INDOOR RESIDUAL SPRAYING
FOR MALARIA CONTROL

Supplemental Environmental Assessment: Indoor Residual Spraying for Malaria Control in Benin

Amendment to include all Regions in Benin Using Pyrethroids, Organophosphates and Carbamates

Indoor Residual Spraying (IRS) Indefinite Quantity Contract (IQC)

March, 2011

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United States Agency for International Development

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EXECUTIVE SUMMARY

The President's Malaria Initiative (PMI) led the first large-scale spraying program in Benin in 2008 in Ouémé-Plateau, and has supported three rounds of indoor residual spraying (IRS) since then. During the last 12 months, one round of spraying was completed, protecting 636,000 people in four communes. A fourth round of IRS was implemented in the south of Benin beginning August 2010. With FY 2011 funding, PMI-supported IRS will be shifted to the north of Benin, where a total of 118,000 households will be sprayed and an estimated 500,000 residents protected.

According to the data available, the north of the country is better suited to IRS because it has lower ITN coverage, lower vector pyrethroid resistance rates, higher child mortality rates, and only one seasonal transmission peak. Meanwhile, in the formerly sprayed areas in the south, PMI will support efforts to ensure universal coverage with and adequate use of ITNs. The PMI will also continue supporting the NMCP entomological and malaria case surveillance system in Ouémé-Plateau.

This document has been prepared to serve as the environmental documentation for IRS. The previous environmental documentation covered use of bendiocarb, deltamethrin, alpha-cypermethrin and fenitrothion in Ouémé-Plateau and was prepared in accordance with the United States Agency for International Development (USAID) Code of Federal Regulation (CFR) (216) regarding and governing the use and application of pesticides.

The environmental documentation outlined the monitoring and mitigation measures that would be employed by the contractor to minimize or reduce any unintended adverse impacts of pesticide application. The 2008 Supplemental Environmental Assessment (SEA) limited its geographic coverage to the following region; Ouémé-Plateau hence this document has been prepared to allow expansion of the IRS program into the entire country and to allow for choice between three insecticide classes approved by WHO (pyrethroids, organophosphates and carbamates) to be considered in the annual decision-making process. The reason for preparing the SEA at class level and national in scope is based on the fact that periodic amendment of the SEA due to change in location (as is the case with Benin which sprayed in 2008-2010 in 1 region and then switched to another in 2011) or change of insecticide class is not cost effective and is avoidable if the scoping occurs at national level in scope and class level in terms of insecticides. This ensures that if in the preceding year the location and insecticide remain the same or changes then only an annual letter of justification is prepared instead of a new SEA as has been the case.

Therefore the proposed action analyzed in this document is to allow for a 5 year IRS program using a rotational or mosaicing technique using a carbamates based insecticide in the Atacora region for the 2011 spray operations scheduled to commence in May but not within 30 feet of natural water bodies, wetlands or marshes, organic farming areas, beekeeping areas or national forests, parks or habitats. The following assessment draws heavily on the 2009 SEA as well as the Programmatic Environmental Assessment (PEA) for Integrated Vector Management, approved in March 2006 (http://www.ehproject.org/PDF/ehkm/ivm-env_assessment.pdf).

In 2011 PMI's support to IRS in Benin will shift from Oueme-Plateau region to the Atacora region targeting all the districts as shown in the table 2 below:

Table 1. Spray communes in Oueme-Plateau from 2008-2010.

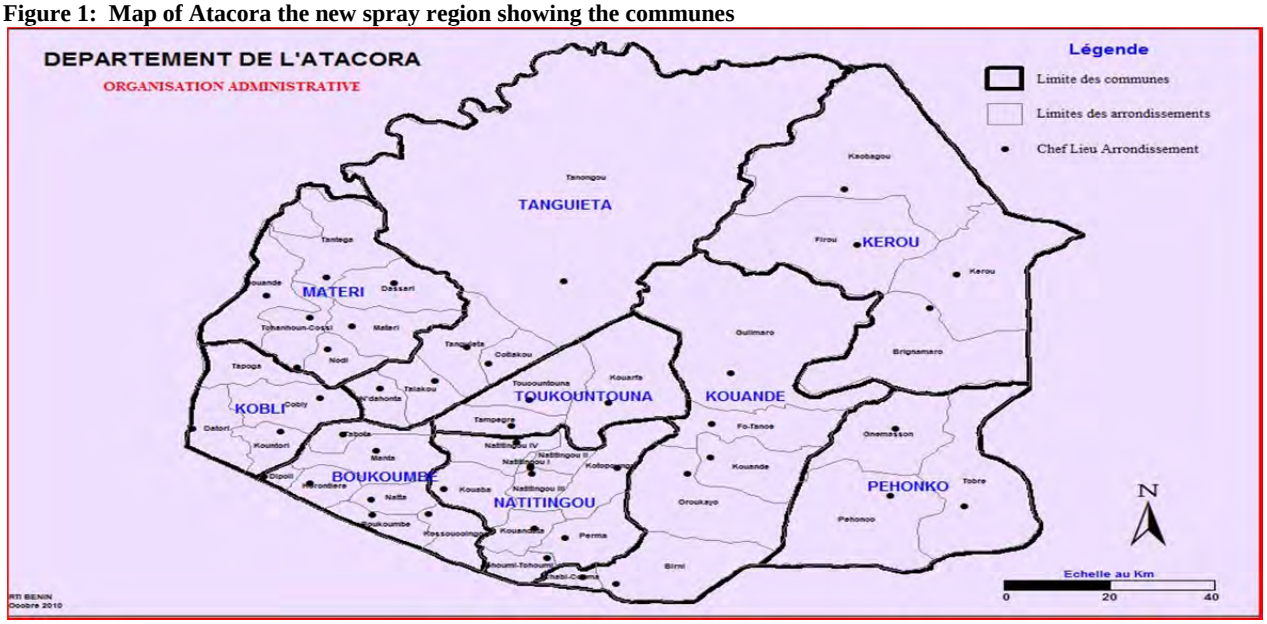
Communes	Wards
Dangbo,	18
Adjohoun,	35
Semi-Kpodji,	38
Akpro-Misserete	40

Table 2. Proposed spray communes in Atacora region in 2011

Communes	Wards
Boukoumbé	7
Cobly	4
Kérou	4
Kouandé	6
Matéri	6
Natitingou	9
Péhonco	3
Tanguiéta	5
Toucountouna	3
TOTAL	47

PMI may consider expanding to additional regions other than Atacora over the next five years within the country and such expansion will be covered by this SEA amendment. An annual letter report explaining the current program will be submitted prior to the implementation of any spray campaign. If expansion does occur in other parts of Benin, USAID Environmental Officers will be notified in writing prior to procurement of insecticides to document the extent of expansion and adherence to the safer use action plan. This SEA is intended to suffice for a period of five years (2010-2015).

Figure 1: Map of Atacora the new spray region showing the communes



Based on technical discussions with the *Service de Lutte Contre le Paludisme* (National Malaria Control Program (NMCP) and *Centre de Recherche Entomologique de Cotonou* (CREC),

regarding detailed entomological studies analyzing susceptibility and efficacy, a carbamate based insecticide will be used for the 2011 IRS operations in Atacora. The studies indicated that the *Anopheles gambie* is highly susceptible to the carbamate class of insecticides, as compared to organophosphates and pyrethroids, in the 9 communes of Atacora. Every year, PMI and its implementing partner will continue to work closely with NMCP and *CREC* when selecting insecticides, as resistance to carbamates might become an area of concern.

Adverse Impacts and Mitigation Measures

Based on USAID's experience with implementation of IRS in fifteen other sub-Saharan African countries under the President's Malaria Initiative (PMI), the most likely potential adverse health impact of the IRS intervention is unintentional pesticide exposure, leading to health impacts on beneficiaries and spray operators. To mitigate this risk, all individuals involved in the implementation of spraying – from spray operators to wash persons to storekeepers – will be trained in the best management of IRS, and community members will be informed on how to minimize direct exposure to insecticides (e.g., staying out of houses sprayed for two hours, removing furniture and food from houses prior to spraying, etc).

The highest risk to the environment is the likely contamination to the biodiversity found in Benin i.e. (rivers, lakes, wetlands, marshes, forests) etc in the mentioned regions.

Although based on preliminary mapping exercises and reconnaissance visits in Atacora region conducted in 2010, November, there seem to be no settlements or homesteads close to these natural water bodies, as a risk mitigation, during the detailed logistical assessment, mapping of structures will be undertaken and houses within 30 feet from water bodies will not be sprayed as a measure of minimizing risk to contamination from spills.

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

Continued Adherence to the Original Safer Use Action Plan

PMI/Benin and its implementing partners will continue to adhere to the conditions detailed in the Safer Use Action Plan (SUAP), summarized below (originally contained in the 2008 SEA) and highlighted in the Environmental Monitoring and Mitigation Plan (EMMP) found in section 6 of this report.

Policy, Planning and Institutional Requirements

- Prohibit the use of IRS insecticides in sensitive ecosystems. In line with the established best practices for IRS, and relevant national and USAID policies, measures will be established to assure adequate protection of sensitive ecosystems.
- Continue to monitor vector susceptibility, and respond if and when results indicate resistance is developing.
- Promote inter-sectoral collaboration frameworks and institutional arrangements to facilitate comprehensive approach to vector control and associated pesticides management. Coordination between the malaria control program and major stakeholders will be strengthened. This will include collaboration with:

- Ministry of Agriculture, Livestock and Fisheries – for appropriate integration of vector and pest management activities aimed at enhancing judicious use of insecticides especially within the rural farmer community settings.
- The Benin Environmental Agency (ABE) is responsible for the enforcement of environmental monitoring and effective mitigation of the negative impacts of projects on the environmental resources.
- USAID and the implementing partner are also required to enforce monitoring and mitigation measures.

Operational Requirements

The IRS implementing partner will work closely with NMCP to access relevant country level authorization, support, or consent it may need from NMCP and other relevant national agencies to implement the IRS program:

- Quality assurance for commodity procurement and IRS operations, to minimize risks to human health and the environment. This will include ensuring legitimate procurement sources and verifiable chain of custody of commodities, as well as effective compliance inspections of IRS activities in the field.
- Ensure compliance with national regulations on pesticides and Ministry of Health (MOH) guidelines on IRS and vector control. Compliance with established national procedures for registering, importing, transporting, labeling, handling, use, storage, and disposal of pesticides.
- Train relevant categories of workers involved in IRS operations (e.g. district program managers/coordinators, spray operators, storekeepers, pesticide transporters, and supervisors) on best practices in accordance with national pesticides regulations and recommendations/guidelines of World Health Organization (WHO) and this SEA. Criteria for reprimanding non-observance of best practices by these workers has been established and used in previous spray operations in the country.
- Ensure use of appropriate personal protective equipment and best practices, including effective field supervision of spray operations, for adequate protection of spray operators and other handlers of pesticides.
- Train health workers in the management of insecticide poisoning. This will include program-specific guidelines on poison treatment; designation of district hospitals within the target areas for appropriate treatment of insecticide poisoning; Training of IRS workers to recognize early danger signs of poisoning and appropriate action.
- Enforce protection of foetus and suckling-children against exposure in spray operations. Pregnant women and breast-feeding mothers will be excluded from direct handling of pesticides (e.g. spray operations, washers). Before each spray season, pregnancy testing will be established for potential female handlers of pesticides.
- Undertake Information Education and Communication (IEC) activities for targeted communities and households to reduce exposure. This will provide information on the removal of food, cooking and water utensils, covering of unmovable furniture with cloths prior to spraying; exclusion of spraying rooms used by pregnant women or sick individuals who are unable to leave their homes; preventing the reentry of sprayed rooms for at least one hour after spraying; sweeping of floor residues before re-entry of children or animals and disposal of dead insects in latrines or pits.
- Establish strict practices to reduce environmental contamination. This will include comprehensive auditing of pesticide stocks and usage, as well as enforcing best practices related to the handling, washing and disposal of pesticides; progressive use of waste/wash

water, ablution blocks and evaporation tanks. IRS field activities should be in full compliance with the Ministry of Agriculture (Department of Plant Protection) as well as relevant USAID regulations and the recommendations outlined in this SEA.

- Provide training support during the Training of Trainers (ToT), , to strengthen the supervisory capacity of the Benin Environmental Agency (ABE) within the target districts for day-to-day monitoring of IRS activities.

In addition, NMCP will carry out routine inspections of all IRS districts, including unannounced spot inspections, to verify compliance with all relevant national regulations and guidelines, as well as procedures outlined in the safer use action plan. Benin Environmental Agency (ABE) in coordination with NMCP and RTI will independently conduct compliance inspections of IRS activities and facilities in the IRS districts.

Conclusion

Once a year, a joint meeting will continue to be held by the technical partners (e.g. PMI, RTI and ABE) under the auspices of NMCP to review the findings from the above evaluations, generate lessons learnt, and identify priority areas requiring strengthening and map out remedial actions. Effort will be also be made to include feedback from target communities. This systematic approach will enable timely corrective actions and progressive strengthening of environmental safeguards and program compliance over time.

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

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT'S MALARIA INITIAVE- INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN BENIN.

PROGRAM/ACTIVITY DATA:

Environmental Document Number GH-11-xxx
Program/Activity Number: GH-I-01-09-00012
Country/Region: Africa/ Benin
Program/Activity Title: IRS for Malaria Control in Benin
Sub-activity:

Funding Begin: 2010 **Funding End: 2014**

SEA Prepared By: Tito Kodiaga
Current Date: **March, 2011**

IEE Amendment (Y/N): Y
Filename & date of original IEE:

ADDITIONAL ELEMENTS: (Place X where applicable)

CONDITIONS: _X__ PVO/NGO: ____

Other Relevant Environmental Compliance Documentation:
This IEE references the following USAID environmental compliance documentation that is already in effect for ongoing activities globally under USAID:

- Integrated Vector Management for Malaria Vector Control: Programmatic Environmental Assessment: 03/2007
- Supplemental Environmental Assessment for Benin IRS 2008

This IEE references the following USAID environmental compliance documentation that is already in effect for ongoing activities under USAID/BENIN SO 3:

- Benin Integrated Family Health Program (BIFHP): Benin Insecticide Treated Mosquito Net Action Plan, 06/1998

APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:

The United States Agency for International Development, Global Health Bureau has determined that the proposed indoor residual spraying effort, as described in the Supplemental Environmental Assessment: Indoor Residual Spraying for malaria control in Benin dated December, 2010, responds to the needs of the community and country as it relates to managing malaria in Benin as well as conforms to the requirements established in 22 CFR 216.

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

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Acronyms/Abbreviations

ACT	artemisinin-based combination therapy
ADS	Automated Directives System
AL	artemether/lumefantrine combination therapy
ANC	antenatal care
AS/AQ	artesunate/amodiaquine combination therapy
BCC	Behavior change communication
DHS	Demographic Health Survey
EIA	Environmental Impact Assessment
EMMP	Environmental Monitoring and Mitigation Plan
GFTAM	Global Fund to Fight AIDS, Tuberculosis, and Malaria
IEC	information, education and communication
IPTp	intermittent preventive treatment in pregnancy
IRS	indoor residual spraying
ITN	insecticide treated net
LLIN	long-lasting insecticide treated net
M&E	monitoring and evaluation
MOH	Ministry of Health
MOP	Malaria Operational Plan
NGO	Non-Governmental Organization
PMI	President's Malaria Initiative
PPE	Personal Protective Equipment
RTI	Research Triangle Institute
SEA	Supplemental Environmental Assessment
SP	sulfadoxine-pyrimethamine
SUAP	Safer Use Action Plan
UNEP	United Nations Environment Program
UNFAO	United Nations Food and Agriculture Organization
USAID	United States Agency for International Development
USG	United States Government
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme

1.0 BACKGROUND AND PURPOSE

1.2 Malaria Burden in Benin

Malaria is a leading cause of morbidity and mortality among children under five in Benin. The Benin Health Management Information Systems (HMIS) data also suggest a high burden of morbidity from anemia, much of which is likely caused by malaria. The Benin 2006 Demographic and Health Survey (DHS) found that among children 6–9 months old, 79% had anemia (25% mild, 46% moderate, and 8% severe).

Malaria transmission and epidemiology

The primary malaria vector in Benin is *Anopheles gambiae s.s*. The widespread distribution and continuous breeding of *An. gambiae* result in endemic transmission nationwide, with three distinct regions. In the coastal region of the southern part of Benin, which has many lakes and lagoons, transmission is heterogeneous because of the presence of both *An. melas* and *An. gambiae*. Inland, malaria is holo-endemic. Finally, in northern Benin, malaria is seasonal, with a dry season (November to June) and a rainy season (July to October), during which malaria rates are highest.

Vector resistance to pyrethroid insecticides affects the malaria situation in Benin by reducing the efficacy of ITNs as well as IRS. If nets are not replaced in a timely manner, they eventually deliver a sub-lethal pyrethroid insecticide dose that selects for resistance, by selectively killing 'susceptible' vectors. The potential impact of sub-lethal ITNs on vector resistance could be significant; however, the current test for assessing ITN insecticidal decay, the WHO bioassay, is difficult to scale up.

A more efficient method, based on a chemical (colorimetric) test, has been developed, standardized, and is being tested by PMI against the WHO method and has proven to be efficient and effective. To help manage pyrethroid resistance, the PMI in Benin will not use pyrethroids in its spraying program. This SEA however, covers possible future use of pyrethroids because the resistance can be reversed after certain durations if no further use of pyrethroids is undertaken (rotation to manage resistance). If through contionus annual entomological studies results indicate a reversal in resistance, then this class of pesticides will become eleigible. In order to avoid amendment of the SEA over the 5 year period due to switch in pesticide class, pyrethroids have thus been considered.

President's Malaria Initiative

Malaria prevention and control is a major foreign assistance objective of the U.S. Government (USG). In May 2009, President Barrack Obama announced the Global Health Initiative (GHI), a six-year, comprehensive effort to reduce the burden of disease and promote healthy communities and families around the world. Through the GHI, the United States will invest $63 billion over six years to 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.

The President's Malaria Initiative (PMI) is a core component of the GHI, along with HIV/AIDS, maternal and child health, and tuberculosis. The PMI was launched in June 2005 as a 5-year, $1.2 billion initiative to rapidly scale up malaria prevention and treatment interventions and reduce malaria-related mortality by 50% in 15 high-burden countries in sub-Saharan Africa. With passage of the 2008 Lantos-Hyde Act, funding for PMI has now been extended through FY2014 and, as part of the Global Health Initiative (GHI), the goal of the PMI is now to reduce malaria-related mortality by 70% in the original 15 countries by the end of 2015. 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 artemisinin-based combination therapies (ACTs), insecticide-treated nets (ITNs), intermittent preventive treatment of pregnant women (IPTp), and indoor residual spraying (IRS).

Benin became a PMI focus country in 2008. Large-scale implementation of ACTs and IPTp and wide-spread distribution of ITNs began in 2009 and has progressed rapidly with support from PMI and other partners, in spite of the country's weak health infrastructure.

1.2.1 Project Objectives

The purpose of this project is to continue implementing Indoor Residual Spraying (IRS) as an intervention aimed at reducing malaria transmission and prevalence in Atacora region.

Indoor Residual Spraying is the organized, timely spraying of an insecticide on the inside walls of houses or dwellings. It is designed to interrupt malaria transmission by killing adult female mosquitoes when they enter houses and rest on the walls after feeding, but before they can transmit the infection to another person.

Figure 2 . Map showing Oueme Plateau IRS regions since 2008 highlighted in red and new region (Atacora) highlighted in green where IRS will commence starting 2011.

1.3 History of Malaria Control in Benin

National Malaria Control Plan and Strategy

The NMCP has a five-year National Malaria Strategic Plan currently ending in 2010. The review process leading to the development of a new Strategic Plan for the next five years started in May 2010, and has yet to be completed. The vision behind the NMCP 2011-2015 strategy is to continue to promote universal access to malaria prevention and treatment interventions by scaling up a package of interventions that promote positive behavior change, achieve rapid and sustainable high coverage levels, and prevent and treat malaria.

The core interventions of the 2011-2015 strategy will include:

- Universal coverage with ITNs with a special emphasis on distributing LLINs through mass distribution campaigns planned for 2010 and 2013, routine distribution to pregnant women during antenatal care services, and to children under five years during routine immunization;
- Expanding IRS, currently conducted in four communes in Ouémé-Plateau in 2008-2010 to 9 communes in Atacora region;
- Universal access to ACTs, as well as improved diagnosis and management of severe malaria;
- Emphasis on the treatment and prevention of malaria in pregnancy, particularly IPTp;
- Intensive IEC efforts and social mobilization at all levels;
- Integration of malaria control activities within the health system with an emphasis on human resource development; and
- Strong monitoring, evaluation, and operations research to monitor progress, evaluate impact, and continuously improve interventions.

In its 2011-2015 Strategic Plan, the NMCP will attempt to enhance coordination capacity within the decentralized structures at the department level. Under this approach, six departmental coordinating structures will be supported to improve health outcomes through implementation of policies and strategies defined by the national coordination structures.

1.3.1 Indoor Residual Spraying

In September 2009, the NMCP developed its national IRS strategy. This strategy aims to scale up IRS from four to 20 communes out of 77. However, full funding for this strategy has not yet been obtained, and PMI plans to continue spraying in a limited number of communes. Between 2010 and 2015, the NMCP would like to add four new communes per year to the number of communes already being sprayed. The new communes would be chosen by a national committee based on malaria epidemiology and entomological data, with a "knock down/keep down" strategy for vector control envisioned as the overall approach. This strategy proposes the use of IRS to drive malaria transmission down, followed by universal ITN coverage to sustain gains from IRS. Transmission following the shift to universal ITN coverage will be monitored closely to verify that the "keep down" strategy is working. This strategy is based on empirical experience in Benin and has been generally accepted by PMI. The spraying already completed in Benin has been successful in significantly bringing down entomologic indicators.

The PMI is the only NMCP partner currently supporting IRS in the country. To date, PMI/Benin has supported three rounds of IRS with a carbamate insecticide in Ouémé-Plateau department in southern Benin. IRS began in July 2008 in four communes. In each round, upwards of 150,000 houses were sprayed, protecting a total population of about 550,000 residents each year. The insecticidal effect lasted at least four months, which was sufficient to cover the local major transmission periods of malaria.

CREC undertook a detailed entomological study "***Results of Entomological Studies in Atacora Region by Prof. Martin Akogbeto, October, 2010"*** (See annex section for complete report) in the 9 communes in Atacora region in October 2010 to determine the susceptibility of the vector (Anopheles gambie) to 3 different classes of insecticides namely;-Pyrethroids (permethrin and deltamethrin), organochlorine (DDT) and carbamates (bendiocarb). The results of the study show 95-98% vector morbidity to bendiocarb in all the 9 communes from the household sampled. There is an extremely high level of resistance to permethrin and DDT in all the 9 communes with a morbidity

of between 0-15% observed during this study. It is against this background study that Atacora region will use a carbamate in the planned spray operations

CREC presented the results of its study in Atacora (September/October 2010) and its recommendations to use Bendiocarb in Atacora in 2011 and to already identify a "Product B" for future operations (after 2011), in case of vectors' resistance increase.

Based on the national IRS strategy and with PMI guidance, FY2010 funding will support spraying in the north of the country. In July 2010, the MOH and PMI selected Atacora department, in northwest Benin, aiming at a target population size of 500,000 inhabitants. The north of the country may be better suited to IRS because it has lower ITN coverage, higher child mortality rates, and only one seasonal transmission peak. This area will also be sprayed with a carbamate; a final confirmation of the insecticide choice was made after resistance testing in October 2010 confirmed continued susceptibility to carbamates.

1.3.2 Insecticide-treated nets (ITNs)

The NMCP strategy is to support free distribution of LLINs through antenatal clinics (ANC) and vaccination clinics; distribution of highly-subsidized LLINs through community-based channels; free distribution through mass campaigns; and the sale of LLINs in the commercial sector. The PMI procured one million LLINs in FY 2010 for support to private sector distributions and routine services. With FY 2011 funding, PMI will procure approximately 410,000 LLINs for free distribution to pregnant women at ANC visits and to children at vaccination clinics, as well as for social marketing through the private sector. In addition, the PMI will support behavior change communication (BCC) activities including mass media and community-level approaches (e.g. local radio stations, women's groups) to increase demand for and promote correct and consistent utilization of LLINs.

1.3.3 Environmental Management

The National Malaria Control strategy does not expressly mention environmental management as part of its strategy to control malaria and this is because NMCP does not consider this intervention to be significant in the control of malaria. NMCP should consider this intervention but is subject to the availability of financial resources since this intervention is costly.

