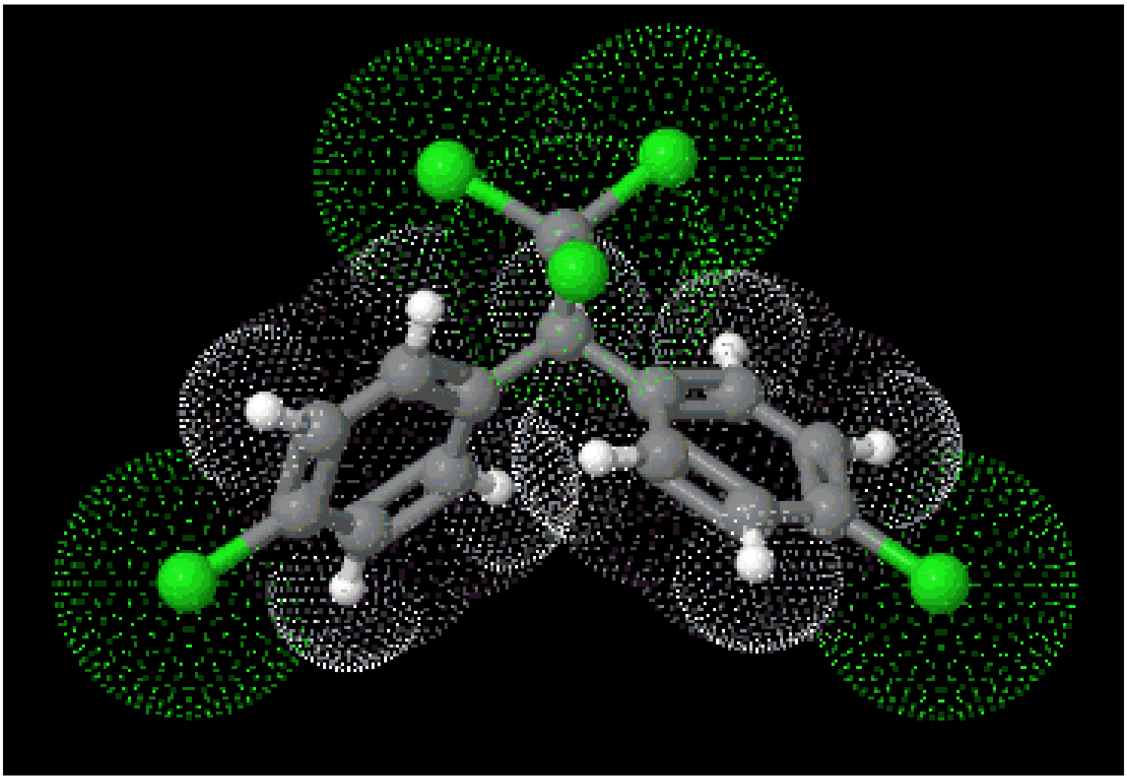
ROAD MAP FOR THE DEVELOPMENT OF ALTERNATIVES TO DDT



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ACRONYMS AND ABBREVIATIONS

AFRO	WHO-Regional Office for Africa
AusAID	Australian Agency for International Development
BMGF	Bill and Melinda Gates Foundation
BRS Secretariat	Secretariat of the Basel, Rotterdam and Stockholm Conventions
CDC	Centers for Disease Control and Prevention
COP	Conference of the Parties
DDT	Dichlorodiphenyltrichloroethane
DFID	Department for International Cooperation
DPRK	Democratic People's Republic of Korea
DTIE	Division of Technology, Industry and Economics
EMRO	WHO Regional Office for the Eastern Mediterranean
FAO	Food and Agriculture Organization
FECO	Foreign Economic Cooperation Office
GEF	Global Environment Facility
GMP	Global Malaria Programme
GRULAC	Latin American and Caribbean Group
GMAP2	Second Global Malaria Action Plan
Icipe	International Centre of Insect Physiology and Ecology
IGOs	Intergovernmental organizations
IRS	Indoor residual spraying
ITNs	Insecticide treated nets
IVM	Integrated vector management
IVCC	Innovative Vector Control Consortium
JICA	Japan International Cooperation Agency
JMPS	Joint FAO/WHO Meeting on Pesticide Specification
LPDR	Lao People's Democratic Republic
MDGs	Millennium Development Goals

MERN	Ministry of Environment and Natural Resources
MH&FW	Ministry of Health and Family Welfare
MoCF	Ministry of Chemicals and Fertilizers
MoEF	Ministry of Environment and Forests
n.a.	Not available
PAHO	Pan American Health Organization
PEEM	Panel of Experts on Environmental Management for Vector Control
PMI	President’s Malaria Initiative
POPs	Persistent organic pollutants
PRC	People’s Republic of China
RBM	Roll Back Malaria Partnership
RDP	Rural and development programmes
RIDL	Release of Insects with Dominant Lethality
SCRCs	Stockholm Convention Regional Centers
SDC	Swiss Agency for Development and Cooperation
SEPA	State Environmental Protection Administrator
TPP	Target product profile
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UN-Habitat	United Nations Human Settlements Programme
UNICEF	United Nations International Children’s Emergency Fund
U.S.A.	United States of America
USAID	U.S. Agency for International Development
USDA IR 4 project	United States Department of Agriculture’s Minor Crop Pest Management Program Interregional Research Project # 4
VCAG	Vector Control Advisory Group
WFP	World Food Programme
WHA	World Health Assembly
WHO	World Health Organization

WHOPES	WHO Pesticide Evaluation Scheme

1 INTRODUCTION

The Stockholm Convention on Persistent Organic Pollutants[1] (POPs) entered into force in May 2004. Among others, its declared goal is to reduce and ultimately eliminate the use of DDT in order to protect human health and the environment. The Convention stipulates that the production and use of DDT shall be restricted to disease vector control in accordance with the World Health Organization (WHO) recommendations and when locally safe, effective and affordable alternatives are not available to the Party in question. Parties intending to produce and/or use DDT are requested to notify the Secretariat accordingly.

At its sixth meeting, held in Geneva, Switzerland, from 28 April to 10 May 2013, the Conference of the Parties (COP) to the Stockholm Convention, through decision SC-6/1 on DDT[2] (dichlorodiphenyltrichloroethane) invited the United Nations Environment Programme (UNEP), in consultation with the World Health Organization (WHO), the DDT expert group and the Secretariat (of the Stockholm Convention), to prepare a road map for the development of alternatives to DDT and to present it to the COP at its seventh meeting in 2015. The COP further requested UNEP to prepare the road map in line with paragraph 2 of the same decision, which concluded that countries that are relying on DDT for disease vector control may need to continue such use until locally safe, effective, affordable and environmentally sound alternatives are available for a sustainable transition away from DDT.

The Convention also established a mechanism to periodically evaluate the continued need for DDT for disease vector control on the basis of available scientific, technical, environmental and economic information. Relevant indicators in the evaluation are to include the production and use of DDT, the availability, suitability and implementation of the alternatives to DDT, and the progress in strengthening the capacity of countries to transfer safely to reliance on such alternatives.

Indoor Residual Spraying (IRS) and Long Lasting Insecticidal Nets (LLINs) remain the core vector control interventions for malaria[3] and visceral leishmaniasis, the two vector borne diseases where DDT is currently used. Other vector control measures, both chemical and non-chemical, are complementary methods to be used under specific local conditions. In its report of January 2013, the DDT expert group concluded that “in certain settings, there is a continued need for DDT for disease vector control in accordance with WHO recommendations and guidelines on the use of DDT, until locally appropriate and cost-effective alternatives are deployed for a sustainable transition away from DDT”[4]. The DDT expert group’s conclusion is in line with the revised ‘WHO Position Statement on the Use of DDT in Malaria Vector Control’ of 2011 stating that it is expected that there will be a continued role for DDT in malaria control until equally cost-effective alternatives are developed. It further notes that a premature shift to less effective or more costly alternatives to DDT, without a strengthening of the capacity (human, technical, financial) of Member States (of the WHO) will not only be unsustainable, but will also have a negative impact on the disease burden in endemic countries[5].

Available data suggests that India is currently the only producer and exporter of DDT and that production remained relatively steady in recent years. India has reportedly exported DDT to five countries in 2012/2013 (two belonging to the Asia Pacific Group and three belonging to the African Group) and two countries in 2013-2014 (both belonging to the African Group). Use of DDT is also largely concentrated in India. While 7 countries reported the use of DDT for the reporting period 2009 to 2011, 17 countries are currently listed in the DDT register. Malaria has been reported by countries as the primary disease targeted, followed by leishmaniasis (only in India), and chikungunya and dengue (only in Mauritius). Overall, DDT use for malaria control has decreased in recent years, while use for leishmaniasis control has increased. Six countries reported having stockpiles of DDT, at least one of which was obsolete and in need of disposal.

Against the background of a continued need for DDT for disease vector control, it is necessary to make the development and deployment of alternatives to DDT for disease vector control a priority. The purpose of the road map is to provide a thematic guide and sketch the steps that are needed to achieve this goal. In doing so, it specifies the areas in which action is warranted, the activities that need to be undertaken, the actors that are responsible for them, and a tentative timeframe, as appropriate. In order to become a success, implementation of the road map will need to be a multi-stakeholder effort in which all partners have an active and important role to play and engage in close collaboration. While the road map requires action at the local, national, regional and global level, its ultimate target is countries, namely the Parties to the Stockholm Convention. The focus is on providing assistance through a variety of means – such as the provision of guidance material, decision support tools and research. The Global Environment Facility (GEF) as the financial mechanism of the Stockholm Convention, has financed projects tailored to the specific needs of each country – in order to build capacity to manage insecticide resistance, develop and implement integrated vector management (IVM) strategies, and assess and deploy chemical and non-chemical alternatives. It is not expected that there will be a single, universally applied alternative to DDT, but multiple approaches adapted to the specific ecological, programmatic and social context where vector control is implemented. Local adaptation requires local capacity to plan, target, implement, monitor and evaluate vector control. Therefore, throughout the roadmap there is an emphasis to support countries in the IVM principles of capacity-building, evidence-based decision making, cross-sector collaboration, multiple interventions, and legislation/community engagement. The ultimate objective of the road map is to make locally safe, effective, affordable and environmentally sound alternatives available for a sustainable transition away from DDT.

The activities specified in the road map require additional and substantial funding for both coordination and implementation. A number of the activities are already ongoing and currently implemented by partners; for these, minimal funding is needed to supplement coordination, information management, and reporting. Other activities however, will require dedicated funding. Implementation of the roadmap will result in a positive return on investment for a sustained and ecologically sound approach to vector-borne disease control, with optimal use of resources, judicious use of pesticides and, eventually, without the continued need for DDT.

If the road map is successfully implemented, it is expected that the COP will ultimately conclude that countries no longer need to rely on DDT for disease vector control because locally safe, effective, affordable and environmentally sound alternatives are available for a sustainable transition away from DDT.

This document first provides a short analysis of the situation, elaborating in particular on recent developments in the production, trade, use and consumption of DDT, some background on the global policies and strategies for vector control, and an overview of the status of vector control tools and chemical and non-chemical alternatives. Next, an overview is given of the actors that will be responsible for implementing the road map. Finally, each of the elements featured in the road map is elaborated upon.

2 SITUATION ANALYSIS

2.1 Status, Challenges and Opportunities in Vector Control

2.1.1 Status of Malaria and Visceral Leishmaniasis

According to the WHO's 2014 World Malaria Report, 97 countries have ongoing malaria transmission, with an estimated 3.2 billion people at risk and 1.2 billion at high risk. It is estimated that there were 198 million cases of malaria worldwide in 2013, of which more than half a million were lethal, mostly in Africa. [6] Malaria is not only a public health problem, but also imposes significant economic costs on many endemic countries[7].

More than 98 countries and territories are estimated to be endemic for leishmaniasis. Each year, *ca.* 0.2 to 0.4 million new cases of visceral leishmaniasis (also known as *kala-azar*), the most serious form of the disease, occur. The disease affects mainly the poor and is to a large extent concentrated in only six countries (Bangladesh, Brazil, Ethiopia, India, South Sudan and Sudan), where more than 90 % of cases are reported.[8] In total, it is estimated that there are 300,000 cases and over 20,000 deaths annually. *Ca*. 310 million people are at risk.[8]

It should be noted that the primary indicator for measuring the effectiveness of alternatives to DDT is morbidity, rather than mortality. The type of vector control intervention used will have a direct impact on the number of infected people, but only an indirect effect on mortality. Depending on changes in the quality of health care and other factors, mortality may increase despite improved access to vector control interventions and *vice versa*. It is therefore difficult to establish a causal relationship between the availability of alternatives to DDT and mortality.

2.1.2 Progress in Combatting Malaria

Substantial progress has been made in the fight against malaria. For example, in 2013, almost half of the population at risk in Africa had access to an insecticide-treated nets (ITNs), compared to 3 % in 2004. Globally, an estimated 123 million people were protected by indoor residual spraying (IRS), representing 3.5 % of the population at risk.[9] Significant progress has therefore been made. In total, 64 countries are on track to meet the Millennium Development Goals (MDGs) target of reversing the incidence of malaria and 55 countries will meet the targets defined by the Roll Back Malaria Partnership (RBM) and World Health Assembly (WHA) of reducing malaria case incidence rates by 75 % by 2015. In the past decade, the scale-up of interventions helped to reduce malaria incidence by 30 % globally, and by 34 % in Africa.[9]

Much of these successes can be attributed to increased coverage with vector control interventions[9]. This has been made possible by a substantial increase in funding over the last decade. In 2013, total funding for the fight against malaria amounted to USD 2.7 billion[10], 82 % of which were international investments, as compared to less than USD 100 million in 2000[11].

2.1.3 Remaining Challenges: Insecticide Resistance and Others

However these gains are fragile and threatened by drug and insecticide resistance, lack of tools and strategies for 'outdoor and residual transmission' and overall lack of funding and capacity. In fact, the countries with the heaviest malaria burden are not yet on track to achieving the WHA and RBM targets[12]. For example in Tanzania[13], as well as Zambia and Zimbabwe[14] upsurges in malaria, including situations where there has been an increase in the *Anopheles funestus* populations, highlight the need for complementary vector control tools and strategies, improved entomological monitoring and effective insecticide resistance management actions.

Insecticide resistance is one of the main reasons for the continued need for DDT. Vector control interventions are limited to the use of a few insecticides. In consequence, the spread of resistance especially to pyrethroids (such as deltamethrin or lambda-cyhalothrin), but also to DDT as well as carbamate and organophosphate insecticides presents a grave threat to control of *Anopheles* vectors of malaria and *Phleobotmus* vectors of visceral leishmaniasis, necessitating additional mitigation measures[15]. Since 2010, 49 countries reported at least one case of insecticide resistance, with resistance to pyrethroids, the most widely used insecticide, most frequently reported[16]. Taking into account incomplete reporting, resistance is likely more widespread. Malaria vectors resistant to pyrethroids are often also resistant to DDT which has a similar mode of action. There are however situations, for example with *Anopheles funestus* in South African countries (Botswana, Swaziland, Mozambique, Zimbabwe, Malawi, Namibia and Zambia) where mosquito populations are resistant to pyrethroids but continue to be sensitive to DDT[17].

As a result of pyrethroid resistance, many programs have reduced spray coverage. The high cost of non-pyrethroid alternatives is contributing to this decrease. In the Africa region, the share of the population at-risk protected by IRS peaked at 11% in 2010, but subsequently decreased. In 2013, 55 million people were protected, representing only seven percent[18]. In some documented instances (*e.g.*, the Kagera Region Tanzania[19]) reduced IRS coverage resulted in higher transmission rates[20].

Challenges also remain with regard to other types of interventions: The WHO estimates that 278 million people at risk of malaria in Sub-Saharan Africa had no access to ITNs.[21] All types of interventions require funding. However, the World Malaria Report notes that international and domestic funding falls short of the estimated USD 5.1 billion needed. Funding now seems to be stagnating[22].

2.1.4 Integrated Vector Management

IVM is the accepted management strategy for addressing these challenges, including insecticide resistance. IVM is defined as "a rational decision-making process to optimize the use of resources for vector control" [23] and includes five pillars:

i) Advocacy, social mobilization and legislation: Promotion and embedding of IVM principles in designing policies in all relevant agencies, organizations and civil society; establishment or strengthening of regulatory and legislative controls for public health; empowerment of communities
ii) Collaboration with 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
iii) Integrated approach: Ensure rational use of available resources by addressing several diseases, integrating non-chemical and chemical vector control methods and integrating with other disease methods
iv) 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
v) 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

One of the key principles of IVM is to use a range of both chemical and non-chemical interventions selected on the basis of local evidence regarding the vectors, disease and disease determinants.[23] In the framework of IVM, insecticide resistance management is not simply rotation of insecticides but a comprehensive approach across sectors to reduce selection pressure and achieve sustained vector control through a combination of chemical and non-chemical approaches.

The strategy foreseen by the road map endorses the IVM approach. Management of insecticide resistance, capacity for evidence-based decision-making, availability of a range of chemical and non-chemical interventions, and the use of complementary vector control measures are at the core. The decision of using an intervention or a combination of interventions should be based on sound scientific information within the IVM principles.

2.2 Vector Control

The objective, as also outlined in the Global Malaria Action Plan[24] (GMAP; discussed below in more detail), is to reach universal coverage for all populations at risk with locally appropriate malaria control interventions. Categories for vector control can be classified into environmental, mechanical, biological, and chemical (see Table 1). These are not to be seen as mutually exclusive. Instead, they are complementary and should be combined whenever possible.[25]

Table 1: Methods used to control vector-borne diseases[25]

Category	Method	Leishmaniasis	Malaria
Environmental	Source reduction		+
	Habitat manipulation		+
	Irrigation management & design		+
	Proximity of livestock		+
	Waste management		
Mechanical	House improvement	+	+
	Removal trapping	+	
Biological	Natural enemy conservation		+
	Biological larvicides		+
	Fungi		(under development)*
	Botanicals		+
Chemical	Insecticide-treated bednets	+	+
	Indoor residual spraying	+	+
	Insecticidal treatment of habitat		+
	Insecticide-related targets		(under development)*
	Biorational methods		+
	Chemical repellents	+	+

* Changed from ref [25]

These vector control methods may differ in their efficacy depending on local conditions and on the disease targeted. Most methods are applicable for several diseases and can thus be used where these coexist. For example, house improvement, biological larvicides and insecticide-treated bednets all work for both malaria and visceral leishmaniasis. By contrast, environmental methods may work for malaria but are not promising for visceral leishmaniasis.[25]

Chemical interventions dominate vector control. The most widely used interventions for disease vector control are ITNs and IRS.[25] Alongside pyrethroids, DDT is among the most commonly used chemical for IRS if one includes visceral leishmaniasis control in India. For malaria control in Africa, bendiocarb and pirimiphos methyl use now far outweighs DDT use[26]. The use of other methods, such as larviciding is still negligible. Figure 1 gives an overview of the share of insecticides used for vector control for the period between 2000 and 2009 (all types of interventions). It should be noted that this data takes into account all types of vector control, i.e. not only against malaria and leishmaniasis, but also dengue, chagas and others.

