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in cooperation with ICIPE, KEMRI

Framework for strengthening Integrated Vector Management in malaria control programmes

October 2013

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Table of Contents

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PAN Germany is a charitable organisation which provides information on the adverse effects of pesticides and promotes environmentally friendly and socially just alternatives. We are part of the Pesticide Action Network International. Our work areas range from critical assessments of the pesticide industry to constructive interaction with policy-makers to practical services for farmers and consumers.

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This framework

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About this document

This document presents a decision making framework to assist malaria control programme funders achieve a significant reduction in malaria morbidity and mortality through cost-effective, ecologically sound and sustainable Integrated Vector Management (IVM) interventions. Community- and ecosystem-based IVM provide effective vector control and minimize risks to human health and the environment. This framework aims to strengthen these aspects of IVM in malaria control programs. This 'holistic' IVM will reduce individual, community and environmental exposure to pesticide hazards and risks. It will support the Stockholm Convention goal to reduce reliance on, and ultimately eliminate use of, the persistent organic pollutant DDT.

The framework is a tool to assess whether new and on-going malaria project applications incorporate least toxic, effective and participatory disease control measures. It will assist donors to collaborate with malaria programme applicants or managers to incorporate robust pre-planning and planning phases that gather the information and collate the data essential for evidence-based control strategies. The framework can be used by officials who plan, design, fundraise for, implement or monitor a programme to combat malaria and other vector-borne diseases to assess whether they have adequately addressed key elements of IVM.

The framework focuses particularly on three key elements of a holistic IVM strategy:
a) evidence-based decision making at community level by community members
b) social mobilization to support communities becoming primary stakeholders in IVM
c) use of non-chemical approaches to vector control within community-guided IVM
These IVM strategies are additional to, and compatible with, the use of bed nets and medicinal therapies.

The framework presents questions that funders can request applicants to respond to. When successful applicants for malaria funding address the points covered in these questions, the initiatives will incorporate elements of holistic IVM. The framework provides indicators for malaria control programme officials to assess whether IVM is adopted in their projects and programmes.

This document is based on literature from disease control programme planning and incorporates lessons from on-the-ground activities that adopt sustainable IVM-based controls. It draws on WHO work and publications, in particular: the IVM handbook (WHO 2012a); Guidance on Policy-making for IVM (WHO 2012b) and Malaria Indicator Survey (WHO 2012c). It took inspiration from the International Centre for Insect Physiology and Ecology (ICIPE) implementation of IVM strategies that target malaria in Africa (ICIPE 2012). And it draws on effective experiences in Mexico, Kenya, Ethiopia and Senegal (PAN Germany 2010, ICIPE 2012, PAN Africa & PAN Germany 2013). Many excellent technical IVM manuals and guides are available and key references are listed in Annex 3.

This is a living document developed with experts of diverse experience and backgrounds. Feedback from those involved in financing or implementing malaria programmes will inform a next version. We invite all readers to give feedback.

Integrated Vector Management: Safe and sustainable

IVM is globally acknowledged as an important decision-making process to manage disease vectors and reduce reliance on chemical controls. A sustainable, long-term IVM approach will, at the same time, improve living conditions in vast stretches of malaria endemic areas.

Effective implementation of IVM takes a holistic approach. It adopts ecological strategies for vector control that benefit the environment. And it works with local communities through existing social structures to deliver the information, training and support necessary for them to effectively participate in malaria prevention programmes. A good IVM project will be integrated within the national and local health systems and with a national malaria control programme. IVM strategies are promoted in addition to, and are compatible with, the use of bed nets and artemisinin-based combination therapies (ACTs).

The World Health Organisation (WHO) promotes IVM for many reasons, for example it is a rational, evidence-based decision-making process, it optimizes resources for vector control, and it ensures communities benefit from improved vector-borne disease control. Furthermore, IVM can help phase out the use of DDT for Indoor Residual Spraying (IRS), supporting government commitments under the Stockholm Convention to eliminate this persistent organic pollutant. In June 2013 governments agreed to promote IVM as a tool for reducing pesticide hazards by adopting the International Code of Conduct on Pesticide Management. The quotes in Box 1 from WHO documents explain some reasons for adopting IVM.

Box 1 **WHO definitions and advice on IVM**

IVM is a rational decision-making process to optimize the use of resources for vector control … It is based on evidence and integrated management, promoting the use of a range of interventions – alone or in combination – selected on the basis of local knowledge about the vectors, diseases and disease determinants. The IVM approach addresses several diseases concurrently, because some vectors can transmit several diseases and some interventions are effective against several vectors. IVM will reduce the pressure imposed by insecticides to select for insecticide resistance … IVM encourages effective collaboration within the health sector and with other public sectors, and the empowerment of communities. (WHO 2012a)

The primary stakeholders in IVM are the communities that will benefit from improved vector-borne disease control. (WHO 2012a)

Understanding the basics about the locally-prevailing vectors of human disease is a prerequisite to people's involvement in vector control, personal protection or vector surveillance. Four aspects are considered of key importance for those involved in an IVM strategy: to identify vectors, understand their life cycle, to explore vector breeding sites, and to understand the role of the vector in transmitting disease. (WHO 2010)

Vector control is often not sufficiently adapted to local or changing circumstances because many countries lack capacity in decision-making for vector control. Such decisions should be based on evidence about the characteristics of local vectors and human behaviour and on the effectiveness of vector control methods. Furthermore, aspects of global change, such as climate change, environmental degradation, water scarcity and urbanization, are affecting the distribution of vector-borne diseases. Vector control must be adapted locally to these diverse and changing conditions and also to community preferences and needs. (WHO 2012 b)