1.3.3 Major Partners in Malaria Control

Benin has many technical and financial partners in the health sector. The following table describes the most significant contributors to malaria control, and the opportunities for collaboration.

Table 3. Major Malaria Control Partners

Bilateral Donors		
Country	*Current Activities*	*Collaboration with PMI activities*
Belgium	The Belgian Technical Cooperation (CTB) is focused on improving the management capacity of selected health zones.	While CTB's focus is not directly on malaria, it actively provides support to enhance capacity and sustainability of peripheral health units, and in supporting community-based health financing schemes

		known as *mutuelles de santé*.
China	The Chinese government has built hospitals and clinics, and has sent medical teams to the clinics that they support. In addition, they have imported significant amounts of ACTs (Arsuamoon) into the country.	IRD provides support to CREC, which is a sub-grantee of USAID through an agreement with Research Triangle Institute (RTI). The focus is on vector research and other aspects of malaria prevention.
France	The French Cooperation supports malaria research through the Development Research Institute (IRD) and the Centre de Recherche Entomologique de Cotonou (CREC).	IRD provides support to CREC, which is a sub-grantee of USAID through an agreement with Research Triangle Institute (RTI). The focus is on vector research and other aspects of malaria prevention.
Japan	JICA (Japan International Cooperation Agency) has a small health portfolio in Benin.	JICA is focused on the renovation and/or construction of dispensaries and clinics.

2.0 Alternatives Including the Proposed Action

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

2.1 Preferred Action

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

PMI is committed to using IRS as a vector control method in Benin, in line with the NMCP's Strategic Plan. The purpose of this project is to implement a five year IRS program in selected regions in Benin as agreed and in consultation and concesus between PMI and NMCP and when showing endemic transmission as a key intervention to reduce malaria transmission, using a WHO-approved insecticide. The proposed action excludes areas that are within 30m of water bodies, wetlands or marshes are near sensitive habitats such as organic farming areas, areas of beekeeping, and within national forests, parks or other protected areas.

The Atacora department, in northwest Benin, will be the spray location in 2011 using a carbamates and the operations aim at a target population size of 500,000 inhabitants.

The decision on specific districts within the regions in Benin, type of pesticide, method (rotation, mosaicing, etc) will be made using the following information: transmission rate, epidemic status of malaria in region, vector status, vector behavior, ecology, and human and socio economic indicators such as organic or sensitive economic habitats. (This information will be submitted in the annual letter report to the Bureau Environmental Officer).

The decision was made not to spray Oueme in 2011 because of the fact that Spray activities in Oueme-Plateau required two spray rounds due to the fact that this region experiences two rainfall seasons. This would have an impact on the cost and overall budget availed by USAID which would not be able to cover 2 spray rounds. PMI and NMCP wanted to continue with IRS but in an area where annual IRS was sufficient. Hence, Atacora was chosen because the region not only experiences a single rainy/transmission season but also has the highest prevalence rate of malaria 18.6% compared to the national rate of 16.1%.

2.1.2 IRS Application Process

The IRS application process in Atacora region will be similar to the approach that was used previously in Oueme Plateau and is described below.

Pesticide Procurement

Once an insecticide of choice for the IRS is selected by a country (see section 2.3 on insecticide selection criteria), the next stage is the procurement of the pesticides which are imported from the country of manufacture.

Any pesticide selected must be registered for IRS use by the host government in this case the Ministry of Agriculture in Benin. PMI program does not allow for the procurement of pesticides that are not approved for IRS by WHO and by the host government. See section 2.3 figure 14 for the entire list of WHO approved pesticides for IRS.

The insecticides of choice from the approved classes (in this case carbamates for 2011 spray campaign) is a duly registered product by CNAC as shown in the list of approved chemicals for use in Benin in the annex section. The product will be purchased using international practices in procurement through competitive bidding and following the criteria for selection of the best bids as outlined in the bid documents. Should the economic and resistance criteria between formulations be similar (that is to say similar cost and similar vector susceptibility) then toxicity of formulations should be considered when making procurement decisions.

Inventory of the insecticides will occur at all points of the freight. The insecticides will first be freighted to Cotonou, where the contractor's logistics team will verify that the quantities supplied tallies with the request made as indicated in the way bill. The insecticides will then be transported directly to the implementing partner (RTI's) rented and managed warehouses in the different districts where the spray operations will concentrate. During geographical reconnaissance and logistics assessments, the need for refurbishments to either the central or district level warehouses to meet United Nations Food and Agriculture Organization (UN/FAO) requirements for pesticide storage and stock control manual will be assessed. The guidelines are available through the following link. *www.fao.org/docrep/V8966E/V8966e00.htm*

Identification of warehouses (Storage Facilities)

The procured pesticides are categorized as hazardous and toxic and can cause potential adverse impacts to human health, animals, and natural environment if not properly stored according to the UN FAO Pesticide Storage and Stock Control Manual/guidelines for storing pesticides. *www.fao.org/docrep/V8966E/V8966e00.*

Before pesticides are procured or transported to the spray areas suitable warehouse(s) must be identified and they should meet the UN FAO standards for pesticide storage. They include among others the need to have the stores;

1. Spacious enough to store pesticides in bulk
2. Located as far as possible from; flood plains, wetlands, markets, schools and residential areas
3. Well ventilated and allowing for air circulation
4. Built of concrete or other solid material
5. Adequate roofing that is not susceptible to leaks
6. Adequately secured
7. At least 2 exit access for emergency purposes

During the logistical assessment the program will identify warehouses in the new districts that meet the above mentioned requirements. They may require minor rehabilitation especially aimed at

enhancing security by fitting new locks and doors, enhancing ventilation and access and using plastic to ensure that the pesticides do not get wet and so that any spill can be contained by the plastic.

The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide

Benin's Ministry of Agriculture is responsible for the control of pesticides in the country including issuing import permits, pesticide registration, transportation and storage. Even though the existing system for pesticide importation, control, distribution and storage is fairly adequate RTI acknowledges the need to continue strengthening capacity of the government of Benin in pesticide control and management. For this reason the Implementing Partner will employ the following pesticide chain management in its Benin IRS programs to ensure control.

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

Supply Chain and Disposal Options

The supply chain of insecticide will be as follows:

Manufacturer (Pesticide)- Implementing Partner will ensure that the required chemical imported meets all the standards and specifications for Pesticide Procurement.

▼

Distributor Storage (Pesticide) Implementing Partner and NMCP will esure that insecticide is distributed to the regions and districts directly from the port of entry.

▼

District Storage (Storekeeper and Supervisor) Pesticide will be stored in warehouses meeting the specifications detailed in the UNFAO Manual for storage and transport of pesticides.

▼

Spray Operators (spray operators must sign out all pesticide received daily and return empty sachets at the end of the day, see *Distribution*).

▼

District Storage (empties).

▼

Destruction of empty sachets and other wastes in a government certified incinerator in Porto Novo.

Health and Safety in Warehouse(s)

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

- Warehouse must be double-padlocked and guarded at all times
- All the storage facilities must have thermometers installed for temperature recording
- Soap and clean water for washing must be available at all times
- Presence of trained storekeepers
- Pesticide stacking position and height in the warehouses must be within the necessary level
- The central warehouses must have at least 2 exit access routes in case of fire outbreak

- Fire extinguishers must be available in the storage facilities and all workers trained on how to use this device.
- Hazard warning notices must be placed in the outside of the store in the local language preferably.
- First-aid kits must be available in all the stores

Insecticide Distribution and Management Process at District and Lower Levels

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

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

Personal Protective Equipment (PPE)

Each spray team will consist of six or seven spray operators. Each spray operator will be provided with the following safety equipment to be used during the spraying in accordance with WHO and FAO specifications:

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

Figure 3. PPE used in the spray operations (overalls and boots)

Figure 4. PPE used in the spray operations (gloves and visors)

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

- 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.
- Particular attention will be paid to washing gloves, as wearing contaminated gloves can be more dangerous than not wearing gloves at all.
- Spray operators will wash before eating at the end of the daily spray operation.
- Eating, drinking and smoking during work will be strictly forbidden at all times during the operation. If spray operators need to drink water in the course of the operation, they must clean their hands thoroughly to avoid any exposure.

Procurement of Other IRS Equipment

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

Spray Nozzles

The program will procure 8002E nozzles for the spray cans which are the standard size recommended by World Health Organization.

Spray Cans

The spray operators who implement IRS use 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 homes and structures. 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.

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

Figure 5 and 6. Spray Pumps used in IRS operations

Pregnancy Tests

All the female spray operators and washers will be subjected to a mandatory pregnancy test before eventually being recruited as spray operators or washers. Pregnant operators must not be included in the spray operations because of the possible effects the pesticides can have to the unborn baby through exposure. Every month, repeat pregnancy testing must be done to the female candidates selected until the operations are concluded. Overall, all the spray operators are subjected to a general physical examination to ensure that they are in good health. Results of pregnancy tests will be available upon request.

2.1.3 Training of Spray Operators

The individuals recruited for IRS campaigns in the new districts as well as the spray operators in the old ones will receive intensive training on the use, operation, calibration and repair of the spray pumps and practical exercises during a 5-day period prior to the beginning of the spraying campaign. They will also receive training to understand proper hygiene, 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 WHO's "Manual for Indoor Residual Spraying" (WHO 2002). Potential spray operators must also pass written and practical tests at the end of training. In this way, spray operators will be prepared to conduct appropriate application of the insecticide.

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

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

IRS spray operators will be trained by instructors in back-to-back sessions for 5 days in the same topics but with more emphasis on practical aspects of IRS.

From the post IRS training test and on the basis of performance during training, graduates of this training will then be assigned to various categories of work including;

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

The above teams will then receive additional specialized training in accordance with the area of assignment having gone successfully through IRS training.

Clinician Training

The clinicians in the health care facilities will be given refresher courses and specific training (April 22nd, 2010) on handling of carbamates exposure incidents that is always likely to occur when using pesticides. Acute exposure can happen through dermal contact which could lead to skin and eye irritation or ingestion which could lead to poisoning.

Driver Training

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

2.1.4 Supervisory Actions during IRS

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

To ensure adequate supervision, the districts will have spray operators organized into teams of five to six spray operators and a team leader to ensure strict supervision during the implementation phase. A team will be under the management of one supervisor. Implementing Partner district teams (in each district) will provide oversight to ensure the goal of providing day-to-day. Supervisors will observe spray teams to ensure spraying occurs according to best practices. Supervisors will travel between spray teams and will observe spray operators and team leaders in the preparation, spray technique, and sprayer and PPE clean up during the IRS campaign, as well as compile all data collected by their respective teams.

Each district will maintain 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.

At the end of each day, spray leaders at each operational site will meet with their manager to discuss the day's events, challenges faced, and recommendations for resolving problems. At the end of each spraying day, IRS partners' coordination meetings will be held with the IRS project, IEC implementers, and the district health team, presided by the District Chief Medical Officer or designate. During these meetings, the partners will assess the progress of spray operations, ensure that the planned work schedule is strictly adhered to, and make recommendations as necessary to the IRS project or IEC implementers.

The IRS district coordinator will hold a weekly meeting with the district chief medical officer and the IRS managers to discuss operational issues and their solutions. At this time, the supervisors and coordinators should review the PPE and performance requirements that ensure environmental protection. The Implementing Partner will maintain records of program performance reports which will be able to demonstrate adherence to WHO technical standards, quality of training and supervision, procurement activities, and environmental compliance. Such reports include the pre- and mid-spray environmental compliance report, reports on core IRS indicators and end-of-spray evaluation reports.

Supervision will be monitored by ensuring Information Education and Communication (IEC) effectiveness on beneficiary populations 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.

Supervision will also require observing each spray group at work, spray group leaders, spray team leaders, and spray operators; and checking spray team habits to ensure best practices for insecticide storage and solid waste management. Since the 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.

2.1.5 Equipment Decontamination

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

Water used to rinse out sprayers at the end of each day must be re-used at the beginning of the next day's work to save water and reduce the potential for pollution from contaminated rinse-water. The best practice for rinse-water re-use is called "progressive rinse." With this rinse method, 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, and so on; the seventh container is empty). During the end-of-day cleanup,

the remnants of a pump charge from the field 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 will be returned empty from the field (the uncommon situations where more insecticide returns is where the distance to the new site makes it difficult for the team to reach to empty their sprayers. Even then, the amount coming back will be less than a full drum). The spray operator will then fill the pump less than half-full with a cup of water from the second container, close and shake the pump, and dump the sprayer water in the third container.

The spray operator will repeat those steps with the fourth and fifth containers, then with the sixth and seventh containers, making sure to rinse the outside of the sprayer only at the sixth container (although not in the sixth container). The following day, spray pumps are filled with liquid from containers in the same sequential order: container one, then container three, then container five. Any remaining liquid in the fifth and seventh containers are quite dilute and will be disposed in a soak pit

Construction of soak pits and Staging areas

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

The overall principle of the soak pit also referred to as a bio-bed is to absorb the toxic chemicals in the pesticide through a filtration process so that the waste water that finally reaches the underground has been purified and no longer contains the chemical components. Soak pits must be located away from sensitive ecosystems like flood plains and wetlands or in areas where the water level is high to avoid underground contamination.

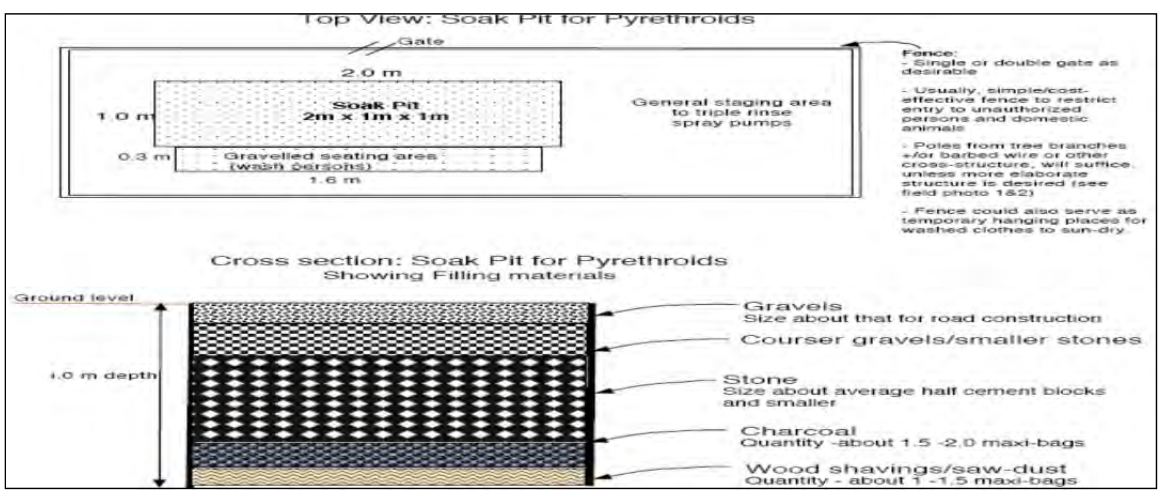

Figure 7. Outline of Soak Pit including design

Figure 8 and 9. Soak pits used in 2008-09 spray rounds in Oueme-Plateau.

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

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

Soak pit sampling

Due to the increased risks of using carbamates, a sub section of the soak pits will be sampled to determine if proper degradation is occurring. A sampling plan will be prepared in consultation with a hydro geologist and reviewed prior to the actual sampling.

2.1.6 IRS Solid Waste Disposal Preferred Option

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

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

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

- 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.
- Ash and slag produced by high-temperature incineration of pesticides are, in principle, considered inert, unless determined otherwise and can be disposed as normal waste, preferably in a dug out pit.

An incinerating facility is already available and located in the regional hospital of Oueme (Porto Novo) and is owned by the government (MOH). This facility has previously been used in the disposal of the IRS wastes from the 2008-2010 spray rounds. This facility satisfies the above mentioned requirements for disposal of empty insecticide sachets and will be used in the incineration of all the accumulated solid wastes materials generated from Atacora. An agreement has been reached between NMCP and the hospital to accept the wastes from Atacora region.

The following IRS waste disposal mechanism were considered but rejected mainly because of the high technological advancement of these methods and the absence of these types of infrastructure inBenin. They include;

Autoclaving

Autoclaving is an efficient wet thermal disinfection process. Typically, autoclaves are used in hospitals for the sterilization of reusable medical equipment. They allow for the treatment of only limited quantities of waste and are therefore commonly used only for highly infectious waste, such as microbial cultures or sharps. It is recommended that all general hospitals, even those with limited resources, be equipped with autoclaves.

The advantages and disadvantages of autoclaving wastes are the same as for other wet thermal processes discussed in the subsequent sections below. The physical requirements for effective steam autoclave treatment are normally different from those required for sterilizing medical supplies. Minimum contact times and temperatures will depend on several factors such as the moisture content of the waste and ease of penetration of the steam.

Research has shown that effective inactivation of all vegetative micro-organisms and most bacterial spores in a small amount of waste (about 5–8kg) requires a 60-minute cycle at 121°C (minimum) and 1 bar (100kPa); this allows for full steam penetration of the waste material. This option was rejected due to the cost implication in terms of investments.

Encapsulation

Disposal of pesticide wastes in municipal landfills is less advisable if it is untreated than if it is pre-treated. One option for pre-treatment is encapsulation, which involves filling containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarters filled with sharps and chemical or pharmaceutical residues. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, cement mortar, or clay material.

After the medium has dried, the containers are sealed and disposed of in landfill sites. This process is relatively cheap, safe, and particularly appropriate for establishments that practice minimal programs

for the disposal of sharps and chemical or pharmaceutical residues. This technology is viable but was rejected due to the cost of this type of investment.

Gas Phase Chemical Reduction

GPCR is a non-incineration technology that uses hydrogen to reduce the contaminants down to their basic components. In the case of chlorinated hydrocarbons (such as PCBs), the basic components are methane and hydrochloric acid. Because hydrogen is used, rather than oxygen (as in incineration processes), there is no risk of forming dioxins and furans during the GPCR reactions. Contaminants are conveyed to the GPCR reactor, which has a hydrogen atmosphere, and is heated to a temperature of about 875°C. The combination of heat, hydrogen and steam breaks down the contaminants into *methane* and *hydrochloric acid*. The *hydrochloric acid* is neutralized with a caustic solution (sodium hydroxide), which creates slightly salty water. This water is held and tested to ensure it is clean, before it is reused in the plant as cooling water, or disposed of. This technology was rejected because it is expensive and unavailable in Benin.

Shipment to other nations

Other countires in Africa all have incinerating facilities capable of disposing carbamates wastes. However, the disposal of wastes through export will require the fulfillment of inter-governmental requirements for the transportation of hazardous wastes as per the Stockholm Convention. This option is thus rejected due to the existing inter-country requirements and overall costs for transboundary shipping.

2.2 Alternative IRS Geographical Sites Considered

The map in **figure 2** illustrates areas suitable for IRS (e.g., high malaria transmission and mosquito density), but this might change over the 5 year project implementation period.

The preferred alternative in 2011 for IRS implementation in terms of geographical scope is the Atacora and it is preferred based on the following considerations;

- The region is in the northern part of Benin and does not experience a year long transmission hence it is a good choice when considering the cost of using a short lasting insecticide (carbamates) since pyrethroids cannot be used in this region due to resistance.

- PMI did not have adequate resources to be able to undertake IRS in regiosn that have year round transmission which would then require spraying twice in a year and for that matter, the perefered location was one that experiences seasonal and not annual transmission and hence Atacora.

- The region has the highest prevalence of malaria as compared to the other regions and hence becomes a suitable choice based on this justification.

- The Atacora region has low use of ITNs and hence provides the need and suitable justification for implementing another intervention in this case IRS.

- In terms of socio-econmic profle, the Atacora region is the least developed and hence requires an intervention of this nature because malaria prevalence in a poor region exercebates poverty. The poor are more vulnerable to the impacts and burden of malaria.

This alternative includes the whole of Benin which is categorized as malaria endemic. It however excludes all the special habitats such as wetlands, marshes, within 30 ft of water bodies, as well as areas of sensitive habitats such as bee keeping areas, organic farming, and national forests, parks and other protected habitats. All methodologies remain the same.

2.3 Insecticide Class (es) Selected and Alternatives Considered

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

To date WHOPES has so far approved the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines and organophosphates. **Figure 10** below highlights the recommended insecticides for IRS in vector control. The proposed action includes the use of carbamates, organophosphates and pyrethroid formulations. In spite of the fact that DDT like pyrethroids exhibit resistance, its use and consideration in this SEA has been rejected and is explained in detail in section 2.3.2 below. The reasons for including pyrethroids in spite of the existing resistance are also explained in the same section.

WHO recommended insecticides for indoor residual spraying against malaria vectors

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

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

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

Figure 10. WHO List of Approved IRS Pesticides

2.3.1 Preferred Insecticide Class

Carbamates will be the insecticide of choice for the 2011 spray campaign in the new region following the completed studies on resistance conducted in October 2010 by Center for Entomological Research of Cotonou (CREC). The results of which are presented in the paragraph below on vector susceptibility to the insecticide as a consideration of insecticide selection. The NMCP considered the following factors in their making their preference namely:

- **Approval by the World Health Organization Pesticide Evaluation Scheme:** Only insecticides approved by WHO see **figure 10** above can be used in IRS. Organophosphates, carbamates, organochlorines and pyrethroids are WHOPES approved classes of pesticides for use in IRS and thus any can be used based on entomological data and host country registration status.

- **Registration for use in the country:** One of the key USAID and WHO requirements when making considerations for including other pesticides for IRS use in a country is the registration status. According to the USAID CFR 216, when dealing with a project that uses pesticides, then a fundamental requirement is the registration status of such pesticides by USEPA, the host government and WHO.

  Pesticide registration in Benin is a function of the Ministry of Agriculture, Livestock and Fisheries (MAEP) under the National Committee for Registration and Control of Pesticide Products (CNAC). See annex section for the complete list of pesticides registered for use in Benin by CNAC.

  Even though bendiocarb was cancelled for use by USEPA (voluntary) and hence not allowed for use in the US, it is approved by WHO and the government of Benin and hence the reason for allowing its use in the PMI program. On the other hand pyrethroids and organophospahets are registered by the Benin government for public health use.

- **Vector susceptibility to the insecticide;-**Vector susceptibility is vital in IRS and hence requires that insecticides with high level of susceptibility are used. CREC undertook a detailed entomological study **(See annex section for complete report)** in the 9 communes in Atacora region in October 2010 to determine the susceptibility of the vector (Anopheles gambie) to 3 different classes of insecticides namely;-Pyrethroids (permethrin and deltamethrin), organochlorine (DDT) and carbamates (bendiocarb). The results of the study show 95-98% vector morbidity to bendiocarb in all the 9 communes from the household sampled. There is an extremely high level of resistance to permethrin and DDT in all the 9 communes with a morbidity of between 0-15% observed during this study. It is against this background study that Atacora region will use a carbamate in the planned spray operations.

a) **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 carbamates are expected to have duration of 3 to 6 months in terms of effectiveness; however, the duration of effectiveness varies under different climatic conditions. Three pyrethroids, known as longer-lasting pyrethroids, can last up to eleven months based on various field trials. For this reason, pyrethroids make the best choice during insecticide selection due to the longer residual effect. However, they have been rejected for use in Benin due to resistance. Technical information on duration of effectiveness on the primary wall surface types will continue to be considered when selecting insecticide class (es).

b) **Pesticide must be appropriate for use on the wall surfaces of the selected location**: Structures in the targeted regions are mostly from mud walls, cement or burnt bricks. Near major towns and commercial centers, cement and brick walled houses are predominant.

Carbamates are known to function well on mud and cement walled houses hence suitability is achieved.

Fig. 11. Houses in Atacora region.

c) **<u>Ecological impact:</u>** The PEA for IVM assessed the toxicity of IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and 'other aquatic' organisms. In summary, Carbamates are similar in toxicity to non target organisms. Apart from propoxur, which has a low toxicity consequence on fisheries and other aquatic organisms, the rest of the insecticides are all highly toxic to the same. 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 result into low-to medium toxicity apart from lambda cyhalothrin and propoxur that are categorized as highly toxic to mammals. In avi-fauna, only propoxur is categorized as highly toxic with the rest categorized as low-medium in toxicity. Full results can be found in Table 19 of the PEA for IVM.

d) **<u>Human health impact:</u>** The PEA for IVM also assessed 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, carbamates pose less non-cancer risks than organophosphates when risks are assessed via any pathway. Full results can be found in tables 7, 8, 9, 10, and 11 in section 5.2.2 If organophosphates 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.

