Reducing and Eliminating the use of Persistent Organic Pesticides

Guidance on alternative strategies for sustainable pest and vector management

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UNEP

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Preface

Persistent Organic Pollutants (POPs) are chemicals that persist in the environment, accumulate in high concentrations in fatty tissues and are bio-magnified through the food-chain. Hence they constitute a serious environmental hazard that comes to expression as important long-term risks to individual species, to ecosystems and to human health. POPs chemicals may cause cancer and disorders in the reproductive and immune systems as well as in the developmental process. They constitute a particular risk to infants and children who may be exposed to high levels through breast-milk and food.

During the last two decades much attention has been given to this group of substances at the international level after it became apparent that they are transported through the environment across borders. Individual countries alone are unable to control the environmental pollution from such border-crossing substances and critical concentrations have been reached in some regions, even in places where they have never been produced or used. Negotiations on a global, legally binding instrument to reduce and / or eliminate releases of POPs started in Montreal, Canada in 1998 under the auspices of UNEP. In May 2001 126 countries and the EU agreed and adopted the text of this global treaty, referred to as the Stockholm Convention on Persistent Organic Pollutants.

The decision by the UNEP Governing Council in 1997 to initiate these negotiations followed recommendations by the Intergovernmental Forum on Chemical Safety (IFCS) for international actions to reduce the risks to human health and the environment arising from a first list of twelve POPs. The IFCS recommendations were also endorsed by the World Health Assembly (WHA) in May 1997. Through the adoption of Resolution 50.13 (promotion of chemical safety, with special attention to persistent organic pollutants) the Assemby requested the Director-General of the World Health Organization, *inter alia*, to continue efforts to enhance technical cooperation with Member States for the determination of their capacity-building needs, and for the implementation of programmes for the management of chemical risks, in collaboration with participants of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) and other organizations.

In 1997 the Governing Council further requested UNEP to initiate a number of immediate actions including the improvement of access to information and expertise on alternatives to POPs. Information exchange and education programmes should enable governments of Member States to make their own decisions on replacing POPs with alternatives. In this context UNEP was requested to develop guidance on the selection of alternatives to POPs pesticides.

In response to these requests, this guidance document has been prepared jointly by the United Nations Environment Programme (through its Chemicals unit), the Food and Agriculture Organization of the United Nations (through the Global IPM Facility) and the World Health Organization (through the Secretariat of the Panel of Experts on Environmental Management for Vector Control - PEEM). It is a guide for the onset of national efforts to assess, select and develop alternative strategies to POPs pesticides in line with the basic principles for more sustainable practices in pest and vector control. It takes into account various aspects of public health, the environment and agriculture with the objective of fostering holistic and integrated approaches while ensuring that strategies of different sectors are compatible, coordinated and mutually reinforcing. Implementation of such strategies will also be promoted through regional training workshops, pilot studies and support to develop and implement national action plans.

This document is part of a package of UNEP products aimed to facilitate and support the development of initiatives at all levels to reduce and/or eliminate releases of POPs. These products are all available through the POPs homepage at http://www.chem.unep.ch/pops/ . Drafts of this document were reviewed by a large number of experts both from within and outside of the three UN agencies, whose valuable and constructive comments and contributions to both contents and structure of the draft text are gratefully acknowledged. Special thanks are extended to Johan Mörner, who produced the first draft manuscript, and to Barbara Dinham, Hermann Waibel and Peter Kenmore who provided substantial inputs into the document. Robert Bos (WHO), Marjon Fredrix (FAO) and Agneta Sundén Byléhn (UNEP) were responsible for its final development and editing.

Introduction

Persistent Organic Pollutants (POPs) are chemicals that:

- are extremely stable and persist in the environment,
- bio-accumulate in organisms and food chains,
- are toxic to humans and animals and have chronic effects such as disruption of reproductive, immune and endocrine systems, as well as being carcinogenic, and
- are transported in the environment over long distances to places far from the points of release.

With the evidence that POPs are transported to regions where they have never been used or produced, the international community decided in 1997 to work towards the establishment of a Convention that will serve as an international, legally binding instrument to reduce and / or eliminate releases of twelve POPs, as identified in the UNEP Governing Council Decision 19/ 13C. The initial list of POPs contains the nine pesticides that are listed in the accompanying box. The decision also includes PCBs (mainly used in electrical equipment) and two combustion by-products, dioxins and furans. The UNEP Governing Council also requested that criteria and a procedure be developed to identify further POPs as candidates for international action. This request has been complied with and more substances are therefore likely to be included in the list.

The nine pesticides in the initial list of the Stockholm Convention on POPs

aldrin
toxaphene
DDT
chlordane
dieldrin
endrin
HCB
heptachlor
mirex

Pesticides now classified as POPs started to be used on a large scale after World War II in agriculture and for disease vector control. Crop protection and disease vector control strategies became dominated by the application of these pesticides. Ecological science and thinking, the basis for earlier efforts to control pests and disease vectors, lost its prominence.

The control of disease vectors (such as malaria mosquitoes) by pesticides saved the lives of millions of people. The negative impact of pesticides on agro-ecosystems as well as on the environment and human health started, however, to become increasingly evident in the 1950s. A landmark in public awakening was the publication, in 1962, of *Silent Spring*, in which Rachel Carson eloquently warned against continued unrestricted use of chlorinated pesticides, in particular DDT. Evidence continued to mount in the following decades supporting her fundamental point: pest control which ignores ecology not only fails (see chapter 2), but it creates additional problems affecting health and environment (Carson, 1962).

Effects of POPs on Health and Environment

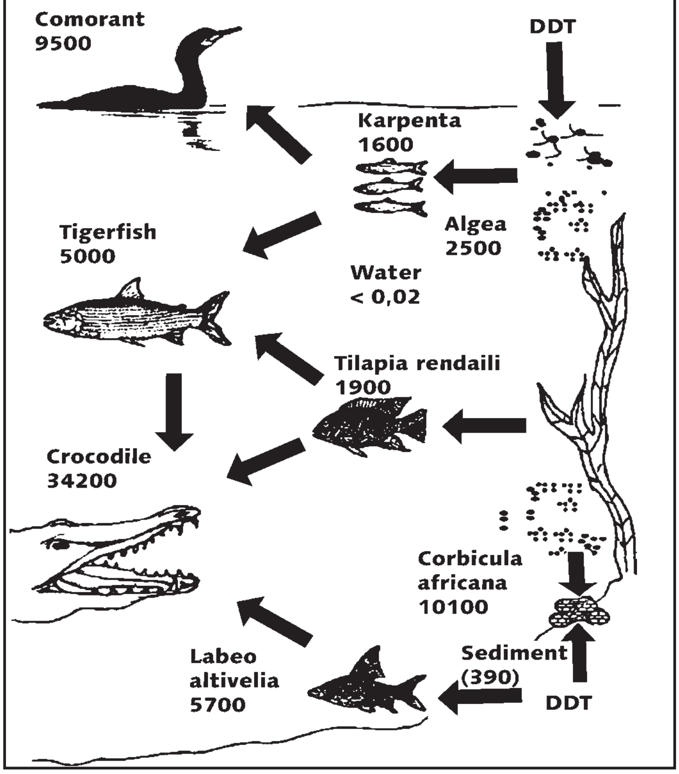
Persistence, Transport and Bio-accumulation

POP pesticides and their residues are now found as pollutants all over the world. Being semi-volatile, they are transported over long distances. This volatility is greater in tropical than in moderate or cold climates, and eventually they end up being trapped in the coldest parts of the planet. High levels are thus detected in organisms in the Arctic area, where few if any pesticides were ever used. Examples of residue levels found in northern ecosystems are given in table A1 in annex 1. It has also been noted that such levels, for example as detected in breast milk, remain unchanged, or even rise, in regions where use was banned decades ago.

The persistent nature of POP pesticides is demonstrated by their slow rate of degradation in soil, particularly in cold climates. Their half-life sometimes extends over more than a decade (table A2 in annex 1). Several metabolites of POP pesticides are stable and toxic as well.

Another property of these compounds is their solubility in fatty substances and tissues, which leads to their accumulation in body fat. Concentrations will further increase hundreds of times through food webs (biomagnification, see figure 1). At the higher consumer levels in such webs harmful effects such as egg thinning have been observed. These are thought to reflect a broader range of more insiduous disruptive impacts on vertebrate endocrine systems.

Figure 1.
Mean levels of DDT residues (ppb in fat) in the Lake Kariba ecosystem, showing accumulation through food chains.
From: Berg et al., 1992.



