Strategies to Replace DDT and Control Malaria

Summary of the report by Pesticide Action Network

Malaria is a major global health problem and has a devastating impact on communities around the world, particularly in Africa. Current strategies promoted by donors such as USAID for controlling malaria rely on prevention of infections and on treatment—but with reliance on a cocktail of chemicals—some of which become ineffective over time. More sustainable tools that have proven to work in malaria endemic regions must be analyzed, strengthened and implemented. They can reduce the burden of malaria while protecting human health and the environment, enhancing general health status, ensuring long-term sustainability of the control efforts and contributing to overall development of marginalized rural and urban areas.

Sustainable malaria control solutions

Efficacy of chemical pesticides for malaria control is undermined by the development of vector resistance, vector behavioral adaptations, logistics and funding problems. Furthermore, pesticides pose established and suspected threats to human health and the environment. Effective and sustainable malaria control methods include a combination of environmental management, biological control, improved surveillance, use of anti-malaria drugs, education and community involvement. These strategies are proven to work—and are safe for human health and the environment.

Solution #1 Environmental Management

Reducing vector habitat: Implementing a set of activities to create permanent or long-lasting impacts on land, water or vegetation that eliminate vector habitat is key to any long-term solution for malaria.

Prior to the 1940s a number of large scale projects were implemented which effectively reduced malaria. These projects focused on the reduction or elimination of mosquito breeding habitats—such as in the southern U.S. Large scale interventions have been successful in Panama, Italy, Malaysia, Indonesia, the Tennessee Valley of the U.S. and the Zambian copper belt.

Targeting the larval stages of the mosquito life cycle: with activities that reduce larval breeding sites. For example, malaria epidemics associated with irrigated rice lands are minimized by introducing intermittent irrigation to control breeding sites. This has been successful in Sri Lanka, Kenya, and China.

Promoting personal protection: Preventing community contact with vectors as much as possible. Example activities include: locating houses away from breeding sites to reduce the human-vector contact, providing screens in houses, repairing cracks and holes in walls. Sri Lanka has been successful with this method.
Solution #2 Biological Control

Uses natural enemies of mosquitoes and biological toxins to suppress the vector population.

**Bacterial larvicides**: Natural toxins of *Bti* and *Bs* are lethal to larvae of many mosquito species. These are environmentally safe larvicides. *Bti* is an important part of malaria control in the U.S. and its application has proven to be effective in parts of Kenya and Tanzania.

**Predators (e.g. larvivorous fish)**: Larvivorous fish have been used for mosquito control for at least 100 years. *Gambusia*, guppies, *Tilapia* and carp, among others, feed on mosquito larvae thereby decreasing the abundance of mosquitoes.

**Botanicals including repellents, larvicides (e.g. neem), biological insecticides and medicinal herbs**: Several plants are significant botanical repellents of mosquitoes. Neem oil extracted from neem tree seeds has repellent properties and has been successfully tested as a larvicide for mosquito control. Citronella is most commonly found in herbal insect repellents. Neem oil and citronella oil mixed with coconut oil are effective against the most common adult mosquitoes. The modern drug ACT is derived from a medicinal herb (*Artemisia annua*), and *Euphorbia hirta* found in tropical areas exhibits antimalarial activity.

**Other biological controls**: Nematodes have shown potential to reduce mosquito larvae. Certain fungal pathogens can be used on indoor surfaces of houses against adult mosquitoes. The aquatic plant *Azolla* has shown promise of controlling mosquito populations under experimental conditions.

Case studies

**Zambia**: One prominent example of a malaria control strategy which incorporated environmental management as the central feature is a program implemented between 1929 and 1949 in former Northern Rhodesia, present-day Zambia. During the English colonial period four copper mining companies were operating in the country. The area was known to be hyper endemic for malaria, which was probably the leading cause of death. The mine funded a malaria control and general sanitation program. The program used a number of strategies, most of which were centered on environmental management (clearing vegetation, modifying river boundaries, draining swamps, oiling and house screening). Many breeding sites were identified along the nearby Luanshya River, and its bank was modified and vegetation cleared. Housing conditions were improved and houses were screened. Water supply and sanitation facilities were also improved and a hospital was established. Mosquito nets and quinine administration was provided for prevention and cure of malaria. The program was implemented for 20 years and DDT was only utilized in the last five as an additional intervention strategy. The environmental management strategies proved to be sustainable over the long-term enabling development of the Zambian copper belt by effectively controlling malaria. The project required significant input of labor.

**Kenya**: Kenya has one of the highest number of malaria cases in Africa. There are concerns about the use of pesticides in Kenya and other East African countries. In addition to potential harmful effects on humans and the environment, they can adversely affect the economy. Between 1997 and 2000 Europe imposed a ban on imports of fish products from the region around Lake Victoria due to elevated insecticide residues in East African products.

To demonstrate how malaria can be controlled in different settings in Kenya in a more ecological and cost-effective way, two pilot projects were initiated in 2004 and 2005 in urban Malindi and...
rural Nyabondo by the Swiss foundation BioVision. Scientific assistance comes from two local research institutions (International Center for Insect Physiology and Ecology and the Kenyan Medical Research Institute), with support from local civil society organizations.

To educate the community about the dangers of stagnant water pools as mosquito breeding sites, local people are trained to become ‘mosquito-scouts’. Public awareness campaigns provide malaria information, ‘mosquito days’ are held to activate the local community for environmental management, and malaria awareness is incorporated into school curriculums. Biological agents like Bti and neem are used to kill mosquitoes in their larval stage. LLINs have been distributed to improve personal protection. Monitoring and evaluation is carried out and results are assessed to adapt malaria interventions to the local situation.