Table 1 **Key elements of Integrated Vector Management**

	Element	Description
1	Advocacy, social mobilization and legislation	Promotion and embedding of IVM principles in designing policies in all relevant agencies, organizations and civil society; establishment of strengthening of regulatory and legislative controls for public health; empowerment of communities.
2	Collaboration within the health sector and with other sectors	Consideration of all options for collaboration within and between public and private sectors; application of the principles of subsidiarity in planning and decision-making; strengthening channels of communication among policy-makers, vector-borne disease programme managers and other IVM partners.
3	Integrated approach	Ensuring rational use of available resources by addressing several diseases, integrating non-chemical and chemical vector control methods and integrating with other disease control methods.
4	Evidence-based decision-making	Adaptation of strategies and interventions to local ecology, epidemiology and resources, guided by operational research and subject to routine monitoring and evaluation.
5	Capacity-building	Provision of the essential material infrastructure, financial resources and human resources at national and local level to manage IVM strategies on the basis of a situational analysis.

Source: WHO (2012a): Handbook for Integrated Vector Management

The human elements of IVM are often overlooked. People living in high-risk malaria areas must understand the basic causes of this and other vector-borne diseases and how to protect themselves against locally-prevailing vectors. Sadly this is rarely the case. A holistic IVM programme will ensure local communities have the knowledge and support to establish and manage prevention activities. Their involvement is a key to truly effective implementation. This aspect is stressed in the WHO key elements of IVM strategies listed in Table 1.

An evaluation of IVM projects in Kenya and Ethiopia found that these have been: "highly effective in reducing the threat of malaria by reducing mosquito densities using eco-friendly means … The projects have had high value for money and are highly scalable and sustainable" (ICIPE 2012). A review of 40 studies that emphasised environmental management interventions concluded these are "highly effective in reducing morbidity and mortality" (Keiser et al. 2005).

A global concern with the current approaches to malaria reduction is the problem of resistance to the pesticides used against mosquitoes (and their larvae) in IRS and in situ and the resistance of the parasite to ACTs (see Box 2). Pesticide use is problematic too because of risks to health and the environment from poor chemicals management. When used, it should be guaranteed that pesticide handling is in accordance with WHO standards.

Box 2 **Resistance**

Resistance to insecticides is an increasing problem in vector control because of the reliance on chemical control and expanding operations, particularly for malaria and dengue control. Furthermore, the chemical insecticides used can have adverse effects on health and the environment. (WHO 2012b)

… the threat of insecticide resistance appears to be growing rapidly. Currently, we are highly dependent on the pyrethroids, as they are the only class of insecticides used on insecticide-treated mosquito nets. Resistance to pyrethroids has now been identified in a wide variety of settings, many of those in the most highly malaria-endemic countries in Africa." (WHO 2011)

Road construction is not just good for economic development but is also a tactic against malaria – as it reduces puddles and pooled water as potential mosquito breeding sites on uneven dirt tracks and unpaved roads.

IVM and related environmental management techniques are unlikely to eradicate malaria alone – but neither will long-lasting insecticide treated nets (LLITN), IRS or ACTs (or current pesticide spray regimes). Integrated approaches which take both local ecological conditions and social mobilization into account have proven successful (PAN Germany 2010), and will, for example:

- ► address problems of resistance to the pesticides currently used for IRS and potential problems with resistance to pesticides incorporated in LLITNs
- ► reverse the current trends that have seen a rise in pesticide use for malaria control (WHO 2011a)
- ► support government commitments under the Stockholm Convention to reduce reliance on DDT for IRS, and ultimately to eliminate its use for disease vector control
- ► address the health concerns related to use of DDT in many malaria programmes (urogenital malformations in new-born boys, impaired semen, cancers [see Annex 3])
- ► reduce dependence on highly hazardous pesticides in developing countries
- ► break transmission rates from vectors that cannot be controlled by LLITNs or IRS, notably *Plasmodium falciparum* in intensely endemic areas of Africa (Ferguson et. al. 2010 ; Reddy et al. 2011)
- ► reduce the exposure hazards that arise from poor pesticide management and procurement, gaps in monitoring worker exposure or lack of pesticide awareness
- ► engage communities to deploy interventions based on knowledge of the origins of malaria and evidence-based prevention strategies to reduce vector populations
- ► be cost-effective and sustainable, and thus vital when international funding for malaria control is falling from its peak of US$ 2 billion in 2011 (World Malaria Report 2011)

Donors play an important role in promoting IVM by assessing the extent to which applicants have considered and investigated its adoption. An effective project will demonstrate that it has gathered data and carried out appropriate planning in two steps:

Step 1: Pre-planning to gather data for a complete assessment of the disease situation (situation analysis)

Step 2: Planning the IVM programme design based on information obtained

The frameworks provided here guide donors to assess whether these steps have been addressed, assist malaria funding applicants to incorporate IVM strategies, and indicate how to approach planning IVM programmes and projects.

Step 1
Pre-planning an IVM Programme

Currently, few malaria reduction projects or programmes incorporate holistic IVM. Donors can play a vital role in guiding ecosystem-based, community-driven strategies, based on:

A ► evidence-based decision making at community level by community members

B ► social mobilization to support communities becoming primary stakeholders in IVM

C ► increased use of non-chemical approaches within a community-guided IVM

The first step in an IVM programme is pre-planning to gather information and data for an evidence-based strategy that is appropriate for the local communities, ecology, disease profile and infrastructure (often termed a situational analysis). Applicants should demonstrate they have gathered this information and considered how to incorporate it in an IVM strategy.