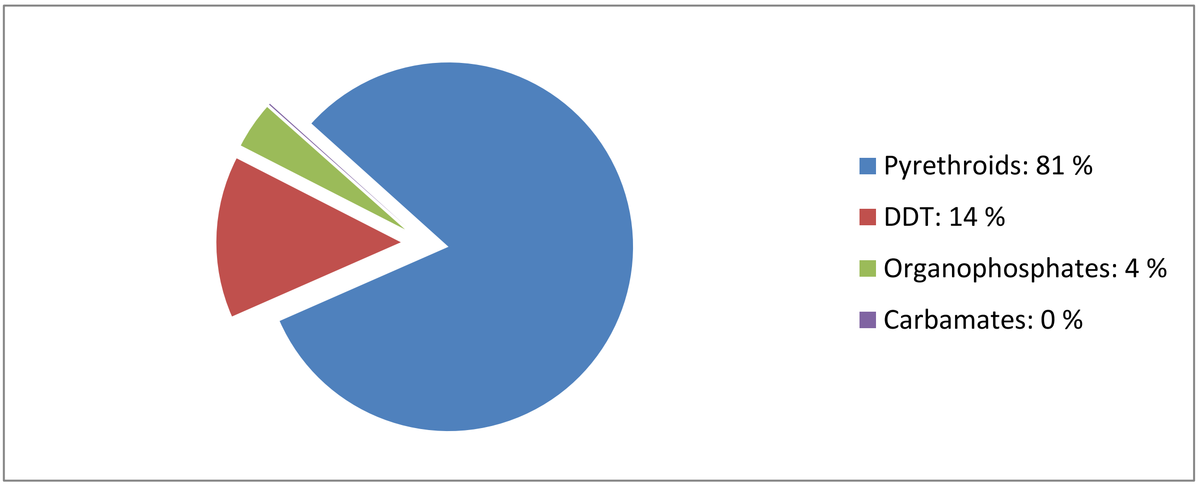

Figure 1: Proportion of vector control insecticides use, by global shares expressed in spray coverage (not amount of active ingredient; rounded)[26]

The different types of insecticides were used very differently. All four types of insecticides were used for IRS, in the case of DDT and carbamates almost exclusively so. By contrast, organophosphates also found application in space spraying, to a minor extent larviciding. Pyrethroids were predominantly used for IRS, but also treatment of nets and space spraying. Space spraying is not recommended for malaria and *Anopheles* control, only for *Culex* and *Aede*s control during outbreaks of aboviruses such as West Nile or Dengue.[26]

2.2.1 Indoor Residual Spraying with DDT

Because of its low cost and long duration of effectiveness, DDT spraying has been a prominent vector control strategy since the 1940s[27]. Today, the use of DDT for vector control is restricted to IRS[28]. Space spraying or larviciding with DDT is not recommended and for reasons of textile adhesion, it is not possible to treat mosquito nets with DDT.

Under the Stockholm Convention, Parties are requested to notify the Secretariat if they intent to produce or use DDT for the acceptable purpose, *i.e.* for disease vector control. This information is maintained by the Secretariat of the Basel, Rotterdam and Stockholm Conventions (BRS Secretariat) in the DDT register[29]. According to paragraph 4 Part II, Annex B of the Convention, every three years, Parties are requested to provide to the Secretariat and the WHO information on the amount used, the conditions of such use and its relevance to that Party's disease management strategy. The following information on production, use, trade and stockpiles of DDT is based on the DDT register, the report of the DDT expert group of 2013, which relies on the information provided by Parties for the reporting period from 2009 to 2011, and the latest report of the DDT expert group[i], which provides additional information obtained from the only producer and important users of DDT.

[i] To be published as an INF-document for the next Conference of the Parties to the Stockholm Convention to be held in Geneva in May 2015.

2.2.1.1 Production

According to a study conducted for the Secretariat[30], the People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK) and India were producing DDT for disease vector control at least during the period between 2003 and 2007 (see Table 2). The DPRK has reportedly produced an additional 155 tonnes for use in agriculture. It is not known whether production in the country has continued beyond 2007.

Table 2: Annual production of DDT in 2003, 2005 and 2007[30]

Country	Amount of DDT (tonnes)		
	2003	2005	2007
China	450	490	n.a.
DPRK	n.a.	n.a.	5
India	4,100	4,250	4,495

According to the DDT register (as of January 2015), three parties are currently registered for acceptable production of DDT, namely Ethiopia, India and Namibia. In 2006, 2006 and 2009 respectively, Ethiopia, India and Namibia notified the Secretariat that they produce DDT for disease vector control in accordance with the WHO recommendations and guidelines. China had notified the Secretariat of its production in 2005[31] but has then ceased production in 2007[32]. Ethiopia, while registered, has not reformulated or produced DDT since its source of technical grade material from China ceased in 2007. Likewise Namibia, while registered, has never produced or reformulated DDT. In 2015 the only production facility is in India[33].

For the reporting cycle of 2009 to 2011, of the 24 Parties that responded to the DDT questionnaire, only India reported production of DDT. The total production reported by India over the three years amounted to 10,246 tonnes or 3,315, 3,610 and 3,192 tonnes in 2009, 2010 and 2011, respectively. This constitutes a decrease compared to previous years.[34]

The only facility known to have ongoing DDT production is 'Hindustan Insecticides Limited' a governmental enterprise under the Ministry of Chemicals and Fertilizers. According to company information, production amounted to *ca.* 3,872 and 2,786 tonnes of technical grade DDT[ii] in 2012/2013 and 2013/2014[iii], respectively. Most of this technical grade DDT was used to prepare DDT formulations of 50 % for domestic use; a much smaller share was used to prepare DDT formulations of 75% for export (see Table 3).[35]

Table 3: Production of DDT in India[35]

Formulation of DDT (in tonnes[iv])	2012/2013	2013/2014
Technical grade material (98% - 99 % active ingredient)	3,872	2786
Formulated products for export (75 % active ingredient)	383	100
Formulated products for domestic use (50 % active ingredient)	5,869	6,183

2.2.1.2 Trade

Trade in DDT according to the information submitted by Parties during the 2009 to 2011 reporting period is shown in Table 4.

[ii] 98% - 99%
[iii] Financial year: April 1st to March 31st
[iv] Rounded

Table 4: Trade in DDT (2009 – 2011)[36]

Exporting country	Importing country	Active ingredient	Amount (in tonnes[v])
China	South Africa	95 %	200
India	Gambia	75 %	14
India	Mozambique	75 %	202
India	Namibia	75 %	16
South Africa	Botswana	75 %	1
South Africa	Namibia	75 %	100
South Africa	Swaziland	75 %	13
South Africa	Zambia	75 %	33
Total			579

According to the latest DDT expert group report, only India continued to export DDT after 2011. The recipient countries were Botswana (*ca.* 30 tonnes[vi] in 2012/2013), Myanmar (*ca.* 12 tonnes in 2012/2013), Namibia (*ca.* 77 tonnes in 2012/2013), South Africa (a total of *ca.* 85 tonnes in 2012/2013 and 2013/2014) and Zimbabwe (a total of *ca.* 280 tonnes in 2012/2013 and 2013/2014). In total, *ca*. 382 and 102 tonnes were exported in 2012/2013 and 2013/2014, respectively. Thus, exports decreased substantially. The number of importing countries decreased from five in 2012/2013 to two in 2013/2014 – while Botswana, Myanmar and Namibia discontinued import, South Africa and Zimbabwe were still importing, albeit at lower amounts.[37] Table 5 provides an overview.

Table 5: Export of DDT from India[37]

Country	Amount (in tonnes[vii])			
	2012/2013		2013/2014	
	98 % - 99 % active ingredient	75 % active ingredient equivalent	98 % - 99 % active ingredient	75 % active ingredient equivalent
Botswana	23	30	-	-
Myanmar	9	12	-	-
Namibia	57	77	-	-
South Africa	33	44	31	41
Zimbabwe	164	219	46	61
Total	286	382	77	102

2.2.1.3 Use

According to the WHO, use of DDT has experienced an overall increase between 2000 and 2009 and reached its peak in 2009 with more than six thousand tonnes of active ingredient used globally (see Figure 2).

[v] Rounded
[vi] 75% active ingredient
[vii] Rounded

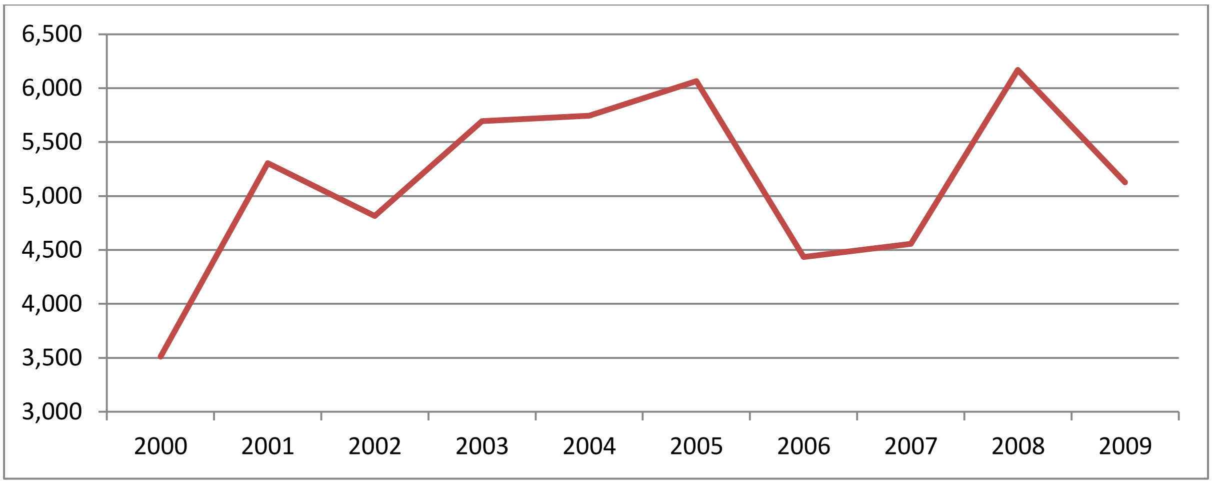

Figure 2: Trend in the global use of DDT for vector control, as reported to WHO, in tonnes of active ingredient per year[38]

Ca. 4,953 tonnes, 5,219 tonnes and 3,950 tonnes of DDT were used for disease vector control in 2003, 2005 and 2007, respectively. While the majority was used for malaria control, *ca.* 20% were used for control of visceral leishmaniasis. India accounted for ca. 86 % of global use between 2003 and 2007. Ecuador, Mexico and Venezuela had phased out the use of DDT in 2000, while Gambia, Mozambique, Zambia and Zimbabwe had reintroduced it in 2008, 2005, 2000 and 2004, respectively. In 2007, an estimated 13 countries were using DDT for disease vector control.[39]

According to the DDT register (as of January 2015), 17 Parties are currently registered for acceptable use of DDT, including 13 from the African Group (Botswana, Eritrea, Ethiopia, Madagascar, Mauritius, Morocco, Mozambique, Namibia, Senegal, South Africa, Swaziland, Uganda and Zambia), three from the Asia-Pacific Group (India, Marshall Islands and the Republic of Yemen), and one from the Latin American and Caribbean Group (GRULAC) (Venezuela).[40] In 2012, Myanmar informed the Secretariat that it had discontinued the use of DDT[41]. China followed with the same notification in 2014[42].

For the reporting cycle of 2009 to 2011, only twelve of the Parties registered for acceptable production of DDT responded to the DDT questionnaire. Of these, 7 reported use of DDT for disease vector control, namely Eritrea, Mauritius, Mozambique, India, South Africa, Swaziland and Zambia. Although not listed in the register, Gambia also reported use. Table 6 lists the amounts used by the respective countries as per the national reporting. Five of the registered Parties reported no use (Ethiopia, Madagascar, Morocco, Uganda, and the Republic of Yemen). In total, more than 20,000 tonnes of formulated DDT – corresponding to *ca.* 10,246 tonnes of active ingredient – were used between 2009 and 2011. India accounted for *ca.* 98 % of global use, making it by far the largest user, followed by South Africa (*ca*. 168 tonnes), Zambia (*ca*. 57 tonnes) and Eritrea (54 tonnes).[43]

Table 6: Amount of DDT used by countries during the reporting cycle 2009-2011[43]

Country	**Formulated material[viii] used (tonnes[ix])**			**Sub-total**
	2009	2010	2011	
Eritrea	13	18	23	54
Gambia	21	15	15	51
India	6,830	6,694	6,446	19,970
Mauritius	0	1	0	1
Mozambique	1	2	3	6
South Africa	85	21	62	168
Swaziland	5	3	4	12
Zambia	32	25	0	57
Sub-total	6,987	6,779	6,553	
Grand total				20,319

At least in India, use has continued between 2012 and 2014, with 6,183 tonnes reportedly used for disease vector control in 2013/2014.[44]

Between 2000 and 2009, about 81 % of DDT was used against malaria and 19 % against leishmaniasis[45]. During the reporting cycle of 2009 to 2011, DDT was mainly used for malaria control. India reported the use of DDT for control of visceral leishmaniasis and Mauritius for control of *chikungunya* and dengue.[46] Since 2008/2009, use for control of visceral leishmaniasis has increased substantially, while use for control of malaria has steadily decreased. In 2013/2014, more than 40 % of DDT in India was reportedly used for control of visceral leishmaniasis (see Figure 3).[47]

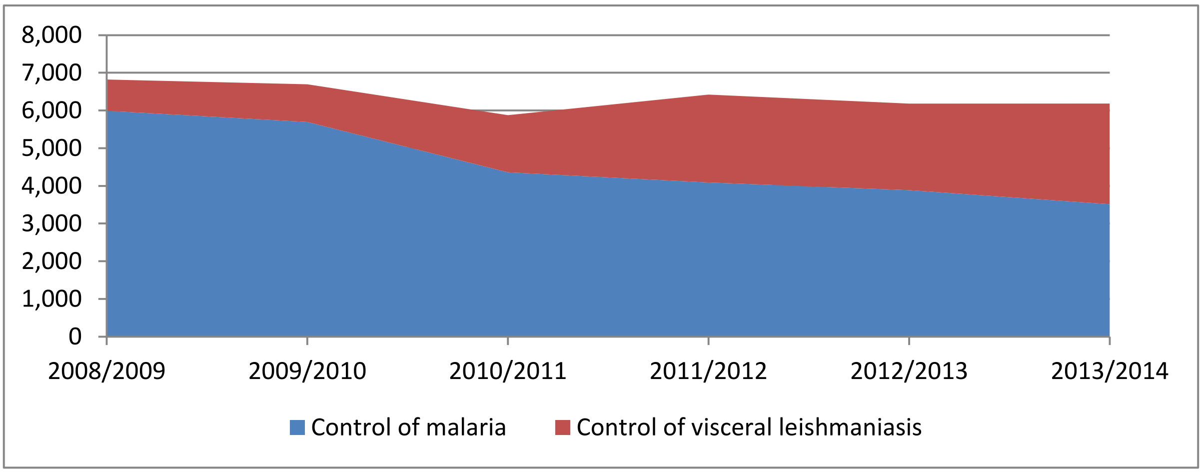

Figure 3: DDT use in India between 2008/2009 and 2013/2014 (in tonnes)[47]

2.2.1.4 Stockpiles

For the reporting cycle of 2009 to 2011, six out of 24 countries provided information on stockpiles of DDT. The largest stocks were held by India (2,046 tonnes of DDT at 50 % active ingredient), followed by South Africa (36 tonnes at 75 %). Total reported stockpiles amounted to 2,126 tonnes. Swaziland reported unspecified stocks of obsolete DDT.[48] The information is summarised in Table 7.

[viii] Note: The percentage of active ingredient of DDT in the formulation used in India 50 %, whereas that of the other countries is 75 %
[ix] Rounded

Table 7: DDT stockpiles during the reporting cycle 2009-2011[48]

Country	Active ingredient	Amount (in tonnes)
Gambia	75 %	14
India	50 %	2,046
Jordan	75 %	25
Mauritius	75 %	5
South Africa	75 %	36
Swaziland	n.a.	n.a.
Total		2,126

There may be additional stocks that were not reported. For example, Ethiopia has about 1,300 tons of obsolete insecticide (over 99% DDT) that needs to be disposed of[49] and Bangladesh reportedly had stockpiles amounting to 602,389 tonnes of obsolete DDT[50].

2.2.1.5 Concentrations in Humans and the Environment

The Conference of the Parties to the Stockholm Convention established a Global Monitoring Plan to evaluate the effectiveness of measures implemented. UNEP and the World Health Organization jointly implement a human milk survey on concentrations of POPs in human milk, which was selected as a core matrix. The sampling protocol and the data reporting assess baseline concentrations (*i.e.*, mothers not exposed to known sources of POPs) of primiparae reporting one sample *per* country. According to the protocol, it is recommended to prepare pools containing milk from 50 mothers for each 50 million of population. Data are available since 2001 and Figure 4 shows the concentrations in these national pools starting with the oldest samples at the left side of the graph. It can be seen that in recent years, relatively high concentrations have been detected. For orientation: the WHO "safety level" is at 2,000 ng *per* gram lipid.