The interventions have resulted in larval and mosquito reductions and reduced malaria cases among children. From Malindi it is reported that malaria cases have been reduce by half (from 10,000 to 5,000) under the project.

Sri Lanka: Sri Lanka is one of the Asian countries most affected by malaria, as traditional rice growing practices facilitate the breeding of mosquitoes. As mosquitoes developed resistance to DDT and malathion, non-pesticide reliant approaches began to gain importance. Farmer Field School training was established in Sri Lanka in 1995, providing practical field-based sessions with groups of rice farmers. The aim was to reduce the use of, and dependence on, pesticides not only in paddy cultivation but also for disease vector control. Enthusiastic participation by communities was seen in ecosystem management activities like leveling land to reduce puddles, draining

**Current Primary Methods of Malaria Control**

**Insecticide-Treated Nets (ITNs):** A powerful malaria control tool, two types of bednets are available: conventional treated nets which need regular treatment with pyrethroid insecticides and Long Lasting Insecticide treated Nets (LLINs), which remain effective for at least three years. Concern about the sustained effectiveness of ITNs due to pyrethroid resistant vectors was sparked by a study in Benin where ITNs lost their efficacy.

**Indoor-Residual Spraying of insecticides (IRS):** Spraying of insecticides on all surfaces inside homes irritates and kills mosquitoes which are exposed to these residues. Twelve insecticides are recommended by WHO for IRS in vector control, with DDT and pyrethrroids thought to be the most cost-effective. However, resistance of mosquitoes to DDT and pyrethrroids is widespread and cross-resistance between these chemicals severely limits the choice of insecticide.

**Pharmaceutical treatment:** Until the 1980s chloroquine was an effective treatment against malaria. However, resistance has been reported since the 1960s. Today, the WHO recommends the treatment of a *P. falciparum* infection with an Artemisinin-based Combination Therapy (ACT) and *P. vivax*, except where it is resistant to chloroquine, with chloroquine and primaquine.

**Preventative medications:** In areas of high transmission, WHO recommends the administration of intermittent preventive treatment (IPT) with sulfadoxine-pyrimethamine. It should be administered to pregnant women at least twice during the second and third trimesters of pregnancy, and three times in the case of HIV positive pregnant women. Currently, no serious adverse effects have been reported during trials of chemoprophylaxis in children.

Field modification for personal protection, Oaxaca, Mexico. Source: Mendez-Galvan (2008)

fields to prevent mosquito larvae reaching the adult stage, covering water containers and minimizing pesticide use to conserve natural enemies of pests and mosquito vectors. As a result there was lower mosquito larvae density observed. There was also increase in use of bednets due to increase in community awareness.

**Vietnam**: Postwar population movements and shortages in drugs and insecticides contributed to the resurgence of malaria in Vietnam after the 1970s. In 1991, the government launched the National Malaria Control Program. DDT spraying was abandoned and insecticide-treated nets became the key intervention. IRS became more targeted using pyrethroids. Mefloquine and later Artemisinin-based drugs replaced the chloroquine, quinine and sulfadoxin/pyrimethamin treatments to which parasites had become resistant. The key factors for the success of malaria control efforts in Vietnam were a holistic approach based on extensive communication campaigns, public education about malaria, and promoting prevention strategies. The strategy established active leadership at all levels of government, mobilized and trained communities in malarial areas, provided technical support and ensured sufficient funding. Epidemiological surveillance was strengthened through mobile teams. The result was a dramatic decrease of the malaria burden in Vietnam. Today, malaria causes fewer deaths than tuberculosis or acute respiratory infections, and most rural areas and medium and major urban areas have largely remained malaria-free. Even though the National Program proved successful in some regions, addressing the malaria problem in the Central Highlands and the mountainous districts of the Central coast provinces remains an extremely complex task.

**Mexico**: The Mexican model provides a unique example of an ecosystem approach to fighting malaria. Adoption of environmental management practices and improvement of personal hygiene, in combination with effective identification and treatment of malaria cases, led to dramatic reductions in malaria transmission and discontinued use of DDT. In 1959 the first guidelines for eradicating malaria were implemented and DDT underpinned the strategy. Since the 1970s the use of DDT in agriculture declined due to environmental concerns and in 1987 DDT was exclusively restricted to public health programs.

The development of new strategies was encouraged by the North American Regional Action Plan to reduce human and environmental exposure to DDT, under which Canada, Mexico and the U.S. agreed to phase out DDT from their shared environment. Following on this success, the Pan American Health Organization (PAHO) led the implementation of a Regional Program of Action and Demonstration of Sustainable Alternatives to DDT for Malaria Vector Control in Mexico and Central America, in partnership with UNEP and with funding from the Global Environment Facility (GEF). The PAHO pilot program successfully demonstrated that pesticide-free techniques and management regimes could cut cases of malaria in many Latin American countries.

Malaria remains a major public health problem in Asia, Africa and Latin America. Growing concerns about impacts on the environment and human health of the use of DDT and other pesticides in malaria control calls for reducing reliance on insecticides for vector management, as also reflected by the World Health Assembly and many international treaties.

Several effective sustainable strategies exist and have been used successfully in many regions of the world. It is time that these strategies were adopted and encouraged by major donors like the USAID in their funding of malaria control work in Africa and other regions.