Low levels of POPs in the environment can equally cause disturbances to organisms. Studies on predatory birds, aquatic mammals (i.a. dolphins and whales) and laboratory rodents have shown effects such as immunotoxicity, carcinogenicity and reproductive disorders. Residue levels in extensive faunal samples in the USA and Europe up to 1973, and in Africa up to 1995 have been compared. Table A3 in the annex presents data for freshwater fish as an example. The levels in Africa today are in most cases higher than they were in the industrialised countries when restrictions were initiated in the 1970s, and are sufficiently high to endanger several species (Wiktelius and Edwards, 1997).

Toxicity

Although all POP pesticides are toxic to humans, the acute toxicity varies - endrin being the most toxic, while others such as heptachlor and HCB are less acutely toxic. Acute toxicity is a property POP pesticides share with other pesticides. Many insecticides and nematicides of the organophosphate and carbamate groups have much higher acute toxicity than the "worst" POPs. The decisive criteria for compounds to be included on the POPs list have been, however, their persistence and bio-accumulation, and consequently, their long-term toxicity. Considering the high acute toxicity of many commonly available alternative pesticides, this guidance document proposes integrated pest end vector management strategies as alternatives to POP pesticides, leading to an overall reduced reliance on pesticides.

Chronic adverse effects of pesticides on human health, due to prolonged periods of exposure, were first recognised in the 1960s. Several of the POP pesticides are carcinogenic in experimental animals and therefore are possibly carcinogenic to humans[1]. Some are also suspected to depress the immune system (Repetto and Baliga, 1996). Toxicity values (LD_{50}) and established or seriously suspected health effects of the current POP pesticides as well as of certain other pesticides are presented in Table A4 in Annex 1. More recently, the health hazard presented by prolonged low-level exposure has become a matter of concern. There is a suspected link to disruptions of the endocrine system, whereby pesticides mimic or block normal hormone activity. Such hormones include androgen, oestrogen and testosterone.

Since the introduction of persistent organic pesticides new hazards have been discovered with great regularity, adding to the accumulated weight of evidence of the risks they represent for the global ecology and for health. References to relevant sources of information on pesticides and pesticide hazards are given in Annex 1.

Example of effects on health and environment

Taking the example of DDT, there is conclusive evidence that

- populations of birds of prey declined already in the 1960s as a result of eggshell-thinning. This was caused by DDE, a very stable metabolite of DDT (Faber and Hickey, 1973).

- DDT disturbs sexual development and behaviour in birds such as gulls (Fry and Toone, 1981).

And there are strong indications that

- the capacity of the immune system is impaired by DDT, but also by certain synthetic pyrethroids - pesticides that have been promoted as DDT alternatives (Rehana and Rao, 1992).
- the nervous system can suffer permanent damage from exposure during the foetal stage or early in life (Eriksson, 1992, Hussain *et al.*, 1997).
- lactation in women can be impaired by DDT/DDE - providing a possible link with oestrogen mimicry (Gladen & Rogan, 1995, Rogan *et al.*, 1987).

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1) Classifications of POPs pesticides for their cancer hazard are presented in monographs published by the WHO International Agency for Research on Cancer; narrative summaries are available on http://monographs.iarc.fr

The current status of POP pesticides use

Starting in the early 1970s, one country after another restricted or banned the use of POP pesticides, often with the use of DDT for public health applications (disease vector control) as the only exemption.

The last known uses for each of the POPs pesticides are summarised in table 1 (Mörner, 1996). Data on the use of certain pesticides are difficult to obtain and may be unreliable. The table nevertheless provides some insight for what purposes the POPs pesticides have been or are being used.

Production and use of the pesticides on the initially agreed list of POPs has, for all practical purposes, already ended in high-income countries, except for some products for termite control. Their use in low-income countries has been reduced, often because of growing trade restrictions on agricultural produce containing pesticide residues. DDT and possibly a few other POP pesticides are, however, still used in a number of countries. A significant portion of this use is that of DDT for the control of malaria vectors and of chlordane and heptachlor for termite control. The task of assisting these countries in identifying viable alternatives and making these alternatives operational is a key objective of the present document.

Table 1: The POP pesticides - examples of last known uses

POP pesticide	Last known uses
aldrin	Against termites and other soil pests, termites attacking building materials, in grain storage, and for vector control
camphechlor (toxaphene)*	Control of insect pests in cotton and other crops
chlordane	Against termites and other soil pests, termites attacking building materials
DDT	Control of medical and veterinary vectors, such as malaria-transmitting mosquitoes, plague-transmitting fleas and trypanosomiasis-transmitting tsetse flies
dieldrin	Control of locusts, termites, human disease vectors
endrin	Formerly used against insects and rodents. No current or recent uses are known
heptachlor	Against termites and other soil pests, termites attacking building materials
HCB	Formerly used for seed treatment against fungal diseases, as well as for industrial purposes. No current or recent agricultural uses are known.
mirex	Against leaf-cutting ants, termites in buildings and outdoors, and also as a fire retardant and for other industrial purposes

* Camphechlor is the generic name, while toxaphene initially was a trade name. The latter is now, somewhat erroneously, also used as a generic name.

Experience is available on reducing reliance on pesticides. Some important lessons have been learned:

- Production levels in agro-ecosystems can be maintained and improved using less pesticides when the ecology of the systems is understood; field observations are the basis for alternative management decisions.
- Replacement of certain pesticides with other pesticides without understanding the basic ecology will result in the continuation of current problems faced by pest and disease vector management.
- For vector control to be more sustainable, it should build on ecosystem-based science and integrated management approaches.
- Existing tools, including traditional and indigenous knowledge bases, to manage pests and disease vectors should be drawn upon.
- Expertise, decision making and adequate resources to manage systems should be decentralised to local levels.
- New science, technologies and decision-making procedures should be included in management strategies and operations.
- Participatory approaches in monitoring, managing and evaluating pest and vector control are essential to their sustained succes.

A process of change towards sustainable solutions

Reduction and / or elimination of POP pesticides, as mandated by the Stockholm Convention, provide an opportunity and a challenge to re-think strategies used in pest and vector control. This is not merely a question of “replacing pesticide A with pesticide B”. The introduction and chapter 2 of this guidance document give an insight in the history of the use of and the problems associated with the disproportionate reliance on POP pesticides. Chapters 2, 3 and 4 cover the current status and use of POP pesticides, and introduce alternative management strategies (IPM and IVM), firmly based on proper assesment of the local ecology. The elimination of POP pesticides is an entry point to building sustainable solutions.

Change does not happen overnight. It is a process that requires time to build sufficient capacity at different segments and layers of society to enable and support change. POP pesticides and alternative management strategies for pest and vector control are of concern to many stakeholders. Their early involvement and support in the search for sustainable solutions will improve and expedite the process and increase the acceptability of change.

Stakeholders

Stakeholders will represent different sectors, organisations, groups and individuals. Each will have different interests and a different role. Though not an exhaustive list, the following should give an idea of who will be involved, and what contributions they can make to the process:

- **Farmers and local communities** can design and improve their own alternative strategies. They learn “by doing” research in their own fields and by participating in Farmer Field Schools where they develop the capacity to make well-informed decisions. They can engage in pilot projects and other activities. Local communities can also be stimulated to engage in effective environmental management for the control of disease vectors.

- **Unions for farm workers, construction workers, health staff** and other groups contributing to the regulation of labour conditions can push for safer pest and vector control methods, and be on the alert for continued use of POP pesticides.

- **Pesticide companies** can pledge "from cradle to grave product stewardship". They should also favour the development of pesticides compatible with IPM / IVM, and should take every measure to ensure that pesticide users are made aware of risks and of necessary precautions to be taken.

- **The various public sectors of government,** at all levels, have a crucial role in revising policies, regulations and legislation on pesticides, and on pest and vector management, harmonising them and making them supportive of IPM and IVM. They should actively enable and support local efforts by farmers, health staff, communities and households to implement IPM and IVM through technical backstopping, information exchange, training and financial assistance. They should implement international agreements regulating trade and use of hazardous chemicals, upgrade facilities for chemical analysis, and address the present obsolete pesticide situation. Systems and structures should ensure that new stocks do not accumulate. Activities may require the technical and financial assistance of international organisations and external support agencies.

- **Multilateral organisations and non-governmental organisations** have an important role. They can influence and facilitate policy reform, often through comparative examples from different regions. They can also lobby to influence policy-makers, carry out independent assessments and evaluations, disseminate information and set up pilot projects. They have an overview of trade in pesticides, as well as of obsolete pesticide stocks, and can assist in disposal operations. They must clearly never recommend or facilitate the procurement of POP pesticides beyond what is permitted under the Stockholm Convention.
  In the application of DDT for malaria control, WHO guidelines should be strictly adhered to.