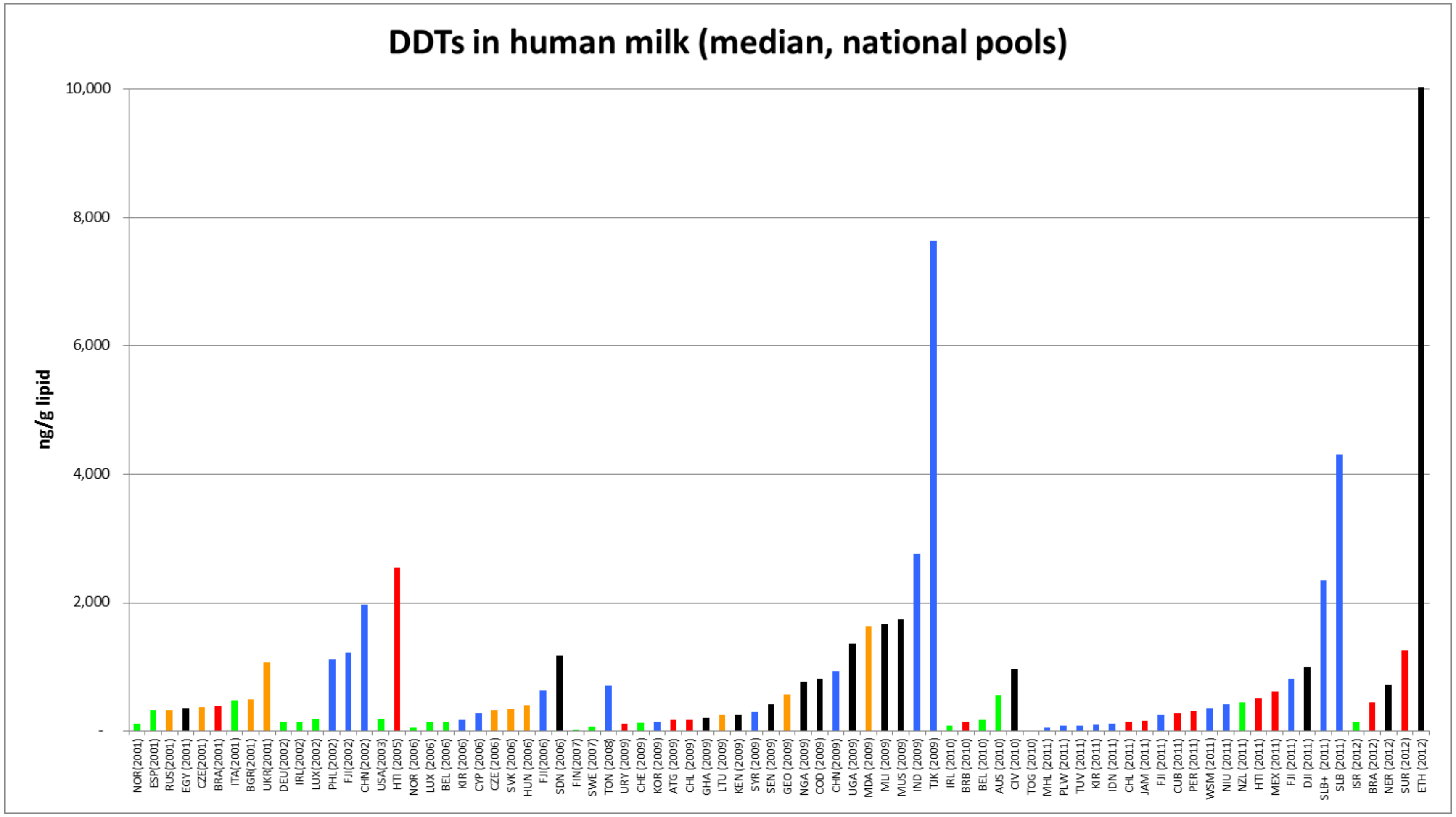

Figure 4: Concentrations of DDTs in human milk
Countries are designated by ISO-3 code and sampling year
Color codes are: Africa-black, Asia-Pacific-blue, CEE-orange, GRULAC-red, WEOG-green
Note: right bar for ETH(2012) goes out of range (concentration: >22,000 ng/g lipid)

Figure 5 shows results for countries where more than one result is available. The green bars identify countries where the more recent sample has lower concentrations than the previous. For Fiji, no trend could be established. The data have to be interpreted with care since the populations are not always the same and for most countries only two samples are available.

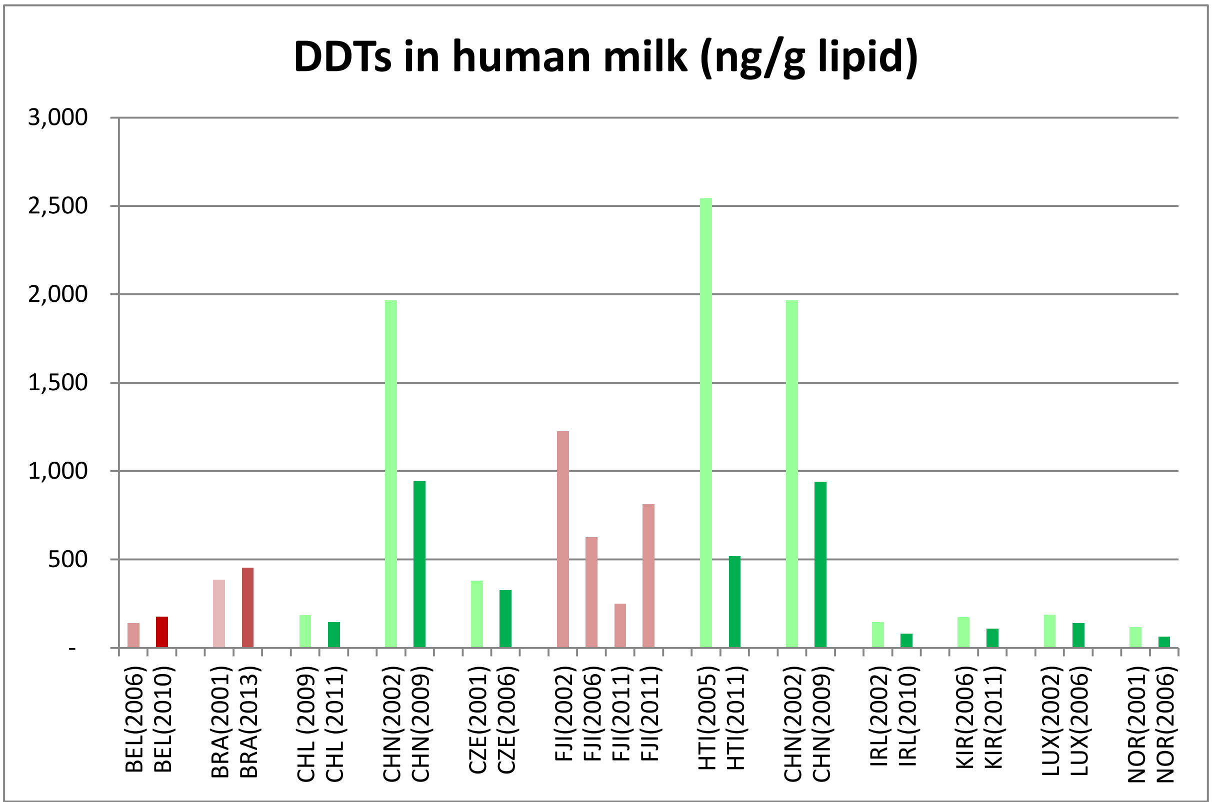

Figure 5: Concentrations of DDTs in human milk for countries where at least two samples are available
Countries are designated by ISO-3 code and sampling year

2.2.2 Indoor Residual Spraying With Other Chemicals

2.2.2.1 Existing Chemicals

Chemical alternatives to DDT have been available and in use for decades[51]. In addition to DDT, the WHO Pesticide Evaluation Scheme (WHOPES) recommends 13 insecticides for IRS against malaria vectors (status: November 2014) (see Table 8). These belong to the chemical classes of organophosphates, carbamates and pyrethroids. Pyrethroids use has significantly increased over the past decade and is the most widely used insecticide for spray operations[52]. DDT has the longest duration of effective action (exceeding six months), meaning that the frequency of spraying needed for other insecticides is higher. While some of the newer pyrethroid formulation are beginning to approach DDT in terms of effectiveness duration, carbamates have a much shorter duration of effectiveness. As regards organophosphate insecticides, there is a new formulation of pirmiphos-methyl with a longer duration of effectiveness but a high unit cost[53].

Carbamate and organophosphate insecticides have significantly higher unit cost compared to DDT. By contrast, pyrethroids are significantly cheaper. Unit costs to spray 250m^2 are approximately USD

1.80 for pyrethroids, USD 6.00 for DDT, USD 13.00 for the carbamate bendiocarb; and USD 23.50 for the organophosphate primiphos-methyl CS.

Insecticides recently recommended by WHOPES after evaluation for safety and efficacy include:

- Primiphos-methyl Capsule Suspension: Developed by Syngenta under the brand name Actellic® 300CS this formulation received recommendation in July 2013 with an expected duration of residual activity of 4–6 months[53]
- Deltamethrin polymer-enhanced 62.5 suspension concentrate (SC-PE) (K-Othrine Polyzone®): Developed by Bayer CropSciences, it was recommended for IRS in July 2013. Some trials found its residual efficacy to be superior over the deltamethrin WG formulation, while others found it to be the same (about 6 months).

Table 8: WHO recommended insecticides for IRS against malaria vectors[54]

Insecticide compounds and formulations	Class group	Duration of effective action (months)
DDT WP[x]	Organochlorines	>6
Malathion WP	Organophosphates	2-3
Fenithrothion WP	Organophosphates	3-6
Primiphos-methyl WP & EC[xi]	Organophosphates	2-3
Primiphos-methyl CS[xii]	Organophosphates	4-6
Bendiocarb WP	Carbamates	2-6
Propoxur WP	Carbamates	3-6
Alpha-cypermethrin WP & SC[xiii]	Pyrethroids	4-6
Alpha-cypermethrin WP-SB[xiv]	Pyrethroids	Up to 4
Bifenthrin WP	Pyrethroids	3-6
Cyfluthrin WP, WG[xv]	Pyrethroids	3-6
Deltamethrin SC-PE[xvi]	Pyrethroids	6
Deltamethrin WP, WG	Pyrethroids	3-6
Etofenprox WP	Pyrethroids	3-6
Lambda-cyhalothrin WP, CS	Pyrethroids	3-6

2.2.2.2 New active ingredients and formulations

The Innovative Vector Control Consortium (IVCC) is working with industry to develop new or improved formulations of existing insecticides. There are at least three other new active ingredients being developed for IRS but are at least 5-10 years away from the market[55]. With regard to new formulations of existing insecticides, Chlorfenapyr 240 SC, which is a suspension concentrate formulation containing 240 g of active ingredient per litre for IRS against malaria vectors, is still under development and review by BASF Germany[66].

Other formulations that are currently being investigated include the following:

[x] Wettable powder
[xi] Emulsifiable concentrate
[xii] Capsule suspension
[xiii] Suspension concentrate
[xiv] Water dispersible granules packaged in water soluble bags
[xv] Water dispersible granules
[xvi] Polymer enhanced suspension concentrate

- DEET microencapsulated: An experimental hut trial of DEET MC was conducted in Tanzania and published in 2014. The initial trials were promising and further development was recommended.[56]

- Malathion and Propoxur. Malathion, an organophosphate has been used for IRS since the 1960s, is still used by the malaria control program in India but little elsewhere. Likewise propoxur, a carbamate is little used, but is now being formulated in Ethiopia for their IRS program. Both are WHOPES recommended[57], but fell out of use with the development of pyrethroids that had fewer issues with toxicity, smell, bulk and user acceptability. Now with pyrethroid resistance there is a renewed interest in these compounds and possible reformulation to improve duration of effectiveness and user-acceptance[68].

- Entomopathogenic fungi: Fungi, such as *Beauveria bassiana* and *Metarhizium anisopliae* have an advantage over the current fast-acting insecticides by disrupting feeding and killing the mosquito later in her life, but before she is infectious, reducing the selection pressure and potential development of resistance seen in the other chemical insecticides.[58] Application of entomopathogenic fungi, maybe through spray, through application to resting areas such as clay pots[59], and to eave screens as listed below. Work is ongoing to improve formulations and persistence[60].

2.2.3 Other Chemical Interventions

IRS and LLINs remain the core vector control interventions for malaria[61], meaning that the other chemical (and non-chemical) alternatives should be seen as complementary methods used in a context-specific manner. The below list is not exhaustive, but aims to give a broad overview of the main areas of research and development.

2.2.3.1 Long-lasting insecticidal nets

Chemical vector control interventions that are not based on IRS include, amongst others, the use of insecticide-treated nets. It is possible to distinguish between conventional (abbreviated as ITNs) and long-lasting insecticidal nets (LLINs). LLINs are defined as maintaining insecticidal efficacy with up to 20 washes. By contrast, ITNs will lose effectiveness after being washed two or three times, with traditional laundering practices . In addition to the physical barrier of an intact net with no holes, the insecticide treatment often has an excite-repellent and lethal effect on the mosquito, providing both personal protection for the persons under the net and, when community coverage is high, an impact on the overall vector population, providing a “mass effect”. The duration of effective action ITNs and LLINs is about one and three years, respectively.[62] There are new combination LLINs under development that are hoped to be effective against certain types of pyrethroid-resistant vectors[68].

Research and development of LLINs with new insecticides or combinations is ongoing. Recently, ICONMAXX®, a ‘dip-it-yourself’ mosquito net treatment kit developed by Syngenta based on the slow-release capsule suspension (CS) of lambda-cyhalothrin, received WHO recommendation. It has an estimated duration of insecticidal efficacy of 30 to 36 months depending on the local settings. This technology is useful for converting untreated nets that may be widely available in the community, such as the ‘bundling strategy’ for treating hammock nets in Cambodia[63].

Other formulations for LLINs that are currently being investigated include the following:

- Deltamethrin /PBO PermaNet® 3.0 by Vestegaard[64]: It is described as “the first long-lasting insecticide-synergist combination bed net”[65] and is now under consideration by the WHO Vector Control Advisory Group.

- Permethrin/PBO Olyset Plus® by Sumitomo[66] has a similar strategy as the deltamethrin/PBO net to overcome the metabolic –type of pyrethroid resistance
- Chlorfenyapyr/alphacypermethrin Interceptor G2® by BASF[67] is undergoing WHOPES field testing[68].
- Permethrin/pyriproxyfen[69, 70] the Olyset Duo® by Sumitomo is being developed in collaboration with IVCC and currently undergoing field testing[71].

A variation of LLINs are durable wall linings. Insecticide-treated polyethylene netting hung on the inside walls of dwellings kills mosquitoes in a way similar to IRS but assures a uniform dosing and can be formulated for slower release and longer efficacy[72]. The first generation of durable wall linings incorporated deltamethrin. To address the widespread problem of pyrethroid resistance more recent presentations incorporate other chemicals, including the organophosphate insecticide pirimiphos-methyl[73].

2.2.3.2 Larviciding

Larviciding refers to the application of chemicals or bio-toxins into the aquatic habitats of larvae and pupae to kill or arrest development and the emergence of adult mosquitoes. Larviciding and environmental management was the original malaria vector control method but was surpassed by IRS and later LLINs that can be more easily applied across wide areas with standard technologies and approaches and with much less technical expertise, time and effort. Larval control is especially difficult in the rural African context where the malaria vector larval habitats can be widespread temporary pockets of water. Larviciding will be most effective where larval habitats are 'few, fixed and findable'[74]. In well-defined settings where it is feasible, the elimination of larval habitats can be a cost-effective and long-term solution[74]. The WHO Interim Position Statement notes that larviciding should normally be used as a supplement to the core interventions (ITNs or IRS) and that larviciding should never be seen as a substitute for ITNs or IRS in areas with significant malaria risk[75]. A review of studies evaluating the effectiveness of larval source management showed mixed, but overall positive results. Thus, while additional research is necessary, "larval source management is another policy option, alongside LLINs and IRS, for reducing malaria morbidity in both urban and rural areas where a sufficient proportion of larval habitats can be targeted"[76].

While the WHOPES-recommended insecticides for LLINs and IRS are contact insecticides with a rapid uptake and impact on the adult mosquito, a different set of chemicals used for larviciding. These include, insecticides that can be injected, biotoxins and juvenile hormone mimics that arrest development and prevent emergence of the adult mosquito [77]. Although larviciding is so far practiced on a sporadic basis, when done properly with a quality-assured product and in ecological contexts where the larval habitats are 'few, fixed and findable' it may be an efficient tool for complementary vector control particularly in *peri*-urban habitats. However, current investments in larviciding often lack appropriate quality control on the larvicide itself and the required monitoring and evaluation, reducing its contribution to malaria control[78].

A novel approach for larviciding, still very much in the early development stage is "auto-dissemination". This was initially developed initially for *Aedes* container-breeding mosquitoes. The idea is that female mosquitoes pick up traces of the juvenile hormone mimic pyriproxyfen, carry it to the sites and deposit sufficient toxicant to the water resulting in inhibition of mosquito adult emergence from the pupae. (as noted above with the Olyset Duo net, pyriproxyfen also decreases the lifespan and fecundity when picked up by an adult female mosquito). Still under development, it is unsure if it will work against *Anopheles* that often oviposit in larger bodies of water than the container-breeding *Aedes.*[79, 80]

2.2.3.3 Treated clothing and blankets

Insecticide-treated clothing, especially with micro-encapsulated permethrin is a well-developed technology, especially for military uniforms and outdoor recreational clothing. A review from 2014 provided clear evidence that biting is prevented through treated clothing; however, this is not the case for exposed areas, such as hands[81]. For malaria and visceral leishmaniasis, the results varied more and depended to a far extent on how the materials are used[93]. Insect Shield[TM82] is one of the largest commercial producers of treated materials for military and civilian use.

A subset of the treating clothing is the use of permethrin-treated blankets and scarves. Permethrin treated blankets or top-sheets were first tried among Afghan refugees in Pakistan in 1999[83]. More recent work demonstrated the potential of treated blankets to provide substantial personal protection even against pyrethroid resistant mosquitoes and that they may prove particularly useful where LLINs are unsuitable or net usage is low[84]. One micro-encapsulated permethrin-treated blanket has been approved by EPA and is currently being considered for use in emergency relief operations[85].

2.2.3.4 Animal treatments

The role of domestic animals in the epidemiology of malaria has been recognized since the earliest days of malaria control[86]. For vectors with zoophilic tendencies there have been numerous attempts at zooprophyhylaxis[87] and with dipping or sponging cattle with insecticide[88].

2.2.3.5 Topical and spatial repellents

Topical repellents (applied to the skin) are widely used around the world to provide individual protection against mosquito bites. A recent review and meta-analysis indicate that, there is little evidence that topical repellents provide a public health impact when used in isolation[89]. The main challenges are compliance and correct use. However, there may be situations in which topical repellents can have an impact, namely when used in combination with other personal protection measures or over relatively short exposure times. The analysis concluded that additional trials examining doses and alternative modes of repellent delivery were required[90].