2.3.2 Rejected Insecticide Classes

Even though Organochlorine (DDT) are WHOPES approved and hence need to principally have been considered in this SEA (which is a class level considering all WHOPES approved pesticides) its

consideration in this SEA has been totally rejected due to the environmental sensitivity and public emotions related to the use of this pesticide including that of handling which presents a programmatic as well as a country capacity challenge to use this chemical and thus is not a preferred option.

The other reason for not including DDT in the SEA is due to the fact that most of the countries implementing PMI are now moving away from the use of this chemical following the determination of other longer lasting and environmentally friendly chemicals. In the same vein, there is currently no known source of DDT production (from aWHO perspective) after China which was undertaking the manufacture of the chemical halted further production in 2010.

Lastly, the Economic Community of West African States (ECOWAS) a regional economic block in that part of Africa has halted the use of DDT in its member states owing to the economic implication its use portends in terms of export of agricultural products to Europe.

Furthermore, likewise to pyrethroids, the predominant malaria vector, *Anopheles gambiae*, has developed high resistance to DDT which was extensively used in cotton production hence contributing to resistance. In Benin, it was reported that DDT resistance in *An. gambiae sensu lato (s.l.)* was also the result of massive use of DDT house spraying applications in several districts of the country during the WHO malaria eradication campaign in the 1950s.

Pyrethroids on the other hand have not been entirely rejected and could be considered for use in future for as long as the current resistance is reversed. Pyrethroids are cheap as compared to carbamates, organophosphates and DDT. Pyrethroids also have a longer residual effect and hence suitable for areas with all year long transmission. Currently the use of pyrethroids is rejected due to entomological findings that indicate a high level of resistance a situation that is likely to change and can only be justified by routine entomological studies. In the event that there is a reversal in the resistance to pyrethroids, then the use of this WHOPES approved chemical will be considered because of its numerous comparative advantages.

2.3.3 No Project Alternative

Indoor Residual Spraying is a critical intervention among the other interventions in the control of the spread of malaria. This is more so due to the fact that IRS is targeted at attacking the malaria vector and preventing or reducing transmission hence minimizing cases of incidences that would then be mitigated through curative approach. IRS is a preventive approach to reduce the incidence of succumbing to the malaria parasite because it reduces the vector population drastically hence bringing down the incidences and cases of malaria.

Malaria is a leading cause of morbidity and mortality among children under five in Benin. The Benin HMIS data also suggest a high burden of morbidity from anemia, much of which is likely caused by malaria. The Benin 2006 Demographic and Health Survey (DHS) found that among children 6–59 months old, 78% had anemia (25% mild, 46% moderate, and 8% severe).

As described in the paragraph above, a no project scenario/alternative will mean that the status quo is maintained and the malaria situation will remain the same. In effect the households targeted under the IRS program will not have the benefit of IRS as an intervention. This way the no action alternative does not meet the overall goal of the President's Malaria Initiative which is to reduce the cases of malaria transmission, malaria related mortality in Africa and seeks to reduce malaria

mortality by 50% in up to 15 countries (total population:175 million) in sub-Saharan Africa in five years.

3.0 AFFECTED ENVIRONMENT

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

The NMCP projects that in the next 5 years, IRS intervention with support from USAID and other partners like Global Fund is likely to expand and spread all over the country. Benin is categorized 100% endemic in terms of malaria prevalence hence the need to adopt national blanket coverage approach.

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

3.1 Overview of Benin

3.2.1 Position and Size

Benin is a slim, rectangular country situated in West Africa. Benin has a narrow 100-kilometer (62-mile) coastline along the Bight of Benin, in the Atlantic Ocean. The country is bordered to the west by Nigeria, to the north by Niger and Burkina Faso, and to the east by Togo. Benin has a land area of 112,622 square kilometers (42,985 square miles), making it slightly smaller than the state of Pennsylvania. Both the capital, Porto-Novo, and Cotonou, the largest city, are located on the coast in the southeast of the country.

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3.2.2 Administrative and Political Units

Administratively, Benin is divided into 12 departments (average 650,000 inhabitants per department), 77 communes and three autonomous areas (Cotonou, Porto Novo and Parakou), 546 *arrondissements*, and 3,747 villages.

Table 4. Administrative organisations in Benin

Cadres territoriaux	Nombre
Départements	12
Communes	77
Arrondissements	546
Villages/quartiers	3747

Source : Annuaire des statistiques sanitaires 2009

Table 5. Communes in Benin by Region (Département)

Département (Nombre de commune)	Communes (nombre d'arrondissements)
Alibori (6)	Banikoara (10), Gogounou(6), Kandi(10), Karimama(5), Malanville(5), Ségbana(5)
Atacora (9)	Boukoumbé (7), Cobly(4), Kérou(4), Kouandé(6), Matéri(6), Natitingou(9), Péhunco(3),Tanguiéta(5), Toucountouna(3)
Atlantique (8)	Abomey-Calavi(9), Allada(12), Kpomassè(9), Ouidah(10), So-Ava(7), Toffo(10), Tori Bossito(6), Zê(11)
Borgou (8)	Bembérèkè (5), Kalalé(6), N'Dali(5), Nikki(7), Parakou(3), Pèrèrè(6), Sinendé(4), Tchaourou(7)
Collines (6)	Bantè(9), Dassa-Zoumè(10), Glazoué(10), Ouèssè(9), Savalou(14), Savè(8)
Couffo (6)	Aplahoué(7), Djakotomey(10), Dogbo(7), Klouékanmey(8), Lalo(11), Toviklin(7)
Donga (4)	Bassila(4), Copargo(4), Djougou(12), Ouaké(6)
Littoral (1)	Cotonou (13)
Mono (6)	Athiémè(5), Bopa(7), Comé(5), Grand-Popo(7), Houéyogbé(6), Lokossa(5)
Ouémé (9)	Adjarra(6), Adjohoun(8), Aguégué(3), Akpro-Missérété(5), Avrankou(7), Bonou(5), Dangbo(7), Porto-Novo(5), Sèmè-Podji(6)
Plateau (5)	Adja-Ouèrè(6), Ifangni(6), Kétou(6), Pobè(5), Sakété(6)
Zou (9)	Abomey (7), Agbangnizoun (10), Bohicon(10), Covè(8), Djidja(12), Ouinhi(4), Zagnanado, Za-Kpota(8), Zogbodomey(11)

Source : Annuaire des statistiques sanitaires 2009

Population

In 2010, Benin's population is estimated to be nine million, of which approximately 18% are children under-five and 6% are pregnant women2. In 2006, more than one third of the country's population was living in poverty3. In 2008, Benin ranked 161 out of 179 countries4 on the Human Development Index and in 2009, had a gross national income per capita purchasing power parity of only $1,510 USD. Life expectancy is 54 years for men and 55 years for women. Educational levels are low – six out of every ten women and four out of every ten men have had no schooling, and the literacy rate is 28% for women and 55% for men7. For the period from 2001–2006, the infant mortality rate was 67 per 1,000 live births, the under-five mortality rate was 125 per 1,000 live births, and the maternal mortality ratio is 397 per 100,000 live births (with estimates taking into account issues of undercounting running as high as 850).

Figure 12. Map of Benin showing administrative regions and districts.

3.3 Physical Environment

Climate

Benin is characterized by unusually dry conditions. This is due primarily to two very important factors. First, the situation of the coast which is rather well protected from the western winds; second, the Atacora Barrier in the West and North West which decreases the amount of rainfall.

There are two climatic zones in Benin, a southern and a northern. Southern has an equatorial type of climate which has 2 seasons – wet and dry; each season occurs twice in a year. The hot and dry seasons occurs from January to April and during the month of August. The rainy seasons occur from May to July then September to December. The average monthly temperature in southern Benin ranges from 20° to 34° Celsius. The rain amount increases rapidly in east side. Sea breezes temper the climate during much of the year. In northern climatic zone the wet and dry seasons occurs only once. It has the most extreme temperature. Hot and dry season is between November and June; cooler and very wet weather between July and October.

June is the wettest month in all districts. The area around Cotonou and the coast is broadly hot and humid. In the dry season the harmattan (hot dry wind that blows from the northeast or east of Sahara) blows from December to March. On average amount about 890 mm (about 35 in) of rain falls yearly in northern Benin, mainly from May to September.

Topography, Geology and Soils

Benin can be divided into five natural regions: A coastal area, low, sandy and about 2 to 5 kilometers wide, bounded by lagoons; A plateau zone called "La terre de barre" made of iron clay cut with marshy dips; A silica clayey plateau with wooded savannah extending North of Abomey to the foothills of the Atacora hills; - A hilly region in the Northwest, the Atacora, with elevation ranging from 500 to 800 metres and constituting the water reservoir for Benin and Niger Republics.

Soils

A large variety of soils can be found in Benin. Fersialitic soils with high gravel contents are dominant on the crystalline basement, while ferralitic and hydromorphic soils prevail in the sedimentary basins in the south of Benin. In general, small scale variability of the soils is very high, and many soil types are associated with other soil types. Five major sol types can be identified in Benin and they include;-granitto gneissiques; ferralitic soils; hydromorphic soils;vertic green soils: and rough undeveloped mineral soils.

Soil distribution in Benin

A close look at the soil map for Benin reveals that ferallitic and hydromorphic soils dominate in the southern part. The crystalline basement in Central Benin is mainly characterized by Acrisols and Lixisols (sols ferrugineux lessivés). In the Atacora Mountains in north-west Benin, shallow soils (Lithosols, sols peu evolués lithiques) are widespread.

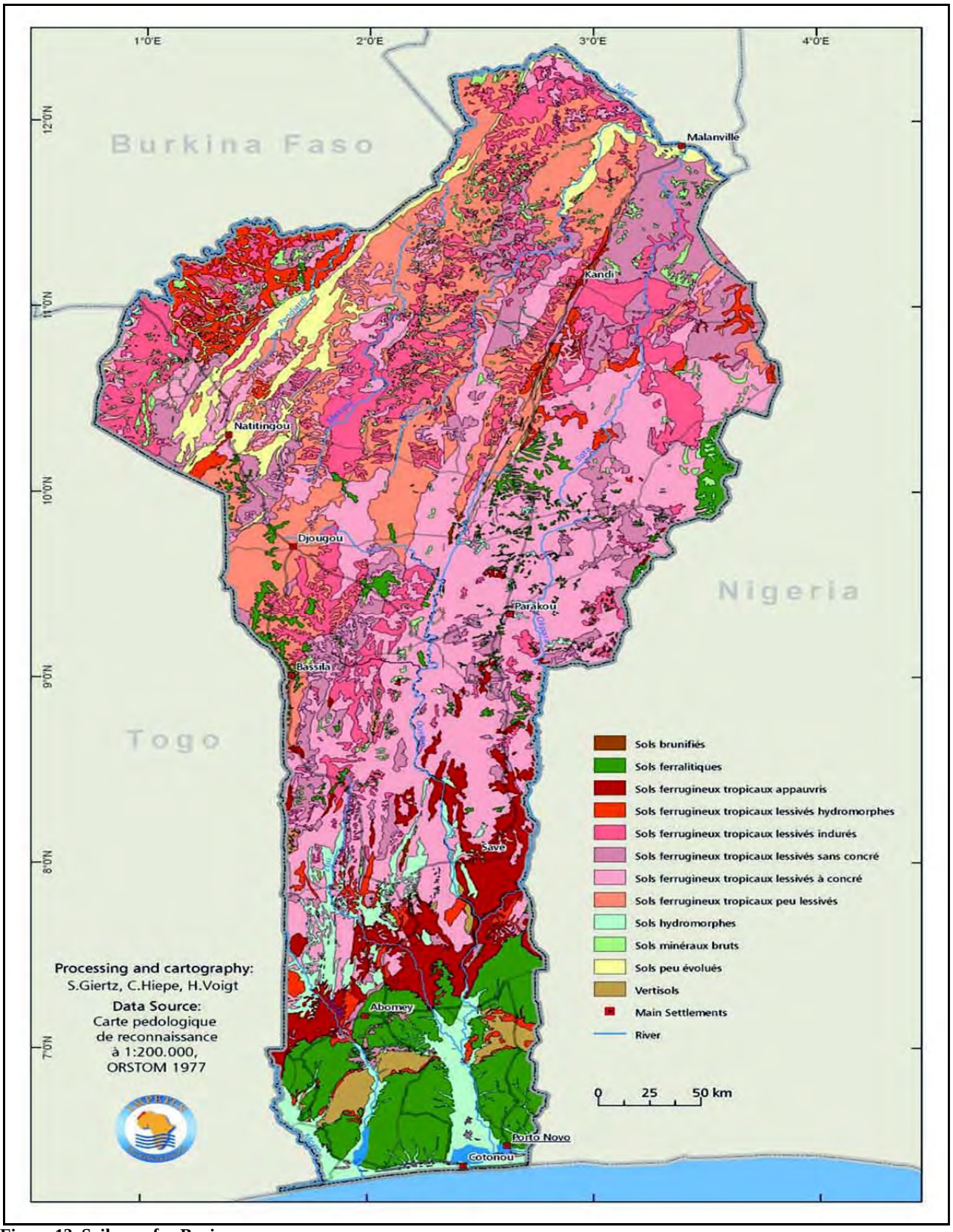


Figure 13. Soil map for Benin

Hydrology

Benin has a diverse and dense network of surface and underground water resources and basins that form the hydrological network described in detail in the section below. Four large sets of water basins exist in Benin and include: the Niger basin, hydrographic basins of the Volta, coastal watershed which includes side west all Mono-Couffo side is all Ouémé-Yéwa. The entire coastal watershed empties into a lagoon system that connects the two Western sets and is.

It should be noted that as a mitigation measure, IRS activities will not be conducted within 30 ft from water bodies and in habitats classified as Ramsar sites, absolutely no IRS will be conducted.

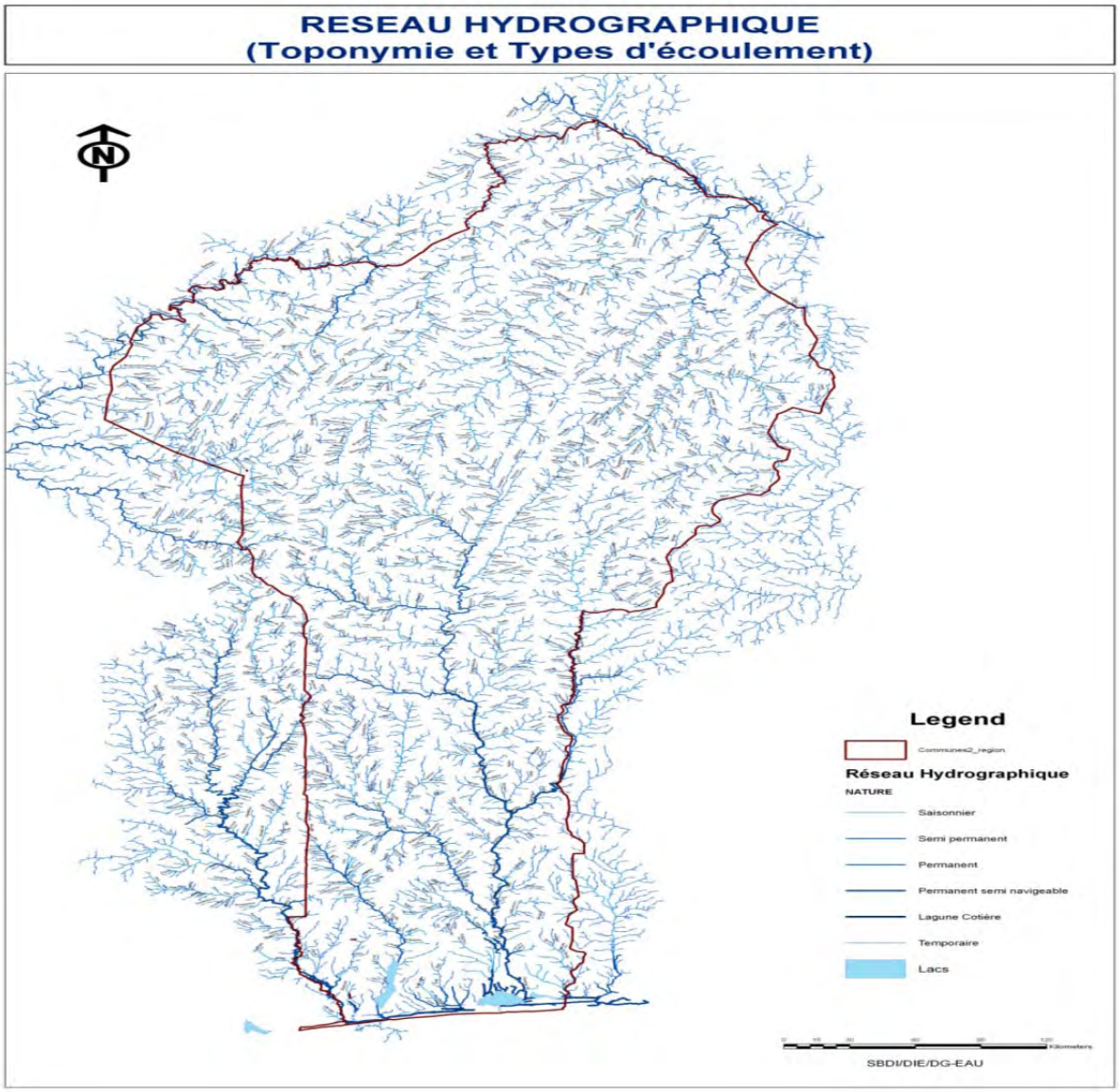


Figure 14 : Hydrological network

Le réseau hydrographique est structuré en grands ensembles hydrographiques qui sont des ensembles sous-régionaux. La figure 2 présente ces grands ensembles.

Figure 3 Les grands ensembles hydrographiques

12

Figure 15. Principal hydrological network

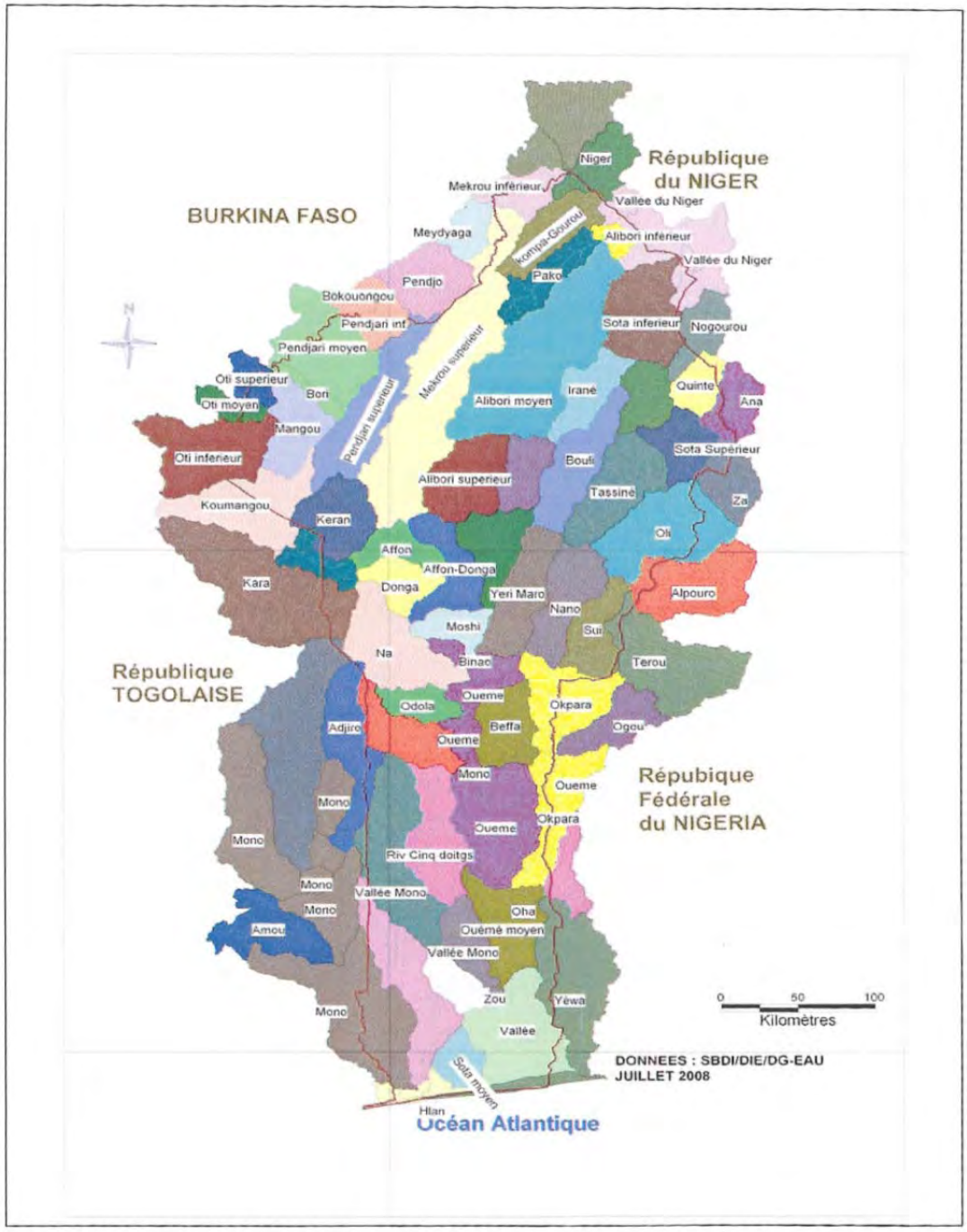


Figure 5 : Les Sous Bassins versants du Bénin

15

Figure 16. Sub watersheds of Benin

Ouémé River

The Ouémé River is Bénin's longest fluvial basin (length: 510 km, surface: 50,000 km2). It springs out of the Tanéka hills (about 9°51 NS) in the Atacora Mountains and flows into the Atlantic Ocean by the Cotonou channel. Its two important tributaries are the Zou River (150 km) and the Okpara River (200 km). The Ouémé River drains the largest part of Bénin's cotton belt. The upper basin of the Ouémé River has a sub-humid tropical climate characterized by one humid season, with 5 months of rainfall (from April–May to September–October) and one dry season per year (Bormann and Diekkrüger, 2004). Average annual rainfall amounts range between 1180 mm (Kpassa) and 1380 mm (Donga). The lower basin is characterized by a sub-equatorial climate with 6 to 8 months of rain per year, divided over two rainy seasons per year. The amount of rainfall in the lower basin is rather variable from one year to another (Anthony et al., 2002).

The Ouémé basin, with an area of 50,000 km2, is the largest river catchment area in the Republic of Bénin. It drains part of the northern, the central and the southern regions of the country (Anthony et al., 2002). The Ouémé River provides drinking water, water for domestic use and irrigation water. It also is an important means of transportation for people of the area. It is used for commercial transport and business between the neighbouring country Nigeria and the Republic of Bénin. Biodiversity of the Ouémé River is remarkably high, with a large diversity of fish, molluscs, shellfishes, insects, amphibians, reptiles and birds. The Ouémé River contains more than 120 fish species (Lalèyè et al., 2004), of which approx. 90% are used for human consumption.

The Oueme Valley is composed of three morphological units: the Allada plateau and the Sakete-Pobe plateau to the East and the flood plain which lies between them (Dangbo and Adjohoun are within this zone). To the south of the Oueme Valley lies the delta of the Oueme, which then lets out into the lagoon of Porto Novo and the Nokoue Lake, along with its mangroves and seasonal streams. This delta is an amphibic landscape, and very fertile for agricultural purposes. All of the communes selected for the IRS are divided between the plateau and the river valley, and it is evident that this River is the economic lifeblood of this region.

The Lake Nokoue, which is South of the Oueme Valley, is connected to the sea through the Cotonou Channel (Cotonou lagoon) which separates the eastern and western parts of the town. Otherwise, the Lake Nokoue is surrounded by a system of lagoons and shallows to which it was initially connected, and which presently are shut off from one another due to the urban development. The fluctuations of the lagoon water levels are related not only to the rainfalls but also to the groundwater dynamics depending on the hydraulic continuity existing among them.