- **Multi- and bilateral external support agencies** will need to finance many of the crucial activities. In general, it is important that aid policies are consistent with and supportive of IPM and IVM. They must never procure POP pesticides for overseas projects beyond what is permitted under the Stockholm Convention, or support their use in other ways. They should support research on and development of alternatives, particularly to DDT for effective malaria control.

- **The national and international research community** can do research in areas of key importance to the development and implementation of IPM and IVM, and particularly on alternatives to POP pesticides. They should also increase research on pesticide effects on health and environment.

- **Consumers and consumer groups** -locally as well as in other, importing, countries- can exert strong pressure, for example by demanding that the food they buy has been produced without the use of POPs pesticides and does not contain residues of POPs pesticides.

- **Schools and universities** have a crucial role for the future. Modern, integrated management concepts should be introduced in curricula and innovative research should strengthen the evidence base for these concepts.

Steps in the process of change

In the process of change towards more sustainable solutions several steps can be distinguished. Some steps may overlap in time.

Analysis of the present situation
As a first step it is important to analyse the present situation. Several issues need to be taken into account:

- Current policy framework. An assessment is needed of policy issues related to pesticides in a broad sense, as well as what kind of strategies for management of pests and vectors are promoted by the existing policies.
- Present status and current use of POP pesticides. In this connection, the identification of stocks of obsolete pesticides needs attention.
- Current practices for pest and vector control. For agriculture, it will be important to find out what knowledge base, analysis and procedures farmers use to come to decisions on the application of pesticides, and what the actual use is at farm level. Similarly, it has to be analysed how decisions concerning vector control activities are made, to what extent vector ecology and biology are used as key criteria and what the actual pesticide use levels are.

Identification of alternative approaches
The situation analysis will be a starting point from where to further identify and discuss opportunities for change at policy level, as well as for alternative approaches for management of pests and vectors at field level.

- Policies may be changed in a number of ways to be more supportive of alternative approaches and to make agricultural production systems and public health services less dependent on pesticides. The situation analysis is an entry point to identify and prioritise areas for change.
- Current practice and management strategies used in the field will give insight into whether and how IPM and IVM strategies can be used to improve decision making and reduce reliance on pesticide use.

Developing National Action Plans
To reduce and / or eliminate POP pesticides and to move towards more sustainable pest and vector management strategies, a national action plan will be needed. Certain activities can be tested at pilot scale before scaling them up to implementation at the national level.

Pilot activities
At the policy level studies may be implemented to gain a better insight into the policy framework. Workshops can be held with senior government officials to discuss the existing policy framework and to identify areas for change. Exchanges with other countries might provide ideas on how to implement change. Field visits can be made to pilot projects to familiarise policy makers with alternative approaches for pest and vector control.

At the field level pilot projects can be set up to educate farmers and community members in the ecology of pest and vector species and to involve them in the planning and design of IPM and IVM programmes. Data from these pilot activities should be made available to stakeholders. Field visits will help to strengthen interest in IPM and IVM approaches. Monitoring and evaluation of these activities will yield important information to further improve pilot activities and to plan for action at national level.

National implementation
The pilot activities will be a good starting point to develop plans for national implementation. At all stages regular monitoring and evaluation of activities will be needed to further improve programmes.

The aims of this document

This document presents basic principles for alternatives to POPs pesticides in agricultural pest management, as well as management of disease vectors of humans and animals, with malaria as the most obvious example. This document also addresses termite control in building and construction as there have been and still are many uses for POPs pesticides for this purpose. To provide recent and illustrative examples, a few case studies include pesticides not on the initial list. Post-harvest pests and pests in the food industry are not specifically covered or exemplified since POP use is probably negligible, but the principles presented are obviously relevant also for their integrated management. Efforts to reduce / eliminate POP pesticides will have to take into consideration a range of issues, from policy reform to intersectoral collaboration. Figure 2 gives an overview of these issues and they will be addressed in greater detail in this document.

The aims of the document are three-fold:

- to provide guidance on more sustainable alternative strategies and steps to be followed for phasing out POP pesticides;

- to promote the adoption of Integrated Pest Management (IPM) and Integrated Vector Management (IVM) as the approaches of choice, leading to reduced reliance on pesticides;

- to raise awareness of potential impacts of activities in one sector on the pest / vector management situation (including the effectiveness of POP pesticide alternatives) under the responsibility of another sector and to promote intersectoral collaboration to deal with such impacts.

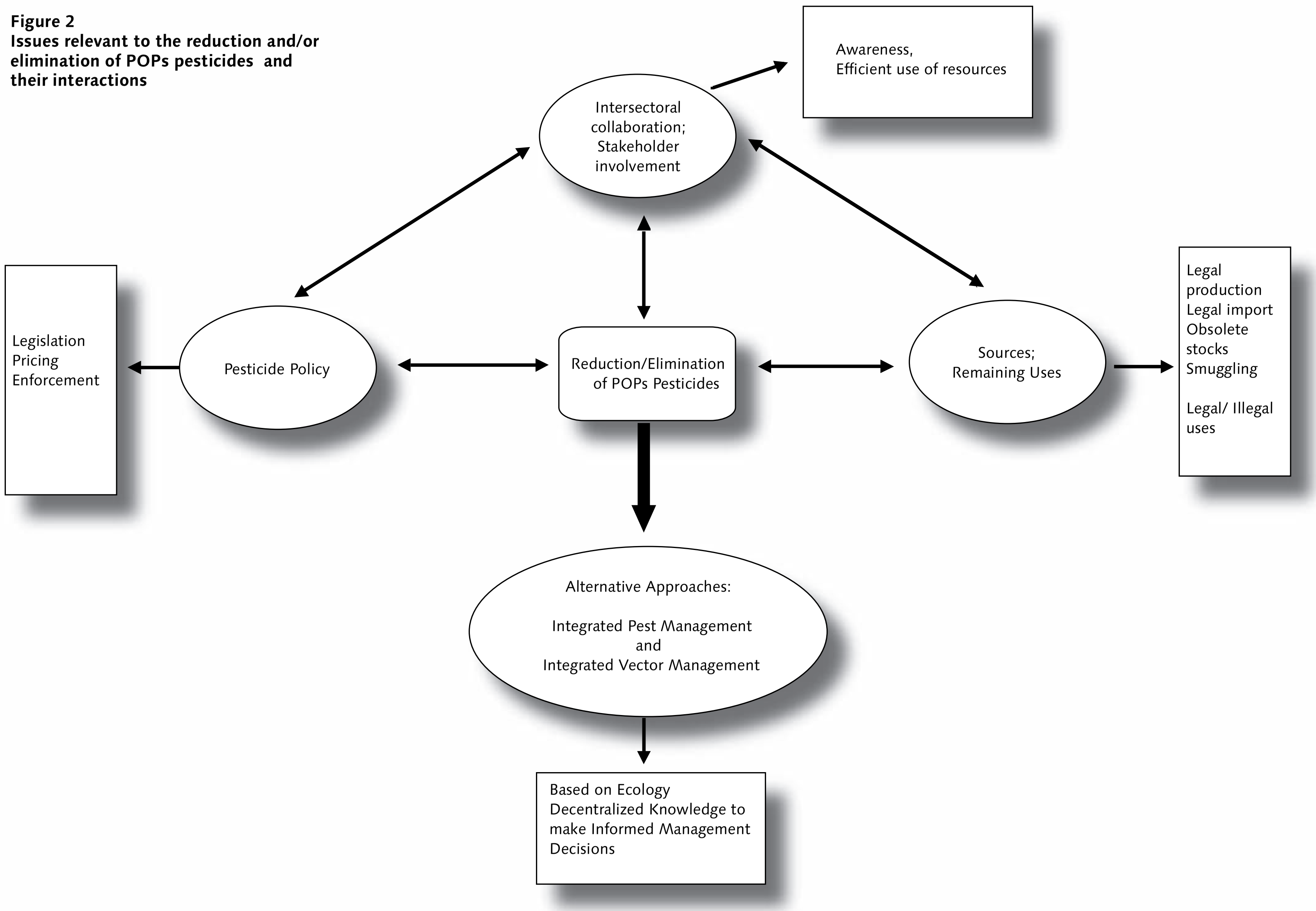
Who should use this guidance document?

