Training spray operators, team leaders and base supervisors:

Participants include Spray operators, team leaders and base supervisors identified by the local communities at the health post level. PMI AIRS staff will supervise the trainings sessions.

The training includes:

- Insecticide application technique
- Handling a spray pump
- Communication strategies in the field
- Spray operation organization
- Completing Daily Spray Operator forms for accuracy
- Team Leader protocols for checking Spray Operator data (physical and mathematical checks)
- Use of PPE to prevent toxic exposure, environmental compliance and avoidance of spraying in environmentally-sensitive areas.

Following the training, a post-training exam is given, and only candidates that receive high scores will qualify as spray operators. The SNH will identify outstanding trainees and designate them as team leaders to supervise a number of operators. Spray operators will initially be chosen based on their completion of primary school and must pass written and practical tests of their ability to read, write and record critical spray information, and make calculations. They will then undergo medical exams to determine their physical capability for providing appropriate application of the insecticide. All female workers will be subjected to a mandatory pregnancy test before training and recruitment as spray operators or washers. Pregnancy tests will then be conducted every month during IRS operations.
Storekeepers
Participants will include storekeepers. Training for all storekeepers includes IRS logistics and supply chain management, insecticide storage and security, inventory tracking (stock card use), spill control and management, and IRS waste storage and management. Following the training, an exam will be given, and only those who achieve a high enough score will qualify as storekeepers for the IRS spray campaign. AIRS Senegal Logistician will work with the ECO and train storekeepers to manage stock and IRS waste effectively.

Pump technicians
Technicians for each spray “base” will be trained on technical maintenance and repair of the spray pumps and progressive rinsing systems.

Washers
AIRS Senegal staff will lead a training for washers, on how to wash coveralls and other PPE to prevent contamination.

Data Clerks and District Data Manager
Data clerks will be trained in IRS data entry; using the IRS database; and methods for reviewing data and assuring data accuracy and quality. The M&E Coordinators and Database Manager will complete the trainings.

TOT for IEC Coordinators
Participants will include HPN and IEC Coordinators. Training will include modules on the IEC communication protocol, and messaging for the IEC/BCC campaign. The PMI IRS implementing partner with the NMCP Communication department will complete the training.

The main purpose of mobilization is to remind beneficiaries about the positive benefits of IRS in controlling and preventing malaria and malaria-related deaths, and to remind them of their roles and behaviors before, during, and after spray operations. Mobilizers are trained to conduct house-to-house mobilization during the first cycle of each IRS campaign. Once the risks and benefits of IRS have been explained, households have the option of declining to participate.

Door-to-door communication is the main strategy used for community outreach. PMI IRS implementing partner develops, prints, and distributes household IRS cards as well as IRS fliers and brochures with key IRS messages.

In 2014, PMI continued to support communication activities in areas targeted for IRS to inform potential beneficiaries about the timing of spray activities, what they can expect, the precautions they need to take, and the health benefits of IRS. Finally, tools to collect data on communications activities were revised and materials to support BCC activities (posters, training guides, and manuals) were produced.

TOT for M&E Coordinators
The TOT curriculum will consist of IRS data entry; using the IRS database; and methods for reviewing data and assuring data accuracy and quality.

Health Workers in Poison Management
Participants include health facility staff identified by the District Coordinator and the Poison Control Center (PCC). The Chief Medical Officers will conduct the trainings. Health facility staff will be trained and prepared for handling insecticide poisonings, skin irritations, and other potential IRS spray campaign injuries. General poison control guidance will be provided. When new pesticides will be used, additional training specific to the symptoms and treatment for that chemical will be provided. Acute exposure can occur through dermal contact, which could lead to absorption into the blood stream as well as skin and
eye irritation, inhalation or ingestion. The Poison Control Center (PCC) will be in charge of certifying intoxication cases reported in the field.

**TABLE 9: TREATMENT MEDICINES FOR WHO-RECOMMENDED PESTICIDES**

<table>
<thead>
<tr>
<th>Pesticide Class</th>
<th>Treatment Medicine(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organochlorine (DDT):</td>
<td>Activated Charcoal (priority)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td></td>
<td>Phenobarbital</td>
</tr>
<tr>
<td></td>
<td>Cholestryamine resin</td>
</tr>
<tr>
<td>Organophosphates:</td>
<td>Atropine sulfate or Glycopyrolate (priority treatment)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td>Carbamates:</td>
<td>Cholestryamine Atropine (priority)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam (for seizure)</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>Promethazine</td>
</tr>
<tr>
<td></td>
<td>Panadol</td>
</tr>
<tr>
<td></td>
<td>Diazepam</td>
</tr>
<tr>
<td></td>
<td>Lorazepam</td>
</tr>
<tr>
<td></td>
<td>Calamine cream</td>
</tr>
<tr>
<td></td>
<td>Vitamin E</td>
</tr>
<tr>
<td></td>
<td>Hydrocortisone cream</td>
</tr>
<tr>
<td></td>
<td>Salbutamol</td>
</tr>
<tr>
<td></td>
<td>Activated charcoal</td>
</tr>
<tr>
<td>Chlorfenapyr</td>
<td>Activated charcoal</td>
</tr>
<tr>
<td></td>
<td>Benzodiazepine (seizures)</td>
</tr>
</tbody>
</table>

**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 PMI IRS BMPs for storage, including prohibiting lighted materials in the warehouse and in the vicinity of pesticides, providing proper ventilation, etc.