Recent community-based trials of topical repellents include the following:

- Para-menthane-diol (PMD) (lemon grass oil): A trial in Ghana showed high user acceptance, a protective efficacy of more than nine hours and a decrease of absolute malaria prevalence by 19.2 % in the repellent village, as compared to 6.5 % in the control village[91].
- Picardin: A randomized control trial of the repellent Picardin is ongoing in Cambodia. Preliminary indications do not show evidence long-term community impact in this low transmission setting [92].
- DEET (diethyltoluamide): A trial carried out in the Lao People's Democratic Republic (LPDR) to determine whether the use of repellent in combination with LLINs could reduce malaria more than LLINs used in isolation found no impact of repellent use on malaria incidence[93].

It should be noted that these are trial situations focused on efficacy. The challenge of long-term compliance and effectiveness remains.

Mosquito behaviour elicited in response to airborne compounds including movement away from a chemical stimulus, loss of host detection, anti-feeding as well as knockdown and mortality are collectively referred to as spatial repellency. Spatial repellents do not require physical contact of the mosquito with the treated surface but act in the vapour state at a distance[94]. Currently used spatial repellents include metofluthrin, transfluthrin, linalool and the undecalactones. Metofluthrin has the unique characteristic of volatizing at room temperature and thus not requiring a heat source like a coil, electric mat or lamp[95]. Transfluthrin is widely used in mosquito coils and mats and may have slightly more insecticidal rather than repellency actions[96]. Linalool was seen to have some repellency when presented as a candle, but more recent tests in Tanzania concluded that the tested 73 % d-linalool agar gel emanators do not provide protection against malaria vectors[97]. Lactones, derived from fruit and dairy products, are a promising new class of spatial repellent that show efficacy similar to or greater than that of DEET but has the added advantage of a pleasant smell[98].

A related paradigm are push and pull systems. Originally developed for indoor use against *Ae aegypti*[99] whereby a spatial repellent (the 'push') is combined with an attractant lethal trap (the 'pull'), there is interest to adapt this strategy for *Anopheles* vectors of malaria in Tanzania[100] and in Kenya[101].

2.2.3.6 Trap and kill technologies

In addition to the traps used as part of the push-pull systems to attract female mosquitoes foraging for blood meals, two other technologies are being developed to trap and kill the female mosquitoes when they are foraging for a carbohydrate meal or searching for an oviposition site:

- Attractive Toxic Sugar Baits[102] were first developed by researchers in Israel[103]. Research is ongoing in Florida, Africa and Israel[104]. The technologies usually rely on sugars and fruits to attract carbohydrate feeding mosquitoes, combined with an oral poison, often boric acid, spinosad or an essential oil such as eugenol.
- Trap and kill technologies for blood-meal seeking *Anopheles* are being developed in Tanzania and Kenya[105]
- Attractant-bait lethal oviposition traps were designed primarily for container-breeding mosquitoes such as *Aedes aegypti* and *Ae albopictus*[106]. The technology kills the ovipositiong mosquito, sometimes with a non-irritant insecticide like bifentrhrin[107].

2.2.3.7 Systemic insecticides

Systemic insecticides[108] are commonly used in veterinary medicine, for example fluralaner against ticks and fleas on dogs[109], fipronil in control of the sand fly vectors of visceral leishmaniasis through 'feed through' baits for rodents [110], and oral dosing for cattle[111]. Ivermenctin, widely used for nematode treatment in cattle and humans is also toxic to mosquitoes that feed shortly after the host has been given the drug[112]. This strategy is attracting considerable attention for situations with vectors that are highly anthrophphilic and difficult to control, such as *Anopheles dirus* in the Mekong sub-region, where the drug would be given to the human population at risk, or the more zoophilic *An arabiensis* in Western Africa, where the where the drug would be given to both humans and their domestic cattle[113]. There are still however a number of safety, regulatory and business challenges for ivermectin to be considered for vector control.

2.2.4 Non-chemical Alternatives

The non-chemical interventions listed below are to be seen as complementary measures. They do not replace IRS and LLINs and their use must be adapted to the specific local context.[114] As mentioned above, IVM is the accepted global strategy for vector control. Alternatives to DDT will thus require a combination of interventions adapted to the specific ecological, economic and programmatic context. In addition to new formulations of existing chemical pesticides, there has been considerable work on development of bio-pesticides using entomo-pothogenic fungi as mentioned above for use against adult mosquitoes, and bacterial larvicides listed below.

2.2.4.1 Bacterial Larvicides

As bacterial larvicides can be highly variable in their performance, they should only be used if recommended by WHO[115] and in the context of well-planned and executed programmes[116]. Used mostly for area-wide application of the WHO recommended *Bacillus thuringiensis israelensis, strain* AM65-52, WG against *Aedes* container larval habitats[117] misting or ultra-low volume application of this bacterial larvicide has had limited use against malaria vectors[118], but is under consideration for malaria vector control in a number of peri-urban situations in Africa.

2.2.4.2 Housing Improvements

The link between housing and malaria has been known since the earliest days of malaria control and has been shown more recently to have an impact on malaria morbidity[119, 120]. The United Nations Human Settlements Programme (UN-Habitat), through the RBM Vector Control Working Group's work stream on Housing and Malaria, and others are coordinating efforts to include housing improvements as complementary measures in current vector control strategies[121]. Elements of housing improvement under investigation include eave tubes with WHOPES-recommended insecticides or pathogenic fungi[122], ceilings[123], insecticidal paints[124] and insecticidal barrier approaches, fences or curtains[125]. In developing low-cost houses for vulnerable or poor populations, governments and partners should be encouraged to prioritize malaria-prone communities.

2.2.4.3 Endosymbionts

Bacteria in the genus *Wolbachia* is prevalent in many insect species, with a number of *Aedes* (but not *Ae aegypti)* and *Culex* species found naturally[126]. *Anopheles,* which are not natural hosts, can be infected in the laboratory. *Wolbachia* strategies include both population suppression and decreased competency. There have been recent advances for *Aedes* and dengue, with field releases in Australia[127]. Establishment of *Wolbachia* infections in *Anopheles* populations appears to be much more difficult, but there were recent success in laboratory infection of *An stephensi* that resulted in reduced susceptibility to *Plasmodium*[128].

Similar to the *Wolbachia* strategies, there is a large body of work exploring the relationship between microbiota of the mosquito midgut and how this influences vector competency to suppress development of *Plasmodia*[129].

2.2.4.4 Genetic-base Population Suppression or Replacement

Strategies with genetically modified mosquitoes (*transgenesis*) and their endosymboints (*paratransgenesis*) aim to either suppress the population through self-limiting genetic changes or to replace the population with individuals less competent to transmit the pathogen[130]. There have already been field trials of population suppression using the strategy of 'Release of Insects with Dominant Lethality' (RIDL), with releases of genetically modified *Aedes aegypti* in the Caymen Islands, Malaysia and Brazil[131]. In *Anopheles*, there has been laboratory development of a RIDL system producing flightless female *An stephensi*[132]. Potential population replacement of *An stephensi* refractory to *Plasmodia* has also been developed[133]. While transgenesis and paratransgenesis, are very active areas of research, there remain many technical and regulatory hurdles before these can be applied in the field for malaria control[134].

3 Overview of Stakeholders

This section provides an overview of the actors that will be responsible for the coordination and implementation of the road map for the development of alternatives to DDT. For the road map to be a success, it will be necessary that all relevant stakeholders are actively engaged in carrying out the various activities. Regular exchange on progress, challenges and opportunities will be an essential means of moving forward.

3.1 Parties to the Stockholm Convention

The Parties to the Stockholm Convention are at the core of the road map, being both important implementing actors and the ultimate target group, *i.e.* the intended beneficiary of the road map. Parties' responsibilities may vary depending on whether they

i) have ongoing production of DDT;
ii) currently use DDT for disease vector control;
iii) phased out the use of DDT for disease vector control; and/or
iv) are potential donor countries.

Those belonging to the first three categories will need to make the necessary organizational arrangements, including for instance to:

- allocate roles and responsibilities among relevant governmental bodies;
- foster inter-agency cooperation (implementation of the road map will require participation by various ministries, *e.g.* environment, health, finance, agriculture, trade, human settlements);
- identify potential partners and stakeholders in IVM and establish a national working group; and
- secure financial and human resources.

Parties and the relevant governmental entities are the key to developing the national policies, human resources and partnerships to develop and deploy the new tools and processes outlined in the roadmap. The existence of a conducive public health regulatory framework is a prerequisite for successful implementation of IVM. A national action plan should be in place, identifying, among others, specific policy needs tailored to the country in question, and road map activities should be well integrated into the National Implementation Plans (NIPs) submitted under the Stockholm Convention. Among others, countries will need to:

- conduct situation analyses (covering status of DDT production and use, stockpiles, insecticide resistance *etc*.) on a regular basis;
- evaluate the continued need for DDT at the local, regional and national level;
- participate in the compilation of lessons learned and good practices from projects and programmes using non-chemical alternatives;
- engage in the establishment and coordination of national, regional and global information sharing mechanisms;
- initiate and/or participate in public-private partnerships;
- review and, where necessary, adapt the regulatory framework;
- participate in the implementation of DDT-related GEF and other projects as well as webinars; and
- participate in activities to scale up the deployment of non-chemical alternatives.

A key responsibility for national regulatory authorities will be to participate in the assessment of and approve alternatives to DDT. Finally, with regard to stockpiles of DDT, concerned Parties will need to update national inventories, collect obsolete stocks and repackage and dispose, as appropriate.

As indicated in activity 1.1.4, Parties are among the responsible actors to generate funding for implementation and coordination of the road map. Recipient countries will need to contribute towards funding and make in-kind contributions for implementation activities, while donor countries will be responsible for providing the necessary financial and/or technical resources.

Countries will also contribute towards road map implementation through the Global Alliance: Nominated through the Bureau of the Stockholm Convention, each UN region is represented by two members in the Steering Committee. In addition there is a bilateral representative.

3.2 UNEP Chemicals Branch

Chemicals Branch of the Division of Technology, Industry and Economics (DTIE), UNEP, will be responsible for overall coordination of the implementation of the road map activities. In doing so, UNEP Chemicals Branch will rely on the comparative advantage it has gained through its past work on DDT, including its leadership in the 'Global Alliance for the development and deployment of products, methods and strategies as alternatives to DDT for disease vector control'. The membership and participation of UNEP Chemicals Branch in bodies such as the Global Alliance will serve to achieve synergies and promote a common agenda.

The UNEP Chemicals Branch, including in its role as a leading participant in the coordinating and implementing body, will be responsible for the following activities:

- Make initial provisions for the coordination and implementation of the roadmap, such as establishing communication channels with relevant stakeholders
- Lead consultations on the terms of reference and nomination of members of the coordinating and implementing body as well as an initial budget for implementation
- Gather information from all relevant stakeholders on progress made in implementing the road map activities as well as the challenges and opportunities that were encountered; present this information in annual interim reports and bi-ennial progress reports to the COP

UNEP Chemicals Branch will also serve as the hub for gathering important data, including – in close cooperation with the BRS Secretariat – on the global situation in terms of production, trade, use, and stockpiles of DDT as well as human and environmental exposures (among others making use of its role in the global coordination group of the Global Monitoring Plan). This information will be featured in synthesis reports to be prepared regularly by the UNEP Chemicals Branch that will also assess developments in the fields of insecticide resistance, cost-effectiveness of DDT and alternatives, barriers to the deployment of alternatives and ongoing national and international projects of relevance. The reports will be prepared in consultation with relevant stakeholders, including WHO, the Global Alliance, the IVCC, the GEF, and the Stockholm Convention Regional Centers (SCRCs).

In addition, UNEP Chemicals Branch will contribute towards the strengthening of country and local capacities by participating in the development of standardized monitoring and information management tools and strategies, and update, enhance and synthesize decision support tools for national vector control programs. Use of these tools and strategies are among the agenda items to be featured in webinars to be co-conducted by UNEP Chemicals Branch. As regards the development and deployment of chemical alternatives to DDT for IRS, the role of UNEP Chemicals Branch will be more that of facilitating and monitoring.

3.3 World Health Organization

WHO is represented in the Steering Committee of the Global Alliance and will assume a central role in the implementation of the road map. WHO's main mechanism to coordinate global efforts to control and eliminate malaria is the Global Malaria Programme (GMP). This includes the annual World Malaria Report, which provides data on the impact of malaria interventions. The GMP is currently developing the 'Global Technical Strategy for Malaria'[135] which will serve at the technical basis for RBM's Second Global Malaria Action Plan (GMAP2)[136] (discussed below in more detail). The road map and the efforts undertaken by WHO will need to be complementary and mutually reinforcing.

As outlined in its position statement on the use of DDT in malaria vector control[137], WHO is committed to the global goal of reducing and eventually eliminating the use of DDT while minimizing the burden of vector-borne diseases – this reflects WHO's double commitment. WHO promotes IVM as the management approach to control transmission of malaria and other vector-borne diseases[137]. WHO regularly publishes recommendations on the use of DDT for IRS. These are to be followed by Parties to the Stockholm Convention using DDT for vector control.

The WHO will be involved in roadmap coordination and implementation from an early stage, including preparatory activities. Its tasks include the following:

- Through Resolution 60.18 of 2007, the World Health Assembly requested the Director-General to support the sound management of DDT use for vector control in accordance with the Stockholm Convention, and to share data on such use with Member States[138]. For example, WHO will regularly update, consolidate and make available its data on issues such as insecticide resistance. WHO will also participate in the establishment and coordination of relevant information sharing mechanisms on issues such as best practices in IVM. The Regional Offices, particularly the Regional Office for Africa and the Regional Office for South-East Asia, as well as relevant country offices will play an important role in data gathering.
- WHO will continue to work on guidance material and training manuals to inform policy-making at the national and local levels.
- WHO's Pesticide Evaluation Scheme (WHOPES) will play a central role in the development and deployment of chemical alternatives to DDT for IRS. WHOPES promotes and coordinates the testing and evaluation of pesticides for public health, including DDT. WHOPES comprises a four-phase evaluation and testing programme for studying the safety, efficacy and operational acceptability of public health pesticides and for preparing specifications for quality control and international trade[139]. The testing and evaluation coordinated by WHOPES is thus an essential step towards the selection and ultimately deployment of chemical alternatives to DDT for IRS. WHOPES will work in close cooperation with the POPs Review Committee (POPRC) in assessing potential POPs characteristics of new active ingredients and formulations. One of the roles of WHOPES is to set specifications for recommended products. A second role of WHOPES is to promote the save and judicious use of pesticides among member states, supporting national programmes, national regulatory authorities and working with manufacturers and distributors to implement, in collaboration with FAO, the 'International Code of Conduct on the Distribution and Use of Pesticides' and provide other technical guidance for pesticide management.[140] To facilitate the development of new products and paradigms WHO established the Vector Control Advisory Group (VCAG). The complementarity of the two groups is outlined below[141].

Table 9: Jurisdictions of VCAG and WHOPES in vector control innovation

	VCAG	WHOPES
	Innovative vector control paradigms	Innovative products from established vector control paradigms
Scope	Assesses 'first in class' prototype products of new paradigms; does not assess existing paradigms with established target product profile (TPP)	Evaluates individual product claims for commercially produced pesticides
Evaluation	Efficacy: Requires entomological and epidemiological data Safety: Requires risk assessment Other: Parameters including target product profile, user compliance/acceptability, economic feasibility, manufacturing sustainability and strategic/policy role	Safety: Requires risk assessment Quality: WHO specifications developed through Joint FAO/WHO Meeting on Pesticide Specification (JMPS) Efficacy: Requires entomological data only
Data	Reviews published and unpublished data submitted by innovator	Reviews data from WHOPES supervised laboratory and field trials according to WHO testing guidelines
Outcome	Issues recommendations on the public health value of the paradigm and the associated first in line prototype to policy setting groups	Issues recommendations on the efficacy, safety/risk and quality standards of public health pesticides for use by member states for product registration and procurement

3.4 Global Alliance on DDT

Establishment of the Global Alliance for the development and deployment of products, methods and strategies as alternatives to DDT for disease vector control was endorsed by the COP to the Stockholm Convention through decision SC-4/2 on DDT. Leadership of the partnership was transferred from the Secretariat to UNEP Chemicals Branch, following decision SC-5/6. The strategy of the Global Alliance is geared towards the achievement of four goals:

1) Strengthen the base of knowledge available to inform policy formulation and decision making
2) Overcome the complexity and cost of deploying alternatives to DDT
3) Make available new alternative vector control chemicals
4) Develop non-chemical products and approaches for vector control

These goals align well with the road map and are reflected in the road map's areas of action. Overall, the Global Alliance will occupy a leading role in facilitating implementation of the road map, in particular through its Steering Committee, composed of experts from governments, civil society, industry and IGOs. The Global Alliance can serve as an important platform for communication and offers a large potential for fostering synergies and ensuring a multi-stakeholder commitment. The outputs of its five thematic groups will contribute towards achieving the goals of the road map. The thematic groups are:

- Cost effectiveness of alternatives to DDT
- Strengthening of in-country decision making in IVM
- Reduce barriers to bring new chemicals and products on the market
- Reduce barriers to bring new non-chemical products into use
- Malaria vector resistance patterns and mechanisms.

Given its prominent role in implementation of the road map, the Global Alliance will participate in most of the activities (for more details, see the next chapter). Its notable responsibilities include, but are not limited to, participating in gathering and consolidating of relevant guidance material and training manuals (potentially also in translation activities as in-kind contribution); establishing and coordinating information sharing mechanisms; and compiling lessons learned and good practices on the use of non-chemical alternatives. The Global Alliance will also be actively involved in activities related to the elimination of DDT stockpiles and waste.

3.5 DDT Expert Group

The DDT expert group has been established as part of the process for DDT reporting, assessment and evaluation, as adopted on an interim basis through decision SC-2/2 and revised through decisions SC-3/2 of the COP to the Stockholm Convention. The DDT expert group assesses scientific, technical, environmental and economic information on the production and use of DDT for disease vector control on a regular basis. This information will feed into the assessments and monitoring done under the road map.

Moreover, the DDT expert group regularly assesses the continued need for DDT for disease vector control and provides policy recommendations to the Parties of the Stockholm Convention. Upon existence of sufficient evidence, the DDT expert group is expected to ultimately recommend that locally safe, effective, affordable and environmentally sound alternatives are available for a sustainable transition away from DDT.

3.6 BRS Secretariat

The BRS Secretariat, including in its role as a member of the Steering Committee of the Global Alliance, will cooperate closely with UNEP Chemicals Branch in the overall coordination of the road map, including in preparatory activities, such as the setting up of the coordinating and implementing body, in which it will also be represented. The BRS Secretariat will consolidate the relevant information it receives from Parties, in particular through the national reporting under the Stockholm Convention, and provide it to UNEP Chemicals Branch, the Global Alliance and other relevant stakeholders in order to keep them updated on important developments. The BRS Secretariat will also co-organize webinars, including by providing the technical facilities.