This document is meant in the first place for the champions in the transition away from POP pesticide use. These are the policy-makers, decision-makers and opinion-makers in agriculture, public health or any other sector where pesticides are presently being used. They will here find both inspiration and information. To eliminate POPs pesticides, a whole range of people need to be involved -for example farmers, provincial public health officers, schoolteachers, journalists, pesticide salesmen, people in local NGOs. Through the present document these stakeholders will be involved in a collective process that allows elimination / reduction of POPs pesticides, and in defining sustainable alternative strategies for pest and vector management.

How to use this document

- To follow a road map, leading to further thoughts and discussions, read chapter 1 and look at the flowchart folding out at the back cover of the document.
- To acquaint yourself with IPM and IVM, go to chapter 2.
- To read about specific issues, see chapter 3.

Figure 2
Issues relevant to the reduction and/or elimination of POPs pesticides and their interactions



- To get inspired by examples that are using alternative approaches, read the case studies in chapter 4.
- To learn what a word means, consult the glossary in the annex.
- To find out where more information is available, go to the bibliography in the annex.
- Do you want to know who does what? Consult the annex .
- If you have access to the Internet, the resource list of web sites in the annex will get you started.

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1.

Reducing/Eliminating the use of POPs pesticides and selecting alternative management strategies: a roadmap

As described in the introductory chapter, one needs to look beyond mere replacement of POPs pesticides by other pesticides to more sustainable alternative practices based on integrated management principles. Achieving better health and environment through such integrated strategies requires the participation of a wide range of national and international institutions, organizations, commercial companies and individuals.

People working in agricultural production, public health and building construction and maintenance need to develop and make use of new pest management strategies. Another important group consists of consumers and their organizations, who can make demands for safer products and services. An obvious prerequisite for success is a favourable policy and regulatory environment. Governments, NGOs, donors, international organizations and other institutions have the responsibility to encourage and set the framework for a transition away from hazardous and undesirable products and practices.

This chapter will lead the reader through a series of questions and illustrative conclusions, supported by pertinent information, to provide guidance for a first analysis of a specific situation. It is suggested to read the support information before moving to the next indicated question, even if in a first instance you feel you know the answer. A word of caution: the "roadmap" is obviously an over-simplification, and detailed answers will not be provided. It is, however, anticipated that this chapter will provide entrance points for further discussions. The flow-chart on the fold-out at the back of the document summarises the main issues of the roadmap.

The roadmap

1. Do you know or suspect POP pesticides are being used in your country?

No – go to point 2
Yes – go to question 3

This question is easier to answer if POP pesticides are in predominantly legal use, for example in vector control programmes, and the extent of their use (production and imports) may be available in official statistics. Agrochemical companies should also be able to provide information, but care should be taken that commercial interests do not introduce bias into the assessment.

Local knowledge, community contacts, direct observations and interviews with traders and dealers can give information on which pesticides are being used and for what purpose. Accumulations of empty containers at various sites may also be an indication of usage of the chemical(s) in question. The household use of pesticides and repellents should not be overlooked. A complicating factor can be that not everyone may be aware which substance they are actually dealing with. “DDT” is sometimes used as a popular generic term for any pesticide. Chemical analysis may be essential to determine the nature of a formulated pesticide. This highlights the importance of the availability of analytical facilities.

A review of documented imports and / or use in the past may provide leads concerning current less visible uses. Such information may be available from a number of ministries, from international organizations and sometimes from industry. Chemical residue analysis can also help answer the question. An example where actual usage may be suspected comes from Africa: analyses of marketed cereals in a West African country showed residue levels of aldrin, dieldrin and DDT much above what would be expected from background contamination, and above FAO maximum residue levels, in 22 – 29% of samples (Osibanjo and Adeyeye, 1995).

2. Monitoring

Even if no evidence of POP pesticide use can be found – whether legal or illegal – it is still important to continue monitoring as long as these substances are produced or used elsewhere.

An example:

On several brands of mosquito coils imported into a number of countries in recent years, the labels did not mention any active ingredients. It was eventually found that the coils contained up to 10% DDT, a pesticide banned in these countries. Import would never have taken place, had this been known (Yen and Kalloo, 1998).

3. Is their use illegal or legal?

It is illegal – go to point 4
It is legal – go to question 5

Relevant government authorities can provide information on the legal status of POP pesticides. The authority responsible for pesticide registration varies from country to country[1]. The registration of pesticides for use in agriculture and of those for use in public health campaigns may also reside under different authorities. International agencies (UNEP, FAO) regularly review the legal status of pesticides in their Member States.

[1] For information on authorities, see: Royal Society of Chemistry. 1996. *World Directory of Pesticide Control Organisations*, Third Edition (compiled by G. Ekström).

4. Illegal use

Illegal use of POP pesticides can occur for a number of reasons:

- Countries may lack the resources, commitment and / or infrastructure to implement and enforce legislation.

- Information on restrictions or bans have not reached everyone concerned – local pesticide dealers, health personnel, extension workers, farmers, etc.

Training projects should be conducted to sensitise and inform these groups on relevant legislation and other aspects of pesticide management.

Sources for illegal use of POPs pesticides may include:

- Stocks of obsolete pesticides

There are considerable, often poorly managed, stocks of obsolete pesticides in many developing countries. A significant part of these stocks are POP pesticides and some of these may find their way to the illegal market.

Immediate action required includes containment of the stocks to ensure that they are neither used, nor threaten the environment. Disposal plans must then be drawn up and implemented. For a further discussion on obsolete pesticides, see sections 3.4 and 4.12.

- Diversion of legal stocks to illegal use

It may be legal to import or produce some POP pesticides with restricted uses, e.g. only for vector control. These pesticides will then be available in the country, presenting a significant risk that parts of the legal stocks will be diverted to illegal purposes, e.g. crop protection, see chapter 2 (pages 37 and 38).

- Illegal imports

Regional co-operation can help counteract smuggling. Efficient implementation of the Rotterdam Convention (formerly the PIC procedure) will also assist governments in stopping unwanted imports. Information sources are provided in annexes 3 and 4.

5. Why are POP pesticides still used?

Alternatives are considered too costly – go to point 6
Alternatives are considered ineffective – go to point 7
There is insufficient public awareness – go to point 8

Cost and effectiveness are sometimes closely related. Using a pesticide with weaker or shorter effect may lead to higher application rates and / or more frequent treatments – and higher costs. Replacing DDT with other pesticides for indoor residual treatments may, for example, also require operational changes. More frequent treatments need to be made with some alternative pesticides, while others, such as the modern synthetic pyrethroids, have a residual activity comparable to that of DDT. As they are less bulky, operational problems may be even smaller. A thorough analysis of each situation is always required.

Countries that are economically dependent on the export of agricultural products to countries with strict pesticide residue standards have often already phased out more persistent pesticides. In at least one country in southern Africa, for instance, the decision to interrupt the use of DDT for malaria vector control was made under pressure from the tobacco growers.

6. Costs of alternatives

There may be different reasons for the perception that alternative approaches are too costly:

- Often, not all costs of current practices are considered or the costs of alternative approaches may be overestimated. The costs of pesticide impacts on health and environment have hitherto been neglected in economic analyses, but it is now increasingly accepted that these factors also must be taken into account. See also sections 3.2 and 4.1.

- Economic concepts such as discounting the cost of expenditures in the future may favour certain interventions over others at the expense of sustainability. For example, in economic evaluations comparing capital-intensive environmental management measures of an infra-structural nature with a programme of recurrent spraying interventions for disease vector control, a high discount rate will tip the balance in favour of the latter option. For more information see WHO, 1986 and Phillips *et al*., 1993.

- Alternative pesticides may need to be imported into a country with domestic production of POP pesticides, imposing a burden on the balance of trade, creating a political predicament over real or perceived risks of employment loss and preventing recovery of investments in production facilities. A government or a company may therefore be reluctant to favour alternatives, and this might be reflected in prices, tax and duty policies, marketing, etc.

  Several African countries are in the process of changing import policies so that material for mosquito nets will be exempt from import duties aimed at protecting the local textile industry. A similar exemption for pyrethroids intended for the impregnation of mosquito nets may follow. More information can be found on the *Roll Back Malaria* web site http://mosquito.who.int/cgi-bin/rbm/home.

- Production of older pesticides, such as the POPs, is usually cheaper than production of newer, less hazardous ones. To lessen the difference, companies can, on a voluntary basis, decide to decrease profit margins on “alternative” pesticides if this will encourage a shift away from unsuitable (POP) pesticide use in low-income countries. A parallel is the case of pharmaceuticals, where producers have opted for lower prices on certain medicines against tropical diseases and HIV/AIDS.