Information on the combustion byproducts of pyrethroids can be found in Table 10 below, and the 2012 PEA. Fire-fighting instructions can be found in the Material Safety Data Sheet (MSDS) for the pesticide(s) in storage.
<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Combustion Byproduct</th>
<th>Extinguishing Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha-cypermethrine</td>
<td>Open burning of lambda-cyhalothrin creates nitrogen oxides, hydrogen chloride, and hydrogen fluoride (WHO, 1997)</td>
<td>Extinguishing media: For small fires use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. For large fires, use Alcohol-resistant foam, Water spray. Extinguishing media, which must not be used for safety reasons: Do not use solid water stream as it may scatter and spread fire. Specific hazards during firefighting: As the product contains combustible organic components, fire will produce dense black smoke containing hazardous products of combustion. Exposure to decomposition products may be a hazard to health. Special protective equipment for firefighters: Wear full protective clothing and self-contained breathing apparatus. Further information: Do not allow run-off from fire-fighting to enter drains or watercourses. Cool closed containers exposed to fire with water spray.</td>
</tr>
<tr>
<td>Bendiocarb</td>
<td>Fine dust may form explosive mixtures in air. The product is not flammable, but when heated above 125ºC will evolve toxic fumes of methyl isocyanate. Water is the preferred extinguishing medium as it decomposes any methyl isocyanate.</td>
<td>Water fog or fine spray, carbon dioxide, dry chemical, foam. Fire fighters should wear full protective gear, including self-contained breathing apparatus (AS/NZS 1715/1716). Keep unnecessary people away and move all other personnel to windward side of fire. Bund area with sand or earth to prevent contamination of drains or waterways. Dispose of fire control water or other extinguishing agent and spillage safely later.</td>
</tr>
<tr>
<td>Delta-methrine</td>
<td>Combustion and/or pyrolysis of deltamethrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, and hydrogen bromide (UK PID, 2006)</td>
<td>Suitable extinguishing medium: Water spray jet, carbon dioxide (CO₂), dry powder, foam. Extinguishing media which should Product itself is non-combustible not be used for safety reasons: Fire extinguishing measures to suit surroundings.</td>
</tr>
<tr>
<td>Bifenthrin</td>
<td>Not available</td>
<td>Suitable extinguishing media: Carbon dioxide (CO₂), Foam; Powders Not suitable extinguishing media: Water (the product is hazardous for the environment - do not dilute it) Specific fire-fighting methods: Isolate fire area. Evacuate downwind. Contain the extinguishing fluids by bunding (the product is hazardous for the environment). Do not attempt to fight the fire without suitable protective equipment. Do not breathe fumes Protection of fire-fighters: Self-contained breathing apparatus and complete protective clothing</td>
</tr>
<tr>
<td>Cyfluthrin</td>
<td>Combustion and/or pyrolysis of cyfluthrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, hydrogen chloride, and hydrogen fluoride (UK PID, 2006)</td>
<td>Not available to-date.</td>
</tr>
</tbody>
</table>

### 8.1.3.14 Prevention of Residential Exposure

NMCP, DREEC and the PMI IRS implementing partner and other partners will work with relevant institutions at all levels to carry out an IEC campaign/BCC to sensitize residents to IRS activities, in accordance with WHO guidelines and also Senegal National Malaria Strategy Plan 2014-2018 and PMI.
Malaria Operational Plans. The IEC campaign (as well as IRS Project supervisors and Health Workers who will also instruct residents on best practices prior to spraying) should focus on the following elements of residential safety during an IRS program:

- Clear homes of mats or rugs, furniture, cooking 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 \( \frac{1}{2} \) 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, if soap and water are unavailable, or if symptoms persist, contact program staff or go to nearest health facility which has the appropriate medical intervention.
- If spraying during the rainy season, the teams should 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, such as a tarpaulin, 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.
8.2 PREVENTING ENVIRONMENTAL CONTAMINATION FROM END OF