As an IVM approach will not be familiar to all projects and programmes, donors may consider separately funding this pre-planning step. Donors may consider this step onerous; but when pesticides are part of a malaria control programme, donor face obligations to ensure applicants can guarantee that: sound pesticide management and procurement practices operate; pesticide handling meets WHO standards; communities will not be adversely affected by spray regimes or LLITNs; the project is sustainable over time; and resistance assessment and monitoring strategies are clearly in place.

Water is an essential basis of life – for humans and the environment, as well as vectors transmitting diseases such as malaria. Local communities, including farmers, need information on managing water resources to prevent mosquito breeding sites.

The guide for a situational analysis in Table 2 suggests content for pre-planning and provides indicators to establish that information has been gathered. In summary, it covers:

1. ► **Availability of a Malaria Indicator Survey (MIS) for the project country**
2. ► **Local determinants of malaria:** epidemiological and vector related data
3. ► **Demographic data and determinants of disease** such as: living conditions, proximity to mosquitoes, population movements, access to health care, knowledge of malaria among communities and health workers
4. ► **Environmental determinants of disease**, such as: climate, land-use, water bodies, vector breeding habits
5. ► **Political, economic environmental, social and technological factors** (PEEST analysis)
6. ► **Information gaps**

These questions should be applied initially to assess the project for its IVM strategy and can be returned to throughout the project to adjust interventions to changing conditions.

Children are curious – if school systems support it, they can easily learn about vectors and their ecosystems and can become important stakeholders of programmes to reduce malaria and other vector born diseases.

Framework 1
Questions for situational analysis

Table 2	Content of a situational analysis to inform IVM development in malaria projects and programmes	
	Question	Indicator
1.	**Is a Malaria Indicator Survey (MIS) available for the project country?**	**MIS title and year of publication mentioned if available.**
2	**Describe the local determinants of the disease by providing the following data:**	**Note that a National MIS might provide information to answer the following questions.**
2.1	**Epidemiological data**	
2.1.1	What are the malaria prevalence and incidence rates in the project area?	Data present and source of data identified.
2.1.2	What are the number / kind of repeated episodes of malaria per household?	Data present and source of data identified if this is available from a separate project. Efforts should be made to have this as part of the project baseline data.
2.1.3	What are the number / kind of repeated episodes per person?	Data present and source of data identified if this is available from a separate project. Efforts should be made to have this as part of the project baseline data.
2.1.4	What are the entomological human biting rates / inoculation rates?	To be seen as supplementary information. If this could be made available it could indicate important evidence.
2.1.5	What is the status of other vector-borne diseases prevalent in the project area that will be reduced by project interventions along with malaria (e.g. Japanese encephalitis, leishmaniasis, dengue, lymphatic filariasis, schistosomiasis or chagas disease)? Which proactive efforts will be made for optimal planning to maximize impact on malaria and other prevalent vector borne diseases?	Other vector borne illnesses identified and disease statistics over time obtained for those that can be tackled using malaria control strategies. Proactive efforts described.
2.1.6	What is the disease stratification? Does the country have up to date information on different malaria levels in different areas – high, moderate, low or none?	Maps present and source of data identified.
2.2	**Vector related data**	
2.2.1	What are the main vectors in the project area? Which Plasmodium species are prevalent? What is the status of insecticide resistance in vectors? What is the status of drug resistance in parasites?	Data present and source of data identified.
2.2.1.1	What is the seasonality of their occurrence? What are the local densities and fluctuations of the vectors? Are dry season refuge areas known?	Data gathered from interviews with community and local malaria control officials.
2.2.1.2	Is their biting and resting occurring mainly indoors or outdoors; or is this unknown? Does biting occur (partly) in the early evening before people sleep or exclusively at night; or is this unknown?	This information is often not available. Possibly local malaria control officials can provide data on these questions.
2.2.2	Are the results of recent insecticide susceptibility tests (WHO bioassay) available, and if so, do they indicate reduced susceptibility to pyrethroids and/or other insecticide classes?	Data present and source of data identified

3	**Demographic data, determinants of disease: human related factors**	*Note that a National MIS might provide information to answer the following questions.*
3.1	What is the profile of malaria cases in the community? What is the larger community statistical description?	Statistical data collected on gender, age, education level, economic status, travel history, geography of malaria sufferers and overall community members.
3.2	Has a community-based physical mapping of the local population and disease characteristics been incorporated in the project? Who are the local stakeholders that should be involved in that mapping exercise?	Local stakeholders of various sectors identified; leadership of community based physical mapping exercise identified from within the community; this exercise conducted and maps created.
3.3	Where do vulnerable human groups live in relation to vector hot spots? What human behaviours are relevant to vector biting habits: for example adult and children sleeping patterns; use of bed nets. Do vectors bite early evening or later when most people are in bed?	Mapping completed of homes with children under age 5, with women of childbearing age, and mapping of significant vector breeding grounds is available. behaviours such as time of sleeping, use of bed nets and time of vector biting patterns documented and correlated.
3.4	Which human populations live close (<500m) to major vector breeding grounds (e.g. perennial water bodies or swamps)?	Populations identified; numbers assessed.
3.5	What are the patterns of population movement?	Patterns of population movement in the community mapped with special emphasis on activities that can cause increased human-vector contact (e.g. working outdoors at dawn or dusk in areas where the vector has an outdoor biting characteristic at these times).
3.6	Which meetings where people congregate in large numbers at the community level could be used strategically to support the implementation of a community-based IVM approach? How often/where do these meetings take place?	Community meetings that could be strategic to implement a community based IVM approach are detailed.
3.7	What is the nature and quality of community access to diagnostic and treatment services (including community-based treatment)?	Listing of medical facilities, community health workers and other health care services, both government and non-government. Include such relevant data as: distance from settlement for each health facility; frequency of visits to these facilities; number and per cent of cases treated at facilities related to total cases in the target community. This information may require active surveillance as usually only cases reported at clinics are known.
3.8	How accurate is diagnosis (rapid diagnostic testing and microscopy) and how effective is the medication they receive (if known)?	Effectiveness of malaria treatment medicines measurable through a community survey (number of days from start of medication to recover fully from symptoms of current infection; this information correlated with drug efficacy data from standard pharmacology texts). Effectiveness of preventative medicines (numbers contracting malaria while taking preventative medicines) – measurable through survey of medical personnel or community health workers.