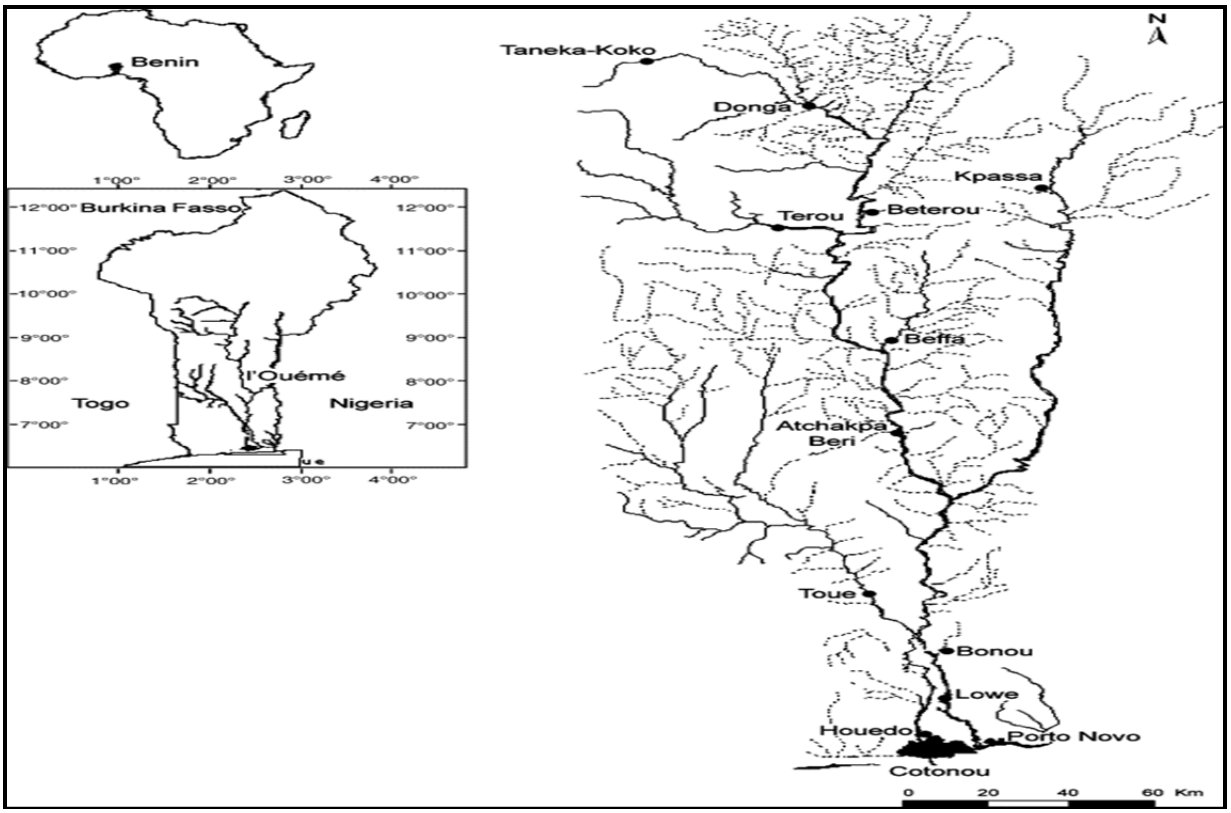


Figure 17. Map of the Ouémé River catchment and its position in the Republic of Bénin and the African Continent (Source: Lalèyè et al., 2004)

Oti River in Atacora region

The Oti River begins in the Atakora hills of Benin at an altitude of about 600 m and flows through Togo and Ghana. In Benin, the Oti River is referred to as the Pendjari River. Tributaries include the Koumongou, Kéran, Kara, Mô, Kpanlé, Wawa, Ménou, and Danyi Rivers. Due to the regularization by the Kompienga Dam in Burkina Faso, the Oti River has a permanent flow with an annual average flow of 100 to 300 m3/s, and can reach more than 500 m3/s. Virtually all the tributaries stop flowing during the dry season, however, and their annual average flows are only in the range of 5 m3/s. In Ghana, the Black Volta, the White Volta and the Oti join the main Volta at Volta Lake, which was created by the Akosombo Dam.

The Niger River

The Niger River is shared by nine countries in West and Central Africa— Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, and Nigeria.

The Niger River's hydrologically active basin covers a surface area of nearly 1.5 million square kilometers shared among the nine countries according to the following approximate percentages: Benin (2.5 percent), Burkina Faso (3.9 percent), Cameroon (4.4 percent), Chad (1.0 percent), Côte d'Ivoire (1.2 percent), Guinea (4.6 percent), Mali (30.3 percent), Niger (23.8 percent), and Nigeria (28.3 percent).

The catchments of several right-bank tributaries of the Middle Niger River are situated in northern Benin, occupying 2.5 percent of the total area of the Basin (37,500 square kilometers). Benin is densely populated, with 65 inhabitants per square kilometer, on average. More than 1.95 million

people live in the Niger Basin in Benin. The land within the Basin is used primarily for grazing and livestock, although there are areas, once used for groundnut farming, that are now used for cotton farming. Cotton farming in this area now contributes one-third of the national production. The Mekrou River, a tributary of the Niger, crosses the "W" International Park, an extensive protected sanctuary for flora and fauna, shared by Benin, Burkina Faso, and Niger.

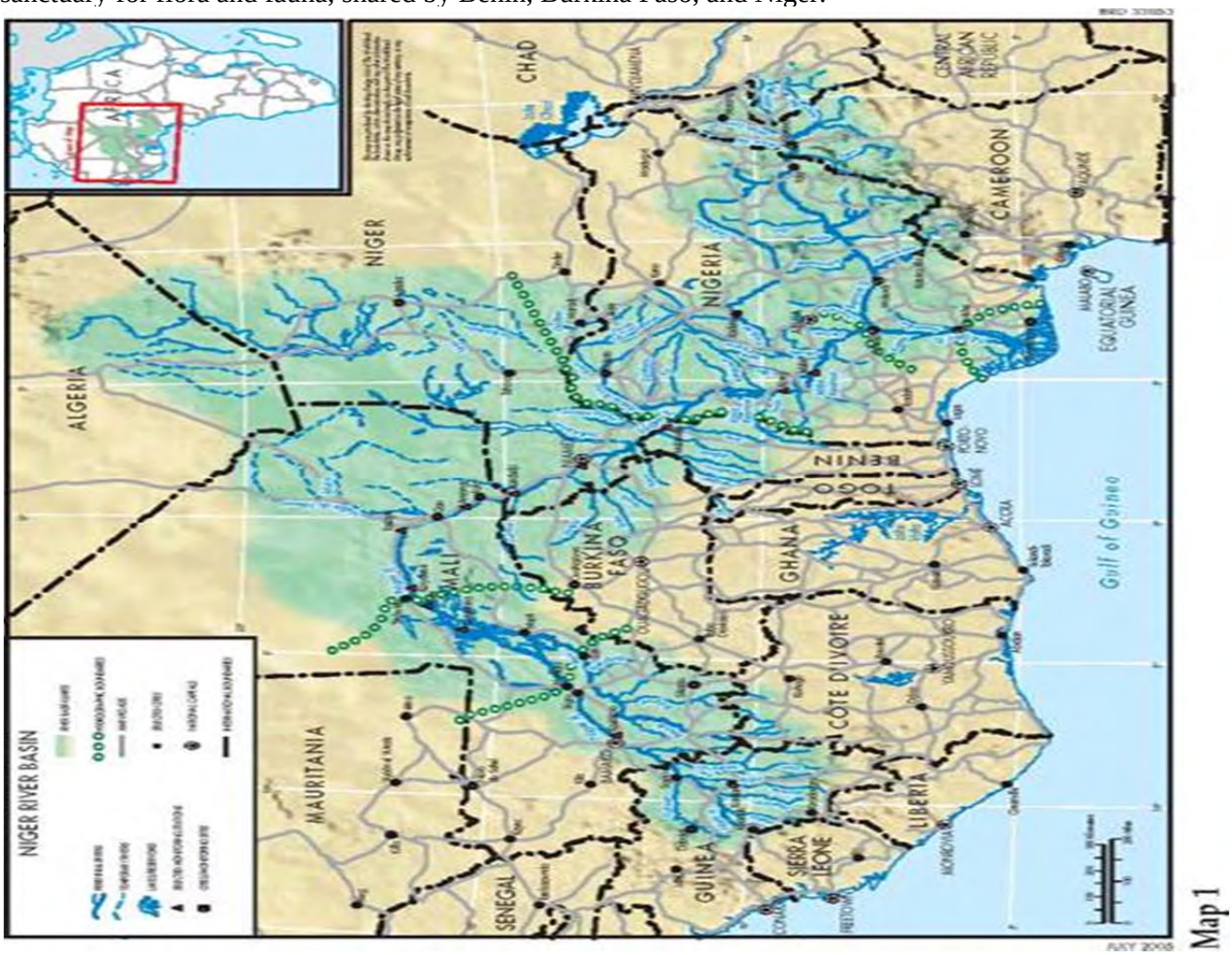


Figure 18. Map of Niger River Basin traverses Benin

Volta River Basin

The basin is shared by six riparian countries, of which Burkina Faso (46%) and Ghana (39%) share the major portion, and the remaining 15% are shared by Togo (6%), Benin (4%), Mali (3%), and Cote d'Ivoire (2%) (Barry et al. 2006). The Volta River Basin is the 9th largest in sub-Saharan Africa with an estimated area of 400,000 km2. The Volta basin stretches from approximately latitude 5 0 45' N in Ghana to 14 0N in Mali. The widest stretch is from approximately longitude 50W to 20E along latitude 110 N, but the basin becomes narrower towards the coast of the Gulf of Guinea. The Volta basin is spread over six West African countries.

Figure 19. Map of Volta River Basin traverses Benin

3.3.1 Biological Environment

Benin has two main national parks (protected) in the entire country and the flora, fauna and birdlife in these habitats are described below. IRS operations will not be undertaken in areas where national parks or protected areas are existing unless buffer zones are created or a physical distance of over 30 metres is considered when undertaking IRS in such environments.

Pendjari National Park

The **Pendjari National Park** (French: *Parc National de la Pandjari*) was initially classified as a National Forest and partial Wildlife Reserve on December 13, 1954. In May of 1961 it became a **National Park,** acquiring the status of Biosphere Reserve in June 1986. It was listed as a Ramsar Site in February 2007. The names *Pendjari National Park* and *Pendjari Biosphere Reserve* are used interchangeably.

The Park lies in northwestern Benin, against the international frontier with Burkina Faso. It is part of the largest group of protected areas in West Africa, the complex of Park W-Arli-Pendjari. This complex straddles the borders of Niger, Benin and Burkina Faso. The Park W-Arli-Pendjari Complex covers a total area of 19,305 square miles (50,000 sq km), of which 4,633 sq mi (12,000 sq km) is in Benin. Pendjari National Park covers approximately one tenth of the complex (1930 sq mi or 5000 sq km).

Named for the Pendjari River, the national park is known for its wildlife, including monkeys, hippopotami, and a prominence of birds. There are also large stocks of game animals including elephants, lions, leopards, buffalo and various antelopes.

The quartzite cliffs of the Atacora Hills form the southeastern boundary of the park. The Pendjari River bounds the park on three sides and forms the international border with Burkina Faso along the park's northern edge. The hills and cliffs of the Atacora range make the northwest one the most scenic areas of Benin. They provide a wonderful backdrop to the Park, which, in its isolation, remains one of the most interesting in West Africa. The rocky cliffs of the area are sparsely wooded with *Burkea africana*, *Detarium microcarpum*, *Lannea acida*, *Sterculia setigera* and *Combretum ghasalense*. On the deep soils of some of the summits and the Atakora escarpment one finds a greater variety of plant species with *Isoberlina doka* and *Afzelia africana*. The Pendjari River has an impressive gallery forest. The park includes both Sudan and Northern Guinea savannas, with areas of grassland dominated by *Acacia sieberiana* and *Mitragyna inermis* or *Terminalia macropter*.

Figure 20. Photo of Pendjari National Park

Avifauna

The Park is renowned for its abundance of birds with some 300 different species in total. Pallid Harrier *(Circus macrourus)* and Lesser Kestrel *(Falco naumanni)* are occasionally recorded and there are a few isolated records for Lappet-faced Vulture *(Torgos tracheliotus)*. Fox Kestrel *(Falco alopex)* is not uncommon, while the African Swallow-tailed Kite *(Chelictinia riocourii)* is a not uncommon dry season visitor. The Booted Eagle *(Hieraaetus pennatus)* has also been recorded here. BirdLife notes that "the Pendjari is notable for large conspicuous species such as African Openbill Stork *(Anastomus lamelligerus)*, Abdim's Stork *(Ciconia abdimii)*, Saddle-billed Stork *(Ephippiorhynchus senegalensis)*, and seasonally, flocks of up to 60 European White Stork *(Ciconia ciconia)*. The African Fish Eagle *(Haliaeetus vocifer)* and Pel's Fishing-owl *(Scotopelia peli)* can also be found."

Among the more notable species recorded are Pied-winged Swallow *(Hirundo leucosoma)*, White-crowned Robin-chat *(Cossypha albicapillus)*, Botta's Wheatear *(Oenanthe bottae)*, Familiar Chat *(Cercomela familiaris)*, White-fronted Black-chat *(Myrmecocichla albifrons)*, Mocking Cliff-chat *(Thamnolaea cinnamomeiventris)*, Common Rock Thrush *(Monticola saxitilis)*, Senegal Eremomela *(Eremomela pusilla)*, Blackcap Babbler *(Turdoides reinwardtii)*, Red-winged Pytilia *(Pytilia phoenicoptera)*, Black-rumped Waxbill *(Estrilda troglodytes)*, Bush Petronia *(Petronia dentata)* and Togo Paradise-whydah *(Vidua togoensis)*.

Grey Tit-flycatcher *(Myioparus plumbeus)* has been recorded as well as several other species of the undergrowth. White-throated Greenbul *(Phyllastrephus albigularis)* has been recorded at Tanguiéta and the White-throated Francolin *(Francolinus albogularis)*, a rare resident, has been spotted in farmland south of Natitingou. South of the park there is a large semi-protected zone known in French as *La zone cygnetique de la Pendjari* where a number of other species have been spotted.

Figure 21. African Openbill Stork, a common sight in the Park and Bearded Barbet, introduced in 1998.

Figure 22. Violet Turaco, introduced in 1998 and Yellow-billed Shrike, introduced in 1998.

W National Park

The **W National Park** (French: *"W" du Niger*) is a major national park in Niger around a meander in the Niger River shaped like a "W," hence its name. While the greatest area of the park is in Niger it also extends through the extreme northern section of Benin (1,938 sq mi or 5,020 sq km) and into Burkina Faso (733 sq mi or 1,901 sq km). The area was declared a faunal reserve and state forest in 1953 and designated a national park on August 4, 1954. In 1996 an 850 square mile section of the park lying within Niger, between Sudan and Guinea Savannas, was named a UNESCO World Heritage Site.

W National Park contains important areas of high biodiversity and significant natural habitats for threatened species. It is home to major populations of hoofed mammals (ungulates) and wild plant species, valuable to both conservation and genetic research. The wetland area of the Park is of international importance for the conservation of birds as a Ramsar site.

The considerable hydrological resources found in W National Park has earned its listing under the Ramsar Convention, which provides for international cooperation for the conservation and wise use of wetlands and their resources.

The rugged landscape consists of gallery forests, rivers, ponds, meadows and floodplains, with widespread shrub savanna, crucial to the populations of African Elephant and the Cheetah. Other animal populations include aardvarks, antelopes, baboons, buffalo, caracal, crocodiles, hippopotamuses, leopards, lions, monkeys serval and warthogs. There are many species of snakes, including pythons and puff adders. Significant numbers of water birds have been recorded. Birdlife includes guinea fowl, wild duck, and partridge, as well as many tropical species.

Sensitive Ecosystem-Valley of Oume River

The valley of the Oueme River is a massive wetland which is internationally protected by the Ramsar Convention, classifying it as a highly sensitive area with endemic fauna and flora.

Basse Vallée de l'Ouémé, Lagune de Porto-Novo, Lac Nokoué (91,600 hectares; 06°39'N, 002°32'E) covers the coastal area between Cotonou and the capital Porto Novo at the mouth of the Ouémé River, with varied ecosystems comprising swamp forest (Mitragyna inermis, Raphia hookeri) and periodically inundated forest (Berlinia grandiflora, Dalium guineense); flooded prairies of Paspalum vaginatum and Typha australis, and floating vegetation dominated by water hyacinth (Eichhornia crassipes) and water lettuce (Pistia stratiotes); and mangrove plantations (Rhizophora racemosa). Some 78 species of fish have been identified and 168 species of birds, as well as Sitatunga, several pythons, and terrestrial and marine tortoises. Human uses of these water bodies include fishing by 24,000 professional and 13,000 seasonal fisher people, bringing employment to some 200,000 people in total; as well as agricultural production, in chiefly of manioc, maize, sugar cane, sweet potatoes, and market gardening. Palm trees (Raphia hookeri) are the object of strong economic activities in construction, palm wine, etc. (Division of Early Warning and Assessment, Water Unit, UNEP 2006)

3.3.2 Socioeconomic Environment

Agriculture and Fisheries

The economy of Benin is heavily dependent on the agricultural sector, notably cotton, as well as on re-export trade, mainly to Nigeria. Cotton remains the major export commodity. It generally represents 70% of total exports, although its share of exports declined from 75% in 1996 to 47% in 2006 and further to 40% in 2008. Re-exports represent an average of 7% of GDP. The economy

remains poorly diversified and vulnerable to external shocks, as witnessed by a significant deceleration of growth to 2.7% in 2009, from 4.6% in 2007 and 5% in 2008. This vulnerability underscores the need to promote economic diversification (including exports) as recommended in the 2009 Country Economic Memorandum for Benin.

Benin produces maize, sorghum, millet, rice, cassava, yams and beans, and palm oil, cashews and peanuts as cash crops. But much is consumed locally, including what is produced by the fishing and livestock sectors. So Benin is still is a net importer of food products from abroad.

Fisheries

Families of fish that are exploited in the different basisn and rivers in Benin include Cichlidae, Centropomidae, Mochokidae, Clariidae, Bagridae, Clatoteidae, Characidae, Mormyridae, and Osteoglossidae. The fish resources are being modified and threatened by overexploitation in certain areas due to the degradation of waterways, however.

Bee Keeping

Apiculture is not a widely practiced economic activity in Benin but mostly undertaken using the traditional methods with modern bee keeping methods gaining slow growth especially through the promotion of this activity as an income generating activity by nongovernmental organizations.

4.0 Environmental Regulations

This section of the SEA outlines and reviews the existing legislations, policies and institutions and identifies requirements as well as gaps and conflicts of the relevant legal and institutional arrangements that would hinder or guide the development of the project in line with the national laws applicable to the IRS program.

Environmental protection is under the Ministry of Environment and Protection of Nature which has instituted the Benin Environmental Agency (ABE) responsible for the technical management of environmental issues including EIA.

Apart from the Government of Benin Environmental Act (*Loi- Cadre sur l'Environnement en Republique du Benin*) (no. 98-030 of 1999) and the *Guide General de Realisation d'une Etude d'Impact sur l'Environnement* (from February 2001), which gives the format and requirements for the Environmental Impact Assessment required by the Beninese Environmental Agency (ABE), there are 6 other regulations that need to be considered and respected for the implementation of the IRS program. These include:

4.1 Law Number 91-004, as of February 11th 1991.

The Ministry of Agriculture is in charge of all chemicals and substances that are used in pest control, therefore it is through the Ministry of Agriculture, that the registration of Bendiocarb and other pesticides will be approved.

Article 1: "The organization of plant pharmaceutical products authorization and their control in importing, marketing and their use in order to provide agriculture with quality products adapted both technically and economically, to ensure the efficient use and with non negative impact on the end user, the consumer and the environment."Article 2: "Plant Health Protection is the purview of the Minister in charge of Agriculture."

Decree No 92-258 of September 8th 1992

Establishing the application modalities of the law No 91-004 on February 11th 1991 on Phytosanitary Regulation. Furthermore, in addition to being responsible for the registration of pesticides in Benin, the Ministry of Agriculture provides for the Plant Protection Service (Service de Protection de Vegetaux) who's role is to ensure surveillance of the pesticide's use, transport, and disposal, as outlined in the excerpts below:

Article 1: In application of the article 2 of the law 91-004 of February 1991, the Plant Protection Service within the Directorate of Agriculture of the Ministry of Rural Development is charged with phytosanitary protection across the territory of the Republic of Benin.

Decree No 2001-235 from 12th of July 2001

This decree touches on the organization of the procedures of the Environmental Impact Assessment for the Government of Benin. This decree outlines the projects in Benin that require a "simple" EIA, and the projects that require an "In Depth" EIA. In the context of PMI IRS in Benin, IRS will require an "In Depth" EIA, in areas where the program lie within wetlands or biodiversity of international significance like RAMSAR sites.

Article 3: Projects that are subject to an "In Depth" EIA are projects that are of great importance, outlined in Annex 1 and those that are described in Article 2, but are taking place in ecologically sensitive zones that are described in Annex 2.

Article 5: All promoters of the project are subject to the approval of the Benin Environmental Agency (Agence Beninoise pour l'Environnement) and their terms of reference of the Environmental Impact Assessment relative to the project.

Law no 98-004-On Workers Conduct from January 27th 1998.

All employees engaged in spraying activities will undergo rigorous training and will have proper WHO approved equipment assigned to them. To minimize risk, all personnel will be managed and supervised such that risks are minimized as much as possible and that they follow safety guidelines approved by the WHO, which will be outlined in the IEC. The following Beninese Workers conduct and safety law outlines that there must be security and heads of establishment. In the context of RTI IRS activities, these requirements will be fulfilled and furthermore, the PNLP and Ministries of Health will assure that all spray teams and personnel have proper access to medication in the event of pesticide exposure.

Environmental Law in Benin LAW No 98-030 of the 12th of February 1999
Chapter 3: Dangerous Chemical Substances

While RTI will assist the Beninese government to implement this IRS program, it is the responsibility of the Beninese Environmental Agency to control and to monitor the use of the chosen pesticide. *Article 83: The Beninese Environmental Agency is responsible for the control and surveillance of the purchase, transport, use and disposal of dangerous chemical substances.*

It is the obligation of those parties using these substances to declare its use to the Agency. Article 84: By law, there is a list of permittable chemicals and for what their end use is, applicable to the Beninese Territory. Article 85: If the use and purchase of these chemicals is not declared, the Agency maintains the right to seize these products.

5.0 ENVIRONMENTAL CONSEQUENCES

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

5.1 Potential Positive Effects

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

5.1.1 Indirect Effects

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

5.2 Potential Adverse Impacts

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

Indirect Effects

Through this action, USAID will be providing NMCP with backpack compression sprayers, unused chemicals, used boots. Upon completion of this program, USAID will no longer supervise the use of this capital which will be handed over to NMCP. This action also temporarily, and in a minor way increases the total pesticide load on the environment. However, carbamates breakdown quickly in sunlight and water and the amount used in IRS is miniscule compared to other sources of pesticide, therefore the pesticide load increase is expected to be negligible.

5.2.1 Contamination of surface water courses and underground water

Spills in water bodies (surface) are a key concern in IRS because it could not only lead to contamination of water routinely used for domestic purposes but carbamates are categorized as toxic to fish and other aquatic organisms. Thus the primary concern for IRS would be the possible release of the insecticides into the existing water bodies from accidental spills during the transportation of the pesticides, application of insecticides to walls, and clean-up of IRS equipment. Contamination of underground water resources is possible during the disposal of rinse water following daily progressive rinse. However, the impacts of this risk are likely to be insignificant because carbamates disintegrate/degrade very rapidly when exposed to sunlight-(soil binding).

5.2.2 Impacts to Birds, Fishes, and other organisms from pesticides:

Table 6 below illustrates the degree of toxicity of the four World Health Organization (WHO) approved pesticide classes to birdlife, aquatic life and insects especially bees including the degree of persistence and bio-accumulation.

Table 6. Pesticide Toxicity

IRS Insecticide	Mammal	Bird	Fish	Other Aquatic	Bee	Persistence	Bioaccumulate
Alpha-cypermethrin							
Bendiocarb							
Bifenthrin							
Cyfluthrin							
DDT		2					
Deltamethrin							
Etofenprox							
Fenitrothion							
Lambda-cyhalothrin							
Malathion							
Pirimiphos-methyl							
Propoxur							

Source: IVM PEA

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

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

Summary of Toxicity of pesticides to Avifauna, Aquatic life, mammals and insects by Class;-

Carbamates:

- Carbamates are highly toxic to bees.
- 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, birds and other aquatic organisms.
- In general both carbamates have low to medium indications for persistency in the environment and bioaccumulation in organisms

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

Organophosphates

- Organophosphates have different characteristics and impacts on different organisms depending on the type of insecticide.
- Fenitrothion has low toxicity on mammals and fish and is not persistent in the environment. However it is highly toxic to bees, birds and other aquatic organisms, 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 fish and other aquatic organism and with very low potential to bio-accumulate in organisms and persist in the environment. Its impact on mammals and birds is low to medium toxicity.
- Pirimiphos-methyl is highly toxic to fish and other aquatic organisms and has a high potential to persist in the environment. It has low to medium toxic effects on mammals and bees. It does not bio-accumulate in organisms.