8.2.1 TRIPLE RINSE AND REUSE OF LEFTOVER PESTICIDE

USAID’s PMI IRS BMP Manual recommends that any remaining pesticide, as well as the water used to rinse out spray pumps at the end of each day, must be re-used at the beginning of the next day’s work to save water, reduce the load on soak pits, and reduce the potential for pollution from leftover pesticide or contaminated rinse-water. This contaminated material should be considered as make-up water rather than pesticide, as it has degraded with exposure to air and sunlight, and so it must be mixed with new insecticide accordingly. This best practice for spray pump cleaning is called “progressive rinse.” As shown in Figure 23, seven barrels/drums/containers of approximately 200-litres each are placed in a line. Every other container is filled with water (e.g. the first container is empty, the second is filled with water, the third is empty, fourth is filled with water, fifth is empty, sixth is filled with water and the seventh container is empty). During the end-of-day cleanup, the remnants of the insecticide prepared in the field and remaining in the pump are emptied into the first container. This will be a limited volume, which should be much less than half of this container, as most sprayers should be returned empty from the field. It is important to train operators to manage this goal of minimizing leftover at the end of the day. The spray operator will then add two liters of water from the second container, close and shake the sprayer, and dump the rinse water into the third container.

The spray operator will repeat those steps with the fourth and fifth containers, then with the sixth and seventh containers. The spray operator then washes the outside of the sprayer using water from the sixth container on the impermeable wash area that drains to a soak pit. The following day, the spray pumps are filled with liquid from containers in the same sequential order: container one, then container three, then container five, and finally seven.
FIGURE 22: THE SEVEN BARREL TRIPLE RINSE SYSTEM

At the beginning of wash operations

<table>
<thead>
<tr>
<th>Barrel #1</th>
<th>Barrel #2</th>
<th>Barrel #3</th>
<th>Barrel #4</th>
<th>Barrel #5</th>
<th>Barrel #6</th>
<th>Barrel #7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
</tr>
</tbody>
</table>

Wash Operation Sequence

1. Empty leftover pesticide from spray pump
2. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.
3. Depressurize and empty 1st rinse into Barrel #3
4. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.
5. Depressurize and empty 1st rinse into Barrel #5.
6. Scoop 2 liters and add to pump. Cap, pressurize and shake pump.
7. Depressurize and empty 3rd rinse into Barrel #7

Note: After this operation is complete, the outside of the pump is washed, along with the spray operators’ helmet, face shield, gloves, boots, and neck protection, in the central wash area, with the washwater directed to the soak pit.
8.2.2 Effluent Disposal Facilities

Wash Areas and Soak Pits (Pyrethroids, Carbamates, OPs and Chlorfenapyr)

Spray operators must completely wash their pumps, most of their PPE, and themselves after triple-rinsing their pumps. Overalls are washed separately by wash-persons provided with protective gear. In order to minimize possible ground contamination from washing spray equipment and PPE, wash operations are conducted on an impervious (plastic or concrete) wash area that continuously slopes to a soak pit. A soak pit is an in-ground filter that contains a layer of charcoal that adsorbs the insecticide from wash water.

Spray operators should never wash themselves, their overalls, or their PPE in any water bodies, or delay washing until they are home. Washing must be performed at designated sites, and all wash-water must be disposed of in a soak pit. Where necessary, construction of infrastructure for proper disposal of contaminated water will be financed by PMI. The site for the soak pits will be selected jointly with the implementing partner’s Operations Manager, Environmental Compliance Officer, District Coordinator and the representative of the District Health Office according to the criteria in 8.1.3.5. The soak pit site must be away from water bodies, bore holes, schools, and other sensitive areas.

The size of the soak pit depends on the number of spray operators that the soak pit supports. According to the USAID PMI IRS BMP Manual, to serve about 30 operators the soak pits should be 2 meters by 1 meter, excavated to a depth of one meter. The bottom of the pit is packed with sawdust followed by hard coal or charcoal, stone aggregates and gravels as shown in Figure 21. The entire soak pit area is fenced complete with a lockable access door to prevent unauthorized entry by children or animals. Soak pits are built by DPS with funding from PMI. New soak pits are constructed before spray operations commence. Existing soak pits are evaluated by the PMI IRS implementing partner and DPS annually and renovated as needed before spray operations begin.

The soak pit as described can be used for pyrethroids, carbamates, organophosphates and chlorfenapyr. The principle of the soak pit, sometimes referred to as a bio-bed, is to absorb the toxic chemicals in the pesticide through a carbon filtration process, so that the water that finally exits the bottom of the soak pit has been purified and no longer contains the chemical components in any significant concentration. The gravel and stone layers work to exclude large particulates such as leaves and sticks that may eventually clog the soak pit, and they also help to distribute the influent across the soak pit bed so that it is not concentrated in one spot. As the wash-water flows through the charcoal layer, the organic chemical contaminants (pesticides) are adsorbed onto and held by the charcoal, where they are eventually degraded by environmental forces, including hydrolysis and microbial action. The sawdust at the bottom helps to regulate the flow rate so that there is enough contact time between the contaminated water and the coal. Research has shown that pesticides on the coal are degraded within three months in the soak pit. Unless the soak pit becomes clogged with foreign matter and will not drain, the soak pit should remain effective for three years, at which time it can be excavated so that the sawdust and coal can be replaced. As long as the foreign matter can be separated from the stone, the three stone layers can be reconstituted using the same material.
Cross section: Soak Pit for Pyrethroids
Showing Filling materials