Continue to point 9 in this chapter for a further discussion on replacing POP pesticides.

7. Efficacy of alternatives

Effective alternatives to all POP pesticides are available. Nevertheless, lack of knowledge about alternative approaches is a major constraint to their adoption.

Distrust of the efficacy of alternative approaches, including alternative pesticides, may have different backgrounds:

- Long reliance on residual pesticides in vector control has created expectations that alternatives should have the same, singular, 'silver bullet' characteristics. Non-chemical methods of vector control are, therefore, often rejected outright. Tailor-made packages of control methods in specific settings will only work if clear decision-making criteria and procedures are designed to support integrated management including chemical, biological and environmental management measures as appropriate.

- Access to information is essential and improving it is, in fact, a major challenge if the pattern of pesticide use is to change. Schools and universities need to ensure that curricula cover information on alternatives and that staff are fully aware of available options. Public sector and NGO workers in agriculture, health services and development in general may need in-service training. Success stories from other countries can provide information and inspiration. A few such stories are presented in chapter 4.

  For those with access to the Internet, many information sources can now be reached. UNEP's POPs website (http://www.chem.unep.ch/pops/) maintains an information system on POPs and alternatives, a collection of studies and action plans for eliminating/reducing releases of POP, and provides links to other relevant sites[2].

- When an attempt is made simply to replace a POP pesticide having long residual activity by another pesticide with shorter effect, re-treatments may be needed more often. This can be illustrated by the case of termite protection of buildings, where no non-POP pesticide alternative of comparable residual effect is available. This is one factor which has led to termites now being controlled using multi-pronged, integrated approaches. (For more information on termites, see termites, see sections 3.7 and section 4. 7).

- Pilot projects have been shown to be an effective and convincing method to generate knowledge and spread information. The Farmer Field School and Farmer Participatory Research approaches have been highly successful in reducing reliance on pesticides and introducing Integrated Pest Management in China, Indonesia, the Philippines, Viet Nam and several countries in Africa. More information on this is found in chapters 2 and 3. If such projects are adequately funded, exchange visits of local participants (and not just officials and scientists) between projects can be made. This will enhance their impact even further.

8. Insufficient public awareness

Public awareness of the hazards that POP pesticides pose to the health of present and future generations as well as to the environment is often lacking, particularly in developing countries. Pesticides are seen as inherently benign, in the same way that medicines are. (Many local languages even use the same word for "pesticide" and "medicine"!). Wide-scale information and training is needed to increase the level of caution and gain support for restrictions and bans.

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[2] For more information on IPM and Farmer Field Schools see:
http://www.communityipm.org and
http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/IPM,
for malaria and IVM see: http://www.psr.org/malaria_handbook.htm.
(More websites and other information sources are listed in annex 4).

It is important that the information reaches all groups, including women and children. Women are usually responsible for the health of the family, and carry a heavy burden in agriculture. Unborn children and infants are particularly vulnerable to toxic effects of pesticides. Children also work in agriculture, and, even more important, are the “keys” to the attitudes of future generations! Training of schoolteachers and provision of appropriate teaching materials is therefore vital.

9. A situation where a POP pesticide is being used has been identified, and an alternative strategy is now to be developed and/or applied. Nearest at hand is often just to look for a replacement pesticide. But - is there actually a need for substitution of POPs pesticides with other pesticides ?

No – go to point 10
Yes – go to point 11

Many pesticide applications are still carried out on a routine basis, or just as an often misconceived insurance, without the need having been determined in advance. This incurs unnecessary costs on already strained private or public financial resources, and puts an unnecessary burden on health and the environment.

A first priority must therefore be to critically assess the field situation based on an understanding of the local ecology. In situations where farmers have been trained to improve their knowledge of agro-ecosystems they can make informed decisions based on observation and analysis of the actual field situation. This is the basis of the Farmer Field School approach, which has found wide acceptance in many countries. More on this subject can be found in chapters 2 and 3.

10. The decision if and when to use pesticides should be taken in the context of an integrated approach.

Ecosystem observation and analysis are the basis for making informed decisions on pest and vector management. A range of methods exists for managing pests and vectors. Preference is then given to non-chemical methods, with chemical pesticides being used as “last resorts”. For a further introduction to integrated approaches, please go to chapter 2. Case studies of malaria control without pesticides, of IPM experiences and of termite management are presented in chapter 4.

11. Though there are many benefits in avoiding the use of pesticides, situations will occur when the risks of pesticide treatments are outstripped by the likely benefits.

It must be realised that there can be no simple-to-use table of “replacement pesticides for POPs”. Each substance, and even formulation, has its own properties.
In choosing a pesticide and application method in a specific situation, a number of factors will have to be assessed:

- The pesticide must be approved in the country of use and recommended for the intended purpose. Recommendations based on relevant local or regional research should be available. Labelling and packaging should fulfil national and international (FAO and WHO) standards (see the annex for references).

Pesticides that have high acute or chronic toxicity, or are potentially harmful to the environment, should only be used in emergency cases, when no other alternatives are available. The amounts applied should be minimised by the complementary use of non-chemical measures.

WHO has classified pesticides according to acute health hazard, and pesticides placed in the three highest categories (Ia, Ib and II) should not be recommended. Pesticides rated as “carcinogenic to humans” or “probably carcinogenic” (IARC 1 and 2A; USEPA B1 and B2) should be avoided. The same applies to pesticides in the PIC procedure / Rotterdam Convention, see table A4 in the annex. Lastly, evidence in recent years points to the endocrine disrupting properties of several pesticides (POPs as well as non-POPs), and even if a specific classification scheme is not available, this should be factored in. Please refer to the annex for suggestions on relevant information sources on pesticides (Tomlin, 2000).

- The risk of inducing or increasing pesticide resistance should be taken into account when pesticide use is among the control options under consideration. Resistance will eventually render a pesticide useless. As the number of acceptable pesticides decreases, there is a looming risk that the overall intensification of their use combined with the effect of their further uncoordinated application by different economic sectors will increase the pressures that lead to resistance. Only stepped-up advocacy of the notion that our decreasing arsenal of pesticides consitutes a valuable resource for future generations to deal with pest and vector emergencies may modify this trend in resistance development. A further discussion of pesticide resistance can be found in section 3.3.

- No pesticide should be recommended if appropriate and affordable protective gear is not available, and unless the use of this gear can be ensured. Persons applying pesticides should have undergone training to reduce risks associated with their use and handling, as required. Training and licensing of pesticide dealers should be made mandatory.

- An appropriate pesticide formulation and application method should be chosen. Different formulations of the same active ingredient may not have the same hazard to users. Granular formulations, for example, are often safer and require fewer protective measures than liquid formulations.

- Only good quality pesticides should be used. Over 30% of pesticides marketed in developing countries do not satisfy international standards. They may contain impurities or other undeclared substances, or too much or too little active ingredient. Using sub-standard pesticides leads to poor control, higher costs, increased risk to users and unnecessary releases into the environment (Kern and Vaagt, 1996).

- Large scale purchases of pesticides, for example for vector control operations by public health authorities, should only be made from companies pledging “cradle-to-grave product stewardship”, meaning, *inter alia*, that the company will take back unused quantities for re-sale or environmentally sound disposal. This is an important measure to safeguard against accumulation of unmanageable stocks of obsolete pesticides.

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2.

Approaches of choice - Integrated Pest Management (IPM) and Integrated Vector Management (IVM)

Alternative approaches that help reduce reliance on pesticides have been developed and tested in recent decades. As a result, Integrated Pest Management (IPM) and, to a lesser extent, Integrated Vector Management (IVM) are increasingly introduced and promoted in agriculture and as part of vector-borne disease control, respectively. Both IPM and IVM start from a thorough understanding of the local ecosystem and recognise that decision making needs to be decentralised to local levels and based on regular field observations and clear criteria. This implies a need for the development of decision-making skills and capacities at those local levels.
A range of measures exists that allow a reduction in reliance on pesticides. Integration aims at the optimal, most cost-effective combination of measures for a local situation. UNEP, FAO and WHO are committed to promote integrated strategies for more sustainable pest and vector management.