Mitigation Measures

In order to minimize contamination of surface water bodies, spraying will be avoided in households that are within 30 meters from the natural water bodies mentioned in section 3. During the detailed logistical assessment to be carried out in June 2010, all the targeted houses will be mapped and those within the specified limits in terms of distance will not be sprayed. Further, mixing of the insecticides before spraying will occur within structures targeted for spraying which act as secondary containment for any spill. This way rapid cleanup of any spill can be made within the confines of the home such that the pesticide cannot spill into any water body.

In order to minimize contamination of underground water sources, all operational sites will have a soak pits constructed for minimizing the potential of this impact becoming significant.

5.2.3 Impacts on Bees

Beekeeping is not widely practiced in Benin and is still considered as an upcoming farming enterprise in many districts in Benin, thanks to the efforts of the local extension staff and a number of non-governmental organizations. Creation of awareness in this sector has resulted in many farmers adopting modern beekeeping production technologies.

Spraying in areas where bees are in existence can lead to the death of the bees. The hives in the province are generally, though not exclusively, located far away from the spray houses thereby minimizing interaction of the bees with the pesticide. However, drift from careless spraying remains a concern as it can cause death if the drift goes to the direction of the hives and this should be mitigated at all times.

Mitigation Measures

All spray teams, supervisors, team leaders and IEC teams will be informed during training to ensure that in areas where bee hives are very close to the structures targeted for spraying should not be sprayed, or at the request of the home owner, they should be sprayed at around midday and not early in the morning. Bees have a tendency of foraging for food early in the morning and if spraying occurs at these times in these areas the drift effect could lead to their deaths.

5.3 Human Exposure Risks/Impacts

Table 7, 8, 9, 10, and 11 below highlight the exposure risks of all WHO approved pesticides in relation to cancer and with respect to exposure dosage, Hazard Quotient and the Life Time Average Daily Dose (LADD). The exposure risk to cancer is presented at different stages of the pesticide application including mixing, spraying, post spraying, dermal risk, etc. Generally, an HQ between 1 and 10 and LADD of x10-6 is generally acceptable risk. It is important to note that the included risk numbers are with no personal protective gear.

Inhalation Exposure and risk during mixing

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

Dermal Exposure and risk during mixing

- On the 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

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

Resident Dermal Exposure and 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 Ingestion after Spraying

- Hereto the only concerns are to adults when using Cyfluthrin and Etofenprox (pyrethroids) and propoxur (carbamate). The risk is also 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). Permethrin has never been used for IRS.

Resident Dermal Exposure and risk due to bathing using contaminated groundwater

- Cyfluthrin and Etofenprox (pyrethroids) have potential impact for dermal exposure using contaminated groundwater. The best management practices 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 have no access to pesticide containers used in IRS. The pesticide containers are only available in IRS storage facilities which are securely double locked.

Worker Exposure and risk due to inhalation during spillage

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

Exposure Risk during Pesticide Preparation -Mixing

Table 7– Adult Worker Intermediate Inhalation Exposure and Risk

	Noncancer		Cancer	
Pesticide	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	1.8E-05	4E-06	NA	NA
Bendiocarb	2.3E-04	1E-01	NA	NA
Bifenthrin	2.9E-05	4E-03	NA	NA
Cyfluthrin	2.9E-05	1E-01	NA	NA
DDT	1.2E-03	2E+00	1.1E-05	4E-06
Deltamethrin	1.5E-05	1E-03	NA	NA
Etofenprox	1.8E-04	2E-03	1.6E-06	8E-09
Fenitrothion	1.2E-03	3E+00	NA	NA
Lambda-cyhalothrin	1.8E-05	2E-02	NA	NA
Malathion	1.2E-03	5E-02	NA	NA
Pirimiphos-methyl	1.2E-03	2E+00	NA	NA
Propoxur	1.2E-03	3E-01	1.1E-05	4E-08

Table 8– Adult Worker Intermediate Dermal Exposure and Risk

	Noncancer		Cancer	
Pesticide	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	1.8E-03	4E-04	NA	NA
Bendiocarb	2.4E-02	1E-01	NA	NA
Bifenthrin	3.0E-03	1E-02	NA	NA
Cyfluthrin	3.0E-03	1E-03	NA	NA
DDT	1.2E-01	2E+02	1.1E-03	4E-04
Deltamethrin	1.5E-03	1E-04	NA	NA

Pesticide	Noncancer		Cancer	
	Predicted Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Etofenprox	1.8E-02	4E-02	1.6E-04	8E-07
Fenitrothion	1.2E-01	1E+01	NA	NA
Lambda-cyhalothrin	1.8E-03	2E-02	NA	NA
Malathion	1.2E-01	2E-01	NA	NA
Pirimiphos-methyl	1.2E-01	2E+02	NA	NA
Propoxur	1.2E-01	1E-02	1.1E-03	4E-06

Spraying

Table 9– Adult Worker Intermediate Inhalation Exposure and Risk

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

Post-Application

Table 10– Adult and Child Resident Acute Dermal Exposure and Risk

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

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

Table 11 – Adult and Child Resident Acute Ingestion Exposure and Risk

Pesticide	Receptor	Noncancer		Cancer	
		Absorbed Dose (mg/kg-day)	HQ	LADD (mg/kg-day)	Cancer Risk
Alpha-cypermethrin	Adult	5.3E-03	1E-03	NA	NA
	Child	8.0E-03	2E-03	NA	NA
Bendiocarb	Adult	7.1E-02	1E-01	NA	NA
	Child	1.1E-01	2E-01	NA	NA
Bifenthrin	Adult	8.9E-03	4E-02	NA	NA
	Child	1.3E-02	7E-02	NA	NA
Cyfluthrin	Adult	8.9E-03	3E-03	NA	NA
	Child	1.3E-02	4E-03	NA	NA
DDT	Adult	3.6E-01	7E+02	1.9E-05	6.6E-06
	Child	5.3E-01	1E+03	Not Calc	Not Calc
Deltamethrin	Adult	4.4E-03	4E-04	NA	NA
	Child	6.7E-03	7E-04	NA	NA
Etofenprox	Adult	5.3E-02	1E-01	2.9E-06	1E-08
	Child	8.0E-02	2E-01	Not Calc	Not Calc
Fenitrothion	Adult	3.6E-01	4E+01	NA	NA
	Child	5.3E-01	5E+01	NA	NA
Lambda-cyhalothrin	Adult	5.3E-03	5E-02	NA	NA
	Child	8.0E-03	8E-02	NA	NA
Malathion	Adult	3.6E-01	7E-01	NA	NA
	Child	5.3E-01	1E+01	NA	NA
Pirimiphos-methyl	Adult	3.6E-01	2E+01	NA	NA
	Child	5.3E-01	4E+01	NA	NA
Propoxur	Adult	3.6E-01	4E-02	1.9E-05	7E-08
	Child	5.3E-01	5E-02	Not Calc	Not Calc

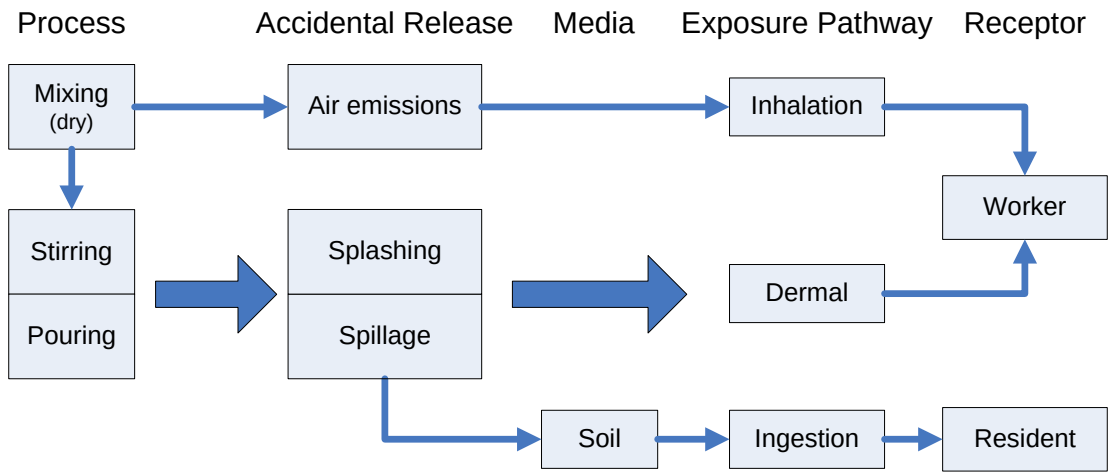
1. **Worker and Resident Exposure Pathway**

Through out 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 after spraying phase of the IRS operations.

2. **Pre Spraying Exposure Pathway**

Preparing pesticide solutions during the IRS will involve pouring the pesticide in the spray can 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 floors. **Figure 23** below shows the possible modes of exposure during preparation of pesticides for IRS.

Figure 23. Conceptual Model for Possible Exposure Pathways from Preparation of Pesticide



3. **Exposure during Spraying**

Inhalation of aerosol vapors during spraying is the main process for worker exposure during IRS. Residents are mainly exposed through dermal contact with sprayed surfaces and incidental ingestion of insecticide after their houses have been sprayed, especially when food or drink are left in the house during spraying. Leaky equipment can also lead to insecticide exposure through dermal contact with the floors and incidental ingestion by children who may come in contact with the spills before they are cleaned up**.** **Figure 24** below shows the possible modes of exposure during preparation of pesticides for IRS use by the sprayers.

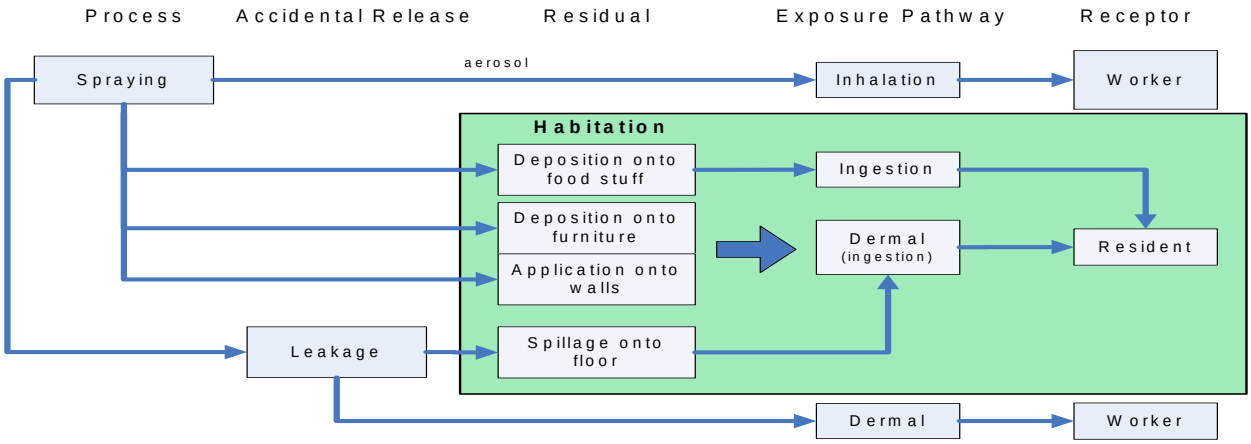


Figure 24. Conceptual Model for Possible Exposure Pathways from IRS

4. **<u>Exposure during Disposal (including Progressive Rinsing)</u>**

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.

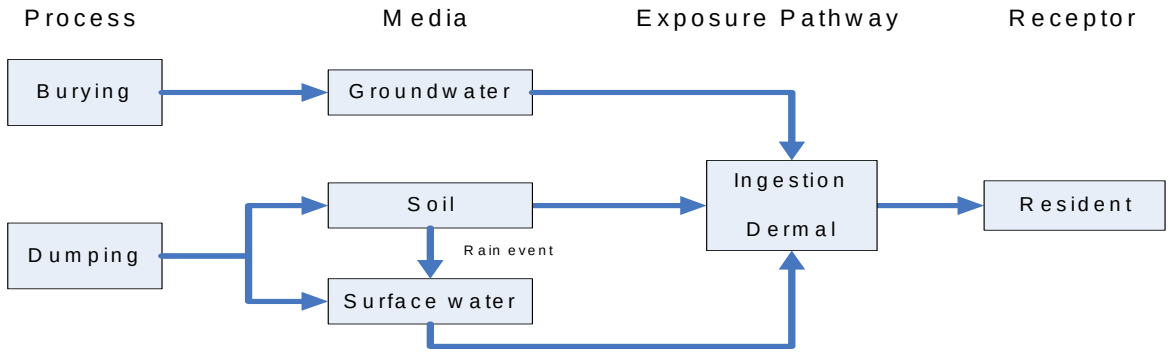


Figure 25. Conceptual Model for Possible Exposure Pathways from Disposal of Excess Pesticide Formulation

5.4 Mitigation Measures

This section outlines the various measures proposed to mitigate against any of the potential adverse impacts likely to occur and outline above. The primary mitigation measures include delivery of a mix of Information Education and Communication (IEC) approaches targeting the residents and spray operators and team, measures also include provision of Personal Protective Equipment (PPE) and training to spray personnel, and thorough and consistent supervision and monitoring.

- **<u>Mitigation Measures for Residential Exposure through BCC/IEC</u>**

District authorities and implementing partner program staff will work with relevant committees, and non-governmental organizations to carry out an IEC campaign to sensitize residents to IRS activities, in accordance with WHO guidelines. The IEC campaign (as well as IRS Program team leaders and

supervisors who will also instruct residents on best practices prior to spraying) will use different strategies for IEC/BCC in line with the host country IEC strtagey including door-door awareness, use of electronic and print media, broncures, village meetings among others. The messages will 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
- Move and keep all animals outside the home during spraying, and for two hours after spraying
- Sweep up any insects killed from the spraying and drop them in latrine pits
- Sweep floors free of any residual insecticide that may remain from the spraying
- 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.
- All households will be informed of the spraying schedule and the purpose of the spraying to give them adequate time to prepare and take their belongings outside and to vacate the house.
- All food items should be secured, covered and taken outside the house.
- All water should be removed from the house and covered properly.
- All utensils, kitchenware and toys should also be removed from the house.
- Each household should avail at least 10 liters of water to spray operators where possible.
- Remove or cover furniture to allow the spray operator easy access to the walls in each room. Any remaining furniture should be covered.
- Cage or keep pets and domestic animals away from the house.
- Occupants must remain outside the house for at least 2 hours after spraying and the house should be kept shut.
- Open the windows and door then wait for 45minutes to air the house.
-

- **<u>Measures to Reduce Exposure during Pesticide Transport</u>**

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

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

Drivers hired specifically for the spray campaign period will receive:

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

- Handling vehicle contamination

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

- **Mitigating Foetal Exposure-Pregnancy Testing**

All the potential female spray candidates will be tested for pregnancy before being recruited into the spray operations. Female persons found to be pregnant should be re-assigned to positions that require less exposure to insecticides. The same applies to breastfeeding spray operators.

- **Mitigating Spray Operator Exposure**

Each spray operator will be provided with the following safety equipment, in accordance with WHO and FAO specifications: These PPEs will be replaced frequently whenever wear and tear is identified or reported. However, the respirators will be replaced everyday.

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

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

Table 12 below summarizes of the acute human side effects of pyrethroids and carbamates and ways for treating each of the outlined side effects or symptoms.

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

Similarly, residential exposure will be monitored using the reported cases of exposure or those reported in the health centres. During the IEC campaign, residents are similarly made aware of the steps to take if exposed and especially if acute symptoms are encountered the advise 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.

Per consultation with the WHO and a number of pesticide occupational safety and health experts in the United States, USAID require cholinesterase monitoring for organophosphates. Should any

organophosphate be used, the PMI Benin team will submit to the Global Health and Africa Bureau Environmental Officers the following:

- A bio-monitoring plan for the upcoming year that outlines:
  - Who is to be monitored
  - The frequency of monitoring
  - The benchmarks used in the blood monitoring
  - The ways workers are informed of the process and the use of the tests included signed consent forms
  - Other factors pertinent to a biomonitoring program
- An annual post spray report that shows (can be included in the environmental compliance report)
  - Levels of AChE activity and any changes
    - Names are not to be given
  - Any interventions that were required
  - Any issues that arose as a product of the biomonitoring program.

Table 12. Summary of Acute Exposure Symptoms and Treatment

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

	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.	The affected person should stop work immediately, remove any contaminated clothing, wash the affected skin with soap and clean water and flush the skin with large quantities of clean water. Care must be taken not to contaminate others, including medical or paramedical workers. Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic organophosphate insecticides are used in areas without easy access to medical care. **Atropine sulfate**. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible. **Glycopyrolate** has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.
Pesticide Type	**Human side effects**	**Treatment**
Deltamethrin	Acute effects include irritability, headache, salivation, sweating, fever, anxiety, rapid heart beat, diarrhea, dyspnea, tinnitus, runny nose, vomiting, edema, hepatic microsomal enzyme induction, peripheral vascular collapse, serum alkaline phosphatase elevation, tremors, ataxia, convulsions leading to muscle fibrillation and paralysis, and death due to respiratory failure. Dermatitis is expected after dermal exposures. Dermal symptoms including itching, burning, and paraesthesia.	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Bifenthrin	Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness. No skin inflammation or irritation observed; however can cause a reversible tingling sensation. Incoordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses.	Depends on the symptoms of the exposed person. Casual exposures require decontamination and supportive care. Wash affected skin areas promptly with soap and warm water. Medical attention should be sought if irritation or paresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline.
Lambda-Cyhalothrin	Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning.	Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for

	Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions. Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis.	several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.
Alpha-cypermethrin	Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia. Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful	Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.
Cyfluthrin	Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Etofenprox	Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.	If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.
Bendiocarb	Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea,	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.

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

Mitigation Measures against Warehouse/Storage Exposure

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

- All primary pesticide storage facilities will be double-padlocked and guarded on a 24 hour basis
- All the storage facilities will be located away from nearby water courses, domestic wells, markets, schools, hospitals etc
- Soap and clean water will be available at all times in all the facilities
- A trained storekeeper will be hired to manage each facility
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed
- All the warehouses will have at least two exit access routes in case of fire outbreak
- A fire extinguisher will be available in the storage facilities and all workers will be trained on how to use this device.
- Warning notices will be placed outside of the store in the local language(s) with a skull and crossbones sign to caution against unauthorized entry
- All pesticides will be used and any remnants will be stored under lock and key until the next rounds of spraying.

- **Mitigation Measure for disposal of wash water**

Described in Section 2.

- **Mitigating Exposure Impacts through Container Re-use**

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

- **Pesticide Exposure and Treatment**.

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

Table 13. Drugs Recommended for Treatment of exposure

Name of drug	Active ingredients
Promethazine	Promethazine Hydrocloride
Panadol	Paracetamol

Diazepam	Benzodiazapine/Diazapam
Lorazepam	Lorazepam
Calamine cream	Calamine, zinc oxide, glycerol, phenol, purified water, sodium citrate, betonite,
Vit E	Tocopherol, fragrance, mineral oil, deionized water, sodium hydroxide, stearic acid
Hydrocortisone cream	1% hydrocortisone
Salbutamol	Salbutamol 100 mcg, suspended inert aerosol
Salbutamol tablets	Salbutamol sulphate 4 mg
Activated Charcoal	Activated Charcoal

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

- **Warehouse/Store Keeping Training**

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

- **Supervision**

Supervisors will observe spray teams (in a ratio of approximately one supervisor to five-six spray teams) to ensure spraying occurs according to best practices. Supervisors will travel between spray teams and will observe spray operators and team leaders in the preparation, spray technique, and sprayer and PPE cleanup during the IRS campaign, as well as compile all data collected by their respective teams. Team leaders will also provide supervision in a ratio of approximately one team lead per five or six spray operators.

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

5.4.1 Pesticide Quality Assurance

The procurement and use of pesticides that do not meet the necessary quality assurance standards can compromise the overall spray quality and desired vector action while at the same time could expose the residents and spray operators to hazards related to altered toxicological characteristics.

Under what is known as the **New Procedures**, experts from the "FAO/WHO Joint Meeting on Pesticide Specifications" (JMPS) produce, on an annual basis, an evaluation of products from insecticide manufacturers (analogous to the GMP system). The current and future lists can be found at the following website: http://www.who.int/whopes/quality/newspecif/en/. These New Procedures illustrate the pesticides that have been approved by this Joint Committee after manufactures submitted their products for evaluation. This meeting has thus profiled a list of pesticides that they have evaluated and concluded that these pesticides have attained a status equivalent to the reference profile supporting the existing FAO and WHO specifications. The contractor has confirmed that it only procures insecticides from those manufacturers receiving this approval from WHOPES.

Further to this Quality Control mechanism, the contractor will randomly take for analysis certain batches of pesticides that will be procured in ISO Certified and accredited laboratories to determine active ingredient and incorporate another additional step for ensuring pesticide quality assurance.

5.5 Cumulative Impact

Carbamates degrade very quickly when exposed to light and to the external environment, thus the cumulative adverse impacts of this project is insignificant.

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

5.6 Environmental Consequences Summary

The main environmental consequences of IRS application in Benin can be summarized as follows;-

Risk to Bio-Physical Environment

IRS is a highly controlled indoor activity in terms of chemical application that further involves only very small doses of the chemical at low concentrations. Furthermore, the pesticides of choice by the government of Benin including pyrethroids, organophosphates and carbamates all disintegrate rapidly in the external environment and bind easily with soil.

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

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

Wild animals including avi-fauna and bees are also not at a risk in relation to pesticide exposure because all the protected areas in Benin are under the supervision *Centre National de Gestion des Réserves de Faune* (CENAGREF) and no settlements are allowed in these areas. Since IRS only targets areas with high population and settlements, by default these protected areas are thus not eligible for IRS and in effect translating to limited risk if not none at all.

Human Exposure

Exposure to human beings can occur during the application process and is capable of adversely affecting the spray operator especially if the proper use of PPE is not followed or deliberate exposure of the pesticides. Similarly the target residents are likely to be exposed if adherence to the required time before re-entering the house is not followed. Use of Carbamates, pyrethroids and organophosphates in IRS pose very little risks to human health albeit with a difference in risks in terms of toxicity. However, in the event that organophosphates are used in this program, bio-monitoring for cholinesterase inhibition will be required for all the spray operators using an approved standard monitoring protocol by World Health Organization.

5.7 Conclusion

The table below is a 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). The matrix shows that pyrethroids are the most cost effective, but lack country preference (due to disease management) even though are considered less detrimental to human health and the environment; Carbamates emerge tops due to the disease management effect, higher country preference but have the disadvantage of higher human health risk and higher cost but will be used in the new districts due to resistance recorded on pyrethroids.

5.8 Decision Criteria Matrix

The table below is a 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) carbamates emerge as the pesticide of choice in the new districts mainly due to resistance reported on pyrethroids. However, the decision is likely to change depending on changes in cost or resistance issues if detected in carbamates.

Table 14. Decision Criteria Matrix

Criteria	Pesticide choice	Susceptibility	Socio-economic Impact	Cost		Human and ecological impacts	
IRS in new region	Organophosp ates	0	+++	-	+	--	
	Carbamates	0	+++	-	+++	--	3
	Pyrethroids	--(in new region_	+++	0	+	--	0
	DDT	--	+	---	---	---	
No Action		0	---	---	---	--	-8

Key/Legend 0= net zero effect

-=net negative effect +=positive effect

--=moderate negative effect ++=moderate positive effect

---=significant negative effect +++=significant positive effect

6.0 ENVIRONMENTAL MITIGATION AND MONITORING PLAN

This Environmental Monitoring and Mitigation Plan (EMMP) presents the Best Management Practices (BMP) 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 that will be pulled out and provided to the Benin's IRS management team and will be used as the tool for ensuring adherence to mitigation and monitoring practices.

6.1 Scope of the EMMP

The EMMP consists of a series of components defined by project phase: pre, during, and post spray.