Gravels
Size about that for road construction

Courser gravels/smaller stones

Stone
Size about average half cement blocks and smaller

Charcoal
Quantity - about 1.5 - 2.0 maxi-bags

Wood shavings/saw-dust
Quantity - about 1 - 1.5 maxi-bags
8.2.2.1 **MOBILE SOAK PITS (MSP)**

To reach certain targeted spray areas, operators must travel a great distance, and they may not be able to return at the end of the day to a centralized wash area for clean-up. Sometimes the operators will spend several days in the field, finding lodging and food in the villages where they finish their work for the day. The next day, they either continue to work at the same village, or travel on to the next nearby targeted spray area. Working this way can reduce transportation requirements, shorten the working day, and result in greater productivity. However, operators need a different system for clean-up at the end of the day.

In this situation, the operators carry a MSP filter, wash barrels, and a tarpaulin with them, and construct a temporary wash facility at a suitable site within the village where they will stay. The mobile soak pit filter is a 20-25 L bucket with highly adsorbent activated carbon that removes pesticide contamination from the wash water, so that the water that exits to the ground is purified. In 2014-15, Abt Associates tested the MSPs and each MSP has the capacity to filter the rinses of 5 spray operators’ pumps for at least 40 days.

The MSP can use a four-barrel rinse system to minimize the number of barrels that the spray team must carry, and reduce the necessary size of the wash area constructed. The four-barrel rinse system uses three barrels for rinse water, but only one barrel to receive both the leftover pesticide, and the water from all three rinses. This system simplifies the reuse of all leftover pesticide and rinse-water the following day, as the operators draw from only one barrel, instead of four. See Figure 24.
FIGURE 25: MOBILE SOAK PIT FILTER LAYERS

Particulate Filter Material (e.g., sponge, mattress material.) (~5”)

Activated carbon (~7”)

Particulate Filter Material (e.g., sponge, mattress material.) (~3’’)
This schematic shows a 4m x 4m (not to scale) wash area, sloped to the MSP filter at the center, and covered with a tarp. A hole is dug in the center of the area to receive the MSP filter. An X is cut in the center of the tarp to allow rinse-water to drain into the MSP. There is a rectangular boot wash at the entrance to the wash area, so that mud does not drain to and clog the MSP. There are two rows of rinse barrels so that two operators can wash up at one time. The large barrel on the left receives both leftover pesticide and all rinse-waters.
8.2.3 IRS SOLID WASTES DISPOSAL

IRS solid wastes must be classified as contaminated with insecticide, or non-contaminated, according to the guidance below. Contaminated solid wastes should be stored with pesticide stocks, separated from non-contaminated wastes and IRS commodities. Empty pesticide sachets and bottles must be fully accounted for and stored in sealed containers labeled with the pesticide and item identity.

At the local site level, contaminated solid wastes are separately collected, counted, and stored in labeled and sealed boxes. Unusable gloves, plastic bags, boots and plastic sheeting are decontaminated, air-dried under the sun and packaged by washers in clean containers. All such decontaminated solid wastes are then transferred to the main warehouse in Kaolack. In Kaolack, decontaminated gloves are disposed of properly as ordinary garbage. Decontaminated plastic wastes are recycled in facilities approved by the Environmental Directorate.

Other contaminated wastes, including empty insecticide sachets, plastic containers, and masks, will be temporarily stored in the District warehouse. At the end of the spray campaign, the material will be relocated to the central storage facility in Kaolack (or other district capital if PMI IRS activities expand or move to other districts). All contaminated material will require disposal in an environmentally responsible manner as prescribed by the PMI IRS BMPs.

Incineration under specific conditions is highly recommended by PMI, the United Nations Environment Program (UNEP) and WHO/FAO for mask and sachet disposal. Incinerators recommended for disposal of contaminated wastes must meet the following key requirements:

- The recommended combustion temperature is between 1,100°C and 1,300°C.
- An after-burner is required, with a residence time of at least two seconds.
- The incinerator should have emission control, including particulate matter filters.

Masks and empty insecticide sachets are transferred to the SOCOCIM (Cement Manufactory) an incineration facility approved by the DEEC and that complies with PMI and WHO specifications. Ash and slag produced by high-temperature incineration of these lightly contaminated wastes are, in principle, considered inert, unless determined otherwise, and can be disposed as normal waste, preferably in a dug out pit.

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

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

Cardboard boxes previously containing intact insecticide sachets or bottles are not considered as contaminated waste. Incineration is not recommended for cardboard boxes unless they have been contaminated by pesticide leakage, or used for the storage of other contaminated wastes. In many cases uncontaminated boxes can be recycled, or can also be disposed of as normal non-hazardous wastes.