3.7 POPs Review Committee

The POPRC is a subsidiary body to the Stockholm Convention. Its mandate is to review chemicals proposed for listing in the Annexes of the Convention in terms of their POPs characteristics. It does so by means of a screening process and compiling a risk profile. Based on the latter, the POPRC decides whether the chemical in question is likely, as a result of its long-range environmental transport, to lead to significant adverse effects on human health and the environment. Under the road map, the role of the POPRC is to participate in the assessment of new active ingredients and formulations in terms of their POPs characteristics and thus their potential hazards to human health and the environment. In doing so, the POPRC will cooperate closely with WHOPES.

3.8 Stockholm Convention Regional Centers

The SCRCs will play an important role in facilitating implementation of the road map at the regional level, in particular those located in the African and the Asia-Pacific regions. The SCRCs will assist in the compilation of guidance material and training manuals, including by translating into the official UN languages. They will also play an important role in the establishment and coordination of regional information sharing mechanisms. The latter will also be used to disseminate the lessons learned and good practices on the use of non-chemical alternatives, compiled by, among others, the SCRCs. Accordingly, the SCRCs will be involved in the implementation of pilot studies for the application of non-chemical alternatives. Finally, the SCRCs could also assume the role of implementing agency in relevant GEF projects.

3.9 Global Environment Facility

The Global Environment Facility (GEF) is the principal financial mechanism of the Stockholm Convention. The COP provides guidance to the mechanism addressing, among others, programme priorities. The GEF portfolio includes four national projects totalling USD 29.6 million in GEF funding and six regional or global projects totalling USD 20.4 million in GEF funding directly related to DDT[142].

An overview is provided in Table 10. These projects are mainly concerned with the introduction and/or scaling up of chemical and non-chemical alternatives to DDT. They also address issues such as the environmentally sound management (ESM) and disposal of DDT wastes and the establishment of collection procedures.

The GEF as well as the implementing and executing agencies will play a key role throughout the road map's areas of action. In particular, national, regional and global GEF projects will serve to build capacity at the national level and assist countries in taking the practical steps necessary to manage insecticide resistance, develop and implementing IVM strategies, and assess and deploy chemical and non-chemical alternatives (among others by means of demonstration projects). In doing so, GEF projects will take into account the information compiled by UNEP Chemicals Branch, the DDT expert group and other stakeholders (*e.g.* to identify priority countries).

At its sixth meeting held in May 2013, the COP requested the GEF to consider increasing the overall amount of funding accorded to the chemicals focal area in the negotiations for the Sixth Replenishment, which were concluded in April 2014. In accordance with the Guidance provided by the COP, the GEF program for the reduction and elimination of POPs will take into account the specific deadlines set forth in the Convention, including the restriction of the production and use of DDT for disease vector control and the goal of ultimately eliminating the production and use of DDT. In addition, the GEF may support, among others, initiatives aimed at:

- eliminating stockpiles of DDT;
- ESM of POPs wastes;
- introduction of alternatives to DDT for vector control; and
- introduction of non-chemical alternatives.

Table 10: DDT-related GEF projects[142]

Implementing Agency	Executing Agencies	Project Name	Country / Region	GEF Grant	Co-financing	Status
UNEP	WHO-Regional Office for Africa (AFRO); National Executing Agencies in the participating countries	Demonstrating Cost-effectiveness and Sustainability of Environmentally-sound and Locally Appropriate Alternatives to DDT for Malaria Control in Africa	Africa	5,485,466	5,986,810	Under implementation
UNEP	WHO Regional Office for Eastern Mediterranean (EMRO); Ministries of Health of the participating countries	Demonstration of Sustainable Alternatives to DDT and Strengthening of National Vector Control Capabilities in Middle East and North Africa	Middle East and North Africa	4,913,114	8,416,402	Under implementation
UNEP	WHO	DSSA Establishment of Efficient and Effective Data Collection and Reporting Procedures for Evaluating the Continued Need of DDT for Disease Vector Control	Global	761,400	655,000	Under implementation
UNEP	WHO-Europe Office, Milieukontakt International, local relevant ministries (health, agriculture, environment, emergency situations, and others) and local NGOs in the participating countries	DSSA Demonstrating and Scaling Up Sustainable Alternatives to DDT for the Control of Vector-borne Diseases in Southern Caucasus and Central Asia	Southern Caucasus and Central Asia	2,045,000	3,740,400	Under implementation
UNEP	PAHO - Pan American Health Organization	Regional Program of Action and Demonstration of Sustainable Alternatives to DDT for Malaria Vector Control in Mexico and Central America	Mexico and Central America	7,165,000	6,410,400	Project closure
UNEP	WHO	DSSA Demonstrating and Scaling-up of Sustainable Alternatives to DDT in Vector Management (PROGRAM)	Global	0	0	Council endorsed
UNEP	WHO Regional Office for Africa	Demonstration of Effectiveness of	Africa	15,491,700	118,720,000	PPG approved

Implementing Agency	Executing Agencies	Project Name	Country / Region	GEF Grant	Co-financing	Status
	as GEF Executing Agency, London School of Hygiene and Tropical Medicine, United Kingdom, Wits University NICD, South Africa, ICIPE, Duke University	Diversified, Environmentally Sound and Sustainable Interventions, and Strengthening National Capacity for Innovative Implementation of Integrated Vector Management (IVM) for Disease Prevention and Control in the WHO AFRO Region				
UNDP	Convention Implementation Office, Foreign Economic Cooperation Office, State Environmental Protection Administration (FECO/SEPA)	Improvement of DDT-based production of dicofol and introduction of alternative technologies including IPM for leaf mites control in China	China	6,000,000	11,650,000	Project completion
UNDP	Convention Implementation Office (CIO), Foreign Economic Cooperation Office (FECO), SEPA	Alternatives to DDT Usage for the Production of Anti-fouling Paint	China	11,610,000	12,250,000	Project completion
UNIDO	Ministry of Environment and Forests (MoEF), Ministry of Health and Family Welfare (MH&FW), Ministry of Chemicals and Fertilizers (MoCF), WHO and other relevant national partners	Development and Promotion of Non-POPs alternatives to DDT	India	10,000,000	40,000,000	Council approved
UNIDO	Ministry of Environment and Natural Resources (MERN)	Environmentally Sound Management and Disposal of Polychlorinated Biphenyl (PCB) - Containing Equipment and DDT Wastes and Upgrade of Technical Expertise in Guatemala	Guatemala	2,000,000	4,000,000	PIF approved

3.10 Global Coordination Group of the Global Monitoring Plan

The Global Monitoring Plan for POPs is an essential component of the effectiveness evaluation. It provides a framework for the collection of comparable monitoring data on the presence of POPs from all regions, in order to identify changes in their concentration over time, as well as on regional and global environmental transport. The global coordination group of the GMP will be responsible for providing relevant data on DDT concentrations in ambient air and human milk to UNEP Chemicals Branch so that environmental and human exposures can be monitored and assessed.

3.11 Roll Back Malaria Partnership, Global Malaria Action Plan, Vector Control Working Group and the Multisectoral Action Framework for Malaria

The RBM is a global multi-stakeholder framework intended to implement coordinated action against malaria, launched by WHO, the United Nations International Children's Emergency Fund (UNICEF), the United Nations Development Programme (UNDP) and the World Bank. Its declared goal is to reduce malaria morbidity and mortality.

An important output, endorsed at the 2008 MDG Malaria summit, is the Global Malaria Action Plan (GMAP), whose purpose is to provide a global framework for action around which partners can coordinate their efforts. In line with the road map strategy, the GMAP's focus is to support countries[143]. Although concerns about the safety of DDT are noted, the GMAP does not specifically aim to bring about a reduction in the use of DDT. However, it notes the challenge of resistance to DDT and other insecticides, particularly pyrethroids, and advocates insecticide resistance management and the use of alternatives and other vector control measures as part of IVM[143]. Moreover, the GMAP beyond 2015 (GMAP2) is currently being prepared. The revised plan will seek synergies with the DDT-related goals stipulated by the Stockholm Convention, thus making a dual commitment of reducing malaria mortality while also reducing the reliance on DDT for disease vector control. Efforts are currently ongoing to include indicators relevant for the road map in the revised GMAP.

One of the mechanisms of the RBM partnership is the Vector Control Working Group (VCWG)[144]. The VCWG focuses on a number of work streams that overlap to a far degree with the road map strategy, including, for example, insecticide resistance (supporting country implementation of resistance management strategies), capacity building for IRS (cost-containment and quality improvement, especially when applying insecticides with higher unit cost than pyrethroids or DDT; and for proper pesticide management, including for DDT), larval source management, housing and malaria, entomological monitoring and IVM. The purpose of the VCWG is to align partners on best practices.

The VCWG will participate in gathering, consolidating and expanding or updating relevant existing guidance material and training manuals, thus building on the networks, expertise and experience gained through the implementation of its work streams. It will also contribute towards the development of standardized monitoring and information management tools and strategies as well as the development of decision support tools for national vector control programs. These activities cut across several of the VCWG's work streams.

The 'Multisectoral Action Framework for Malaria' is an initiative of RBM and UNDP. The framework aims to make development programmes an essential component of malaria control and calls for greater coordinated action among the different sectors, for which it proposes priority social and environmental determinants[145]. The Multisectoral Action Framework for Malaria can make important contributions in the road map implementation, including by sharing experiences on the use of non-chemical alternatives, participating in pilot studies and supporting multi-sectoral approaches in relevant projects.

3.12 UN-Habitat

UN-Habitat will also contribute towards road map implementation. By facilitating improvements to habitation and urban infrastructure, it may contribute towards the development and implementation of non-chemical vector control alternatives (activities 2.4.1, 2.4.2 and 2.4.3), thus achieving reductions in malaria morbidity and reducing the need for DDT. Other UN bodies with a potential role in the road map include UNDP (in particular through the Multisectoral Action Framework for Malaria), the Food and Agriculture Organization (FAO) and the World Food Programme (WFP). FAO and WFP may, for example, facilitate successful collaboration with the agricultural sector.

3.13 Industry/Private Sector

In order for the road map to be successfully implemented, the private sector will need to occupy a central role. Most notably, industry will be responsible for the development of chemical alternatives to DDT for IRS. This includes all stages, *i.e.* selection of new active ingredients and formulations, laboratory studies, product optimisation, field trials *etc*. These activities will require financial investment and dedication to the objective of reducing and ultimately eliminating the production and use of DDT. Important pesticide manufacturers are organized under CropLife International[146], an international federation of crop protection and agricultural biotechnology associations and companies, which is also a member of the Global Alliance. CropLife is also a key partner in promoting stewardship and improved pesticide management practices[147] In addition, there are numerous other commercial-sector entities developing products related to vector control and entomological monitoring that play a key role. Throughout the stages of product development and deployment, pesticide manufacturers will need to cooperate closely with UNEP Chemicals Branch, the WHO (WHOPES, in particular), POPRC, academia, civil society and national regulatory authorities.

The small size and complexity of the vector control market compared to agriculture necessitates partnerships to develop chemical alternatives to DDT. For example, the 'Corporate Alliance for Malaria in Africa' (CAMA)[148], which is implemented by GBCHealth[149], aims to promote private sector cooperation on malaria control projects in Sub-Saharan Africa, establish partnerships and serves as an important institutional link between the public and private sectors. GBCHealth may help in both understanding the economics and return on investment of vector control and leveraging investments for vector control in the workplace and surrounding communities.

The IVCC, a public-private partnership, is another key actor in the development of alternatives to DDT. IVCC collaborates closely with relevant agro-chemical companies and, among others, is engaged in a number of product development partnerships to bring new insecticides, new formulations of existing insecticides and new paradigms for vector control to the market, including potential alternatives to DDT for IRS. It will thus occupy a prominent role in the selection of new active ingredients and formulations, including data mining and proof of concept, assessment and evaluation, pilot testing and product optimisation. IVCC will keep UNEP Chemicals Branch and other relevant stakeholders updated on recent developments and the status of alternatives.

3.14 Civil Society and Academia

Civil society organizations fulfil important functions in terms of capacity-building and information sharing in the development of alternatives. They may, among others, facilitate the collection, analysis and documentation of experiences with the application of non-chemical alternatives or IVM strategies, thereby alerting policy- and decision-makers to costs and benefits of particular interventions. The Pan African Mosquito Control Association (PAMCA)[150], for instance, a professional body compromised of mosquito control and research professionals with the objective of promoting the control of and research on mosquitoes and to disseminate information on the bionomics of mosquitoes, together with the Biovision Foundation[151], organized a symposium on the efficacy, benefits and challenges of alternatives to DDT in malaria vector control[152]. Another example is the Physicians for Social Responsibility Kenya[153], which is also a member of the Global Alliance Steering Committee.

Universities, Research and Training Institutions may contribute towards the development of alternatives and also provide the training for public health entomology and integrated vector management. For example, the International Centre of Insect Physiology and Ecology (icipe)[154], an international scientific research institute based in Nairobi, promotes capacity building, innovative vector control interventions (*e.g.* mosquito traps), and technology transfer of non-POPs alternatives to DDT. Icipe serves as a SCRC which facilitates interaction with important partners, including UINEP Chemicals Branch and the BRS Secretariat.

In terms of road map implementation, civil society will, among others, be an important actor in assessing new active ingredients and formulations in terms of potential hazards, cost-effectiveness and operational acceptability. Civil society may also assist in understanding and responding to the cultural background that may have an effect on the applicability of vector control interventions. Moreover, civil society will be responsible for compiling lessons learned and good practices from projects using non-chemical alternatives as well as other efforts geared towards upscaling the application of such alternatives.

3.15 Other Donors

By far the largest direct international donors for malaria control and elimination between 2005 and 2013 were the Global Fund to Fight Aids, Tuberculosis and Malaria and the President's Malaria Initiative (PMI) led by the U.S. Agency for International Development (USAID) and jointly implemented with the Centers for Disease Control and Prevention (CDC)[155]. Other government donors include the Swiss Agency for Development and Cooperation (SDC), the United Kingdom's Department for International Cooperation (DFID), the Australian Agency for International Development (AusAiD) and the Japan International Cooperation Agency (JICA). Other significant non-governmental sources of funding include the Bill and Melinda Gates Foundation (BMGF).

Currently most international funding is for IRS and LLINs. There was previously some funding for larviciding through PMI. Moreover, there are the types of regional multisectoral activities proposed by the UNDP-RBM Multisectoral Action Framework, such as housing improvements and peri-urban water management. The Global Fund does have a provision for Operational Research[156]. However, it is not known whether any of this has gone into the development of DDT alternatives.

The PMI provides major support to malaria programs in 19 countries in Africa and to a regional project covering six countries in the Greater Mekong Sub-region[157]. While PMI is not able to provide co-financing to the AFRO-II Project[xvii], it provides significant support for some of the individual components, including capacity building for insecticide resistance monitoring and management, cost containment for IRS and operational research[158]. PMI only funds IRS and LLINs for vector control and currently does not fund larviciding, environmental management or other multisectoral or regional vector control initiatives, such as with housing and infrastructure or agriculture. The BMGF is a major supporter of innovation in vector control through their support of the IVCC and other organizations engaged in a four-stage strategy covering (i) risk assessment and biology of mosquitoes, (ii) surveillance, (iii) control, and (iv) monitoring and sustainability. Individual projects supported by the BMGF may play a significant role in achieving the objectives of the roadmap[159].

[xvii] GEF project 4668 on 'Demonstration of Effectiveness of Diversified, Environmentally Sound and Sustainable Interventions, and Strengthening National Capacity for Innovative Implementation of Integrated Vector Management (IVM) for Disease Prevention and Control in the WHO AFRO Region

4 Elements of the Road Map

The ultimate objective of the road map is to make locally safe, effective, affordable and environmentally sound alternatives available for a sustainable transition away from DDT. In order to achieve this objective, it will be necessary to implement a multi-stakeholder effort with active participation and close cooperation of governments, IGOs, industry, civil society, and academia. The road map requires action at all levels – local, national, regional and global. Each actor will contribute according to its comparative advantage, *e.g.*, by providing funding, gathering and sharing information, preparing guidance materials, researching and developing chemical and non-chemical alternatives, and implementing country level projects. The provision of targeted assistance to countries still relying on DDT for disease vector control will be essential in order to strengthen capacity for the insecticide resistance management and IVM.

The road map specifies the areas in which action is warranted, the activities that need to be undertaken, the actors that are responsible for them, and a tentative timeframe, as appropriate. The road map features three overarching areas of action. These are not necessarily to be understood as chronological steps; some are to be implemented simultaneously, while others build upon one another. The overarching elements as well as their sub-components are equally important and the road map can only become a success if they are all implemented. Each of these three overarching areas of action includes various sub-components which, in turn, feature several activities.

1) In order to be able to tackle the substantive components of the road map, it will be necessary to establish overall roadmap management and reporting procedures. This includes planning and coordination as well as periodic evaluation of progress through relevant indicators.

2) A multi-stakeholder effort will be needed to implement the various activities. While some of these are already ongoing (and may need additional support), others are yet to be initiated. Success of the road map will depend on (i) strengthened country- and local-level capacities for policy formulation, decision-making and implementation, and (ii) availability of chemical and non-chemical alternatives.

3) A holistic and environmentally sound approach will also need to tackle the issue of DDT stockpiles and waste. In parallel to the other activities, inventories in affected countries may need to be updated and obsolete stocks collected, possibly repackaged and disposed.

An overview of the road map is presented in Table 11.