6.2 Environmental Mitigation and Monitoring Plan

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

On an annual basis the PMI Benin team will submit to the GH and AFR Bureau Environmental Officer, for concurrence, a letter report that addresses the following issues:

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

This letter report should be reviewed by the PMI team and submitted to the MEO, REA and BEO simultaneously for BEO signature.

ENVIRONMENTAL MITIGATION AND MONITORING PLAN

PRE Spraying Phase

Impact	Mitigation Measure	Monitoring Indicator	Responsibility
Accidental Spills of Insecticides during Road Transportation to warehouse and spray sites (Human Health and Environmental impacts)	Ensure that the drivers identified to haul the insecticide to the spray sites are well trained on the FAO standards and guidelines for the storage, transport and stock control for pesticides	Number of Road Accidents and spills reported Records showing Drivers Training	Contractor –Team responsible for IEC Ministry of Agriculture Ministry of Environment,
Possible environmental contamination caused by warehouse exposure due to poor siting of warehouses, Pilferage and vermin attack of the stored pesticides before spraying	Ensure the selected warehouse is sited away from a flood plain area, water course, wells, schools, markets	Storage facility located outside of floodplain, away from nearby schools, hospitals, water courses	Contractor – Ministry of Agriculture Ministry of Environment
	Secure the selected warehouse and apply all the guidelines for Storage and Stock Control manual by FAO.	Storage facilities secured as per the FAO Storage and Stock Control Manual	Contractor – Ministry of Agriculture Ministry of Environment
Accidental Fires and injuries in the Warehouses	All warehouses must be equipped with a fire extinguisher, thermometer, exit doors and warning signs, and proper stacking position and height as stipulated in the FAO Storage and Stock Control Manual.	Presence of fire fighting equipment, warning signs and at least 3 exits access in the warehouse	Contractor – Ministry of Agriculture Ministry of Environment
	All the workers handling pesticides or other products and equipment in the storage facilities must all have PPE including goggles, gloves, boots, overall, dust masks etc.	Availability of PPE to all the workers.	Contractor –Team responsible for IEC
	All spray operators and store managers must be trained on how to operate the fire extinguishers and what to do in case of fire outbreaks. Develop an Emergency Response Plan	Training in fire prevention and fighting Develop an Emergency Response Plan	Contractor –Team responsible for IEC

Spraying Phase Potential Impacts

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

	Ensure that each Team Leader and Supervisors effectively monitor the spray operations diligently and take action to correct any non compliance issues noted right away.			
	Procurement of sprayers manufactured according to WHO specifications; procurement and proper use of PPE by spray operators, team leaders and supervisors (cotton overalls, face shield, dust mask, broad-rimmed hat, rubber gloves, gum boots) procurement of PPE for wash persons.			
	Prohibition of eating, drinking and smoking during work;			
Cholinesterase Inhibition on Spray Operators if OP is used (Malathion or Fenitrothion)	Develop and implement a biomonitoring plan that includes blood sampling and Cholinesterase Testing to be undertaken every 2 weeks and SOPs exposed will be removed from the field until they recover	Availability of a monitoring plan Number of SOPs Tested and availability of results	Every 2 weeks all spray operators must be subjected to this test.	Ministry of Health Implementing Partner
Residential Exposure	IEC Campaign, instruct residents to: Clear homes of mats or rugs, furniture, cooking implements and foodstuffs prior to spraying	Households cleared and well prepared before the spraying	Daily basis by the team leaders and supervisors	Implementing Partner –IEC Mobilization team, relevant Ministry of Health and Ministry of Environment
	Move all furniture out of the house and for immovable ones, take to the centre of the house	Furniture covered and or moved to the centre of the houses	Cases of residential exposure attributed to lack of or inadequate IEC.	Implementing Partner -IEC Mobilization team, spray operators

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

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

Post Spraying Phase

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

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

6.3 EMP Implementation

This EMP will be implemented by the contractor and NMCP who are directly involved in this project. However other institutions like ABE may undertake their own environmental management actions.

6.3.1 Environment Regulations

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

- **Oversight Monitoring**

As the lead agency responsible for the protection of environment in Benin, ABE is authorized to play the leading oversight role of monitoring the activities of project according to the Environmental Law.

- **Site Inspection Visits**

ABE is also authorized to undertake site visits to inspect and verify for themselves the nature and extent of project impacts. ABE is expected to undertake routine site visits to inspect and verify for themselves the extent to which all projects implemented in Benin adhere to the mitigation measures proposed in this EMP or vice versa and determine necessary action.

6.3.2 Contractor/NMCP

The contractor and NMCP will undertake monitoring of the activities to ensure internal compliance is achieved. The inspection and monitoring will be undertaken by the Implementing Partner Environmental Compliance Inspector and will occur during the pre-spray and spray phases. The inspectors will endeavor to ensure that all the mitigation measures highlighted in the EMP are being followed. They will produce an internal compliance inspection report that will be shared with ABE and USAID.

6.3.3 United States Agency for International Development

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

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Annex 1. Report on Entomological Studies Conducted for Atacora Region in 2010.

INTRODUCTION DE LA PID DANS L'ATACORA

Données de base en prélude à la mise en œuvre de la pulvérisation intra-domiciliaire d'insecticide (PID) dans le département de l'Atacora au Bénin

Par

Professeur Martin Akogbéto

1. Justification de l'étude

Le choix d'une stratégie de lutte anti-vectorielle doit être adapté à son contexte. La pulvérisation intra-domiciliaire (PID) ne peut être envisagée que dans des circonstances données. En raison de la lourdeur de la méthode, les zones où la transmission du paludisme est de courte durée (3-4 mois) sont préférables à celles où la transmission dure presque toute l'année. En effet, il est plus facile et moins coûteux de gérer un tour de pulvérisation que deux dans l'année. C'est pour cette raison fondamentale bien justifiée que le Programme National de Lutte contre le Paludisme a proposé de déplacer la PID de l'Ouémé au nord. En effet, au nord du Bénin, la transmission du paludisme dure environ 6 mois, c'est-à-dire théoriquement de juillet à novembre, alors qu'au sud, elle dure toute l'année. Un autre argument à prendre en considération dans la mise en œuvre de la PID est la nature des murs à traiter. Ces murs doivent avoir une surface ″traitable″, de préférence une surface lisse et non poreuse. Par ailleurs, les agglomérations en bordure des grandes étendues d'eau où des inondations sont fréquentes doivent être exclues pour des raisons de contamination de même que les habitations en paille. De plus, on doit s'assurer que les anophèles de la région choisie sont endophiles et sensibles à l'insecticide de pulvérisation. Enfin, il est souhaitable de faire appel aux critères épidémiologiques (paramètres parasitologiques, cliniques, résistance médicamenteuse) dans le choix des zones à traiter. Les zones où le taux de morbidité et de mortalité du paludisme sont les plus élevés seront prioritaires.

Aucune donnée n'étant disponible à l'heure actuelle sur la transmission du paludisme dans l'Atacora, la présente étude est axée essentiellement sur les aspects entomologiques et sur la nature physique des habitations humaines. Etant donné que la pulvérisation est prévue entre mai et juin 2011, la seule période propice pour réaliser ladite enquête sont les mois de septembre et d'octobre 2010 pour des raisons climatiques et de calendrier des opérations de pulvérisation. Ainsi, ne disposant pas du temps nécessaire pour un suivi-évaluation qui couvre les deux saisons de l'année, nous avons réalisé une étude ponctuelle sur les populations d'Anopheles gambiae et autres espèces rencontrées dans la zone d'étude, le niveau de sensibilité de ces anophèles aux insecticides et l'aspect physique des habitations humaines. Le CREC dispose de beaucoup de données sur la résistance des vecteurs aux insecticides au Bénin mais dans l'Atacora, aucune donnée fiable n'est disponible.

2. Matériel et méthodes

2.1. Zone d'étude

L'étude a été réalisée dans le département de l'Atacora qui compte 9 communes (Natitingou, Tanguiéta, Toucountouna, Matéri, Kobli, Boukombé, Pehunco, Kouandé et Kérou). Les 9 communes ont été toutes prospectées en vue de sélectionner celles qui remplissent les conditions pour la mise en œuvre de la pulvérisation intra-domiciliaire. Toutes les données ont été récoltées entre septembre et octobre 2010 pendant la petite saison pluvieuse.

2. 2. Echantillonnage des populations d'anophèles adultes

Des captures de moustiques de la faune matinale résiduelle ont permis de récolter les anophèles au repos dans les habitations humaines et d'apprécier la densité d'An. gambiae et d'An. funestus par maison et par commune. Ces anophèles ont été classés selon l'état de l'abdomen (à jeun, gorgés, gravides et semi-gravides) pour apprécier leur degré d'endophilie. Les spécimens d'An. gambiae sont conservés individuellement dans des tubes, sur du silicagel pour la PCR (espèce, formes) et l'ELISA/CSP (CS+ Plasmodium falciparum)

2. 3. Sensibilité d'*An. gambiae* aux insecticides

Nous avons récolté des larves d'An. gambiae dans toutes les communes. Après leur élevage, nous avons réalisé des tests de sensibilité aux différentes classes d'insecticides selon les protocoles OMS et CDC. Après les tests, nous avons utilisé les moustiques vivants et morts pour la recherche des mécanismes de résistance (mutation kdr et Ace-1). Cette étude permettra de suivre l'évolution du niveau de résistance après la PID. Les données sur le niveau de résistance phénotypique d'An. gambiae vis-à-vis du bendiocarb et sur la fréquence de la mutation Ace-1 qui est à la base de la résistance des carbamates et des organophosphorés permettront de prendre une décision sur le choix du bendiocarb pour son utilisation en PID dans l'Atacora ou de savoir s'il est nécessaire de faire appel à un autre insecticide.

2.3. Etude de la nature des murs des habitations humaines et de l'utilisation des moustiquaires

Dans chaque commune, nous avons parcouru le milieu urbain et peri-urbain et les zones rurales. Tous les 100 mètres environ, nous nous arrêtons et examinons la nature physique de la maison où nous nous sommes arrêtés et engageons une conversation avec le propriétaire après son consentement. Il s'git d'une brève enquête qui porte sur la nature des murs de la maison (murs en brique ou en banco ou en un autre matériau, murs crépis ou non crépis), le toit de la maison (tôle ou paille), la présence de moustiquaire ou non, le nombre de moustiquaires, le nombre de personnes dormant dans la maison. Les informations sur la nature des murs permettent d'estimer la proportion des habitations offrant des surfaces qui prêtent mieux au traitement insecticide. Celles concernant l'utilisation des moustiquaires s'expliquent par le fait que la faiblesse de la couverture des autres mesures de prévention (MILD, CTA, TPI) doit être prise en compte dans la sélection des communes.

3. Résultats : identification des communes prioritaires et insecticide à retenir pour la PID

3. 1. Sur la base de la nature des murs à traiter et du taux de couverture en moustiquaires

Au cours de notre visite dans l'Atacora, nous avons parcouru des dizaines de kilomètres à pied à visiter les habitations humaines et à vérifier si les murs des maisons sont appropriés au traitement insecticide. Plus de 500 maisons ont été visitées et examinées. Au cours de cette prospection, nous sommes restés rigoureux dans notre démarche, à savoir, maintenir une distance de 100 mètres entre les maisons visitées de manière à parcourir une superficie assez grande afin que les résultats soient représentatifs de la zone choisie. Dans chaque commune, nous avons choisi 2 quartiers, l'un en milieu périurbain, l'autre en milieu rural. Le choix des 2 quartiers a été fait par les élus locaux, en particulier le maire-adjoint ou le secrétaire général de la mairie.

Partout où nous sommes passés, l'habitat est le même; plus de 90% des murs sont en banco. Le choix du banco pour élever les murs des maisons indique le niveau de vie des populations. Malgré leur structure en terre de barre, plus de 80% des murs sont crépis dans la plupart des communes excepté les communes de Péhunco et de Kérou (tableaux I a et h). Dans ces deux communes, nous n'avons prospecté que 122 habitations, ce qui n'est certainement pas représentatif de l'ensemble des maisons, mais, si cette tendance était maintenue, Péhunco et Kérou devraientt être exclus des communes à sélectionner pour la PID et, en compensation, bénéficier de la couverture totale en moustiquaires imprégnées à longue durée d'action. Un autre argument qui renforce la position en défaveur de la mise en œuvre de la PID à Péhunco et Kérou est la présence dans ces communes de petites agglomérations de cases en paille ou en matériaux définitifs trop dispersées. Les murs en paille n'offrent pas une surface hermétiquement fermée et ne sont pas appropriés au traitement insecticide.

Pour l'ensemble des 556 habitations visitées, nous avons enregistré 1 904 personnes et 551 moustiquaires, soit globalement et théoriquement, 1 moustiquaire par habitation et 1 moustiquaire pour 3,5 personnes. Certaines communes sont en deçà de cette couverture. En effet, à Péhunco et Toukountouna, 5 personnes partagent 1 moustiquaire. Une couverture de 1 moustiquaire par habitation observée dans les 9 communes est très théorique et ne fait pas ressortir la différence du niveau de vie dans les ménages. En effet, à Toukountouna, Cobly et Pehunco, plus de 30% des maisons visitées ne disposent pas de moustiquaires. En se basant sur la faiblesse de la couverture des autres mesures de prévention (MILD, CTA, TPI) comme critère de sélection des communes, Toukountouna et Cobly doivent être considérés comme 2 communes prioritaires.

Tableau I : Données sur la nature physique de l'habitat et la possession de moustiquaire dans les communes de l'Atacora

I. a. Commune de Péhunco

Paramètres	Gbéba	Banikani	Total

	Nombre	%	Nombre	%	Nombre	%
Habitations en :	27	-	26	-	53	-
banco crépi	10	37,04	19	73,08	29	54,72
banco non crépi	16	59,26	4	15,38	20	37,74
brique crépie	1	3,70	3	11,54	4	7,55
brique non crépie	0	0	0	0	0	0
Toit en tôle	27	100	26	100	53	100
Toit en Paille	0	0	0	0	0	0
Dormeurs	94	-	125	-	219	-
Moustiquaires	23	-	28	-	51	-
Moustiquaires/Habitation	0,85	-	1,08	-	0,96	-
Personne/moustiquaire	0,24	-	0,22	-	4,3	-
Habitation sans moustiquaires	11	40,74	8	30,77	19	35,85

I.b. Commune de Kouandé

Paramètres	Niaro		Bassilou		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitation	27	-	27	-	54	-
banco crépi	3	11,11	20	74,07	23	42,59
banco non crépi	24	88,89	7	25,93	31	57,41
brique crépie	0	0	0	0	0	0
brique non crépie	0	0	0	0	0	0
Toit en tôle	27	100	27	100	54	100
Toit en Paille	0	0	0	0	0	
Dormeurs	90	-	108	-	198	-
Moustiquaires	31	-	32	-	63	-
Moustiquaires/Habitation	1,15	-	1,19	-	1,16	-
Personne/moustiquaire	0,34	-	0,3	-	3,1	-
Habitation sans moustiquaires	7	25,93	6	22,22	13	24,07

I. c. Commune de Cobly

Paramètres	Zongo		Katouokè		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitations	33	-	33	-	66	-
banco crépi	24	72,73	33	100	57	86,36
banco non crépi	9	27,27	0	0	9	13,64
brique crépie	0	0	0	0	0	0
brique non crépie	0	0	0	0	0	0
Toit en tôle	21	63,64	8	24,24	29	43,94
Toit en Paille	12	0	25	0	37	0
Dormeurs	97	-	93	-	190	-

Moustiquaires	31	-	30	-	61	-
Moustiquaires/Habitation	0,94	-	0,91	-	0,95	-
Personne/moustiquaire	0,32	-	0,32	-	3,1	-
Habitation sans moustiquaires	12	36,36	9	27,27	21	31,82

I. d. Commune de Boukombé

Paramètres	Manta		Konadogou		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitations	38	-	32	-	70	-
banco crépi	29	76,32	26	81,25	55	78,57
banco non crépi	9	23,68	6	18,75	15	21,43
brique crépie	0	0	0	0	0	0
brique non crépie	0	0	0	0	0	0
Toit en tôle	35	92,11	32	100	67	95,71
Toit en Paille	3	0	0	0	3	0
Dormeurs	110	-	108	-	218	-
Moustiquaires	32	-	42	-	74	-
Moustiquaires/Habitation	0,84	-	1,31	-	1,05	-
Personne/moustiquaire	0,29	-	0,39	-	2,9	-
Habitation sans moustiquaires	10	26,32	4	12,50	14	20

I. e. Commune de Toukountouna

Paramètres	Sanga		Tectibayaou		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitations	39	-	36	-	75	-
banco crépi	31	79,49	30	83,33	61	81,33
banco non crépi	7	17,95	6	16,67	13	17,33
brique crépie	1	2,56	0	0	1	1,33
brique non crépie	0	0	0	0	0	0
Toit en tôle	24	61,54	8	22,22	32	42,67
Toit en Paille	15	0	28	0	43	0
Dormeurs	123	-	150	-	273	-
Moustiquaires	25	-	26	-	51	-
Moustiquaires/Habitation	0,64	-	0,72	-	0,7	-
Personne/moustiquaire	0,2	-	0,17	-	5,3	-
Habitation sans moustiquaires	17	43,59	6	16,67	23	30,67

I.f. Commune de Tanguiéta

Paramètres	Yaréga		Thanwassaga		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitations	37	-	37	-	74	-
banco crépi	19	51,35	25	67,57	44	59,46
banco non crépi	3	8,11	13	35,14	16	21,62
brique crépie	15	40,54	0	0	15	20,27
brique non crépie	0	0	0	0	0	0
Toit en tôle	37	100	16	43,24	53	71,62
Toit en Paille	0	0	21	0	21	0
Dormeurs	143	-	141	-	284	-
Moustiquaires	50	-	35	-	85	-
Moustiquaires/Habitation	1,35	-	0,95	-	1,14	-
Personne/moustiquaire	0,35	-	0,25	-	3,3	-
Habitation sans moustiquaires	2	5,41	8	21,62	10	13,51

I.g. Communes de Natitingou et de Matéri

Paramètres	Bérécingou (Natitingou)		Naka-seeka-kani (Matéri)	
	Nombre	%	Nombre	%
Habitations	42	-	53	-
banco crépi	37	88,10	42	79,25
banco non crépi	3	7,14	0	0
brique crépie	2	4,76	1	1,89
brique non crépie	0	0	0	0
Toit en tôle	41	97,62	43	81,13
Toit en Paille	1	0	0	0
Dormeurs	148	-	146	-
Moustiquaires	40	-	53	-
Moustiquaires/Habitation	0,95	-	1	-
Personne/moustiquaire	3,7	-	2,7	-
Habitation sans moustiquaires	14	33,33	10	18,87

I.h. Commune de Kérou.

Paramètres	Kargourou		Maréworou		Total	
	Nombre	%	Nombre	%	Nombre	%
Habitations	30		39		69	
banco crépi	11	36,67	19	48,72	30	43,48
banco non crépi	13	43,33	18	46,15	31	44,93
brique crépie	6	20,00	2	5,13	8	11,59

brique non crépie	0	0,00	0	0,00	0	0,00
Toit en tôle	30	100,00	39	100,00	69	100,00
Toit en Paille	0	0,00	0	0,00	0	0,00
Dormeurs	100		128		228	
Moustiquaires	48		55		103	
Moustiquaires/Habitation	1,6		1,4		1,5	
Personne/moustiquaire	2,1		2,3		2,2	
Habitation sans moustiquaires	0	0,00	0	0,00	0	0,00

3.2. Sur la base de la densité des anophèles récoltés dans les maisons

Au total, nous avons récolté 1076 moustiques après pulvérisation de bombe aérosol à l'intérieur des maisons dans les différentes communes. Plus de 80% de ces moustiques sont représentés par l'espèce An gambiae (81,40%). Deux autres espèces d'anophèles sont rencontrées mais en très faibles proportions : An. funestus (1,23%) et An. broheri (1 spécimen à Yanka). Parmi les Culicinae, nous avons récolté Culex spp (17%), Aedes aegypti (2 spécimens à Cobly) et Mansonia africana (1 spécimen à Thanwassaka).
La répartition des différentes espèces en fonction de leur état physiologique par village et par commune est présentée dans le tableau ci-dessous (Tableau II). An. gambiae, le principal vecteur du paludisme en Afrique est l'espèce majoritaire (4/5). Il a été récolté dans toutes les communes et dans tous les quartiers prospectés. La densité a varié de 2 à 35 femelles par case. Les plus fortes densités ont été récoltées à Boukombé (35 femelles/case) et Cobly (25,86-28,83/case). Cependant, étant donné que le nombre de maisons de capture des moustiques n'est pas représentatif de l'ensemble des maisons dans chaque commune et que les captures n'ont pas été effectuées au même moment bien qu'il s'agisse de la même période (saison pluvieuse pour toutes les communes), nous ne pouvons pas retenir la densité comme critère de sélection. Le seul critère possible ici est la présence d'An. gambiae dans les maisons, ce qui est vérifié pour toutes les localités où nous sommes passés. La plupart de ces anophèles sont capturés gorgés, gravides ou semi-gravides à l'intérieur des maisons, c'est dire que le caractère endophile des anophèles exigé pour la PID est satisfait dans toutes les communes. Cette endophilie est très marquée chez An. funestus : tous les spécimens récoltés sont trouvés gorgés, gravides ou semi-gravides.

Tableau II : Répartition des différentes espèces et de leur état physiologique par village et par commune

		An.gambiae						*An. funestus*					*Culex spp*				
		Jeun	Gor	Sm	Gr	Total	Densité /case	Jeun	Gor	Sm	Gr	Total	Jeun	Gor	Sm	Gr	Total
Pehunco	Gbéba	8	64	3	7	**82**	**11,71**		1			1					
	Banikani	4	11	3	5	**23**	**3,83**						2	11		3	16

Kouandé	Niaro		70		1	**71**	**14,20**		3			3					
	Bassilou		8	1		**9**	**1,80**						3				3
Cobly	Zongo	10	122	30	19	**181**	**25,86**		2			2					
	katoukè	20	120	28	5	**173**	**28,83**						1				1
Boukoumbé	Coutankou	5	111	30	29	**175**	**35**		1	1		2				1	1
	Kounadogou	1	4	2	5	**12**	**6**		1		2	3	1	2		2	5
Tanguiéta	Yanka	3	21	1		**25**	**3,57**						26	57	8	11	102
	Thanwassaka	2	17		1	**20**	**4**		1			1	1	2			3
Toukountouna	Sanga	8	22		3	**33**	**5,50**						8	21		2	31
	Tectibayaou	13	15			**28**	**7**		1			1					
Natitingou	Bérécingou	1	8		2	**11**	**2,20**									3	3
Matéri	Nanka		17		2	**19**	**1,90**						3			12	15
Kérou	Karigourou		1			**1**	**0,25**						1	2			
	Maréworou		16			**16**	**3,20**										
Total		**75**	**610**	**98**	**79**	**862**	**9,69**	**0**	**10**	**1**	**2**	**13**	**45**	**93**	**8**	**34**	**180**

3.2. Sur la base du niveau de sensibilité des vecteurs aux insecticides

En septembre et octobre 2010, nous avons fait des prospections de larves d'An gambiae dans les 9 communes. C'est une étape très difficile de la mission qui nous a été confiée. En effet, il faut identifier les gîtes positifs en larves d'An. gambiae dans un contexte d'inondation due à des pluies diluviennes qui s'abattaient dans la région et qui ont dispersé la plupart des larves dans la période. Par ailleurs, certains gîtes étaient inaccessibles non seulement en raison de l'inondation, mais aussi en raison de la rupture de certains ponts, ce qui ne permettait pas de rejoindre certaines localités. Or, les tests de sensibilité selon la méthode OMS exige des adultes d'anophèles de 2 à 5 jours qu'on ne peut avoir qu'à partir des larves après élevage. Malgré ces difficultés, nous avons réussi à récolter le maximum de larves que nous avons élevées à l'insectarium du Centre de

Recherche Entomologique de Cotonou. Après émergence, les moustiques ont été mis en contact avec les papiers imprégnés d'insecticides. Trois classes d'insecticides ont été testées : les pyréthrinoïdes (la perméthrine à 0,75%, la deltaméthrine à 0,05%), les organochlorés (le DDT à 4%) et les carbamates (le bendiocarb à 0,1%).
Dans les 9 communes, nous avons testé plus de 3 000 femelles d'An. gambiae. Quelle que soit la commune, les résultats sont les mêmes. Les moustiques sont sensibles au bendiocarb partout où nous sommes passés. Les taux de mortalité d'An. gambiae ont varié de 95 à 98%. Concernant la perméthrine, c'est la catastrophe. Dans les 9 communes, An. gambiae a développé une très forte résistance vis-à-vis de ce produit. Les taux de mortalité observés ont varié seulement de 0 à 15%, c'est dire que les 4/5 des populations testées sont résistantes à la perméthrine. Un niveau de résistance similaire, voire plus élevé, a été noté vis-à-vis du DDT. Dans notre dernier rapport sur le suivi-évaluation de la campagne PID dans l'Ouémé, nous avons attiré l'attention du Programme National de Lutte contre le Paludisme sur l'émergence de la résistance d'An. gambiae à la deltaméthrine dans cette région, contrairement aux résultats obtenus jusque là. Si l'émergence de la résistance à la deltaméthrine semble un phénomème relativement nouveau dans l'Ouémé dû peut-être à la promotion des moustiquaires imprégnées d'insecticides, le niveau de résistance noté dans l'Atacora montre que le phénomène est plus ancien. En effet, le niveau observé est très élevé (27-51,4% de taux de mortalité) dans toutes les communes. La forte résistance d'An. gambiae aux pyréthrinoïdes est accompagnée de l'inexistence de l'effet knock-down de la perméthrine et de la deltraméthrine sur les populations de moustiques testées (tables III).