At the time of writing this SEA (March 2015), the PMI Environmental Team visited the cotton factories of SODEFITEX in Valingara and Tambacounda. These facilities also produce a great deal of pesticide solid waste and also incinerate them at SOCOCIM. The Directeur General at Tambacounda mentioned that SODEFITEX will be procuring an incinerator of their own in Tambacounda and is willing to come into negotiations with the PMI AIRS/NMCP program to share the facility for the program’s own waste disposal needs. If this comes to fruition, this will help minimize the environmental risk of transporting contaminated solid wastes a large distance from implementation sites. There will be a need to review specifications and operations to ensure that it meets USAID requirements.
After the solid waste management process is completed, a notification form for contaminated solid wastes is developed according to the Basel Convention, and is jointly signed by all involved parties (producer, carrier and eliminator) and submitted for record keeping.

8.3 **CONCLUSION**

Using the foregoing Best Management Practices and procedures, IRS can be performed safely and provide substantial benefits to the beneficiaries. The EMMR Annual Reporting Form and Certification in Annex A will be submitted to the USAID as part of the annual report.
9. EMMP IMPLEMENTATION

The NMCP/DHMTs, DREEC, SNH, PCC and PMI IRS implementing partner, along with support from DEEC, MoH/NMCP and MoA/DPV, will be responsible for implementation of the EMMP. The staff in charge of implementation of EMMP will be trained to ensure effectiveness of the mitigation measures during spray operation. The DREEC officers, and the implementing partner Environmental Compliance Officer will monitor environmental compliance during the IRS campaign.

The PMI IRS implementing partner will work closely NMCP/DHMTs, DREEC, SNH and PCC throughout the spray campaign. The PMI IRS implementing partner’s Environmental Compliance Officer will conduct environmental compliance inspections during pre-spray activities, during mid-spray operations and at the completion of the spray campaign. These inspections will aim to ensure that all the mitigation measures in the EMMP are being implemented and propose measures for improvement for the next IRS campaign. These compliance inspections achieve the following objectives:

- Observe IRS activities in progress to determine and document whether the intervention is in full compliance with USAID requirements as included in the approved SEA.
- Create a baseline of current compliance status for the purpose of evaluating improvement in future IRS programs.
- Ensure adherence to relevant international rules and regulations, including USA regulations.
- Ensure that all persons in potential contact with pesticides use PPE at all times.
- 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 spray operators, washers, team leaders and supervisors are knowledgeable of the correct way to handle and apply insecticides.
- Determine, in consultation with NMCP/DHMTs, DREEC and SNH officials, the training and support required to improve and ensure future compliance with the SEA.

In addition, PMI has annually-programmed funds to conduct an independent environment compliance audit to ensure that all the mitigation measures are implemented during the spray campaign.
10. Public Consultations

During the preparation of this SEA, consultations with the implementing governmental agencies including the DEEC at the National Level, the NMCP and the USAID Mission PMI staff were conducted at the central level. Also, consultations with the District level malaria and environmental programs several DREEC offices at, Regional Medicin Chefs, District Health Management Team personnel, local stakeholders) for all the 4 districts were undertaken to ensure the information provided in this document was accurate and met the needs of the PMI Senegal malaria control program for the next five years. The SEA also sets out to meet the needs of the Senegal Environmental Impact Assessment requirements to consider all regions as possible IRS implementation areas.

PMI includes public consultations through Information, Education and Communication (IEC) as a vital part of the IRS implementation process. IEC comprises information education as well as communication concepts. This kind of communication is vital to IRS, to ensure high levels of community and household participation, safety, and long-lasting impact of spraying.

IRS IEC activities are led by the NMCP through the DHMTs and IEC Coordinators. An IEC mobilization campaign will be conducted before and during spraying operations. At least two orientation meetings will be held at the community level. The rationale is to have community leaders involved in IRS planning activities at the community level. Additionally, community leaders will play an important role to stimulate behavior change and ensure community adherence to IRS, which in turn will mitigate refusals among households.

The NMCP/DHMTs IEC Coordinators will sensitize the target communities, raise awareness on IRS as a malaria prevention strategy, increase acceptance, and mobilize program beneficiaries to participate in IRS activities by informing them of their roles before, during and after the spray operations.