A number of factors have influenced the evolution process of IPM and IVM. These include:

- *Ecological factors*
  In the past, strategies that relied mainly on the use of chemicals to achieve pest control repeatedly led to failure. In agriculture, frequent treatments disturb the agro-ecosystem balance by killing the natural enemies of pests and cause resurgence and secondary pest release. In addition, populations of previously unimportant pests can increase when primary pests and natural enemies are destroyed. In both agriculture and public health, repeated applications favour the development of resistance in pest and vector populations to the pesticides used as well as cross-resistance to other pesticides.
- *Economic factors*
  Costs of pesticide use have been on the increase, both to individual users and to national economies. The pesticide treadmill is caused by ecosystem disruption. Unnecessary applications (e.g. calendar spray schedules) increase agricultural production costs. Failing control has led to an increased use of pesticides, while yields have declined. The economic costs and externalities associated with the impact of pesticide use on health and the environment have drawn greater attention.
- *An increased knowledge base*
  A growing body of scientific knowledge has contributed to more detailed understanding of ecosystems and of the interactions of the different elements within them. Understanding has also increased how certain pesticide-based practices threaten the sustainability of ecosystems. IPM and IVM have evolved based on increased scientific evidence.

- *Public opinion*
  Increasing concern over effects of pesticides on health and the environment has led to public pressure to reduce their excessive use. For example, groundwater contamination and poisoned wells are a matter of grave concern in countries with intensive agriculture, and in some countries concern over pesticide residues in food is already changing consumption patterns.

IPM and IVM are described in separate sections below, as the management of agricultural pests, disease vectors and other pests is dealt with by different public sectors. There are also obvious technical and managerial differences between managing pests of crops, livestock and buildings on the one hand and managing vectors of human disease on the other. IPM has reached an operational stage in many countries, while Integrated Vector Management is a concept that is only now evolving from the earlier approach of Integrated Vector Control. The IPM and IVM concepts have nevertheless a great deal in common and much can be gained by an improved co-ordination between the two at both policy and operational levels.

Integrated Pest Management – IPM

Agenda 21 (UN, 1992) states that IPM should be the guiding principle for pest control. Many countries and donor organizations have explicitly committed themselves to implementing IPM, and their number is increasing. All major technical cooperation and funding organizations are now committed to IPM, and many have developed specific policy or guideline documents (see annex 3 on selected international organizations and networks).

> *"Chemical control of agricultural pests has dominated the scene, but its overuse has adverse effects on farm budgets, human health and the environment, as well as on international trade. New pest problems continue to develop. Integrated pest management, which combines biological control, host plant resistance and appropriate farming practices, and minimises the use of pesticides, is the best option for the future, as it guarantees yields, reduces costs, is environmentally friendly and contributes to the sustainability of agriculture." (Agenda 21, UN 1992)*

The task of eliminating the use of POP pesticides in agriculture, and in building construction and maintenance provides a challenge for all stakeholders, from farmers to governments to inter-governmental and non-governmental organizations, to change towards more sustainable strategies for pest management. IPM provides an approach to pest management that is based on the knowledge and understanding of different elements of agro-ecosystems and their interactions, which allow to arrive at informed decisions. IPM reduces dependency on pesticide use, while maintaining production levels.

Ignoring ecology, failing pest control
Crop protection strategies that base themselves mainly on the large scale and regular use of pesticides have failed repeatedly. They create problems that are similar for many crops and at many locations. Pesticides disturb the agro-ecosystem balance by destroying the naturally occurring predator and parasite populations. Moreover, as a rule, restoration of such populations takes significantly longer than the restoration and further expansion of pest populations. This favours pest populations to grow without restrictions, leading to increased densities of pests that either were already

important or were of minor significance earlier. Repeated use of pesticides provides a continuous selection pressure on the pest populations, eventually resulting in resistance and cross-resistance. In response, amounts of pesticides applied are usually increased, leading to higher production costs, but seldom achieving adequate control. In the end this vicious circle leads to declining yields. Another common response is to replace certain types of pesticides with others. If underlying crop protection strategies are not changed, however, the same chain of events is bound to happen again.

In the last decades evidence of this process has been collected and documented for numerous agricultural crops: cotton, oil palm, cacao, rubber, citrus, rice, cabbage and other vegetables, soybean, coconuts, cassava, maize, wheat and sugarbeet. A list of selected references for a number of crops is presented at the end of this chapter.

How IPM concepts evolved

IPM as a concept has evolved since its introduction in the late 1950s, when the focus was on combining suitable methods to limit pests in a crop, to what is now a much broader approach within the framework of sustainable agricultural development.

Definitions of IPM abound, reflecting how the concept has changed over time, as well as the various emphases given by different users.

The evolution of IPM definitions:

"Integrated Pest Management means a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilises all suitable techniques and methods in as compatible a manner as possible, and maintains the pest populations at levels below those causing economically unacceptable damage or loss." (FAO, 1967)

"The presence of pests does not automatically require control measures, as damage may be insignificant. When plant protection measures are deemed necessary, a system of non-chemical pest control methodologies should be considered before a decision is taken to use pesticides. Suitable pest control methods should be used in an integrated manner and pesticides should be used on an as needed basis only and as a last resort component of an IPM strategy. In such a strategy, the effects of pesticides on human health, the environment, sustainability of the agricultural system and the economy should be carefully considered." (FAO Field Programme Circular No 8, 1992)

"IPM is a knowledge-intensive and farmer-based management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used such as enhancing natural enemies, planting pest-resistant crops, adapting cultural management, and, as a last resort, using pesticides judiciously" (World Bank 1997)

The IPM policy environment

In spite of commitments of governments to make IPM the guiding principle for pest control, acceptance and implementation of IPM has been slow. There are a number of reasons for this. Government policies may favour pesticide use. Knowledge of the ecology of cropping systems may be limited, or farmers who decide on management of their systems may have limited access to existing knowledge. Factors that encourage excessive pesticide use and counteract the introduction of IPM include:

- pesticide subsidies by governments and / or donors
- low or no import duties or sales taxes on pesticides
- credit and crop insurance institutions requiring farmers to use pesticides
- aggressive marketing by the pesticide industry
- insufficient information on alternative approaches
- orientation towards pesticide use of national education, research and extension systems, as well as plant protection services and a lack of multi-disciplinary collaboration.

(adapted from Farah, 1994)

Progressive expansion of IPM strategies will need a supportive, enabling policy framework. At the field level, knowledge and understanding of the ecology of agricultural production systems is needed to make informed decisions on management. This knowledge needs to be decentralised to local levels. It has to be in the hands of farmers who are responsible for management of their own systems.

Policies, strategies and programmes supporting IPM should be put in place and implemented if reliance on pesticides is to be reduced. They should contain at least the following elements:

- a cohesive national framework – for example, pesticide registration regulations can be made part of the environment policy
- removal of counterproductive financial instruments - pesticide subsidies, for example, must be removed
- enforcement of specific policy supporting measures (e.g. banning or restricting specific pesticides, applying selective taxes)
- strengthening and enforcement of the regulatory framework, restricting or banning pesticides incompatible with IPM or of high toxicity, preferably with budget appropriations allowing effective enforcement
- actions aimed at an increased awareness amongst the public and producers, of the benefits of reducing pesticide use and of using IPM approaches
- training of extension staff and farmers in the principles and field-based decision-making skills needed for IPM
- increasing knowledge on ecology and strengthening the evidence of effectiveness of interventions as basis for decision making (e.g. in Farmer Field Schools, see section 3.5 of the next chapter)
- national priorities for research, training and extension in support of IPM implementation
- encouragement of local IPM initiatives
- ensured participation of local stakeholders (farmers, communities, etc.) in each step, as a vital requirement for success.

IPM at field level

Farmers manage often complex agro-ecosystems. IPM is holistic in its approach, which builds on knowledge about the different elements in the system (soil, water, nutrients, plants, pests, natural enemies, diseases, weeds, weather) and their interactions, to arrive at sound management decisions. As the decision makers, farmers are central to this process and should have the opportunity to improve their knowledge through suitable adult education methods. Farmer Field Schools (FFSs) provide such an opportunity. Their programme aims at strengthening farmers' knowledge and understanding of the agro-ecosystems they manage. They also aim to develop farmers' skills to observe and analyse agro-ecosystems, to come to informed management decisions. FFSs use non-formal adult education approaches, farmers learn by taking part in solution seeking in a problem-based setting. Education is field based, study fields are part of any FFS. FFSs are season-long and follow the development of a crop from seeding through harvest. More details about how FFSs operate is given in section 3.5.

The holistic and farmer-centred approach of IPM is reflected in the following principles:

- grow a healthy crop
- observe your crop regularly
- conserve natural enemies
- empower and give credit to farmers as the experts.