3.9	Has the staff in health centres been trained on non-chemical approaches to IVM? Do health centres give advice on non-chemical approaches to reduce transmission?	Information is made available.
3.10	What activities and actions do communities currently undertake to prevent and control malaria? How are these activities linked with the national malaria programme and activities of stakeholder groups like farmers, women, environment and health organizations or schools etc.? Is the kind and extent of community activities and actions different in different seasons?	Identified which vector management methods listed in Annex 1 of this framework are used and whether activities vary in different seasons. *Note: Information might be available on the basis of the implementation of the WHO guide Monitoring & Evaluation – Indicators for IVM* (WHO 2012d)
4	**Environmental determinants of disease**	*Note that a National MIS might provide information to answer the following questions.*
4.1	What is the relevant meteorological data?	Climate data (confounding data); rainfall data; temperature data provided.
4.2	What is the local land use (including nomadic land use)?	Local land use mapped.
4.3	What are the local ecosystems? What is the seasonal pattern of local water use and spatial distribution of local water? Which ecosystems are mostly associated with malaria transmission (e.g. rural-agricultural; urban; riverine; coastal etc.)?	Local water bodies and community water use points mapped.
4.4	What are the breeding habitats and sites?	Local breeding grounds identified, mapped and enumerated with community input.
5	**PEEST analysis** **(Political, Economic, Environmental, Social, Technological factors that affect malaria control efforts at various levels)**	*Note that a National MIS might provide information to answer the following questions.* *Note: Information might be available on the basis of the implementation of the WHO guide Monitoring & Evaluation – Indicators for IVM* (WHO 2012d)
5.1	**Policy environment** What policies of government, regional administration or local government have direct or indirect impact on the project? Is IVM a national policy? Does the government give priority to training and human resources development on IVM?	Policies listed from all sectors of government that are involved – such as health, agriculture, environment – and from different levels of government.
5.1.1	Will the proposed malaria control programme be static rather than adaptive to local situations and changes over time?	Malaria control programme has built in stages in its process for reviewing local situation and responsive plan adaptation; involvement of cross-departmental and cross-sectorial stakeholders in reporting on local situation and responding to it through regular meetings and plan updating.
5.1.2	What are the policies explicitly encouraging IVM in public health and/or IPM in agriculture?	Policies noted and effectiveness assessed.
5.1.3	Are any policies a barrier to implementation of least toxic, community-based IVM? What are the gaps / shortcomings of inconsistencies in the policy framework that affects the project?	Policies noted and gaps / shortcomings assessed. Strategies to address barriers noted or considered.
5.1.4	What policy instruments – including legislation, regulations or programmes – are in place for operationalizing the beneficial policies?	Policy instruments noted and implementation strategies assessed.

5.1.5	What are the budget allocations for least toxic, non-chemical, community centred approaches?	Budget allocations identified (if exists); potential budget sources identified; potential 'champions' for community IVM identified.
5.1.6	Are approaches in place that aim for control of more than one vector-borne disease?	Approaches such as joint planning of interventions between two disease-specific programmes; or the sharing of expertise or equipment / transport between disease-specific programmes listed.
5.1.7	Will a health and environmental impact assessment be conducted as part of the project to assess the impact of existing programmes in other sectors on malaria risk?	Budget allocation for impact assessment included.
5.2	**Institutional arrangements and capacities** What institutional arrangements are in place for operationalizing the policy instruments? What capacities / human resources are available for planning, implementation, evaluation?	Institutional arrangements in place for operationalizing the policy instruments listed. Capacities / human resources available for planning, implementation, evaluation identified. *Note: Information might be available on the basis of the implementation of the WHO guide Monitoring & Evaluation – Indicators for IVM* (WHO 2012d).
5.2.1	Is there an IVM focal point with financial and operational powers over the malaria control project?	Details of focal point supplied; powers assessed.
5.2.2	Will stakeholders from all levels and sectors be involved in the planning, implementation and evaluation of the project? Are local leaders and NGOs closely involved in malaria control? Are IVM training materials available for communities?	Stakeholders enumerated and interviewed from appropriate categories – government, non-governmental organisations, community, agriculture, medical, environment, research or cross-departmental. Views / vision of each stakeholder described for malaria control. Note – what kind of malaria control practices do they condone, are aware of and accept; and what do they oppose or are unaware of. Clear roles identified for different stakeholders and processes established for regular consultations and meetings; clear processes developed for stakeholder involvement in and responsibility for implementation, evaluation and monitoring of programme.
5.3	**Political environment**	
5.3.1	What are the political agendas of various stakeholder groups with respect to malaria control in the community? In what way do these different political agendas align or oppose each other? What are the political driving forces that stimulate or hinder the implementation of non-chemical approaches and community participation? Who is interested in community based IVM and what are their experiences? Who is opposing it? Who has clear ideas?	Assessment presented.
5.3.2	Are there already organisations / individuals with a mandate to support / coordinate community action and implement non-chemical approaches to prevent malaria?	Assessment conducted; contacts made with relevant organisations and individuals.
6	**Information gaps**	
6.1	What information is / was not available and what gaps need to be covered by the project?	Overview presented by listing the questions.