Table 11: Elements of the road map for the development of alternatives to DDT

Activities/Areas of Action	Responsible actors	Timeline
1 Establish overall roadmap management and reporting procedures		
1.1 Coordinate and implement the road map and provide funding		
1.1.1 Make the provisions for the coordination and implementation of the roadmap; adopt an initial budget for coordination of the road map	UNEP Chemicals Branch	Starting May 2015
1.1.2 Develop the terms of reference and nominate members of the coordinating and implementing body and prepare an initial budget for implementation	UNEP Chemicals Branch in consultation with SC Bureau, WHO, Global Alliance, DDT expert group, BRS Secretariat	June – September 2015
1.1.3 Prepare progress reports to the COP and annual interim reports	Coordinating and implementing body	September 2015 onwards
1.1.4 Generate funding for implementation and coordination of the road map	Coordinating and implementing body; parties; donors, GEF	May 2015 onwards
1.2 Prepare assessment reports, monitor developments and evaluate progress (linkages to effectiveness evaluation)		
1.2.1 Assess and monitor the global situation in terms of production, trade, use (including areas of application and illegal use), stockpiles of DDT (including updating of DDT register), and environmental and human exposures	DDT expert group; global coordination group of the global monitoring plan; BRS Secretariat; UNEP Chemicals Branch	May 2015 onwards
1.2.2 Prepare reports on insecticide resistance, cost-effectiveness of DDT, alternatives and barriers to deployment of alternatives on regular basis	UNEP Chemicals Branch in consultation with WHO, Global Alliance, IVCC, and industry	May 2015 onwards
1.2.3 Regularly assess the continued need for DDT for disease vector control and report to the COP	DDT Expert Group, WHO	Ongoing
1.2.4 Evaluate ongoing national and international projects and status of funding and encourage research where necessary	UNEP Chemicals Branch; Global Alliance; GEF; Regional Centres	May 2015 onwards
1.2.5 Prepare recommendation when locally safe, effective, affordable and environmentally sound alternatives are available	DDT expert group	Upon existence of sufficient evidence

Activities/Areas of Action	Responsible actors	Timeline
2 Implement the road map		
2.1 Strengthen the base of knowledge for policy formulation and decision-making		
2.1.1 Gather, consolidate and – where necessary – expand or update and translate relevant existing guidance material and training manuals, including economic analyses	Global Alliance; WHO; RBM working group; Regional Centres	May 2015 – May 2017
2.1.2 Develop standardized monitoring and information management tools and strategies to support planning, targeting, management and evaluation of vector control operations; update, enhance and synthesize decision support tools for national vector control programs	UNEP Chemicals Branch; WHO; IVCC; industry; RBM working group; academia	May 2015 – May 2017
2.1.3 Establish and coordinate national, regional and global information sharing mechanisms (e.g. on vector resistance mechanisms, best practices in IVM; status of alternatives)	Global Alliance; parties; academia; Regional Centres, WHO	January 2016 onwards
2.1.4 Identify countries still using DDT for vector control; undertake country-specific assessments (epidemiological and entomological field data; capacity to introduce alternatives, and implement IVM; motivation and rational for using DDT; opportunities and challenges etc.)	BRS Secretariat; UNEP Chemicals Branch; parties	September 2015 – September 2016
2.2 Strengthen country and local capacities to manage insecticide resistance, develop and implement IVM strategies, assess and deploy alternatives		
2.2.1 Implement relevant existing national, regional and global GEF projects and report progress and outputs	GEF implementing agencies; parties; donors	Ongoing
2.2.2 Draft and implement national or regional GEF and other projects, featuring among others demonstration projects of chemical and non-chemical alternatives as well as IVM, based on 1.2.1, 1.2.2 and 2.1.4; integrate objectives into national action plans within the reviewed/updated NIPs	GEF implementing agencies; parties; donors	October 2016 onwards
2.2.3 Conduct targeted webinars, provided that the technical preconditions are given, and country-level workshops in the language of the respective country based on 2.1.4; disseminate and train relevant staff in the use of the manuals and materials from 2.1.1 as well as the tools and strategies from 2.1.2	UNEP Chemicals Branch; Global Alliance; BRS Secretariat	June 2017 – June 2020
2.3 Develop and deploy chemical alternatives to DDT for indoor residual spraying (IRS)		
2.3.1 Adapt the workplan of the Global Alliance to support the implementation of the roadmap where necessary	UNEP Chemicals Branch with Steering Committee of the Global Alliance	September 2015 – January 2016

Activities/Areas of Action	Responsible actors	Timeline
2.3.2 Implement a tiered process for the selection of new active ingredients and formulations of existing pesticide classes/agrochemicals suitable for vector control and prepare report on first and secondary screening, laboratory studies (WHOPES Phase I), data mining and proof of concept	IVCC; industry; Global Alliance; WHOPES	Ongoing
2.3.3 Product optimisation and development	Industry, IVCC	Ongoing until 2022
2.3.4 Assess new active ingredients and new formulations in terms of i) POPs characteristics, potential hazards to human health and the environment , ii) impact on disease morbidity, iii) cost and cost-effectiveness, and iv) operational acceptability	WHOPES; POPRC; industry; civil society, academia; regulatory authorities	After first results from 2.3.2. and 2.3.3
2.3.5 Undertake pilot testing on regional basis; evaluations in small-scale field trials/experimental huts (WHOPES Phase II) and large-scale field trials (WHOPES Phase III)	UNEP Chemicals Branch; Global Alliance; DDT using parties; WHOPES; IVCC; industry	after first results from 2.3.4
2.3.6 Develop specifications for quality control and international trade; obtain regulatory approval, make available and deploy active ingredients and formulations that are considered safe, affordable and at least as cost-effective as DDT in vector control, as assessed in 2.3.4 and 2.3.5	WHOPES; national regulatory authorities; industry; donors; parties	2017 onwards
2.4 Sharing experiences and upscaling the application of non-chemical alternatives		
2.4.1 Compile lessons learned and good practices from projects and programmes using non-chemicals alternatives for control of malaria and leishmaniasis (and report back to COP-8)	Parties; Global Alliance; Regional Centres; civil society; academia; UNDP Multisectoral Framework; UN-Habitat	September 2015 – December 2016
2.4.2 Undertake pilot studies where deemed necessary	Parties; Global Alliance; Regional Centres; civil society; academia; donors; UNDP Multisectoral Framework; UN-Habitat	June 2017 onwards
2.4.3 Undertake activities to scale up the development and deployment of non-chemical alternatives, among others by strengthening institutional structures and supporting multi-sectoral approaches, including as part of 2.2.1 and 2.2.2		May 2015 onwards
3 Eliminate DDT stockpiles and waste		
3.1 Update national inventories as part of 2.2.1 and 2.2.2	Parties; GEF implementing agencies; Global Alliance; private sector; bilateral; donors	May 2015 onwards
3.2 Collect obsolete stocks as part of 2.2.1 and 2.2.2		May 2015 onwards
3.3 Repackage and dispose as part of 2.2.1 and 2.2.2		May 2015 onwards

4.1 Establish Overall Roadmap Management and Reporting Procedures

The first overarching element of the road map is of organizational nature. In order to facilitate implementation and continuous evaluation of the road map, it is necessary to establish management and reporting procedures, as outlined below.

4.1.1 Coordinate and Implement the Road map and Provide Funding

This component addresses the overall coordination and implementation of the activities specified in the road map, including, among others, budgeting and preparation of progress reports.

4.1.1.1 Make the provisions for the coordination of the road map; adopt an initial budget for coordination of the road map

Following the meetings of the conferences of the parties to the Basel, Rotterdam and Stockholm conventions to be held in May 2015, UNEP Chemicals Branch will begin to make initial provisions for the coordination and implementation of the road map. This includes tasks such as setting a timetable for the next steps, establishing communication channels with relevant stakeholders, and drafting and adopting an initial budget for coordination of the road map (*i.e.*, covering costs that will be encountered by UNEP Chemicals Branch in relation to the facilitation of road map activities).

4.1.1.2 Develop the terms of reference and nominate members of the coordinating and implementing body and prepare an initial budget for implementation

From June 2015 onwards, UNEP Chemicals Branch will initiate and lead consultations with the Bureau of the Stockholm Convention, the WHO, the Global Alliance for the development and deployment of products, methods and strategies as alternatives to DDT for disease vector control (hereinafter referred to as the 'Global Alliance'), the DDT expert group, and the BRS Secretariat to develop the terms of reference and nominate the members of a body charged with overseeing overall coordination and implementation of the road map.

Important functions of this body will include:

- advising UNEP Chemicals Branch as to its day-to-day work in coordinating the road map;
- initiating implementation of the various activities of the road map;
- identifying key challenges and opportunities encountered during implementation of the road map as well as proposing appropriate responses;
- periodically reviewing the elements of the road map;
- establishing a strategy for the mobilization of resources to implement the road map;
- providing overall strategic advice and leadership; and
- other tasks as decided during the consultations.

The members of this coordinating and implementing body shall be selected in such a way as to represent governments, in particular countries using DDT for disease vector control and important donor countries, civil society, industry and intergovernmental organizations (IGOs). In order to promote synergies, they shall be recruited from existing bodies, such as the Steering Committee of the Global Alliance and the DDT expert group.

Once established, the coordinating and implementing body will further elaborate the substantive activities of the road map. This will also include developing detailed timelines. Another task will be to prepare an initial budget for implementation of the road map. The budget shall be prepared in such a way as to allow for the activities specified in the road map to be carried out. These activities shall be finalized by September 2015.

4.1.1.3 Prepare progress reports to the COP and annual interim reports

Periodic evaluation is a key aspect of efficient road map implementation. The coordinating and implementing body, supported by UNEP Chemicals Branch, will prepare annual interim progress reports and submit bi-ennial progress reports to the COP of the Stockholm Convention. These reports will contain information on progress in carrying out the various substantive activities, elaborate on the funding situation, and – if necessary – propose changes to the organisational arrangements and/or the workplan. This activity will be ongoing for the whole duration of roadmap planning and implementation.

4.1.1.4 Generate funding for implementation and coordination of the roadmap

Based on its resource mobilization strategy, the coordinating and implementing body will take engage in regular fundraising activities. Parties to the Stockholm Convention will be the primary donors. Decision SC-6/1 of the COP to the Stockholm Convention noted the necessity to provide technical, financial and other assistance for a transition away from reliance on DDT for disease vector control.

Projects financed via the GEF will be a key component of roadmap implementation. In addition, steps will be taken to secure financial resources from other sources, including non-governmental bodies, such as the Global Fund or the BMGF. This activity will be ongoing until sufficient resources have been leveraged for coordination and implementation of all activities specified in the workplan.

4.1.2 Prepare Assessment Reports, Monitor Developments and Evaluate Progress (Linkages to Effectiveness Evaluation)

The availability of accurate and comprehensive data on developments related to the production, trade, use, stockpiles and concentrations of DDT, insecticide resistance, and cost-effectiveness of DDT and its alternatives is essential in that it forms the basis of policy-making. It allows the continuous adaptation of strategies to present needs, thereby learning from experiences and responding to new challenges. The gathered information will help in assessing the effectiveness of the proposed activities and feed discussions on potential revisions of the workplan. Preparation of assessment reports, monitoring of development and evaluation of progress will be carried out throughout implementation of the road map, with a final assessment forthcoming after completion of all activities.

4.1.2.1 Assess and monitor the global situation in terms of production, trade, use (including areas of application and illegal use), stockpiles of DDT (including updating of DDT register), and environmental and human exposures

An indirect means of measuring the availability of alternatives to DDT is to assess and monitor the global situation in terms of production, trade and use of DDT itself. Changes in these variables are also expected to ultimately mirror in concentrations of DDT in the environment and human, i.e. a reduction in the use of DDT will lead to reduced environmental and human exposures. A holistic approach will also have to take into account developments in terms of DDT stockpiles. UNEP Chemicals Branch will consolidate relevant information, gathered as outlined below, every two years.

Production, trade and use of DDT are evaluated in regular intervals under the effectiveness evaluation of the Stockholm Convention. Table 12 provides an overview of the outcomes and indicators relevant for DDT. The information provided by parties through national reports and notifications will be consolidated by the Secretariat of the Basel, Rotterdam and Stockholm Conventions (BRS Secretariat) and will be available for UNEP Chemicals Branch to assess and monitor progress in reducing the numbers of countries producing, using and trading DDT as well as the amounts of DDT produced, used and traded. UNEP Chemicals Branch will also rely on information provided by the DDT Expert Group, including in their reports to the COP, as well as other relevant partners and stakeholders, in particular to identify areas of application and illegal uses.

Table 12: Indicators of the Stockholm Convention's effectiveness evaluation relevant for DDT

Outcome: Have the production, use, import and export of DDT been restricted?		
Indicator	**Means of verification**	**Baseline**
Process indicator 1: The date on which each party has implemented measures, including legal and administrative measures, to control the production, import, export and use of DDT that meet or exceed the Convention's requirements.	Section II of part B of the national reports	Entry into force of the Convention
Outcome indicator 2: Changes in quantities of DDT produced, used, imported and exported for use	Section V of part B of the national reports	Entry into force of the Convention
Outcome indicator 3: Changes in quantities of DDT imported or exported for environmentally sound waste disposal	Section V of part B of the national reports	Entry into force of the Convention
Outcome: Have parties transitioned to alternative products and processes?		
Indicator	**Means of verification**	**Baseline**
Process indicator 1: Number of parties who registered DDT use for disease vector control	The register	The year in which the exemption came into effect

UNEP Chemicals Branch will assess and monitor progress in eliminating stockpiles of DDT through the national reports submitted by parties (Section V of Part B), as consolidated by the BRS Secretariat, and through the information provided by the DDT Expert Group, including in their reports to the COP, as well as other relevant partners and stakeholders.

As regards human and environmental exposures to DDT, the monitoring will be conducted under the Global Monitoring Plan. The second phase of the Global Monitoring Plan foresees a reduction of 50 % in the concentrations of PCB in ambient air and human milk.

4.1.2.2 Prepare reports on insecticide resistance, cost-effectiveness of DDT, alternatives and barriers to deployment of alternatives on regular basis

For targeted action to be forthcoming, it is essential to understand the main variables affecting the use of DDT and alternatives. As outlined above, insecticide resistance not only affects DDT, but also alternatives, notably pyrethroids, thus limiting the range of options available. Data on developments in insecticide resistance need to be gathered at local and country level and then consolidated to form a regional and global picture. All insecticides currently in use should be investigated, as well as those considered for future use. In this context, pesticide use will also need to be monitored. This could serve to establish an early warning system, e.g. if data suggests that an insecticide is used too excessively.

It is equally important to have a comprehensive picture of disease trends, among others to understand which types of interventions are needed and where. This will also help to respond to emerging challenges, such as upsurges in visceral leishmaniasis, and to assess the impact of certain vector control interventions. In countries where disease incidence is increasing, there is need for a review of the contribution/impact of the type of vector control interventions used as well as the effect of insecticide resistance on malaria and visceral leishmaniasis trends.

Cost-effectiveness considerations figure prominently in any decision whether to use DDT or alternatives and which vector control methods to opt for. It can be defined as "a measure of cost to achieve a level of effectiveness for a predetermined target"[160]. Policy-makers will need to know their expected return on investment, *i.e.* by how much morbidity can be reduced using a specific method. Cost-effectiveness analysis is concerned with the relative costs and outcomes of alternative options. Both variables need to be measured Costs include:

i) financial and/or human resources needed for a certain vector control method;
ii) the opportunity costs encountered by opting for this intervention; and
iii) external costs, *i.e.* the side effects[161].

Cost-effectiveness analysis is generally used to achieve one or more of the following objectives:

i) To calculate the amount of some impact that can be achieved given a fixed budget
ii) To calculate the costs of achieving a predesigned policy objective
iii) To calculate the average or marginal cost per unit gain in the indicator of interest

Control programmes should be continuously monitored in order to gather sufficient data which can then be used to inform decision-making in other areas. It is important to note that the effectiveness of an intervention may be very context-specific (especially in the case of larviciding).

The (continued) effectiveness and appropriateness of all types of vector control will be periodically evaluated. This includes assessing the strengths and weaknesses of both established interventions in changing contexts as well as new and emerging paradigms.

The WHO, in particular, will play an important role in collecting the data submitted by its member states. To complete the picture, the BRS Secretariat will manage data submitted by Parties. UNEP Chemicals Branch will contribute by gathering information from additional sources, including through the Global Alliance, qualifying quantitative data and compiling consolidated reports. It will be necessary to compile reports on a regular basis to keep decision-makers up to date. The IVCC and industry will contribute by providing information on alternatives to DDT. Regional Centers will play an important role in gathering data at the regional level.

4.1.2.3 Regularly assess the continued need for DDT for disease vector control and report to the COP

At the first meeting, the COP to the Stockholm Convention established an expert group to assess the global production and use of DDT and its alternatives and to examine how parties were proceeding in building capacity to reduce the use of DDT for disease vector control. At its sixth meeting, the COP requested the DDT expert group to undertake an assessment of the continued need for DDT for disease vector control on the basis of factual information provided by parties and observers and compiled by the Secretariat. It is expected that the DDT expert group will regularly assess the continued need for DDT for disease vector control, and report to the COP accordingly.

4.1.2.4 Evaluate ongoing national and international projects and status of funding and encourage research where necessary

The GEF and its implementing agencies will provide information on ongoing projects with relevance to DDT to UNEP Chemicals Branch. UNEP Chemicals Branch and the Global Alliance will evaluate this information and further assess other national and international projects not financed by the GEF. Moreover, UNEP Chemicals Branch will make an assessment of how much funding has been made available for implementation of the road map and make a judgement whether it is sufficient to achieve the objectives.

Though vector control has been a field of intensive study, more research will be necessary. Including through partnerships with the scientific community and research institutions, UNEP Chemicals Branch will encourage research in fields that are identified as a priority. This could include, for example the following topics:

- The negative externalities of vector control interventions related to human health and the environment.
- Unregulated pesticide use for vector control
- The speed and intensity by which resistance accumulates in a vector and the relevant independent variables for a given intervention at a given level of coverage
- Institutional barriers to implementing a system for cost-effectiveness analysis for assessing DDT and alternative vector control strategies[161]
- Challenges and opportunities encountered in inter-sectoral and inter-agency cooperation at the national and international level
- The effectiveness of larval source management in parts of rural Africa where larval habitats are extensive

4.1.2.5 Prepare recommendation when locally safe, effective, affordable and environmentally sound alternatives are available

Further to its regular assessment and reporting on the continued need for DDT for disease vector control, it is expected that the DDT expert group will ultimately provide a recommendation to the COP that locally safe, effective, affordable and environmentally sound alternatives are available. This will be done upon existence of sufficient evidence, as evaluated by the DDT expert group.

4.2 Implement the Roadmap

Once the organisational and reporting mechanisms are in place, the substantive activities of the road map will be carried out (noting that some are already ongoing, independent of the road map). The underlying rationale followed in devising the below activities is that an informed policy-maker is at the heart of successful IVM, including the deployment of a range of vector control options. There are two components to this task: First, the knowledge needs to be available. Second, capacity must be in place to apply this knowledge. It must further be recognized that additional alternatives must be developed, assessed, selected and tested before they are ultimately approved and deployed. This is true for both chemical and non-chemical alternatives.

4.2.1 Strengthen the Base of Knowledge for Policy Formulation and Decision-making

Strengthening the base of knowledge is a multi-stakeholder effort, whereby a range of actors gathers, interprets, exchanges and disseminates different types of information from a variety of sources. This area of activity will therefore require action from Parties (including their national as well as local authorities), academia, WHO, UNEP Chemicals Branch, the SCRCs and others.