The IPM toolbox

The toolbox for integrated pest management contains a range of concepts, methods and measures. Some are listed below:

- General cultural practices to ensure vigorous crops: a plant growing in good conditions is generally less vulnerable to pest damage than a plant already under stress. Cultural practices include soil preparation, water management, nutrient management, etc.
- Host plant resistance – using resistant strains in plant breeding. This is important both during crop growth and storage.
- Crop compensation – crops can tolerate damage in certain stages of development without it leading to yield losses.
- Making the crop or other valuable objects unattractive or unavailable to pests. For example: adjusting planting dates so crop development does not coincide with pest appearance; assuring that cereal stores are tightly sealed.
- Increasing crop diversity, e.g. by crop rotations or multiple cropping.
- Hygiene: e.g. good sanitation of storage buildings, using clean seed when planting.
- Biological control – primarily by conserving and enhancing natural biological control already in the field, and, in selected situations, by introducing natural enemies of a pest. (note: considerable research and thorough evaluations are required to avoid disrupting existing ecosystems before new species are introduced) . The Secretariat of the International Plant Protection Convention (IPPC) has issued criteria and standards for the selection and importation of exotic biological control organisms (IPPC Secretariat, 1996).
- “Bio-rational methods” : pheromones to trap pests or disrupt mating, release of sterile insects to limit reproduction or manipulating the atmosphere (in closed stores) to kill pests.
- When pesticides are used – as a ”last resort” – their toxicity to non-target organisms should be as low as possible and they should be as selective as possible. Certain pesticides of natural origin are compatible with IPM, causing minimum disturbance of natural control mechanisms. A well-known example is the botanical neem (oil extracted from the seeds of the neem tree). A word of caution: it must not be taken for granted that pesticides of natural origin by definition are safer than synthetic pesticides. There are several natural compounds with

varying levels of toxicity, which is why recommendations must be based on reliable information. Neem, for example, has a negative impact on fish and is therefore not suitable for rice paddies where fish are cultivated.
- Phyto-sanitary measures – efficient methods and routines for preventing the introduction and spread of new pests.

IPM will usually not develop by itself and needs to be actively promoted. Pilot projects are very useful and should be developed together with stakeholders, women as well as men. Field exchange visits can be useful for promoting IPM among different categories of stakeholders.

Components of an IPM programme

Steps and processes in a successful IPM programme include:

At the field level
- Improving knowledge and understanding of the ecology of cropping systems.
- Strengthening knowledge and understanding of the impacts of current farmer practices in a cropping system.
- Based on this information, identification of opportunities for IPM strategies to be applied in specific cropping systems.
- Development of training curricula on IPM, including field studies on ecology to fine-tune management and using training approaches suitable for adult learning. Ideally, farmers, trainers and researchers work together in this activity.
- Exchanges with other IPM programmes for field workers, to become familiar with ecological and training approaches, and use them as a source of further local development.
- Pilot training for trainers and farmers.
- Monitoring and evaluation of pilot training activities.
- Well-planned scaling up of training activities, with a focus on building capacity at local levels.
- Continued monitoring and evaluation to improve activities.
- Identifying issues that are not adequately covered (such as other cropping systems, specific problems) and initiating a process to elucidate these.
- Enable farmers to engage in participatory research to develop training curricula for new topics.

At policy level
- Assessing present policies, and how they support or obstruct IPM activities.
- Access to data generated at field level, giving information on IPM.
- Visiting field activities to get familiar with IPM approaches and to discuss opportunities and constraints directly with farmers.
- Accessing information on pesticide policies in other countries which have ongoing efforts in IPM.
- Identifying changes in policy that would support IPM better.
- Organising workshops for policy review, adjustment and harmonization.

Examples of successful implementation of IPM are presented in chapter 4.

Integrated Vector Management (IVM)

Arthropods that transmit rickettsiae, viruses, bacteria or parasites causing diseases in humans and in animals are called vectors. Vector control aims at interrupting disease transmission. Depending on local conditions, it may be a component of greater or lesser importance within an integrated disease control programme.
An overview of components of vector-borne disease control is presented in the box below; an overview of vector-borne diseases in the box on the following page.

Components of integrated vector-borne disease control

I. *measures against the **pathogen**: prophylactic or curative drugs, immunisation when possible*
II. *measures against the **vector**: environmental management and biological and chemical methods*
III. *measures to **reduce contact** between humans and the infected vectors: personal protection measures, such as the use of insecticide impregnated mosquito nets and screening of houses, supported by health education*

Source: Tiffen, 1991

An historical perspective
The history of vector control is very much the history of malaria control.
The incidence and prevalence of other vector-borne diseases (such as leishmaniasis and filariasis) were often significantly reduced as a result of malaria vector control programmes, particularly in the malaria eradication era. It can be roughly divided into three periods:

the pre-DDT era, until approximately 1950, when there was a strong reliance on environmental management (then referred to as naturalistic methods, source reduction or species sanitation), although certainly not to the exclusion of chemical methods (Litsios, 1996). During this period, the control focus was on larviciding to reduce mosquito population densities. This had a considerable public health impact in areas where transmission levels were relatively low and, certainly where infrastructure improvements were involved, the results were highly sustainable.

the eradication era: following the advent of DDT in the 1950s WHO embarked on an extensive programme aimed to eradicate malaria from large parts of the world. The approach was based on indoor residual spraying, killing indoor biting and resting *Anopheles* mosquitoes and interrupting transmission by reducing their lifespan.
The Global Malaria Eradication Programme was conceived as an intense, time-limited effort and achieved dramatic, though sometimes hard to sustain results in Europe, the Eastern Mediterranean, Asia and the Americas.

the post-eradication era: as insecticide resistance and dwindling community acceptance undermined the effectiveness of house spraying campaigns, and political priorities (and therefore resources) shifted in the wake of eradication successes, resurgence of the disease occurred with a vengeance. The Member States of the WHO called an end to the eradication efforts by 1969. A period of disarray followed, with governments slow to dismantle the well-entrenched eradication structures and procedures, until consensus was reached on a new Global Malaria Strategy at the Summit meeting in Amsterdam in 1992 (WHO, 1993).

Insect-borne diseases, their vectors, their global public health importance and their distribution

Disease	Vector Species	Burden of disease [1] estimated 2000 DALYs	Distribution
Filariases			
lymphatic filariasis	*Culex spp.*	5 549 000	tropical urban areas
onchocerciasis	*Simulium spp.*	951 000	W.-Africa, C.-America
Malaria	*Anopheles spp.*	40 213 000	tropics, main burden Sub-Saharan Africa
Leishmaniasis	Sandflies	1 810 000	patchy, Old World
Old world	(*Phlebotomus spp.*)		(semi-)arid zones,
New World	(*Lutzomyia spp.*)		New World humid forests
Trypanosomiasis			
African trypanosomiasis (sleeping sickness)	Tsetseflies (*Glossina spp.*)	1 585 000	Patchy, in W.- and southern Africa
American trypanosomiasis (Chagas disease)	Triatomid bugs	680 000	S.- and C.- America linked to poor housing
Arboviral diseases			
Dengue	*Aedes spp.*	433 000	urban tropics
Japanese encephalitis	*Culex spp.*	426 000	S. and SE Asia, linked to irrigated rice/pigs
Yellow fever	*Aedes aegypti*	not listed	Africa, S. America

1) Global estimate of Disability Adjusted Life Years in 2000 (WHO, 2001a)

The advent of residual pesticides marked a much greater paradigm shift in disease vector control than it did in crop protection. Earlier vector control strategies, which aimed at reducing vector densities, would only have an effect on vector-borne disease transmission where transmission levels were low and were a direct function of such densities. In large areas where transmission of, for example, malaria was very intense, reductions in vector densities had little or no effect. The use of insecticides allowed for a reduction of the lifespan of adult mosquitoes. This so-called longevity is the key determinant of vectorial capacity - simply put: the longer a mosquito lives, the greater the chance it transmits a disease. Moreover, where vector behaviour included indoor biting and resting, the simple application of residual insecticides on the inner walls of houses provided a uniform method of control. The initial results were commensurately spectacular.

For many years, DDT played a key role in vector control. Millions of human lives were saved by the residual house spraying campaigns. Malaria, usually of the unstable type, was eradicated from substantial areas in the temperate and sub-tropical zones and from some small island states in the tropics. The malaria eradication campaigns brought health services to the community level in many countries and provided employment and livelihood for tens of thousands of people. Yet, as part of this paradigm shift, the concept of a flexible malaria control programme geared to generating local solutions to local problems disappeared and traditional multidisciplinary and intersectoral support for malaria vector control operations was replaced by strictly vertical, health sector confined operations. While the new reliance on DDT and other residual insecticides triggered research into the behaviour and genetics of vectors, research on the ecology and biology of vectors came to a virtual standstill. The build-up of an environmental load of DDT and its residues started, although it should be stressed that the proportion of DDT used for public health purposes has been minor compared to the amounts applied in agriculture, until its banning for agricultural use from the first half of the 1970s.