Step 2
Planning vector management projects

The emphasis of the applicant should be on considering and integrating environmental, mechanical and biological vector control methods into their project or programme. Planning will assist country strategies to reduce reliance on DDT. Annex 1 lists the range of interventions available. It shows options for integrating methods into malaria programmes and projects and it supports planning of community-driven vector management.

IVM which stresses localized solutions and evidence-based decision-making is one of the most promising vector management approaches. The concept stresses local environmental management, personal control measures, biological controls and community empowerment. Social and behavioural factors play a key role in determining how people respond to the malaria threat. Policy makers and those developing malaria projects must pay attention to these behavioural factors in deciding among different malaria control strategies.

Projects and programmes should consider: epidemiological and entomological factors; resources for the programme (delivery systems); community engagement and adherence; sociological and demographic factors'; and an assessment of other factors that may negatively affect an IVM programme. Donors can help projects and programmes become more robust in selecting the right vector control interventions and strategies for community empowerment into holistic IVM. They may consider providing seed funding to enable applicants to collect essential planning information and control options.

The choosing of an appropriate vector control option should assess feasibility and success. A critical tool for IVM is Larval Source Management (LSM) which will reduce risks and maintain and/or increase success. Four main categories of vector control methods can be effective (see Box 3) – environmental, mechanical, biological and chemical. The operational manual "Larval Source Management: a supplementary measure for malaria vector control"(WHO 2013) provides guidance on LSM.

Box 3 **Larval Source Management (LSM)**

LSM is the management of aquatic habitats (water bodies) that are potential larval habitats for mosquitoes in order to prevent the completion of immature development. There are four types of LSM:

1. Habitat modification: a permanent alteration to the environment e.g. land reclamation
2. Habitat manipulation: a recurrent activity e.g. flushing of streams
3. Larviciding: the regular application of biological or "chemical insecticides" to water bodies
4. Biological control: the introduction of natural enemies into water bodies

Source: Fillinger and Lindsay (2011)

Access to information and good knowledge about malaria and other vector born diseases are crucial as part of a holistic multisector, multistakeholder and ecosystem-based, community-driven integrated vector management approach. This can help people to contribute to the reduction of malaria and the elimination of DDT.

Framework 2

Steps for funding on malaria vector control in the context of IVM

The following presents a step-by-step decision making framework to identify a national context that will support IVM programmes and projects. This framework can be used by:

- A ► donors to government malaria programmes to support and integrate IVM strategies
- A ► countries in developing an IVM programme, or when funding programmes and projects within their country
- A ► donors to non-governmental stakeholders, and these stakeholders as an orientation for their malaria programme or project planning

The information gathered in Step 1 for pre-planning should enable this decision-making framework to be followed. It will help select and evaluate options for malaria control interventions and allow an understanding of the risks of chemicals in comparison to non-chemical control approaches (Annex 1).

CRITERIA 1 Does the country have a national malaria control policy or strategic plan that: promotes selective and targeted interventions within an IVM program that encourages effective collaboration not only within the health sector but also with other public sectors; empowers communities; and deploys non-chemical approaches, such as LSM, to vector control?

No — The policy/strategic plan should be revised to accommodate selection of vector control interventions in the context of IVM.

Yes — Move to Criterion 2

CRITERIA 2 Does the country have up-to-date information on different malaria levels in different areas (high, moderate, low or none) with areas targeted for various interventions (singly or in combination) well identified?

No Update the information on different malaria levels and determine the targeted areas:

Yes — Move to criterion 3

CRITERIA 3 Does the country have up-to-date entomological information on the malaria vectors from the targeted areas for vector interventions? This is very important information and each country should provide a detailed analysis guided by the questions in Box 4. These details should be available from the pre-planning step 1 information.

No Collect the necessary information.

Yes — Analyse the information and determine which vector intervention (non-chemical vs. chemical) is appropriate or not and move to criterion 4 if chemical is preferred.

CRITERIA 4 The country has effective policies and regulations in place (including national implementation plans for the Stockholm Convention (for countries that are parties to this Convention).

No — Establish the necessary policies and regulations.

Yes — Move to criterion 5.

Box 4 **Important entomological information**

- What are major vector species identified and which molecular forms are available?
- Is the biting, feeding and resting behaviour of the major vector species known?
- Is it known that malaria vectors mainly but not always feed indoors – What is the situation in your country?
- What is the vector resistance status including resistance mechanisms and potential for cross resistance?

Healthy housing – screens on doors, on windows or to close gaps between walls and roofs of houses or huts can be installed by families to reduce human-vector contacts.

CRITERIA 5 There are adequate resources and capacity such as human, financial, information and infrastructure, to safely, effectively and judiciously apply any of the selected vector control interventions. (See answers to "5 PEEST analysis" in Step 1.)