4. Conclusion

Sur la base de la nature des murs à traiter et de la dispersion de certaines agglomérations,

Péhunco et Kérou devraient être exclus des communes à sélectionner pour la PID et, en compensation, bénéficier de la couverture totale en moustiquaires imprégnées à longue durée d'action avant mai 2010. Sur le plan de la densité et de la présence des anophèles dans les maisons La plupart des anophèles capturés sont trouvés gorgés, gravides ou semi-gravides à l'intérieur des maisons, c'est dire que le caractère endophile des anophèles exigé pour la PID est satisfait pour toutes les communes.
Sensibilité des vecteurs aux insecticides Quelle que soit la commune, les résultats sur la sensibilité sont les mêmes. Les moustiques sont sensibles au bendiocarb dans toutes les communes. Concernant la perméthrine, la deltamétrhine et le DDT, c'est la catastrophe. Dans les 9 communes, An. gambiae a développé une forte résistance vis-à-vis de ces produits

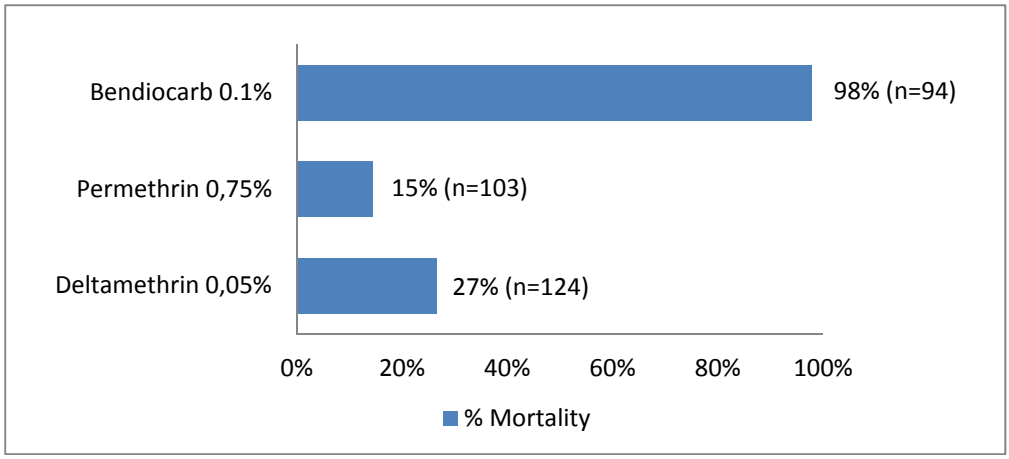
Choix de l'insecticide d'imprégnation

Vu le niveau élevé de la résistance d'An. gambiae aux pyréthrinoïdes dans les 9 communes et la tendance actuelle au niveau international qui consiste à réserver les pyréthrinoïdes uniquement pour l'imprégnation des moustiquaires, un non-pyréthrinoïde

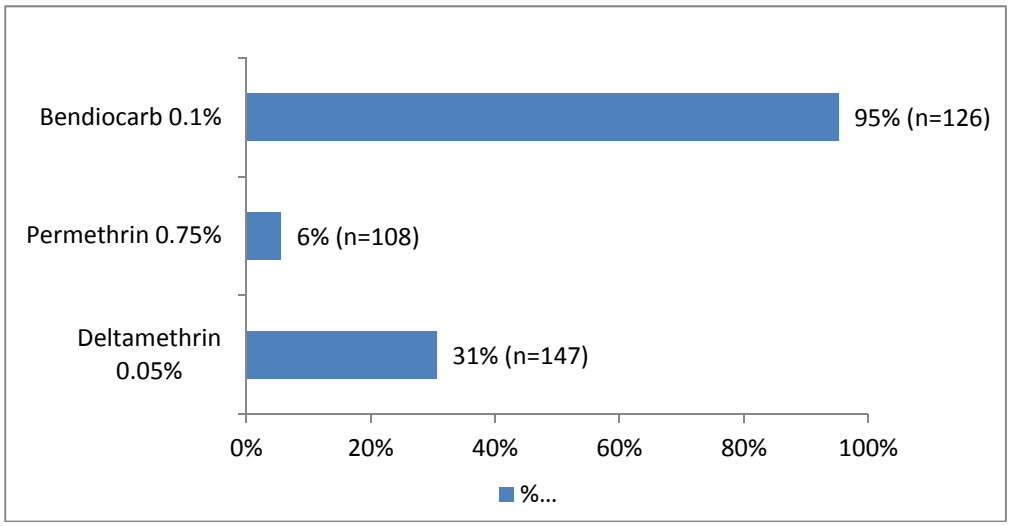
serait la meilleure alternative, soit un carbamate, soit un organophosphoré. Etant donné qu'An. gambiae est sensible au bendiocarb (un carbamate), nous proposons de continuer avec ce produit comme dans la campagne de l'Ouémé en attendant d'identifier un produit B pour une politique de rotation ou pour un éventuel remplacement.

Diagramme faisant la synthèse des résultats des tests de sensibilité d'An. gambiae aux insecticides

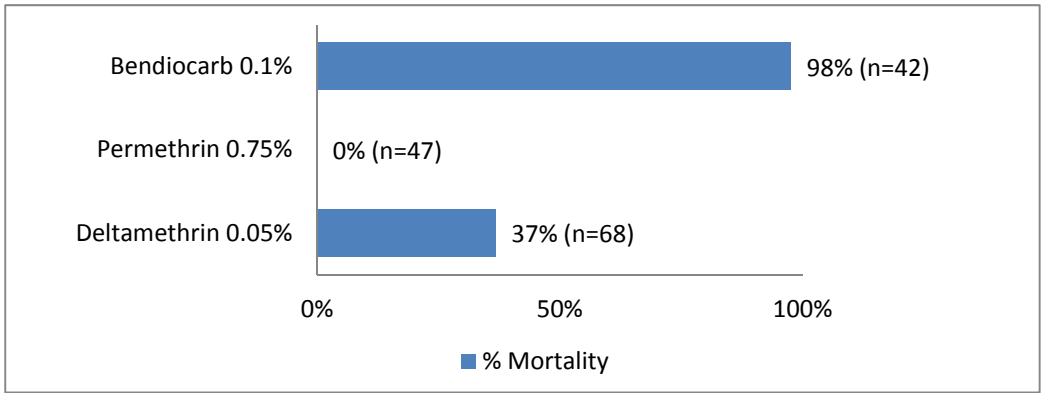
1- Commune de Péhunco



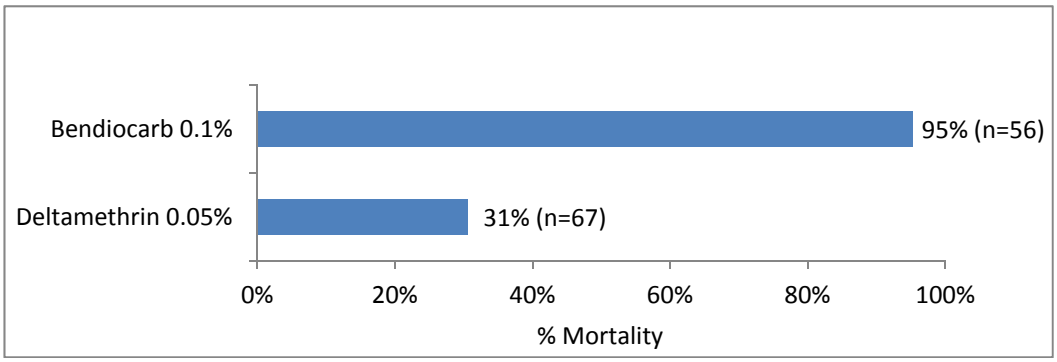
2- Commune de Kouandé



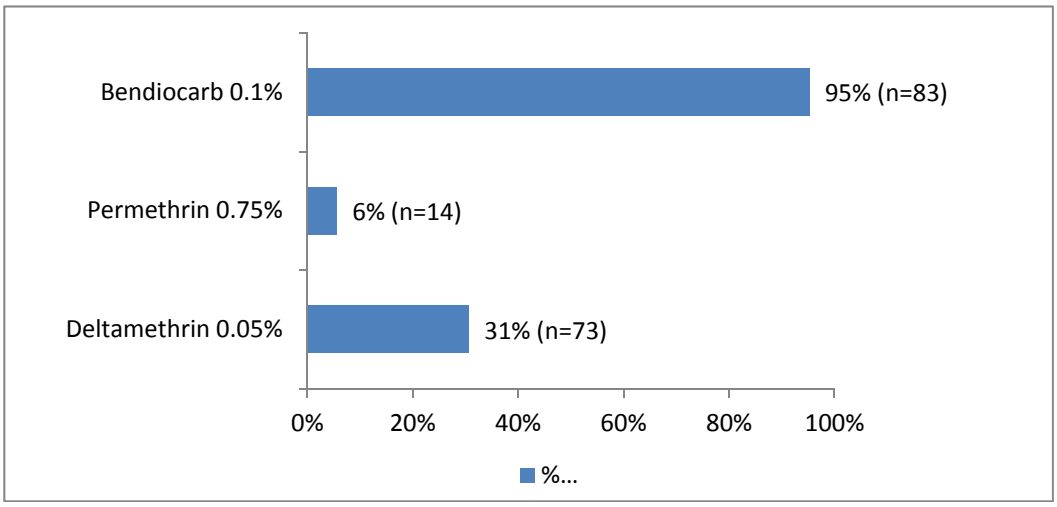
3- Commune de Cobly



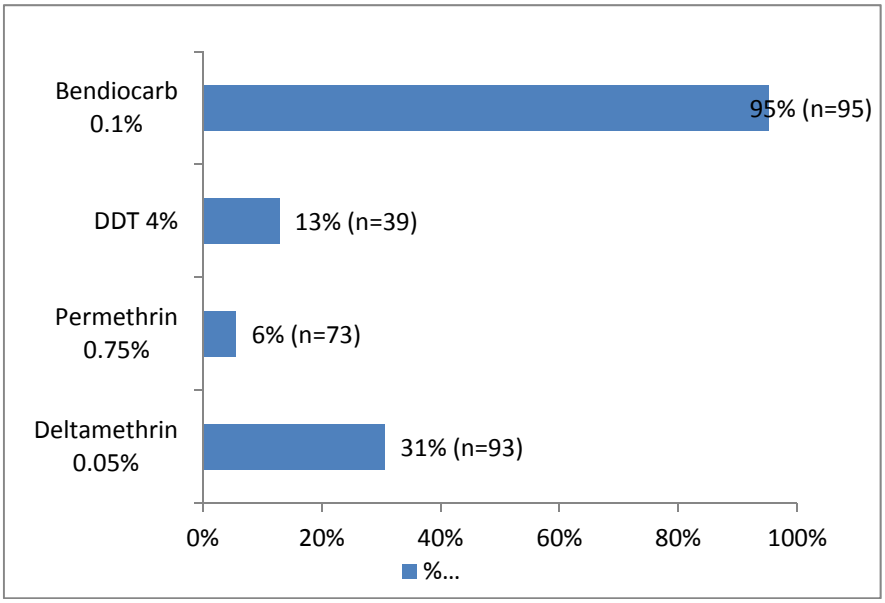
4- Commune de Boukoumbé



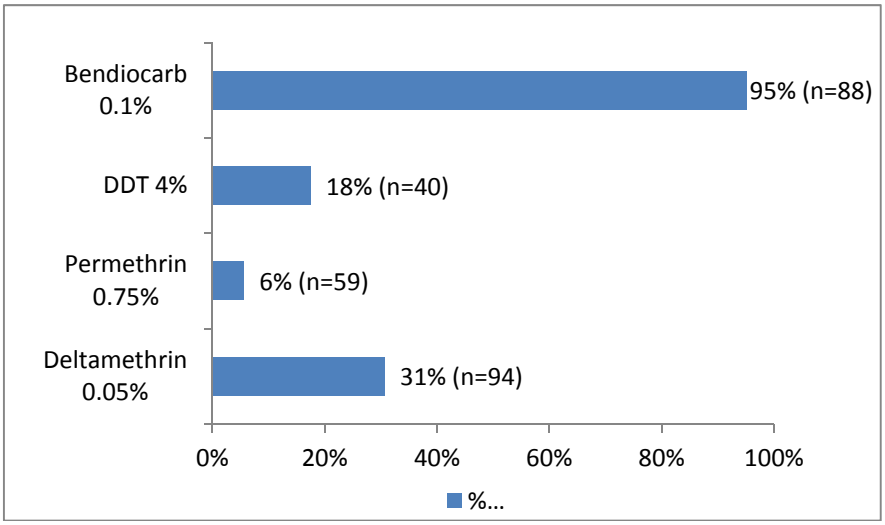
5- Commune de Matéri



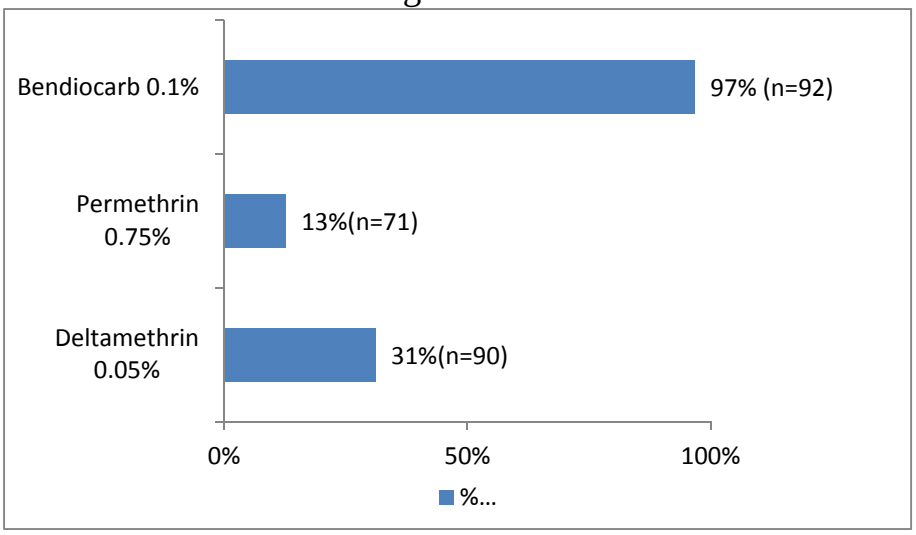
6- Commune de Tanguiéta



7- Commune de Toukountouna



8-Commune de Natitingou



9-Commune de Kérou

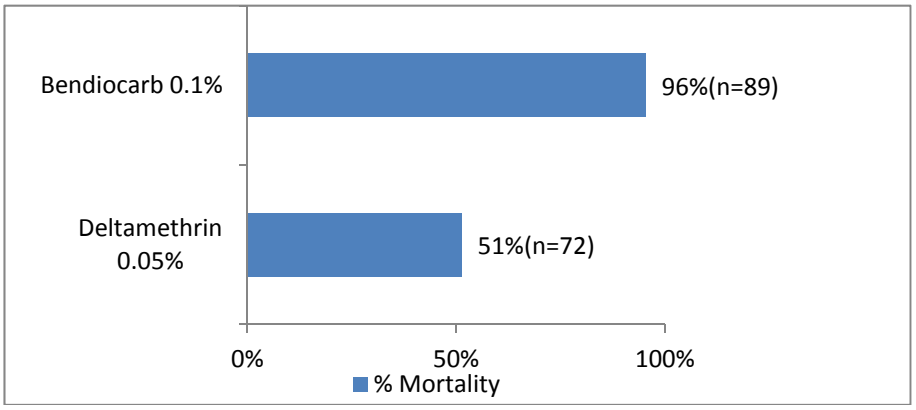


Table III: Knock-down time and percentage of dead *Anopheles gambiae* observed after one hour exposure to papers treated with various insecticides in Atacora, September 2010.

III. a. Pehunco district

	Pehunco district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	
Dead	0	0	0	
Alive	20	20	20	-
% Dead	0	0	0	
Tested	93	121	94	
KD50% (mn)	155,308	68,688	32,783	
KD95% (mn)	245,86	100,283	57,989	

Dead	15	33	92	-
Alive	88	88	2	
% Dead	14,56%	26,61%	97,87%	
Status	**R**	**R**	**S**	

III. b. Kouandé district

	Kouandé district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	
Dead	0	0	0	
Alive	20	20	20	-
% Dead	0	0	0	
Tested	108	147	126	
KD50% (mn)	126,169	68,93	29,509	
KD95% (mn)	179,703	110,794	51,133	
Dead	6	45	120	-
Alive	102	102	6	
% Dead	5,56%	30,61%	95,24%	
Status	**R**	**R**	**S**	

III. c. Cobly district

	Cobly district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	
Dead	0	0	0	
Alive	20	20	20	-
% Dead	0	0	0	
Tested	47	68	42	
KD50% (mn)	No kd	73,41	22,943	
KD95% (mn)	No kd	108,333	41,878	
Dead	0	25	41	-
Alive	47	43	1	
% Dead	0	36,76%	97,62%	
Status	**R**	**R**	**S**	

III. d. Boukombé district

	Boukoumbé district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control		20	20	
Dead		0	0	
Alive	-	20	20	-
% Dead		0	0	
Tested		67	56	
KD50% (mn)		72,36	24,839	
KD95% (mn)		97,379	45,755	
Dead	-	18	56	-
Alive		49	0	
% Dead		26,87%	100,00%	
Status		**R**	**S**	

III. e. Matéri district

	Matéri district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	20
Dead	0	0	0	0
Alive	20	20	20	20
% Dead	0	0	0	0
Tested	55	73	83	19
KD50% (mn)	83,65	64,052	25,029	82,75
KD95% (mn)	104,04	95,126	47,267	143,172
Dead	4	34	79	3
Alive	51	39	4	16
% Dead	7,27%	46,58%	95,18%	15,80%
Status	**R**	**R**	**S**	**R**

III. f. Tanguiéta district

	Tanguiéta district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	20
Dead	0	0	0	0
Alive	20	20	20	20
% Dead	0	0	0	0
Tested	98	93	95	70
KD50% (mn)	99,317	54,234	26,107	143,973
KD95% (mn)	131,736	82,377	46,21	254,167
Dead	12	50	92	12
Alive	86	43	3	58

% Dead	12,24%	53,76%	96,84%	17,14%
Status	**R**	**R**	**S**	**R**

III. g. Toukountouna district

	Toukountouna district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	20
Dead	0	0	0	0
Alive	20	20	20	20
% Dead	0	0	0	0
Tested	130	94	97	65
KD50% (mn)	119,405	74,468	26,534	92,569
KD95% (mn)	193,967	119,439	46,637	117,475
Dead	21	24	92	8
Alive	109	70	5	57
% Dead	16,15%	25,53%	94,84%	12,31%
Status	**R**	**R**	**R**	**R**

III. h. Natitingou district

	Natitingou district			
	Permethrin (0,75%)	Deltamethrin (0,05%)	Bendiocarb (0,1%)	DDT (4%)
Control	20	20	20	
Dead	0	0	0	
Alive	20	20	20	-
% Dead	0	0	0	
Tested	71	90	92	
KD50% (mn)	107,92	71,682	34,599	
KD95% (mn)	158,615	11,553	65,739	-
Dead	9	28	89	
Alive	62	62	3	
% Dead	12,67%	31,11	96,73%	
Status	**R**	**R**	**S**	

III. i. Kérou district

	Kérou district			
	Permethrin 0,75%	Deltamethrin 0,05%	Bendiocarb 0,1%	DDT 0,4%
Control				
Dead		0	0	
Alive		20	20	
% Dead		0	0	
Tested				
KD50% (mn)		57,964	31,725	
KD95% (mn)		92,378	51,887	
Dead		37	85	
Alive		35	4	
% Dead		51,38%	95,50%	
Statut		**R**	**r**	

Légende: R= Résistance r= Suspicion of résistance S= Susceptibility

Annex

- **Registered Pesticides in Benin**

Comité National d'Agrément et de Contrôle des Produits Phytopharmaceutiques

CNAC

RÉPUBLIQUE DU BÉNIN

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Tel. (+229) 20.21.32.90/20.21.32.93 Fax. (+229) 20.21.44.13

LISTE DES PRODUITS PHYTOPHARMACEUTIQUES SOUS

AUTORISATION PROVISOIRE DE VENTE (APV) ***ET AGREMENT HOMOLOGATION (AH)***

Avril 2010

1- AUTORISATION PROVISOIRE DE VENTE

N°	*Nom commercial*	Matière(s) Active(s)	Formulation	Conditionnement	Nature	Firmes	Distributeurs	N° agrément	Date	
									Obtention	Expiration

1.	**GLYPHALM 720 WG**	Glyphosate 720 g/kg	WG (granulé dispersible)	Emballage : Sachet Suremballage : carton de 10 kg	Herbicide total	ALM International SA	***SAMAC***	APV -06.0082/CNAC	18/08/06	17/08/10
2.	**TOUCHDOWN Forte 500 SC**	Glyphosate acide 500 g/l	SC	Bidon de 1 L	Herbicide systémique non sélectif	***SYNGENTA***	***SAMAC***	APV -06.0083/CNAC	18/08/06	17/08/10
3.	**THUNDER 145 O - TEQ**	Betacyfluthrine 45 g/l Imidacioprid 100 g/l	OD	Bidon de 1 L	Insecticide et aphicide coton	Bayer Crop Science	**SDI**	APV -06.0084/CNAC	18/08/06	17/08/10
4.	**CALIFE 500 EC**	Profénofos 500 g/l	EC	Bidon de 1 L	Insecticide coton	SAVANA	*SDI*	APV -06.0085/CNAC	18/08/06	17/08/10
5.	**MALIK 108 EC**	Haloxyfop-r-methyl 108 g/l	EC	Bidon de 1 L	Herbicide coton	SAVANA	*SDI*	APV -06.0086/CNAC	18/08/06	17/08/10
6.	**EMIR 88 EC**	Cypermethrine 72 g/l Acetamipride 16,6 g/l	EC	Bidon de 1 L	Insecticide coton	***SAVANA***	*SDI*	APV -06.0087/CNAC	18/08/06	17/08/10
7.	**PYRINEX QUICK 212 EC**	Deltamethrine 12 g/l Chlorpyriphos ethyl 200 g/l	EC	Bidon de 1 L	Insecticide coton	***YARA West Africa***	*SDI*	APV -06.0088/CNAC	18/08/06	17/08/10
8.	**FUSILADE Forte 150 EC**	Fluazifop-p-butyl 150 g/l	EC	Bidon de 1 L	Herbicide systémique coton	***SYNGENTA***	*SAMAC*	APV -06.0089/CNAC	18/08/06	17/08/10
9.	**KRISS 100 SL**	Acetamipride 100g/l	SL	Bidon de 1 L	Insecticide coton	ALM International SA	*SAMAC*	APV -06.0090/CNAC	18/08/06	17/08/10
10	**ACTALM Super**	Cyfluthrine 0,3 % Pyrimiphos methyl 1,6%	PP	Sachets de 50 g	Insecticide	ALM International SA	*SAMAC*	APV -06.0091/CNAC	18/08/06	17/08/10
11	**FANGA 500 EC**	Profenofos 500 g/l	EC	Bidon de 1 L	Insecticide coton	ALM International SA	*SAMAC*	APV -06.0092/CNAC	18/08/06	17/08/10
12	**PACHA 25 EC**	Acetamipride 10 g/l Lambdacyhalothrine 15 g/l	EC	Bidon de 1 L	Insecticide cultures maraîchères	SAVANA	*SDI*	APV- 07.0093/CNAC	18/07/07	17/07/11