At the discretion of the PMI program, a draft version of the SEA will be distributed to the malaria control partners in Senegal for review.
## Annex A: Environmental Mitigation and Monitoring Plan

<table>
<thead>
<tr>
<th>Category of Activity</th>
<th>Describe specific environmental threats of your organization’s activities</th>
<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
<th>Monitoring Indicator</th>
<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
</tr>
</thead>
</table>
| 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.  
  b. Train drivers  
  c. Ensure that driver has cell phone, personal protective equipment (PPE) and spill kits during pesticide transportation (Phone must be provided by rental company).  
  d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.  
  e. Health test all spray team members for duty fitness.  
  f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE.  
  g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps.  
  h. Provide adequate facilities and supplies for end-of-day cleanup.  
  i. Enforce spray and clean-up procedures. | a-d. Environmental Compliance Officer (ECO).  
  e. Operations Manager (OM).  
  h. ECO  
  i. Chief of Party (COP), Technical Project Managers (TPM) and headquarters environmental staff. | a. Transport vehicles have a valid inspection certificate on-board.  
  b. Drivers have a certificate of training completion.  
  c. Transport vehicles are equipped with cell phone, spill kit, and PPE.  
  d. Storekeeper has records of pregnancy testing for all female team members.  
  e. Storekeeper has medical exam results for all team members.  
  f. Spray operators wear complete PPE during spraying and clean-up.  
  g. Operators mix pesticide properly, and the pump does not leak.  
  h. All facilities are compliant, and materials required for clean-up are present.  
  i. Inspections are performed as scheduled, corrective action is taken as needed. | a-c. ECO inspection of vehicles in the field.  
  d-e. ECO inspection of health records at IRS operational sites.  
  f-h. ECO performs pre-spray inspections of inventories and training records, and mid-spray inspections of PPE use and spray operator performance.  
  i. Monitoring of on-line database for submission of inspection reports. | a-c. 2 inspections per week.  
  d-e. One inspection per campaign, additional inspection if new hires or more than 30 spray days.  
  f-h. ECO pre-spray inspections 2/campaign, ECO mid-spray inspections 5 times/week.  
  i. Weekly |
<table>
<thead>
<tr>
<th>Category of Activity</th>
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<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
<th>Monitoring Indicator</th>
<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
</tr>
</thead>
</table>
| 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.  
b. Prohibit spraying houses that are not properly prepared.  
c. Two-hour exclusion from house after spraying  
d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside. | a-b. IEC officers, OM, ECO  
c. ECO  
d. Spray operators (SO) and Team Leaders (TL) | a. Pre-spray IEC campaigns were executed. Homeowners know responsibilities.  
b. All houses being sprayed are properly prepared.  
c. Homeowners observe 2 hour exclusion.  
d. Lack of incident reports, or incident reports with proper response noted. | a. OM- IEC work records  
b. All houses being sprayed are properly prepared.  
c. Homeowners observe 2 hour exclusion.  
d. Lack of incident reports, or incident reports with proper response noted. | a. OM- IEC work records  
b-d. ECO mid-spray inspections  
b-d. ECO mid-spray inspections | a. Inspect work records 1/campaign,  
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.  
b. Train operators on proper spray technique.  
c. Maintain pumps.  | a-c. TL, District Coordinator (DC), OM, ECO | a. Operators spray only inside of houses.  
b. Operators are trained and know and use proper spray techniques.  
c. Pumps are maintained and operated to eliminate leaks and erratic spraying. | a. ECO mid-spray inspections  
b-c. Training records, ECO mid-spray inspections | a. ECO mid-spray inspections  
b-c. ECO mid-spray inspections 5/wk. |
<table>
<thead>
<tr>
<th>Category of Activity</th>
<th>Describe specific environmental threats of your organization’s activities</th>
<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
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<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Environmental risk from disposal of insecticide (both liquid and solid waste)</td>
<td>a. Choose sites for disposal of liquid wastes according to PMI BMPs.</td>
<td>a-c. Abt OM, ECO, DC</td>
<td>a. Operations sites meet PMI BMPs.</td>
<td>a-b. ECO Pre-spray inspections</td>
<td>a-b. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by</td>
<td>a-2/campaign</td>
</tr>
<tr>
<td></td>
<td>b. Construct soak pits with charcoal to adsorb pesticide from rinse water.</td>
<td>d-f. Abt ECO</td>
<td>b. Soak pits are constructed according to the PMI BMP manual.</td>
<td>c-f. ECO mid- and post-spray inspections and monitoring.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>c. Maintain soak pits as necessary during season.</td>
<td></td>
<td>c. Soak pits perform properly throughout the spray season.</td>
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<td></td>
<td>d. Inspect and certify solid waste disposal sites before spray campaign.</td>
<td></td>
<td>d. Disposal sites have the capacity and policies to properly dispose of wastes.</td>
<td></td>
<td></td>
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<td></td>
<td>e. Monitor waste storage and management during campaign.</td>
<td></td>
<td>e. Wastes are stored and managed according to PMI BMPs.</td>
<td></td>
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<tr>
<td></td>
<td>f. Monitor disposal procedures post-campaign.</td>
<td></td>
<td>f. Waste disposal sites have taken place as agreed and certificates of disposal received.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Risk of diversion of insecticides for unintended or uncontrolled use</td>
<td>a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</td>
<td>a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO</td>
<td>a-d. All pesticide management records are reconciled.</td>
<td>a-b, d. Inspection of pesticide management records. Storekeeper performance checklists. c. ECO mid-spray inspections.</td>
<td>a-b, d. Weekly monitoring by District Coordinators c. 1/campaign by country headquarters. 2/campaign by ECO d. 2/campaign/ store-room</td>
<td>a-b, d.</td>
</tr>
</tbody>
</table>
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.