No — Ensure that the required resources are in place (preferably for more than one cycle). If the required information and/or resources are not in place, malaria control programme funders should consider financing a pre-project implementation phase to guarantee that a project can start with the appropriate data bases and resources.

Yes — Develop the operations plan and move to implementation following the WHO IVM Manual.

WHO requests countries to adopt new malaria vector control strategies (WHO 2012a); IVM strategies are critical for countries that set a goal of 'malaria elimination'. To plan this, country epidemiological and entomological data are very important to classify levels of malaria and guide selection of appropriate vector control strategies.

To sustainably reduce risks from malaria and from chemical interventions a project or programme must decide which mosquito control method is appropriate and how it will be used in a given context. This process must generate research and be guided by a comprehensive analysis of the level of malaria endemicity, vector bionomics, vector population dynamics, the eco-epidemiological setting, the health management system, environmental and social factors and the ability to sustain the programme. At country level, governments need regulatory measures to prevent the creation of man-made vector breeding sites and to ensure proper vector management.

Vector control methods can be divided into environmental, mechanical, biological and chemical methods (see Annex 1). An appraisal of each method will assist in selecting the most appropriate in the local context. The appraisal incorporates the aspects of effectiveness, human and environmental safety, risk of resistance development, affordability, and community participation. Table 3 summarises the requirements; Figure 1 sets out a route map for the selection process.

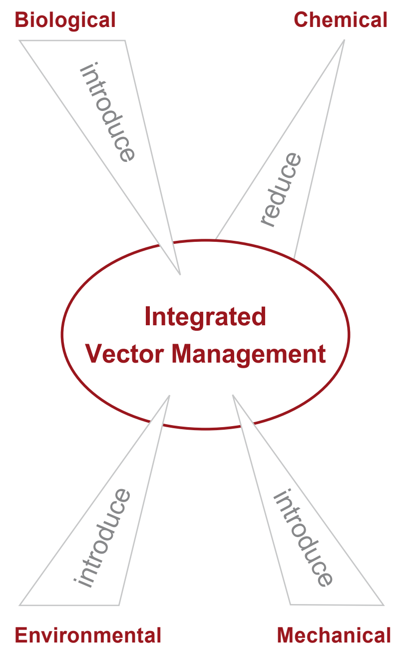
Table 3 **Example of the use of selection criteria for vector control methods against malaria**

Category	Vector control method	Effectiveness	Safely	Risk of resistance	Community participation	Affordability
Environmental	Source reduction	++	+	-	++	++
	Habitat manipulation	±	+	-	±	±
	Irrigation management & design	±	+	-	+	±
Mechanical	House improvement	++	++	-	++	+
Biological	Natural enemy conservation	±	+	+	+	+
	Biological larvicides, e.g., Bti	++	+	+	+	-
	Botanicals e.g., neem oil	+	±	+	+	+
Chemical	Insecticide-treated bed nets	++	±	-	+	-
	Indoor residual spraying	++	±	-	-	-
	Insecticidal-treatment of habitats	±	-	-	-	-
	Chemical repellents	±	±	+	+	±

++ indicates: highly applicable; + applicable; ± partly applicable; - not applicable

Source: WHO 2012: Handbook on Integrated Vector Management–modified to fit current situation

Figure 1 **Route map for selection of vector measures**



IRS and LLINs used for indoor protection will have limited utility against early or outdoor biting. Examples of important vector control methods include:

- Biological control: Larvivorous fish may be recommended for control of *Anopheles* in large water bodies or larger water containers not just but especially in urban settings.
- Endotoxin-producing bacteria, *Bacillus thuringiensis* serotype H-14 (Bt H-14) has been found an effective mosquito control agent and is now widely used.
- Involvement of household and community for mosquito control through the task of eliminating mosquito breeding in and around their houses by filling and draining of mosquito larval breeding.

Any sustainable malaria control program will need to strategically address a complex range of environmental and social determinants in a cost-effective manner. As causal factors differ and change, control programmes need the flexibility to adjust their strategies.

The selection of the IVM components should be based on a situational analysis, as demonstrated in step 1. This helps to establish the: effectiveness and cost effectiveness of the methods, acceptance by communities, availability of resources, environmental safety and feasibility. The aim is to develop a vector control strategy and programme that includes the community and the methods that are adaptable to the local situation and that can be sustained.

Important questions to be answered before planning activities: What are the main vectors and what is their biting and resting behavior?

Annex 1

Vector control methods and their relative risks

Risk A ► Low or no risk to human health or the environment – bioreliant / low pesticide reliant method
Risk B ► Moderate risk to human health or the environment – low pesticide reliant method
Risk C ► High risk to human health or the environment – pesticide reliant method
Risk D ► High risk to the environment or human health – should only be used as a very last resort

	Vector control methods	**Risk Level**			
1	**Environmental management methods**				
1.1	Ecosystem compatible habitat modification (such as clearing of stagnant water, breeding sites physically destroyed or modified, removal of vegetation from near house etc.)	A			
1.2	Habitat manipulation (irrigation management, removal of trash)	A			
1.3	Other				
2	**Mechanical methods**				
2.1	House improvement, including screening of eaves	A			
2.2	Improved sanitation	A			
2.3	Use of long sleeved shirts	A			
2.4	Bednets / untreated (avoid human-net contact!)	A			
2.5	Mosquito screens	A			
2.6	Mosquito traps and targets	A			
2.7	Other				
3	**Biological methods**				
3.1	Botanical repellents (neem, citronella)	A			
3.2	Ecosystem compatible predators (larvivorous fish) or nematodes (under development)	A			
3.3	Bacterial larvicides (Bt)		B		
3.4	Botanical pesticides (pyrethrum)		B		
3.5	Fungi (under development)		B		
3.6	Other				
4	**Chemical methods**				
4.1	Bednets / treated with insecticides		B		
4.2	Treated curtains or hammocks		B		
4.3	Durable wall lining		B		
4.4	Chemical repellents		B		
4.5	Chemical larvicides			C	
4.6	Sponging cattle with insecticides			C	
4.7	Indoor residual spraying with insecticides			C	
4.8	Space spraying of insecticides (areas of land)				D
4.9	Other				