13	**GLYFOS 360 SL**	Glyphosate acide 360 g/l	SL	Bidon de 1 L	Herbicide systémique de post-levée	CHEMINOVA	*PACOGE*	APV- 07.0094/CNAC	18/07/07	17/07/11
14	**LAMBDACAL P 630 EC**	Lambdacyhalothrine 30 g/l Profénofos 600 g/l	EC	Bidon de 1 L	Insecticide coton	*Arysta LifeScience*	***SOGICOM International***	APV- 07.0095/CNAC	18/07/07	17/07/11
15	**LAMBDACAL P 645 EC**	Lambdacyhalothrine 45 g/l Profénofos 600 g/l	EC	Sachet de 165 ml	Insecticide coton	*Arysta LifeScience*	***SOGICOM International***	APV- 07.0096/CNAC	18/07/07	17/07/11
16	**ATO IBI 01**	Betacypermethrine 18 g/l Chlorpyriphos-Ethyl 300 g/l	EC	Bidon de 1 L	Insecticide coton binaire acaricide	CEREXAGRI S.A.	*SICREP*	APV- 07.0097/CNAC	18/07/07	17/07/11
17	**FINISH 360 SL**	Glyphosate acide 360 g/l	SL	Bidon de 1 L	Herbicide systémique non sélectif de post-levée	SAVANA	*SDI*	APV- 07.0098/CNAC	18/07/07	17/07/11
18	**Glyphalm 360 SL**	Glyphosate acide 360 g/l	SL	Bidon de 5 L	Herbicide total systémique non sélectif	ALM International SA	*SAMAC*	APV- 07.0099/CNAC	17/01/08	16/01/12
19	**MAMBA 360 SL**	Glyphosate acide 360 g/l	SL	Bidon de 1 L	Herbicide total systémique non sélectif	*Dow AgroScience*	*SDI*	APV- 07.0100/CNAC	17/01/08	16/01/12
20	**TIHAN 175 O-TEQ**	Flubendiamide 100 g/l Spirotetramate 75 g/l	OD	Flacon de 100 ml	Insecticide coton	Bayer CropScience	-	APV- 07.101/CNAC	17/01/08	16/01/12
21	**Conquest C176 EC**	Acétamipride 32 g/l Cyperméthrine 144 g/l	EC	Bidon de 1 L	Insecticide	*Arysta LifeScience*	*SOGICOM International*	APV-08.102/CNAC	28/08 08	27/08/12
22	**FICAM®VC**	Bendiocarbe 80%	WP	Sachet de 125 g	Insecticide anti-moustique	*Bayer EnvironmentalSciences*	*UNIDIS (Union des Distributeurs)*	APV-08.103/CNAC	28/08 08	27/08/12
23	**COTALM P315 EC**	Lambdacyhalothrine 15 g/l Profénofos 300 g/l	EC	Bidon de 1 L	Insecticide coton	ALM International SA	*SAMAC*	APV-09.104/CNAC	27/04/09	26/04/13
24	**SELECT 120 EC**	Cléthodim 120 g/l	EC	Bidon de 1 L	Herbicide coton	*Arysta LifeScience*	*SOGICOM International*	APV-09.105/CNAC	27/04/09	26/04/13
25	**STEWARD 150 EC**	Indoxacarbe 150g/l	EC	Bidon de 1 L	Insecticide coton	*Arysta LifeScience*	*SOGICOM International*	APV-09.106/CNAC	27/04/09	26/04/13
26	**DEFCAL 8 EC**	Pyraflufen ethyl 8 g/l	EC	Bidon de 1 L	Herbicide - défoliant coton	*Arysta LifeScience*	*SOGICOM International*	APV-09.107/CNAC	27/04/09	26/04/13
27	**TERBULOR 500 EC**	- Terbutryn 167 g/l - Métolachlore 333 g/l	EC	Bidon de 1 L	Herbicide maïs	*AF-CHEM SOFACO*	*SDI*	APV-09.108/CNAC	27/04/09	26/04/13

28	**GLYCEL 41%**	Glyphosate acide 410 g/l	SL	Bidon de 1 L	Herbicide	*EXCEL CROP CARE*	*SUNSHINE*	APV-09.109/CNAC	09/06/09	08/06/13
29	**LAGON 380**	- Isoxaflutole 50 g/l - Aclonifène 333g/l	SC	Bidon de 0,5 L	Herbicide de pré levée du maïs	*Bayer CropScience*	*SDI*	APV-10.110/CNAC	16/04/10	15/04/14
30	**MONCEREN GT 390**	- Imidacloprid 233 g/l - Pencycuron 50 g/l - Thiram 107 g/l	FS	Boîte de 25 L	Insecticide/fongicide de traitement des semences coton	*Bayer CropScience*	*SDI*	APV-10.111/CNAC	16/04/10	15/04/14
31	**TRIPRO**	- Triclopyr 72 g/l - Propanil 360 g/l	EC	Bidon de 1 L	Herbicide de post levee du riz	*SUNSHINE Sarl*	*SUNSHINE Sarl*	APV-10.112/CNAC	16/04/10	15/04/14

2- AGREMENT HOMOLOGATION

N°	Nom commercial	Matière(s) Active(s)	Formulation	Conditionnement	Nature	Firmes	Distributeurs	N° agrément	Date	
									Obtention	Expiration
1.	**Cruiser 350 fs**	Thiamethoxam 350 g/l	SC	Bidon de 1 L	Insecticide Traitement semences	Syngenta Crop Protection AG	SAMAC	AH00.0022/CNAC	17/10/00	16/10/10
2.	**Cruiser 70 ws**	Thiamethoxam 700 g/kg	WP	Bidon de 5 L	Insecticide Traitement semences	Syngenta Crop Protection AG	SAMAC	AH00.0023/CNAC	17/10/00	16/10/10
3.	**Cotodon Plus 500**	Terbuthryne 167g/l Métolachlore 333g/l	EC	Bidon de 1 L	Herbicide	Syngenta Crop Protection AG	SAMAC	AH00.0024/CNAC	17/10/00	16/10/10
4.	**Marshall 35 DS**	Carbosulfan 350g/kg	DS	Tonnelet de 50 kg	Insecticide semences	FMC	ADAIC	AH00.0025/CNAC	17/10/00	16/10/10
5.	**K-OTEK**	Deltamethrine 25 g/l	EC	Bidon de 1 L	Insecticide	Bayer Crop Science	SDI	AH00.0026/CNAC	17/10/00	16/10/10
6.	**K-OTHRINE 25 EC**	Deltamethrine 25 g/l	EC	Bidon de 1 L	Insecticide	Bayer Crop Science	SDI	AH00.0027/CNAC	17/10/00	16/10/10
7.	**K-OTHRINE GRAINS 2 DP**	Deltamethrine 2 g/kg	DP	Sachet de 50 g	Insecticide Stock	Bayer Crop Science	SDI	AH00.0028/CNAC	17/10/00	16/10/10
8.	**Sumithion**	Fénitrothion 500 g/l	EC	Bidon de 1 L	Insecticide riz, fruits et agrumes	Sumitomo	Sumitomo	AH00.0029/CNAC	17/10/00	16/10/10
9.	**Sumicidin**	Fenvalérate 60g/l	EC	Bidon de 1 L	Insecticide céréales, cotonnier, maraîcherères	Sumitomo	Sumitomo	AH00.0030/CNAC	17/10/00	16/10/10
10.	**Sumi alpha**	es-Fenvalérate 24g/l	EC	Bidon de 1 L	Maïs, cotonnnier, maraïchères	Sumitomo	Sumitomo	AH00.0031/CNAC	17/10/00	16/10/10
11.	**Roundup 68 SG**	Glyphosate 680 g/kg	SG	Bidon de 5 L	Herbicide	Monsanto	Monsanto	AH00.0032/CNAC	17/10/00	16/10/10

12.	***Roundup 360 SL***	*Glyphosate 360 g/l*	*SL*	*Boîte de 100 à 480 comprimés*	*Herbicide*	*Monsanto*	*Monsanto*	*AH00.0033/CNAC*	*17/10/00*	*16/10/10*
13.	***Sorghoprim***	*Terbuthylazine 250g/l Terbutryne 250g/l*	*FW*	*Bidon de 20 L*	*Herbicide*	*Syngenta Crop Protection AG*	*SAMAC*	*AH00.0034/CNAC*	*17/10/00*	*16/10/10*
14.	***Cotodon 400***	*Métolachlore 135g/l Dipropetryne 265g/l*	*EC*	*Bidon de 1 L*	*Herbicide*	*Syngenta Crop Protection AG*	*SAMAC*	*AH00.0036/CNAC*	*17/10/00*	*16/10/10*
15.	***Cotalm P 87,2***	*Lambdacyhalothrine 7,2g/l Profenofos 80g/l*	*UL*	*Bidon de 5 L*	*Insecticide coton*	*ALM International*	*SAMAC*	*AH00.0037/CNAC*	*17/10/00*	*16/10/10*
16.	***Dursban B 120/7,2***	*Cyperméthrine 7,2g/l Chlorpyriphos ethyl 120g/l*	*UL*	*Bidon de 1 L*	*Insecticide coton*	*Dow Agro*	*SDI*	*AH00.0038/CNAC*	*17/10/00*	*16/10/10*
17.	***Polytrine C 330***	*Cyperméthrine 30g/l Profenofos 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Syngenta Crop Protection AG*	*SAMAC*	*AH00.0039/CNAC*	*17/10/00*	*16/10/10*
18.	***Fury P 315***	*Zetacyperméthrine 15g/l Profenofos 300g/l*	*EC*	*Sachet de 25g/ 50g*	*Insecticide coton*	*FMC*	*ADAIC*	*AH00.0040/CNAC*	*17/10/00*	*16/10/10*
19.	Fury D 315	*Zetacyperméthrine 15g/l Dimethoate 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*FMC*	*ADAIC*	*AH00.0041/CNAC*	*17/10/00*	*16/10/10*
20.	***Fury P 215***	*Zetacyperméthrine 15g/l Profenofos 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*FMC*	*ADAIC*	*AH00.0042/CNAC*	*17/10/00*	*16/10/10*
21.	***Nurelle D 14,4/80***	*Cyperméthrine 14,4g/l Chlorpyriphos ethyl 80g/l*	*UL*	*Bidon de 1 L*	*Insecticide coton*	*Dow Agro*	*SDI*	*AH00.0043/CNAC*	*17/10/00*	*16/10/10*
22.	***Nurelle D 14/120***	*Cyperméthrine 14g/l Chlorpyriphos ethyl 120g/l*	*UL*	*Sachet de 100 g*	*Insecticide coton*	*Dow Agro*	*SDI*	*AH00.0044/CNAC*	*17/10/00*	*16/10/10*
23.	***Cyclophos 335***	*Cyperméthrine 35g/l Chlorpyriphos ethyl 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Senchim*	*SOTICO*	*AH00.0045/CNAC*	*17/10/00*	*16/10/10*
24.	***Cyclophos 236***	*Cyperméthrine 36g/l Chlorpyriphos ethyl 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Senchim*	*SOTICO*	*AH00.0046/CNAC*	*17/10/00*	*16/10/10*
25.	***Cyperax 35***	*Cyperméthrine 35g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Senchim*	*SOTICO*	*AH00.0047/CNAC*	*17/10/00*	*16/10/10*

26.	***Duel 232,5***	*Cyperméthrine 32,5g/l Profenofos 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide/ acaricide coton*	*Senchim*	*SOTICO*	*AH00.0048/CNAC*	*17/10/00*	*16/10/10*
27.	***Conquest 88***	*Acetamiprid 16g/l Cyperméthrine 72g/l*	*EC*	*Bidon de 0,5 L*	*Insecticide coton*	*Bayer CropScience*	*SDI*	*AH00.0049/CNAC*	*17/10/00*	*16/10/10*
28.	**Percal M**	*Perméthrine 0,4% Malathion 1,6%*	*DP*	*Sachet de 50 g*	*Insecticide des denrées stockées*	*Arysta LifeScience*	*SOGICOM International*	*AH-01/R1-0001/CNAC*	*31/08/01*	*30/08/11*
29.	**Koufla 6 SL**	*Thiabendazole 5% Perméthrine 0,5% Malathion 0,5%*	*DP*	*Sachet de 50 g*	*Fongicide/acaricide*	*Arysta LifeScience*	*SOGICOM International*	*AH-01/R1-0002/CNAC*	*31/08/01*	*30/08/11*
30.	**Kalach 360 SL**	*Glyphosate 360 g/l*	*SL*	*Bidon de 1 L*	*Herbicide systémique non sélectif*	*Arysta LifeScience*	*SOGICOM International*	*AH-01/R1-0003/CNAC*	*31/08/01*	*30/08/11*
31.	***Cotalm P 310 EC***	*Lambdacyhalothrine 10g/l Profenofos 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Alm International*	*SAMAC*	*AH01.0050/CNAC*	*12/03/01*	*11/03/11*
32.	***Cotalm P 210 EC***	*Lambdacyhalothrine 10g/l Profenofos 200g/l*	*EC*	*Bidon de 1L*	*Insecticide coton*	*Alm International*	*SAMAC*	*AH01.0051/CNAC*	*12/03/01*	*11/03/11*
33.	***Cotalm D 312 EC***	*Lambdacyhalothrine 10g/l Dimethoate 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Alm International*	*SAMAC*	*AH01.0052/CNAC*	*12/03/01*	*11/03/11*
34.	***Cyflutralm P 218 EC***	*Cyfluthrine 18g/l Profenofos 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Alm International*	*SAMAC*	*AH01.0053/CNAC*	*12/03/01*	*11/03/11*
35.	***Cyflutralm P 318 EC***	*Cyfluthrine 18g/l Profenofos 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Alm International*	*SAMAC*	*AH01.0054/CNAC*	*12/03/01*	*11/03/11*
36.	***Curacron 500 EC***	*Profenofos 500g/l*	*EC*	*Flacon de 500 CC*	*Insecticide coton*	*Novartis*	*SAMAC*	*AH01.0055/CNAC*	*12/03/01*	*11/03/11*
37.	***Akizon 4SC***	*Nicosulfuron 40g/l*	*SC*	*Bidon de 1 L*	*Herbicide*	*Arysta LifeScience*	*SOGICOM International*	*AH01.0056/CNAC*	*12/03/01*	*11/03/11*
38.	***Havarde 25 F***	*Diméthipine 250g/l*	*SC*	*Bidon de 1 L*	*Défoliant*	*Uniroyal Chemical*	*Gamess-Bénin*	*AH01.0057/CNAC*	*12/03/01*	*11/03/11*
39.	***Racumin TP 0,75***	*Coumatétralyl 0.75%*	*TP*	*Sac de 2,5 Kg*	*Rodenticide*	*Bayer*	*Bayer*	*AH01.0058/CNAC*	*31/08/01*	*30/08/11*
40.	***Ténor 500 EC***	*Profenofos 500g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Senchim*	*SOTICO*	*AH02.0059/CNAC*	*08/05/02*	*07/05/12*
41.	***Dursban B 200/18 EC***	*Cyfluthrine 18g/l Chlorpyriphos ethyl 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide coton*	*Dow Agro*	*SDI*	*AH02.0060/CNAC*	*08/05/02*	*07/05/12*

42.	***KINIKINI***	*Cyfluthrine 9,6 g/l* *Malathion 400 g/l*	*EC*	*Bidon de 1 L*	*Insecticide Systémique binaire (Pyréthrinoïde + Organophosphoré) sur niébé*	*ALM International SA*	*SAMAC*	AH03.0061/CNAC	*08/03/05*	*07/03/15*
43.	**TRIALM 400 EC**	*Triazophos 400 g/l*	*EC*	*Bidon de 1 L*	*Insecticide simple (organophosphoré) sur cotonnier*	*ALM International SA*	*SAMAC*	AH03.0062/CNAC	*08/03/05*	*07/03/15*
44.	***CYPALM 350 EC***	Cyperméthrine 350 g/l	*EC*	*Bidon de 1 L*	*Insecticide (Pyréthrinoïde) sur cotonnier*	*ALM International SA*	*SAMAC*	*AH03.0063/CNAC*	*08/03/05*	*07/03/15*
45.	***GLYPHOGAN 360 SL***	*Glyphosate 360 g/l*	*SL*	*Bidon de 1 L*	*Herbicide*	*AGAN Ashdod*	*SDI*	*AH04.0064/CNAC*	*08/03/05*	*07/03/15*
46.	***DECIS 10,75 EC***	*Deltaméthrine 10,75 g/l*	*EC*	*Bidon de 1 L*	*Insecticide pyréthrinoïde*	*Bayer CropScience*	*SDI*	*AH – 06.0065/CNAC*	*18/08/06*	*17/08/16*
47.	***DECIS 25 EC***	*Deltaméthrine 25 g/l*	*EC*	*Bidon de 1 L*	*Insecticide pyréthrinoïde*	*Bayer CropScience*	*SDI*	*AH – 06.0066/CNAC*	*18/08/06*	*17/08/16*
48.	***SHERPHOS 180 EC***	*Cyperméthrine 30 g/l* *Triazophos 150 g/l*	*EC*	*Bidon de 1 L*	*Insecticide – acaricide binaire*	*Bayer CropScience*	*SDI*	*AH – 06.0067/CNAC*	*18/08/06*	*17/08/16*
49.	***SHERPHOS 280 EC***	*Cyperméthrine 30 g/l* *Triazophos 250 g/l*	*EC*	*Bidon de 1 L*	*Insecticide – acaricide binaire*	*Bayer CropScience*	*SDI*	*AH – 06.0068/CNAC*	*18/08/06*	*17/08/16*
50.	***SHERPA 35 EC***	*Cyperméthrine 35 g/l*	*EC*	*Bidon de 1 L*	*Insecticide pyréthrinoïde*	*Bayer CropScience*	*SDI*	*AH – 06.0069/CNAC*	*18/08/06*	*17/08/16*
51.	***CONQUEST PLUS 388 EC***	*Acétamipride 16 g/l* *Cyperméthrine 72 g/l* Triazophos 300g/	*EC*	*Bidon de 0,5 L*	*Insecticide ternaire acaricide (Inidazoline, pyréthrinoïde et organophosporé)*	*Arysta LifeScience*	*SOGICOM*	*AH – 06.0072/CNAC*	*18/08/06*	*17/08/16*
52.	**LASER 480 SC**	Spinosad 480g/l	SC	Bidon de 1 L	Insecticide Coton	Dow Agro Sciences	SDI	*AH – 07.0073/CNAC*	03/01/08	02/01/18
53.	**DURSBAN 4 E**	Chlorpyriphos éthyl 480g/l	EC	Bidon de 1 L	Insecticide	Dow Agro Sciences	SDI	*AH – 07.0074/CNAC*	03/01/08	02/01/18
54.	**GARIL**	Triclopyr 72g/l Propanil 360g/l	EC	Bidon de 1 L	Herbicide riz	Dow Agro Sciences	SDI	*AH – 08.0075/CNAC*	16/05/08	15/05/18
55.	**CALFOS 500 EC**	Profénofos 500 g/l	EC	Bidon de 1 L	Insecticide-acaricide	*Arysta LifeScience*	*SOGICOM International*	*AH 08.0076/CNAC*	28/08/08	27/08/18
56.	**ALPHACAL P218 EC**	Alphacyperméthrine 18 g/l Profénofos 200 g/l	EC	Bidon de 1 L	Insecticide-acaricide	*Arysta LifeScience*	*SOGICOM International*	*AH 08.0077/CNAC*	28/08/08	27/08/18
57.	**CYPERCAL P 330 EC**	Cyperméthrine 30 g/l Profénofos 300 g/l	EC	Bidon de 1 L	Insecticide-acaricide	*Arysta LifeScience*	*SOGICOM International*	AH-08.R1-0002/CNAC	28/08/08	27/08/18

58.	**TOPSTAR 400SC**	Oxadiargyl 400g/l	SC	Bidon de 1 L	Herbicide riz	Bayer CropScience	SDI	*AH - 09.0078/CNAC*	27/04/09	26/04/19
59.	**LAMBDACAL P 315 EC**	Lambdacyhalothrine 15 g/l Profenofos 300 g/l	EC	Boîte de 1 L	Insecticide – acaricide coton	*Arysta LifeScience*	SOGICOM International	*AH - 09.0079/CNAC*	27/04/09	26/04/19
60.	**LAMBDACAL P 215 EC**	Lambdacyhalothrine 15 g/l Profenofos 200 g/l	EC	Boîte de 1 L	Insecticide – acaricide binaire sur cotonnier	*Arysta LifeScience*	SOGICOM International	*AH - 09.0080/CNAC*	27/04/09	26/04/19
61.	**GALLANT SUPER**	Haloxyfop méthyle ester 104g/l	EC	Boîte de 1 L	Herbicide sur cotonnier	Dow Agro Sciences	*SDI*	*AH - 09.0081/CNAC*	27/04/09	26/04/19
62.	**LASER 480 SC**	Spinosad 480 g/l	SC	Sachet de 50 ml	Insecticide sur cultures maraîchères	Dow Agro Sciences	*SDI*	*AH - 09.0082/CNAC*	27/04/09	26/04/19
63.	**SPINTOR POUDRE**	Spinosad 1.25g/kg	DP	Sachet de 50 g	Insecticide pour le traitement des grains stockés	***Dow Agro Sciences***	***SDI***	*AH - 09.0083CNAC*	27/04/09	26/04/19
64.	**Callifor G**	*Glyphosate 60g/l Fluometuron 250g/l Prometrine 250g/l*	*SC*	*Bidon de 1 L*	*Herbicide coton*	*Arysta LifeScience*	*SOGICOM International*	*AH-09.R1-0007/CNAC*	*27/04/09*	*26/04/19*
65.	***Nurelle D 36/200***	*Cyperméthrine 36g/l Chlorpyriphos ethyl 200g/l*	*EC*	*Bidon de 1 L*	*Insecticide Coton*	*Dow Agro Sciences*	*SDI*	*AH-09.R1-0015/CNAC*	*27/04/09*	*26/04/19*
66.	***Nurelle D 35/300***	*Cyperméthrine 35g/l Chlorpyriphos ethyl 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide Coton*	*Dow Agro Sciences*	*SDI*	*AH-09.R1-0016/CNAC*	*27/04/09*	*26/04/19*
67.	***Dursban B 318***	*Cyfluthrine 18g/l Chlorpyriphos ethyl 300g/l*	*EC*	*Bidon de 1 L*	*Insecticide Coton*	*Dow Agro Sciences*	*SDI*	*AH-09.R1-0017/CNAC*	*27/04/09*	*26/04/19*

68.	**CHANGO 122 SE**	Indoxacarbe 50g/l Cypermethrine 72g/l	SE	Boîte de 1 L	Insecticide coton	*Arysta LifeScience*	***SOGICOM International***	AH - 09.0084/CNAC	09/06/09	08/06/19
69.	**COTTONEX P SC**	Fluométuron 250g/l Prométryne 250g/l	SC	Bidon de 1 L	Herbicide coton	*Agan Ashdod*	***SDI***	AH-10.0085/CNAC	16/04/10	15/04/20
70.	**COTTONEX PG 560 SC**	Fluométuron 250g/l Prométryne 250g/l Glyphosate 60g/l	SC	Bidon de 1 L	Herbicide coton	*Agan Ashdod*	***SDI***	AH-10.0086/CNAC	16/04/10	15/04/20
71.	**COTOGARD SC**	Fluometuron 250g/l Prometryn 250g/l	SC	Boîte de 1 L	Herbicide coton	***Agan Ashdod***	***SDI***	AH-10.0087/CNAC	16/04/10	15/04/20
72.	**MALIK 108 EC**	Haloxyfop-r-methyl 108 g/l	EC	Bidon de 1 L	Herbicide coton	SAVANA	*SDI*	AH-10.0088/CNAC	16/04/10	15/04/20
73.	**EMIR 88 EC**	Cypermethrine 72 g/l Acetamipride 16,6 g/l	EC	Bidon de 1 L	Insecticide coton	***SAVANA***	*SDI*	AH-10.0089/CNAC	16/04/10	15/04/20
74.	**CALIFE 500 EC**	Profénofos 500 g/l	EC	Bidon de 1 L	Insecticide coton	SAVANA	*SDI*	AH-10.0090/CNAC	16/04/10	15/04/20