- 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% to 32%. 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.

- **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.

<table>
<thead>
<tr>
<th>DOSAGE OF ACTIVATED CHARCOAL</th>
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<tbody>
<tr>
<td>Adults and children over 12 years: 25-100 g in 300-800 mL water.</td>
</tr>
<tr>
<td>Children under 12 years: 25-50 g per dose.</td>
</tr>
<tr>
<td>Infants and toddlers under 20 kg: 1 g per kg body weight</td>
</tr>
</tbody>
</table>

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 LORAZEPAN**

- 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

<table>
<thead>
<tr>
<th>Carbamates</th>
<th>Human side effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bendiocarb</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>Propoxur</td>
<td>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.</td>
<td>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.</td>
</tr>
</tbody>
</table>
**SUMMARY OF ACUTE EXPOSURE SYMPTOMS AND TREATMENT OF WHO-RECOMMENDED ORGANOPHOSPHATES**

<table>
<thead>
<tr>
<th>Human side effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Malathion</strong></td>
<td>Oral exposure to malathion should be treated with rapid gastric lavage unless the patient is vomiting. Dermal exposures should be treated by washing the affected area with soap and water. If the eyes have been exposed to malathion, flush them with saline or water. People exposed to malathion who exhibit respiratory inefficiency with peripheral symptoms should be treated via slow intravenous injection with 2–4 mg atropine sulfate and 1,000–2,000 mg pralidoxime chloride or 250 mg toxogonin (adult dose). Exposure to high levels of malathion that result in respiratory distress, convulsions, and unconsciousness should be treated with atropine and a re-activator. Morphine, if indicated, should also be administered.</td>
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<tr>
<td>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.</td>
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</tr>
<tr>
<td><strong>Fenitrothion</strong></td>
<td>Dermal exposure to fenitrothion should be treated by removing contaminated clothing, rinsing the skin with water, washing the exposed areas with soap and water, then seeking medical attention. If fenitrothion gets into the eyes, they should be rinsed with water for several minutes. Contact lenses should be removed if possible and medical attention should be sought. Ingestion of fenitrothion should be treated by rinsing the mouth and inducing vomiting if the person is conscious. Inhalation exposures require removal to fresh air and rest in a half-upright position. Artificial respiration should be administered if indicated and medical attention should be sought.</td>
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<tr>
<td>Fenitrothion is the most toxic to man of the insecticides approved for residual house spraying, and has a relatively low margin of safety. Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor.</td>
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<tr>
<td>Pirimiphos-methyl</td>
<td>Human side effects</td>
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<tr>
<td>Pirimiphos-methyl is also a cholinesterase inhibitor. Early symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, stomach pains, blurred vision, constricted pupils, slurred speech, and muscle twitching. Later there may be convulsions, coma, loss of reflexes, and loss of sphincter control.</td>
<td>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. The affected person should stop work immediately, remove any contaminated clothing, wash the affected skin with soap and clean water and flush the skin with large quantities of clean water. Care must be taken not to contaminate others, including medical or paramedical workers. Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic OP insecticides are used in areas without easy access to medical care. Atropine sulfate. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible.</td>
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<tr>
<td>Pyrethroids</td>
<td>Human side effects</td>
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<tr>
<td>Bifenthrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache,</td>
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<td>dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability,</td>
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<td></td>
<td>abnormal sensations of the face and skin, and numbness.</td>
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<td></td>
<td>No skin inflammation or irritation observed; however can cause a</td>
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<td>reversible tingling sensation. Incoordination, irritability to sound and touch,</td>
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<td>tremors, salivation, diarrhea, and vomiting have been caused by high doses.</td>
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<tr>
<td>Deltamethrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache,</td>
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<tr>
<td></td>
<td>dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability,</td>
</tr>
<tr>
<td></td>
<td>abnormal sensations of the face and skin, and numbness.</td>
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<td></td>
<td>If exposed immediately remove any contaminated clothing. Soak any</td>
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<td>liquid contaminant on the skin clean affected area with soap and warm water.</td>
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<td></td>
<td>Rinseso copiously with water when eye exposures occur or 4 % sodium bicarbonate.</td>
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<td>Vomiting should not be induced following ingestion exposures, but the</td>
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<tr>
<td>Lambda-</td>
<td>Skin exposure leads to transient skin sensations such as periorbital facial</td>
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<tr>
<td>Cyhalothrin</td>
<td>facial tingling and burning. Can irritate the eyes, skin, and upper respiratory</td>
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<tr>
<td></td>
<td>tract. Oral exposure can cause neurological effects, including tremors and</td>
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<tr>
<td></td>
<td>convulsions. Ingestion of liquid formulations may result in aspiration of the</td>
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<td></td>
<td>solvent into the lungs, resulting in chemical pneumonitis.</td>
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<tr>
<td>Alpha-</td>
<td>Acute exposure symptoms include skin rashes, eye irritation, itching and</td>
</tr>
<tr>
<td>cypermethrin</td>
<td>burning sensation on exposed skin, and paraesthesia.</td>
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<td></td>
<td>Acute inhalation exposures may cause upper and lower</td>
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</tr>
<tr>
<td>Pyrethroids</td>
<td>Human side effects</td>
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<tr>
<td>Cyfluthrin</td>
<td>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.</td>
</tr>
<tr>
<td>Etofenprox</td>
<td>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.</td>
</tr>
</tbody>
</table>
SUMMARY OF ACUTE EXPOSURE SYMPTOMS AND TREATMENT OF CHLORFENAPYR