Annex 2

Pesticides recommended for malaria control: Concerns

This list indicates human toxicity concerns associated with pesticides used in malaria control programmes. There are also environmental concerns; nearly all pesticides in malaria programmes are toxic to the important pollinators bees.

Bifenthrin (pyrethroid): Is a possible human carcinogen (Group C) according to US EPA • At least one study provides evidence of endocrine disruption in an intact organism* according to EU • It is highly bioaccumulative ** and very persistent in water/sediment ***

Deltamethrin (pyrethroid): At least one study provides evidence of endocrine disruption in an intact organism according to EU.

Bifenthrin (pyrethroid): Is a possible human carcinogen (Group C) according to US EPA • At least one study provides evidence of endocrine disruption in an intact organism* according to EU • It is highly bioaccumulative** and very persistent in water/sediment***

Deltamethrin (pyrethroid): At least one study provides evidence of endocrine disruption in an intact organism* according to EU.

DDT: At least one study provides evidence of endocrine disruption in an intact organism* according to EU • According to US EPA it is a probable human carcinogen (Group B2) • According to IARC it is a possibly carcinogenic to humans (Group 2B) • In the EU Directive 67/548 it is listed as a substance which causes concern for humans owing to possible carcinogenic effects (Category 3) • It is covered by the Stockholm Convention and by the Rotterdam convention. The following studies document concerns with exposure to DDT:

- WHO (2011): DDT in indoor residual spraying: human health aspects. Environmental Health Criteria 241, World Health Organization
- Bornman R et al. (2009): DDT and urogenital malformations in new born boys in a malarial area. BJU International Eskenazi, B et.al (2009): The Pine River Statement: Human Health Consequences of DDT Use, Environ Health Perspect. 2009 September; 117(9): 1359–1367
- Aneck-Hahn, N.H. et al. (2007): ‚Impaired semen quality associated with environmental DDT exposure in young men living in a malaria area in the Limpopo Province, South Africa‘, J. Androl., (28) 423–434
- Bouwman, H; Kylin, H (2009): Malaria control insecticide residues in breast milk: The need to consider infant health risks. Environ. Health Perspect. (117) 1477–1480
- Cohn, B A et al. (2007): DDT and breast cancer in young women: new data on the significance of age at exposure. Environ. Health Perspect. (115) 1406–1414
- de Jager, C. et al. (2006): Reduced seminal parameters associated with environmental DDT exposure and p,p‘DDE concentrations in men in Chiapas, Mexico: A cross-sectional study. J. Androl, (27) 16–27
- Ukropec, J (2010): High prevalence of prediabetes and diabetes in a population exposed to high levels of an organochlorine cocktail. Diabetologia (53) 899–906

Fenitrothion: According to EU at least one study provides evidence of endocrine disruption in an intact organism*.

Lambda-cyhalothrin (pyrethroid): According to EU at least one study provides evidence of endocrine disruption in an intact organism* • According to the EU Directive 67/548 it is very toxic by inhalation (R26).

Malathion (organophosphate): Highly toxic to bees • US EPA: Suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential • EU: Potential for endocrine disruption (ED), in vitro data indicating potential for endocrine disruption in intact organisms, also includes effects in vivo that may or may not be ED-mediated, may include structural analyses and metabolic considerations.

Propoxur (carbamate): US EPA: Probable human carcinogen (Group B2).

Annex 3

Recommended reading

Key readings

- Ferguson, H M et al. (2010): Ecology: a prerequisite for malaria elimination and eradication. PloS Medicine 7: e1000303.
- ICIPE (2012): Report of the comprehensive external evaluation of the Biovision-ICIPE IVM projects in Kenya and Ethiopia, International Centre of Insect Physiology and Ecology
- Keiser, J; Singer, B H; Utzinger J (2005): Reducing the burden of malaria in different eco-epidemiological settings with environmental management: a systematic review. http://infection.thelancet.com, Vol 5, November 2005
- PAN Germany & PAN Africa (2013): Combating malaria without DDT in Beer, Senegal – report on a pilot project to raise awareness of the causes of malaria and initiate non-chemical methods and activities for its prevention
- PAN Germany (2010): Environmental strategies to replace DDT and control malaria. 2nd extended edition. Pesticide Action Network – Germany
- Roll Back Malaria Partnership / UNDP (2013): Multisectoral Action Framework for Malaria.