The use of DDT in IRS should be limited to very specific situations. Such an assessment must be based on a number of considerations, such as characteristics of the vector control method, operational feasibility, epidemiological impact of disease transmission, entomological data, insecticide resistance etc. Evaluating the appropriateness of using other vector control methods – both chemical and non-chemical – requires consideration of an equal set of variables. It is therefore crucial that the necessary knowledge is available for policy- and decision-makers. This applies at the local, national, regional and global level. Having this knowledge allows policy- and decision-makers to render vector control efficient, effective, ecologically sound and sustainable[161].

Evidence-based decision-making is a key element of IVM. At the local level, this means the "adaptation of strategies and interventions to local ecology, epidemiology and resources, guided by operational research and subject to routine monitoring and evaluation"[161]. Strategies that have been effective in a certain context will not necessarily be successful in another. An important element of informed policy formulation is thus a thorough situational analysis, featuring, among others, the following aspects:

- Assessment of the epidemiological situation, including stratification and mapping in order to determine the geographical distribution of the disease burden, thus allowing an appropriate allocation of resources
- Evaluation of the vector situation on the ground (vector surveillance), including characteristics of the vector(s), prevalence of insecticide resistance *etc*.
- Factors potentially affecting the efficiency or effectiveness of the intervention(s)
- Analysis of local determinants of the disease(s) in question
- Assessment of requirements and resources (needed and available)
- Human behaviour, attitudes and domestic conditions
- Environmental conditions

Once gathered, these types of information will allow the taking of decisions with regard to:

- selection of locally appropriate and affordable interventions;
- the targets and timing of interventions;
- resource allocation and logistical support; and
- stakeholder and community participation.

Continuous surveillance as well as monitoring of implementation are important so that management choices can be adapted according to potential changes in the situation.[161] It is not only important to gather data at the local level, but also to exchange such information at the national, regional and global level. Policy-makers will profit from a lively exchange of best (and worst) practices in vector control.

Data collected at the local level must be supplemented by information that is generally applicable and/or provided at the regional and global level. For example, policy- and decision-makers will need to have access to information on the characteristics, advantages and disadvantages of the various environmental, mechanical, biological and chemical vector control methods. They also rely on guidance material and training manuals developed by expert bodies at the international level, e.g. on IVM. This should include case studies and examples of best practices. Strengthening the base of knowledge also means establishing national, regional and global information sharing mechanisms.

4.2.1.1 Gather, consolidate and – where necessary – expand or update and translate relevant existing guidance material and training manuals, including economic analyses

Country programs need updated guidelines to monitor and evaluate investments in entomological monitoring and vector control. A wealth of guidance material and training manuals on disease vector control are available. In recent years WHO has produced numerous training and guidance documents related to entomological monitoring, vector control and pesticide management. However, there is still a need to gather and consolidate these in order to develop a comprehensive and clear body of materials that is appropriate for practical use by relevant policy- and decision-makers. This effort will be led by the Global Alliance who will reach out to partners with a request for an overview of existing materials, notably the WHO.

Some guidance documents urgently need to be updated. For example, the WHO ‘Guidelines for Cost-effectiveness Analysis of Vector Control’ (Panel of Experts on Environmental Management for Vector Control (PEEM) guidelines 3) was published in 1993 and has not yet been updated, despite a thoroughly altered context and important developments, for instance in terms of insecticide resistance or the range of options available[xviii]. Taking into account that economic analysis will play an increasingly important role in sustaining gains of the past decade[162], the update could for example include recent costing analysis of IRS developed by the PMI and government funded IRS programs (including Botswana, Swaziland and Brazil). The guidelines need also expansion to include use of LLINs and larval source management within the framework of IVM as well as costing for pesticide management through its entire lifecycle, including additional measures that may be required for DDT. Moreover, the document may need simplification and should be redrafted with the aim of making it easily usable[163]. Moreover, this and other documents could be complemented by software and interactive learning tools.

Guidance and training materials related to the economics of vector control, including DDT, will also be consolidated and – where necessary – updated. There is a large literature on the burden of malaria, but less on the economic and social benefits of the absence of malaria, showing a ‘positive return on investment’ that will stimulate domestic spending on malaria control as an engine for economic growth. An example is the RAND Corporation Project Modelling the Economic Benefits of Malaria Control in Sub-Saharan Africa[164] and there is sporadic literature[165][166]; however, more opportunities need to be documented, especially in areas that have seen dramatic decreases in malaria and/or leishmaniasis prevalence over the past six years.

[xviii] Updating the PEEM guidelines 3 was proposed in UNEP/POPs/POPRC.7/INF/19

Results will be used to advocate for domestic investment in malaria control as a means of stimulating social well-being and economic growth. While evidence in the public sector on the positive return for investment for malaria control is sparse, there are well-documented examples from the corporate sector of financially self-supporting workplace vector control programmes resulting in decreased health care costs, decreased absenteeism and increased productivity. Much of this has been coordinated through GBCHealth/Corporate Alliance on Malaria in Africa[167] and RBM[168].

One can also identify some gaps in the existing body of guidance and training materials available. For example, there is a lack of guidance on how to link cost-effectiveness evaluations with environmental assessments[169].

The SCRCs have an important role to play in this context, in that they will be responsible for translating the relevant documents into the language(s) of the region and, where necessary, affected countries. In addition, it would be very useful if the SCRCs could adapt the guidance materials and training manuals to the region- and/or country-specific context. Finally, it is also important to get a clearer picture of the target group of these guidance and training manuals and to adapt accordingly. The next step is then to effectively disseminate and avail these to those in charge of implementing vector control interventions. The Global Alliance and UNEP Chemicals Branch in particular will play a key role in related outreach activities.

4.2.1.2 Develop standardized monitoring and information management tools and strategies to support planning, targeting, management and evaluation of vector control operations; update, enhance and synthesize decision support tools for national vector control programs

Lack of entomological information and appropriate use thereof prevents implementation of effective, locally adapted vector control. Too often, IRS and LLIN programs are implemented without entomological intelligence, not knowing and/or considering if the vector is present, its insecticide resistance status, biting and resting behaviours, larval habitats, etc. Lack of capacity and information prevents development and implementation of vector control measures complementary to IRS and LLINs. There is need to standardized new tools for vector surveillance and information management using mapping and mobile technology and guidelines for targeting, monitoring and evaluating vector control operations.

Parties relying on DDT for disease vector control need decision support tools, optimally in the form of a software or other interactive tools, that help them to manage relevant data and thus to take informed decisions, including evaluations of the continued need for DDT in vector control. The following shall serve as an example to illustrate the types of decisions that can be facilitated via the use of good tools and how they can, for example, help to reduce costs: “Three cycles of indoor residual spraying with a particular insecticide may be necessary to control malaria in situations where transmission is perennial. If there are seasonal variations in the transmission and the majority of cases are reported as occurring during the monsoon and post-monsoon seasons, spraying can be restricted to the peak transmission seasons thereby reducing the cost. This will be more cost-effective than spray coverage throughout the year.”[169]

The above mention guidelines for cost-effectiveness analysis of vector control, although in need of updating, are an important tool for evaluating and comparing chemical-based vector control operations. This will be expanded by developing a standardized system for assessing intervention effectiveness and costs based on certain variables specified by the user (e.g. insecticide resistance, morbidity rate)[xix].

RBM offers a 'Malaria Costing Tool'[170] which allows the user to estimate the resource requirements of proven malaria interventions over a period of time. The tool has last been updated in 2006 and could therefore be renewed and expanded, for example to include insecticide resistance and additional vector control methods, including non-chemical interventions. The WHO has developed a guide for decision-making for judicious use of insecticides[171], both for participants and facilitators; however, this tool only exists as a trial edition since 2004. A related publication on decision making criteria and procedures for judicious use of insecticides in malaria vector control was published in 2002. It aims to explain the 'what', 'where', 'when' and 'how' to apply for IRS, LLINs, larviciding *etc*. Again, this tool could be updated and redesigned in the form of an interactive tool or e-learning course.

A UNEP-led GEF project[xx, 172] aims among others to develop a decision taking tool for governments to assist them in the selection of the best approach in malaria vector control by predicting health, environmental and economic impacts of given intervention methods against the background of parameters such as the malaria burden, demography and policy alternatives. Such tools could be scaled up and made available for global use. The Global Fund has developed a number of tools that can assist in monitoring and evaluation activities, including in the form of online learning modules and templates for project workplans[173]. Lastly, members of the American Mosquito Control Association have developed mapping and information management software that improve the targeting and efficiency of vector surveillance and control[174].

Under this activity, efforts to develop standardized monitoring and information management and decision support tools will be intensified. Some tools are yet to be developed, while others need updating and/or expansion. This will require a multi-stakeholder effort, under the leadership of the WHO. Close cooperation with industry, academia and other stakeholders will be warranted. Some efforts are already ongoing. WHO is developing a manual on entomological monitoring that will help guide national program strategic planning. WHOPES, working with IVCC, CropLife and other partners is forming a 'Data Quality Task Force' to optimize and standardize generation of quality data during the evaluation of new interventions, trapping techniques and surveillance procedures.

4.2.1.3 Establish and coordinate national, regional and global information sharing mechanisms (e.g. on vector resistance mechanisms, best practices in IVM; status of alternatives)

Centralized information sharing and data management systems at the national, regional and global level will be a useful tool for policy- and decision-makers in developing IVM strategies, choosing appropriate vector control methods and enacting appropriate responses to upcoming challenges. Data from the different levels can be used to validate and refine findings, thus allowing for the drawing of a more comprehensive picture. Meanwhile, standard data formats will facilitate the comparability of data and – most importantly – inform vector control operations. Data that was obtained locally can be compared with similar information from other countries in the region. Such exchange may also serve to harmonize methods and establish regional databases. Moreover, meta-analyses of studies on issues such as insecticide resistance can further help in informed decision-making. Depending on the specific needs on the ground, efforts by individual research institutions

[xix] Development of such a software was proposed in UNEP/POPs/POPRC.7/INF/19
[xx] 'DSSA Establishment of Efficient and Effective Data Collection and Reporting Procedures for Evaluating the Continued Need of DDT for Disease Vector Control'

need to be coordinated. A close exchange between governments, donors, the WHO and academia will here be necessary.

At the national level, Parties need to take steps to ensure that information is gathered at the local level and provided accordingly. Guidance should be provided from the global to the national and from the national to the local level on how to interpret and use the data[175].

Some information sharing mechanisms are already in place. Under the Stockholm Convention, Parties are requested to provide information on a regular basis (3 years), which is consolidated by the BRS Secretariat. Moreover, UNEP Chemicals Branch is gathering global data on DDT use, stockpiles and other relevant issues. WHO manages an international database covering information on insecticide usage in national vector control programmes, as provided by its Member States. WHO is also implementing projects to monitor and evaluate the status of insecticide resistance. WHO has numerous networks for information sharing on vector resistance, IVM and status of alternatives in place, for example the WHO Regional Office Regional Advisors for Vector Control and the National Professional Officers at the WHO Country Offices. Other networks specifically related to entomology and vector control include PAMCA, the Africa Network for Vector Resistance, the vector control working groups from the Amazon Malaria Initiative, Roll Back Malaria, the Asia Pacific Malaria Elimination Network, and ACTMalaria. There are nascent national networks, such as the Mosquito Control Association/Nigeria that can be further developed.

One idea is for UNEP Chemicals Branch and WHO, under the umbrella of and in cooperation with the Global Alliance, to establish a standardized reporting system and associated database for environmental impact assessments. The SCRCs will be an important partner in establishing and managing regional information sharing mechanisms. One of the roles of academia will be to gather, review and evaluate relevant research in terms of policy conclusions.

4.2.1.4 Identify countries still using DDT for vector control; undertake country-specific assessments (epidemiological and entomological field data; capacity to introduce alternatives, and implement IVM; motivation and rational for using DDT; opportunities and challenges etc.)

It is critical to identify and then focus efforts on those countries still using DDT for vector control to ensure that it is being used according to WHO guidelines, not diverted to uses beyond IRS for malaria and visceral leishmaniasis, and that stocks are managed through their entire life cycle. Identification of these countries will allow the provision of targeted assistance. For this to be forthcoming, specific assessments are required to understand their continued need for DDT and the barriers for introducing alternatives. In order to develop and implement locally appropriate strategies, it will be necessary to gather epidemiological and entomological field data, and assess their capacity to introduce alternatives and implement IVM.

4.2.2 Strengthen Country and Local Capacities to Manage Insecticide Resistance, Develop and Implement IVM Strategies, Assess and Deploy Alternatives

A strengthened base of knowledge will not translate into the formulation of appropriate IVM strategies and the switch to alternatives, unless capacity for implementation is also built. The DDT Expert Group recommended the following:

- "Funding should be made available to support countries to transition away from the reliance on DDT for disease vector control, with the highest priority to assure that adequate systems and institutional capacity are in place to train and support skilled staff for entomological monitoring, operational research, evidence-based decision making and to monitor programme performance”.[176]

- “Funding should be made available to increase the national policy and management capacity for translating international best practices on disease vector control and implementing quality assurance systems to assess programme performance and impact”.[176]

The WHO Global Strategic Framework on Integrated Vector Management[177] recognizes that developing and deploying locally safe, effective, affordable and environmentally sound alternatives for a sustainable transition away from DDT cannot be reduced to a simple replacement of DDT by another chemical. Rather, it requires a comprehensive, ecologically sound and sustainable approach to vector control across multiple sectors, both public and private. Capacity to phase out the use of DDT is equivalent to capacity to manage insecticide resistance, develop and implement IVM strategies, and assess and deploy alternatives. Such capacity is still lacking in the majority of affected countries. In consequence, monitoring is not carried out, inadequate vector methods are chosen, and resources wasted.[178]

Capacity-building can thus be understood as the “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”[178]. A central means of ensuring the provision of these needs are and will be GEF projects implemented at the national, regional and global level. As a complementary measure, the road map foresees the organisation of targeted webinars and country-level workshops. In order to build the needed capacity, the GEF – as well as other – projects will focus on the development of human resources, *i.e.* build competence in epidemiology, entomology, vector-borne disease control and programme management through the provision of training (or re-training)

Skilled staff is essential to successful implementation of IVM and a prerequisite for employing alternatives to DDT. Trainings of vector control managers are therefore needed. It is particularly important that the training is provided at decentralized levels, since the success or failure of vector control strategies will depend on the human resources available at the local level. It is also important that career development opportunities are available for public health entomologists and other important vector control staff. This will encourage well trained and skilled staff to fill important positions. Moreover, the infrastructure that is needed for IVM and for the deployment of alternatives to DDT must be established and/or improved. This includes entomology laboratories, insectaries, supplies, equipment, transport, and communication technology[178].

In 2012, the WHO has developed a ‘core structure for training curricula on IVM’, which has been adapted to the requirements and conditions of each region. It features six modules, namely basic introduction to vectors of human disease, planning and implementation, organization and management, policy and institutional arrangements, advocacy and communication, and monitoring and evaluation, each of which contains learning units. Use of the curricula and other relevant materials, adapted to the national context and translated accordingly, will be scaled-up. Particular emphasis will be placed on the assessment, selection and deployment of alternatives to DDT.

In 2013 WHO issued guidance on capacity-building for public health entomology and called on countries and partners to implement a series of recommendations for curriculum review, training and career development for entomologists within national disease control programs[179]. Funding and partner support through strong advocacy efforts is needed to implement these recommendations. The special focus of this activity will be those countries still using. Training will include targeted webinars and country-level workshops, using the WHO guidance and training materials.

Insecticide resistance, especially for the malaria vector *Anopheles funestus* in Africa and the leishmaniasis vector in India *Phlebotomus argentipes,* is one reason for the continued need for DDT. Against the background of increasing insecticide resistance, capacity to manage it is crucial. In response to the growing threat of insecticide resistance, WHO developed the Global Plan for Insecticide Resistance Management (GPIRM) in 2012[180]. The WHO-supported, Global Coalition for the Development of Pesticides for Public Health[181] recommended updates to GPIRM to expand the methods of insecticide resistance monitoring through intensity assays, to expand the management response through IVM and to expand the scope of GPIRM to include other disease vectors including *Phlebotomus* and *Aedes.* The result will be a better understanding of impact of insecticide resistance on control failure; the need for DDT in areas of multiple insecticide resistance; and a broader response capability to manage and mitigate the emergence of insecticide resistance among malaria vectors in Africa and malaria and leishmaniasis vectors in India[182].

4.2.2.1 Implement relevant existing national, regional and global GEF projects and report progress and outputs

As discussed above, the GEF currently lists ten DDT-related projects on its website, six of which are currently under implementation. Though in varying ways, all of these feature capacity-building components. The large majority of these projects are explicitly geared towards the demonstration and/or introduction of alternatives to DDT. As part of the road map, it will be ensured that progress and outputs are reported on a regular basis, both during and after the implementation phase. Valuable lessons-learned will be documented and disseminated with the results incorporated into the updated National Implementation Plans.

4.2.2.2 Draft and implement national or regional GEF and other projects, featuring among others demonstration projects of chemical and non-chemical alternatives as well as IVM, based on 1.2.1, 1.2.2 and 2.1.4; integrate objectives into national action plans within the reviewed/updated NIPs

In addition to the existing GEF projects, it will be necessary to draft and implement additional national or regional projects, both via the GEF as well as other venues. These projects should aim to demonstrate the use of chemical and non-chemical alternatives in an environmentally sound manner, but also aim to take a holistic approach by building capacity for IVM.

In drafting these projects, due account will be taken of the most recent information gathered on the global situation in terms of production, trade, use, stockpiles, and environmental and human exposure of DDT (see activity 1.2.1.). The reports on insecticide resistance, cost-effectiveness of DDT and its alternatives as well as barriers to the deployment of alternatives will also be taken into account (see activity 1.2.2.). The projects will be directly targeted at the countries identified as priorities under activity 2.1.4.

The projects will be implemented in close cooperation with the WHO, industry, regional networks such as the Africa Network for Vector Resistance, and academic and research institutions.

4.2.2.3 Conduct targeted webinars, provided that the technical preconditions are given, and country-level workshops in the language of the respective country based on 2.1.4; disseminate and train relevant staff in the use of the manuals and materials from 2.1.1 as well as the tools and strategies from 2.1.2

In order to supplement GEF and other projects, webinars will be organised by UNEP Chemicals Branch and the Global Alliance, with the technical support of the BRS Secretariat, in order to train vector control managers. Country-level workshops will be conducted in the language of the respective country, identified based on its particular needs (see activity 2.1.4). The webinars and workshops will, among others, make use of the guidance materials and training manuals consolidated as part of activity 2.1.1 and also use the tools for monitoring and information management as well as decision support developed under activity 2.1.2.