<table>
<thead>
<tr>
<th>Pyrole</th>
<th>Human side effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorfenapy</td>
<td>As chlorfenapy is a rather new product there are not many cases of poisonings where the symptoms were described. One incident involved someone who experienced an asthma attack after a nearby office was sprayed. The only symptoms reported were respiratory effects. This case was ranked as low severity. Another exhibited general fatigue, hyper-perspiration, nausea and vomiting. He was initially diagnosed as being dehydrated. And a third was hospitalized due to exogenous intoxication with chlorfenapyr with suicidal purposes, initially presenting diaphoresis, headache and cough. Symptomatic management was initiated, but after seven days she presented neurological and respiratory deterioration, causing her death.</td>
<td>As chlorfenapy affects the central nervous system, it can be managed through supportive care and early treatment of seizure through benzodiazepine. No specific symptoms can be said for exposure by inhalation or ingestion. Possible generalized symptoms include nausea and vomiting. Prolonged contact of the skin with the concentrate may cause irritation. Eye contact may cause some discomfort if contact is prolonged. Evidence from prolonged animal studies indicates that repeated or prolonged exposure to high doses of chlorfenapyr can result in spongiform (encephalomyelopathy) and effects on the liver and kidney.</td>
</tr>
</tbody>
</table>
ANNEX D: EMMR FORM

Please see Annual Environmental Mitigation and Monitoring Report (EMMR) Form next page
### Implementing Organization:

Geographic location of USAID-funded activities:

Period covered by this Reporting Form and Certification:

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>Status of Mitigation Measures</th>
<th>Outstanding issues relating to required conditions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport.</td>
<td></td>
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<tr>
<td>1b. Driver training</td>
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<tr>
<td>1c. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation.</td>
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<tr>
<td>1d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1e. Health fitness testing for all operators</td>
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<tr>
<td>1f. Procurement of, distribution to, and training on the use of PPE for all workers with potential pesticide contact.</td>
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<tr>
<td>1g. Training on mixing pesticides and the proper use and maintenance of spray pumps.</td>
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<tr>
<td>1h. Provision of adequate facilities and supplies for end-of-day cleanup,</td>
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<tr>
<td>1i. Enforce spray and cleanup procedures.</td>
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<tr>
<td>2a. IEC campaigns to inform homeowners of responsibilities and precautions.</td>
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<tr>
<td>2b. Prohibition of spraying houses that are not properly prepared.</td>
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<tr>
<td>2c. Two-hour exclusion from house after spraying</td>
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<tr>
<td>Mitigation Measure</td>
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<td>Outstanding issues relating to required conditions</td>
<td>Remarks</td>
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<tr>
<td>2d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside.</td>
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<tr>
<td>3a. Indoor spraying only.</td>
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<td>3b. Training on proper spray technique</td>
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<tr>
<td>3c. Maintenance of pumps</td>
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<tr>
<td>4a. Choose sites for disposal of liquid wastes according to PMI BMPs.</td>
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<tr>
<td>4b. Construct soak pits with charcoal to adsorb pesticide from rinse water.</td>
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<tr>
<td>4c. Maintain soak pits as necessary during season.</td>
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<tr>
<td>4d. Inspection and certification of solid waste disposal sites before spray campaign.</td>
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<tr>
<td>Mitigation Measure</td>
<td>Status of Mitigation Measures</td>
<td>Outstanding issues relating to required conditions</td>
<td>Remarks</td>
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<tr>
<td>4e. Monitoring waste storage and management during campaign.</td>
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<tr>
<td>4f. Monitoring disposal procedures post-campaign.</td>
<td></td>
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<tr>
<td>5a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</td>
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<tr>
<td>5b. Reconciliation of number of houses sprayed vs. number of sachets/bottles used.</td>
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<tr>
<td>5c. Visual examination of houses sprayed to confirm pesticide application.</td>
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<tr>
<td>5d. Perform physical inventory counts during the spray season.</td>
<td></td>
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</tbody>
</table>
Abt Associates/USAID.


Basel Convention. Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT)

Basel Convention. Updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs). 1994


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