* Not a formal weight of evidence approach

** Highly bioaccumulative according to REACH criteria as listed by FOOTPRINT (BCF >5000)

*** Very persistent” according to REACH criteria as listed by FOOTPRINT (half-life > 60 d in marine- or freshwater or half-life > 180 d in marine or freshwater sediment)

- UNEP (2011): Stockholm Convention on Persistent Organic Pollutants (POPs). Available at: http://chm.pops.int/Convention/ConventionText/tabid/2232/Default.aspx
- van den Berg, H et al. (2009): Global Status of DDT and its alternatives for use in vector control to prevent diseases. Environmental Health Perspectives, Volume 117, No. 11
- WHO (2010): Core Training curriculum on Integrated Vector Management. Commissioned by the Neglected Tropical Disease Department. World Health Organization
- WHO (2012): Guidance on policy-making for integrated vector management. By Henk van den Berg, Clifford M. Mutero and Kazuyo Ichimori. World Health Organization
- WHO (2012): Malaria Indicator Survey. World Health Organization. Available at: http://www.rbmwho.int/toolbox/tool_MISToolkit.html
- WHO (2013): Larval Source Management: A supplementary measure for malaria control – An operational manual

Additional readings

- Beier, J et al. (2008). „Integrated vector management for malaria control." Malar J 7(Suppl 1): S4
- PAN International (2011): List of Highly Hazardous Pesticides. Available at:
- http://www.pan-germany.org/gbr/project_work/highly_hazardous_pesticides.html
- Ranson, H et al. (2011). „Pyrethroid resistance in African anopheline mosquitoes: what are the implications for malaria control?" Trends Parasitol 27: 91-98.
- Thomas M B et al. (2012). „Lessons from agriculture for the sustainable management of malaria vectors." PloS Medicine 9(7): e1001262.
- Van den Berg, H et al. (2011): Status of pesticide management in the practice of vector control: a global survey in countries at risk of malaria or other major vector-borne diseases. Malaria Journal 2011, 10:125, doi:10.1186/1475-2875-10-125. BioMed Central – The Open Access Publisher
- WHO (2012): Handbook for Integrated Vector Management. World Health Organization
- WHO (2012): Monitoring & evaluation - indicators for Integrated Vector Management. World Health Organization
- WHO (2012): World Malaria Report, World Health Organization
- WHO (2011): World Malaria Report, World Health Organization

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- Bouwman, H et al. (2006): Simultaneous presence of DDT and pyrethroid residues in human breast milk from a malaria endemic area in South Africa. Environ Pollut 144:902–917
- Ferguson, H M et al. (2010): Ecology: a prerequisite for malaria elimination and eradication. PloS Medicine 7: e1000303.
- Fillinger and Lindsay (2011). Larval source management for malaria control in Africa: myths and reality; Malaria Journal, 10:353 doi:10.1186/1475-2875-10-353
- ICIPE (2012): Report of the comprehensive external evaluation of the Biovision-ICIPE IVM projects in Kenya and Ethiopia, International Centre of Insect Physiology and Ecology
- PAN Africa / PAN Germany (2013): Combating Malaria without DDT in Beer, Senegal. Report on a pilot project to raise awareness of the causes of malaria and initiate non-chemical methods and activities for its prevention. Dakar, Hamburg
- PAN Germany (2010): Environmental strategies to replace DDT and control malaria. 2nd extended edition. Pesticide Action Network – Germany
- Reddy, M R et al. (2011): Outdoor host seeking behaviour of Anopheles gambiae mosquitoes following initiation of malaria vector control on Biolo Island, Equatorial Guinea. Malaria Journal 2011, 10:184
- UNEP (2011): Stockholm Convention on Persistent Organic Pollutants (POPs). Available at: http://chm.pops.int/Convention/ConventionText/tabid/2232/Default.aspx
- WHO (2010): Core Training curriculum on Integrated Vector Management. Commissioned by the Neglected Tropical Disease Department. World Health Organization
- WHO (2011): World Malaria Report, World Health Organization
- WHO (2011a): Public Health Pesticide Registration and Management Practices by WHO Member States. Report of a Survey 2010. Control of Neglected Tropical Diseases. Pesticide Evaluation Scheme. WHO/HTM/NTD/WHOPES/2010 Geneva. World Health Organization
- WHO (2012): World Malaria Report, World Health Organization
- WHO (2012a): Handbook for Integrated Vector Management. World Health Organization
- WHO (2012b): Guidance on policy-making for integrated vector management. By Henk van den Berg, Clifford M. Mutero and Kazuyo Ichimori. World Health Organization
- WHO (2012c): Malaria Indicator Survey. World Health Organization. Available at: http://www.rbm.who.int/toolbox/tool_MISToolkit.html
- WHO (2012d): Monitoring & evaluation - indicators for Integrated Vector Management. World Health Organization (available at: http://apps.who.int/iris/bitstream/10665/76504/1/9789241504027_eng.pdf)
- WHO (2013): Larval Source Management: A supplementary measure for malaria control – An operational manuat

Pesticide Action Network (PAN)

is an international network of over 600 NGOs in over 90 countries. PAN aims to reduce exposure of the most vulnerable communities around the world to highly hazardous pesticides (HHPs), while advancing effective and least toxic alternatives. Some HHPs are commonly used in malaria control activities.

ICIPE

is an international scientific research institute headquartered in Kenya. Objectives are to help ensure food security and better health for humankind and its livestock; to protect the environment; and to conserve and make better use of natural resources. ICIPE's mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building.

KEMRI

is a state corporation and the national body responsible for carrying out health research in Kenya. In its commitment to meeting the health challenges KEMRI has consolidated its research activities into six main research programmes: 1. biotechnology, 2. traditional medicine and drug development, 3. infectious and parasitic diseases, 4. Public health and health systems, non-communicable diseases, 6. Sexual, reproductive and child health.

A healthy world for all.

Protect humanity and the environment from pesticides. Promote alternatives.