4.2.3 Develop and Deploy Chemical Alternatives to DDT for Indoor Residual Spraying

The development and deployment of chemical alternatives to DDT for IRS, alongside the development of non-chemical alternatives, is the core of the road map. Unless non-chemical alternatives become available that can effectively replace IRS without resulting in increased morbidity, the objective is to phase out DDT while at the same time maintaining or, where necessary, increasing IRS coverage, *i.e.* by switching to chemical alternatives.

A number of barriers need to be overcome in order to achieve this goal. One of these is costs. There are two main cost-drivers: Unit costs encountered in procurement and application. As outline above, chemical alternatives, except for pyrethroids, are more expensive than DDT in terms of unit costs, noting that DDT may have additional costs related to waste management and disposal. Reducing the unit cost of the alternative insecticides, as well the cost of application will help programmes currently using DDT, to maintain protective coverage with potential alternatives.

To mitigate higher unit costs, WHO, IVCC and PMI are working with UNITAID to enable better forecasting and procurement procedures to decrease costs as much as possible. As regards work on the improvement of spray application equipment in order improve quality and reduce costs, PMI is documenting best practices for cost containment of operations[183] and the IVCC is working with the U.S. Armed Forces Pest Management Board and WHO to improve quality control of the spray and application equipment efficiency and durability[184]. Under the guidance of WHO, 'best practice' documents for IRS cost-containment are being developed by PMI and will be disseminated through RBM. Improvements in application equipment are managed by WHOPES and WHO collaborating centers for the testing of insecticide application equipment.[185] Improved application equipment is particularly important in India where the 'stirrup pump' is still being used for IRS[186].

Notwithstanding such efforts to reduce costs of procurement and application, it will also be necessary to make available new alternatives. The process for development and deployment of new formulations of existing chemical and new active ingredients is lengthy and may require ten or more years to complete. The steps involved include initial screening; product optimization and development; assessment in terms of i) POPs characteristics, potential hazards to human health and the environment , ii) impact on disease morbidity, iii) cost and cost-effectiveness, and iv) operational acceptability, small scale and large scale field trials, approval and deployment.

Industry and product development partnerships such as the IVCC are developing insecticides with new active ingredients with the goal of bringing three new insecticides to market by 2025. Since 2006, industry has been researching their libraries of over 4 million chemical compounds for the purpose of identifying insecticides that could potentially be used for IRS. From these, nine novel chemical classes have been identified and will move into candidate selection stage by 2015. By 2016 three active ingredients will have been be selected and moved into the final development stage of rigorous testing, which may take up to seven years depending on the time taken to obtain regulatory approval. Thus these may be available by 2025[68]. It is too early determine if any of these new chemicals or the reformulated agricultural pesticides will have the same or superior entomological or epidemiological impact of DDT against malaria and leishmaniasis vectors.

Another means of identifying possible venues towards alternatives is to understand why countries have decided to switch to alternatives in the past. Experience shows that countries phase out DDT because of insecticide resistance (*e.g.*, Uganda and Ethiopia) and to protect the agricultural export market, including for sugar and tobacco (e.g. Malawi)[187]. Awareness-raising may help to convince other countries to follow a similar trajectory.

4.2.3.1 Adapt the workplan of the Global Alliance to support the implementation of the roadmap where necessary

The Global Alliance, including through its Steering Committee and with the assistance of UNEP Chemicals, will be an important actor in the implementation of the road map. In order to best serve this responsibility, the Global Alliance will adapt its work plan in order to align it with the activities specified in the road map to the extent necessary. This may include adding new tasks, setting new priorities, and making adjustments to the work streams. Funding needs may therefore also need to be evaluated.

4.2.3.2 Implement a tiered process for the selection of new active ingredients and formulations of existing pesticide classes/agrochemicals suitable for vector control and prepare report on first and secondary screening, laboratory studies (WHOPES Phase I), data mining and proof of concept

Given the high costs of existing alternatives and the mounting challenge of insecticide resistance, it is necessary to identify new active ingredients as well as new formulations of existing pesticide classes that are equally or more effective than DDT for control of malaria and visceral leishmaniasis. Selection of potential candidates is the first step towards commercialization. Once they are selected, new active ingredients and formulations will undergo a first and second screening and laboratory studies. Data will be gathered in order to obtain a proof of concept, *i.e*. to gain evidence that the chemical in question is potentially suitable as an insecticide for vector control.

As outlined above, WHOPES promotes and coordinates the testing and evaluation of pesticides for public health, including DDT. The first two steps of its evaluation and testing programme for insecticides are the preparatory phase and phase one. During the preparatory phase, the dossier of evidence submitted by the manufacturer is reviewed and requests for complementary trials may be made. Next, in phase one, laboratory studies are conducted: Product characteristics are evaluated in a laboratory setting, with a focus on the biological efficacy and residual effect.

Industry and product development partnerships such as IVCC will occupy a central role in continuing to investigate new formulations of existing chemicals and new active ingredients. Where possible, UNEP Chemicals and the Global Alliance will provide assistance and coordination.

4.2.3.3 Product optimisation and development

There are no new formulations of existing pesticide classes that equal DDT all three areas of cost, duration and effectiveness. There are however, formulations being developed that are significant improvements over previous. Among these are the capsule suspension formulation of lambda-cyhalothrin, the water dispersible granule formulation of deltamethrin, the polymer enhanced suspension concentrate for deltamethrin and the capsule suspension formulation of pirimiphos-methyl. According to the WHOPES assessment, DDT remains the insecticide with the longest duration of effective action[188]. The longer lasting formulations of the pyrethroids are an improvement, but their deployment is often hampered by wide-spread resistance. The new formulation of primiphos-methyl, while currently effective against many vector populations resistant to the other classes, has a much higher unit cost than the pyrethroids and DDT. There is also the re-purposed pyrole pesticide Chlorfenapyr 240 SC under development.

The primary challenge for the development of new chemical alternatives is the size of the market. Whereas the agrochemical market amounts to *ca.* USD 54 billion per year, the vector control market is estimated at less than USD 1 billion[189]. In addition to the small market and low potential returns, the lengthy regulatory processes and risk of product liability for pesticides used in the home environment discourages corporate investment in the development of new public health pesticides.

The small size and complexity of the vector control market compared to agriculture necessitates partnerships to develop chemical alternatives to DDT. The largest initiative to help overcome these hurdles is the Innovative Vector Control Consortium, IVCC.[190] Other efforts to facilitate the development of new pesticide products include the WHO Global Coalition for the Development of Public Health Pesticides[191], the United States Department of Agriculture's Minor Crop Pest Management Program Interregional Research Project # 4 (USDA IR4 project)[192] and the US Armed Forces Pest Management Board[193].

4.2.3.4 Assess new active ingredients and new formulations in terms of i) POPs characteristics, potential hazards to human health and the environment , ii) impact on disease morbidity, iii) cost and cost-effectiveness, and iv) operational acceptability

Phase I of WHOPES also includes an assessment of the risks associated with each chemical. It is foreseen that WHOPES works closely together with POPRC in order to determine whether new insecticides exhibit any of the POPs characteristics and pose a threat to human health and the environment. In addition, new chemicals will be assessed in terms of their impact on disease morbidity, *i.e.* whether they constitute an effective vector control method. For any new insecticide to be brought to market successfully, its cost and cost-effectiveness needs to be evaluated (also see the discussion on cost-effectiveness above). Finally, logistical and operational implications need to be taken into account in order to ascertain whether the insecticide is suitable for use, especially under local conditions in developing countries.

In order to obtain the best available information, industry, civil society, academia and national regulatory authorities will be involved.

4.2.3.5 Undertake pilot testing on regional basis; evaluations in small-scale field trials/experimental huts (WHOPES Phase II) and large-scale field trials (WHOPES Phase III)

If a chemical has passed the selection, laboratory testing and assessment stages, its product properties are evaluated in small-scale field trials, corresponding to phase two of WHOPES. This includes an assessment of biological efficacy and impact on vector behaviour as well as an evaluation of perceived adverse effects on users. The same indicators are then assessed in large-scale field trials (phase three of WHOPES).

UNEP Chemicals Branch, the Global Alliance, Parties and industry can contribute towards the successful undertaking of these trials.

4.2.3.6 Develop specifications for quality control and international trade; obtain regulatory approval, make available and deploy active ingredients and formulations that are considered safe, affordable and at least as cost-effective as DDT in vector control, as assessed in 2.3.4 and 2.3.5

If a new active ingredient or formulation has passed all previous stages, product specifications will be developed by WHO (phase four of WHOPES). National regulatory authorities will play a key role at this stage, since they determine public health pesticide use and ultimately decide which chemicals can be used as insecticides for vector control.

The development and deployment of locally safe, effective, affordable and environmentally sound alternatives to DDT requires approval and regulatory action on three levels. First is to streamline the WHO safety and efficacy evaluation, recommendation and specifications process[194]; second to facilitate the national registration[195]; and third to improve pesticide management practices in the countries[196] to reduce illegal trade and use of substandard and unregistered chemicals.

Once the chemical is approved and the regulatory framework is in place, industry can proceed to market it. Finally, donors will likely need to provide funding in order to allow procurement of the new insecticides. Measures must be taken to ensure that chemical alternatives to DDT for IRS are managed in an environmentally sound manner throughout their life-cycle.

4.2.4 Sharing Experiences and Upscaling the Application of Non-chemical Alternatives

Paragraph 12 of decision SC-6/1 of the COP to the Stockholm Convention invites donors to give priority to the development, deployment and evaluation not just of chemical, but also of non-chemical alternatives.

Non-chemical larviciding and environmental management were the original vector control methods. Due to the challenges involved in deploying non-chemical methods, they are currently seen as supplementary to chemical interventions, rather than possible replacements. Non-chemical methods can nonetheless make an important contribution to control of malaria and visceral leishmaniasis. In particular, they are central to insecticide resistance management. The road map therefore envisages sharing of experiences and upscaling the application of non-chemical alternatives.

4.2.4.1 Compile lessons learned and good practices from projects and programmes using non-chemicals alternatives for control of malaria and leishmaniasis (and report back to COP-8)

A lot of experience has already been gained in using non-chemical alternatives for vector control. Several of the GEF projects listed above demonstrate the use of non-chemical alternatives to DDT, focusing on environmental management and other non-chemical means. In addition to these GEF-supported projects there have been significant developments in non-chemical vector control related to housing. For example, there are a number of initiatives promoting incremental improvements to housing such as changing from thatch to metal roofs (less harbourage for day-time resting vectors) and the closing or screening of eaves (major entry point for mosquitoes). In addition to the structure itself the initiative includes operations research to modify the peri-domestic environment, reducing larval habitats such as brick-making pits[197] and planting vegetation to reduce mosquito house entry.[198] Important partners include the WHO and the GEF-supported AFROII project, RBM Vector Control Working Group[199], UN-Habitat, Habitat for Humanity[200] and other research organizations.

UNEP Chemicals Branch and the Global Alliance will take the lead in compiling the lessons learned and good practices from projects and programmes that have relied on such methods. In order to facilitate this activity, it will be necessary for the SCRCs, civil society, academia, UN-Habitat and other stakeholders to assist in the collection of information.

4.2.4.2 Undertake pilot studies where deemed necessary

In addition to ongoing GEF and other projects, pilot studies will be implemented in order to demonstrate the use of non-chemical alternatives, in particular where new approaches become available. This will also serve to demonstrate applicability of a proven method under different local conditions. This activity will be a joint effort by Parties, the Global Alliance, SCRCs, civil society, and UN-Habitat and will be coordinated with existing initiatives, such as the UNDP Multisectoral Framework.

4.2.4.3 Undertake activities to scale up the development and deployment of non-chemical alternatives, among others by strengthening institutional structures and supporting multi-sectoral approaches, including as part of 2.2.1 and 2.2.2

While the use of non-chemical approaches is now widespread, it will need to be scaled-up significantly in order to have a larger impact on morbidity. Moreover, new approaches or variations of existing ones may need to be developed. Community-participation and multisectoral implementation is essential to the success of non-chemical methods[201]. Moreover, appropriate institutional structures must be in place, e.g. for monitoring and mapping in order to allow targeted larviciding.

The multisectoral approach is in line with other large global strategies, including the Sustainable Development Goals, the UN Platform on Social Determinants of Health and The Libreville Declaration on Health and Environment in Africa. The ‘Multisectoral Action Framework for Malaria’[202] echoes the COP’s encouragement for action across multiple sectors. Specific outputs relevant for the roadmap include the development of non-insecticidal approaches to vector control through improved surface-water management, as in the proposed collaboration with UN-Habitat water/sanitation program in the Lake Victoria Basin, improved housing, and reduction of vector larval habitats in the peri-domestic environment and urban agriculture.

“The Multisectoral Control and Elimination of Malaria in the Lake Victoria Basin”, or Lake Victoria Initiative, is a collaboration between RBM and UN-Habitat for a regional five-country effort to supplement current vector control methods based on LLINs and IRS through complementary improvements in agricultural practices, water and sanitation and housing, including through public-private partnerships with the commercial agriculture sector for workplace and community programs, and better integration of malaria prevention in education curricula. The initiative builds upon the UN-Habitat-Lake Victoria Basin Commission Water Sanitation Project[203] and the GIS-based community monitoring system H2.0 Monitoring Services to Inform and Empower[204].

There are also opportunities for links between vector control and the agriculture and food security sectors through Integrated Pest and Vector Management projects[205] and food security initiatives aimed at increasing agricultural productivity[206].

4.3 Eliminate DDT Stockpiles and Waste

Successful reduction and ultimately elimination of the use of DDT will result in increased amounts of obsolete DDT. A holistic approach will therefore have to take into account the identification, ESM and disposal of DDT stockpiles and waste. Parties to the Stockholm Convention are requested to develop appropriate strategies for identifying stockpiles consisting of or containing DDT as well as products and articles in use and wastes consisting of, containing or contaminated with DDT, manage stockpiles of DDT in a safe, efficient and environmentally sound manner, and take appropriate measures so that DDT waste is handled, collected, transported, stored and disposed in an environmentally sound manner.

Several steps, building upon one another, need to be followed in order to achieve elimination of DDT stockpiles and waste, as outlined below. In order to secure finances, these activities will need to be included in the National Implementation Plans. They may be carried out either directly by Parties or through GEF or other projects. It is assumed that in many cases external funding will be necessary. This could be provided by bilateral donors, the GEF, international financing organizations or other partners. Decision SC-6/1 invites donors to malaria control programmes to ensure that the funding of DDT IRS programmes includes funding for activities for the sound management of DDT.

It is envisaged that these activities will be implemented as part of ongoing as well as new national, regional and global GEF and other projects.

Efforts are already underway. For instance, under the auspices of the Africa Stockpiles Programme, operations are ongoing to clean up and safely dispose of obsolete pesticide stocks[207]. Moreover, the largest share of obsolete DDT from eight participating countries has been destroyed as part of an ongoing GEF project implemented by UNEP and the WHO Regional Office for the Eastern Mediterranean (EMRO), including 23.8 tonnes of DDT and other obsolete stocks in Jordan and 41.2 tonnes of concentrated DDT in Morocco. Moreover, a GEF project to be implemented by UNIDO in Guatemala aims to strengthen national capacities for the ESM of DDT, targeting up to 15 tonnes, as outlined in the latest report of the DDT expert group[xxi].

4.3.1 Update National Inventories as Part of 2.2.1 and 2.2.2

The first step towards a safe, efficient and environmentally sound management of DDT stockpiles and waste is to update national inventories. Inventories are an important tool for identifying, quantifying and characterizing wastes. They will help in the identification of priorities, form the basis of the next steps, and allow effective action to be taken to ensure ESM. Such inventories should feature information on the amounts stockpiled, status of the stockpiles, the location and owner of the stockpiles, storage conditions, the characteristics of the waste *etc*. Availability of such information will allow decision-makers to draft an appropriate strategy for managing the stockpiles.

While most Parties have already undertaken inventories of DDT, these are often of preliminary nature, lacking the needed level of detail and accuracy. It is likely that many existing stockpiles have not yet been accounted for. The updating of national inventories should therefore be made a priority under the revised NIPs and be featured prominently in national action plans.

The Regional Centers will play an important role in the update of national inventories, including through the provision of trainings on how to conduct inventories, the provision of expertise and advice and gathering and comparing country-level data. Some countries may need financial assistance, for example through GEF projects, to enable the updating of national inventories. The

[xxi] To be published as an INF-document for the next Conference of the Parties to the Stockholm Convention to be held in Geneva in May 2015.

Secretariat has developed a guidance on conducting a DDT inventory[208]. Training on how to conduct inventories can also be provided through webinars.

4.3.2 Collect Obsolete Stocks as Part of 2.2.1 and 2.2.2

Once a clear picture of the national situation in terms of DDT stockpiles and waste is available, the next step is to collect obsolete stocks. A high priority should be given to the unsecured stockpiles which may leach into the surrounding soil and water, thus adversely affecting human health and the environment. Again, most Parties with DDT stockpiles will need assistance in conducting this activity, necessitating involvement of the GEF, the Global Alliance (e.g. through the provision of expertise) and others.

4.3.3 Repackage and Dispose as Part of 2.2.1 and 2.2.2

Collected stocks will often need to be repackaged in order to avoid adverse effects on human health and the environment during transport, for example through spills. This is especially important where local solutions (including for example mobile plants) are not available and the waste will be transported across international boundaries. Special storage containers, e.g. so-called 'isotanks' (tanks specially designed for the transport of hazardous substances[209]), will be needed.

Disposal means that the POP content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs. Where destruction or irreversible transformation is not the environmentally preferable option or where the POP content is too low, they can be disposed of in an environmentally sound manner (e.g. permanent storage in salt mines).

Parties will need to identify and evaluate the options available in order to identify one that suits their particular needs. The Secretariat, in cooperation with UNEP Chemicals Branch, has recently developed an updated set of factsheets on POPs destruction technologies which can be used to assist Parties in choosing appropriate solutions. Assistance could also be provided by the members of the Steering Committee of the Global Alliance. Moreover, webinars may help in training those in charge of DDT disposal. Among others, they need to be trained in conducting a risk assessment[210].

Even where sufficient knowledge is available, Parties lacking the financial and technical resources to repackage and dispose of their DDT wastes will need assistance. This will be provided via GEF projects and may include technology transfer (*e.g.* the provision of a mobile plant) or facilitate the export of DDT wastes for environmentally sound disposal in countries having the necessary infrastructure. Involvement of industry in this activity is crucial, notably companies specialized in the disposal of hazardous wastes.

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