WHO position and recommendations on DDT use

The most recent recommendations of the World Health Organization concerning DDT give specific guidance on its proper use. A WHO Study Group (WHO, 1995) arrived at the following conclusions and recommendations:

(1) the information does not provide convincing evidence of adverse effects of DDT exposure as a result of indoor residual spraying as carried out in malaria control activities.

(2) there is, therefore, at this stage no justification on toxicological or epidemiological grounds for changing current policy towards indoor residual spraying of DDT for vector-borne disease control.

(3) DDT may therefore be used for vector control, provided that **all** the following conditions are met:

- it is used only for indoor spraying;
- it is effective;
- the material is manufactured to the specifications issued by the WHO;
- the necessary safety precautions are taken in its use and disposal.

(4) in considering whether to use DDT governments should take into account the following additional factors:

- the costs involved in the use of insecticides (DDT or alternatives)
- the role of insecticides in focal or selective vector control, as specified in the Global Malaria Strategy
- the availability of alternative vector control methods, including alternative insecticides [… *this was a departure from the long-held WHO position that considered DDT to be the insecticide of choice where effective* …]

- the implications for insecticide resistance, including possible cross-resistance to some alternative insecticides
- the changing public attitude to pesticide use, including public health applications.

The WHO outlook with respect to the future of insecticide use for vector control, and of DDT in particular, was clearly stated by the World Health Assembly in 1997. The replacement of DDT should not be limited to alternative pesticides, but should consider alternative strategies and methods that allow an overall reduction of the reliance on pesticides. Excerpts follow in the box.

FIFTIETH WORLD HEALTH ASSEMBLY (Geneva, 5-14 May 1997)

Excerpts from WHA Resolution 50.13: Promotion of chemical safety, with special attention to Persistent Organic Pollutants

The fiftieth World Health Assembly calls, inter alia, *upon Member States*

◊ *to involve appropriate health officials in national efforts to follow up and implement decisions of the UNEP and WHO governing bodies relating to the currently identified persistent organic pollutants;*

◊ *to ensure that scientific assessment of risks to health and the environment is the basis for the management of chemical risk;*

◊ *to continue efforts to establish or reinforce national coordinating mechanisms for chemical safety, involving all responsible authorities as well as non-governmental organizations concerned;*

◊ *to take steps to reduce reliance on insecticides for control of vector-borne diseases through promotion of integrated pest management approaches in accordance with WHO guidelines, and through support of the development and adaptation of viable alternative methods of disease vector control;*

◊ *to establish or strengthen government mechanisms to provide information on the levels and sources of chemical contaminants in all media, and in particular in food, as well as on the levels of exposure of the populations;*

◊ *to ensure that the use of DDT is authorised by governments for public health purposes only and that, in those instances, such use is limited to government-authorised programmes that take an integrated approach and that strong steps are taken to ensure that there is no diversion of DDT to entities in the private sector;*

◊ *to revitalise measures for training and for increasing public awareness in collaboration with inter-governmental and non-governmental organizations, in order to prevent poisonings by chemicals and, in particular, pesticides.*

Source, WHO, 2001

The WHO Action Plan for the reduction of reliance on DDT in disease vector control (WHO, 2001b) defines alternatives as use of alternative **products** for chemical and biological control, alternative **methods** for the application chemical and biological control, environmental management and personal protection, and alternative **strategies** i.e. integrated vector management based on scientifically sound criteria, cost-effectiveness analyses and delivery systems compatible with current trends in health sector reform. This reform may include decentralization, intersectoral action at the local level and subsidiarity in decision-making.

Vector control definitions

In the 1980s, interest in vector control methods other than the application of residual insecticides re-emerged and led to the development of new strategies based on the principles of Integrated Pest Management in agriculture. In a series of meetings the WHO Expert Committee on Vector Biology and Control discussed the various alternatives (environmental management, biological control, genetic control, urban vector control) as well as the principles of integrated vector control (IVC) (WHO, 1983). The IVC approach included (1) personal protection, (2) habitat management and source reduction, (3) the use of insecticides both as larvicides and adulticides, (4) an appreciation of the possibilities of biological control by recognising the role of fish in reducing larval numbers, and (5) training and education. Definitions as they subsequently developed are presented in the box below.

Vector control concepts based on the principles of integrated management

Integrated Vector Control (IVC):

IVC can be considered as the utilisation of all appropriate technological and management techniques to bring about an effective degree of vector suppression in a cost-effective manner. […] The essential requirement of integrated vector control is the availability of more than one method of control, or the ability to use one method that favours the action of another method, e.g. a selective pesticide without detrimental effect on naturally occurring biological control agents. A better quantitative understanding of the action of the control methods on the affected stage or stages of the vector is important and must be based on understanding vector populations and transmission dynamics, possibly with the additional use of transmission models. (WHO, 1983).

Selective vector control

The targeted use of different vector control methods alone or in combination to prevent or reduce human-vector contact cost-effectively, while addressing sustainability issues (WHO, 1995)

Integrated Vector Management (IVM, working definition)

A process of evidence-based decision-making procedures aimed to plan, deliver, monitor and evaluate targeted, cost-effective and sustainable combinations of regulatory and operational vector control measures, with a measurable impact on transmission risks, adhering to the principles of subsidiarity, intersectoriality and partnership. (Bos, 2001)

Elements of IVM

Integrated Vector Management has a number of characteristics that distinguish it fundamentally from its conceptual predecessors:

- IVM starts with an assessment of the local transmission ecology and it is, therefore, essentially an evidence-based, bottom-up approach.

- IVM requires a transparent public decision-making procedure based on clearly defined criteria, to arrive at the locally optimal combination of interventions.

- In building up the combination of interventions, there is a clear sequential hierarchy, starting with locally suitable environmental management methods and personal protection methods, to which may be added biological control methods and eventually, as a final resort, chemical interventions to arrive at the desired level of transmission risk reduction.

- IVM includes both the delivery of vector control interventions and the regulation of activities of other public and private sectors. This includes the effective assessment and subsequent reduction of transmission risks resulting from development activities of other sectors (e.g. irrigation schemes, transport infrastructure, urban planning and development).

- IVM considers all options for intersectoral action and applies the principle of subsidiarity, i.e. decision making at the lowest possible administrative level.

In addition to this, IVM supports the principles of sustainability and is compatible with health sector reform, in particular decentralization and sector-wide approaches, and emphasises the economic aspects of the different options, including synergies resulting from their combination.

The WHO Action Plan for reduction of reliance on DDT

The reduction of reliance on DDT for public health use, and eventually its complete elimination, will need concerted action from government authorities at different levels. WHO has formulated a five point Action Plan, which aims to assist Member States in their efforts to comply with World Health Assembly Resolution 50.13, i.e. to reduce their reliance on pesticides for public health purposes in general and on DDT in particular, without jeopardising the level of protection offered by their vector control programmes (WHO, 2001b).

The five points of this Action Plan are presented below, with their objectives.

A. Country Needs Assessment

1. Ensure that health concerns are mainstreamed in the POPs negotiations in order to prevent any negative health impact as a result of the Stockholm Convention’s regulations concerning DDT.

2. Provide a framework for needs assessment in countries enabling the transition towards a reduced reliance on insecticides while maintaining, and, if possible, improving effective vector control.

3. Provide incentives and leverage funds for strengthening the capacity of governments to promote, utilise and evaluate vector control alternatives.

B. Safe management of DDT stockpiles

1. Prevent damage to the environment and minimise risk to human health.

2. Develop criteria for decision making on options to use, reformulate, repack, or dispose of DDT stocks

3. Establish a reliable and verifiable management process that clearly defines the responsibility for stockpile management

C. Institutional Research Network

1. Formulate joint research projects of health and agriculture scientists / research institutions on the development of integrated pest and vector strategies.

2. Further develop, test and / or implement sustainable, environmentally safe and cost-effective alternatives to the use of DDT for vector control.

D. Monitoring

1. Assist Member States in programming, monitoring and reporting information on the following DDT-related issues:

- Human exposure to DDT
- Public health outcomes of DDT reduction
- Production, storage and usage of DDT
- Efficacy and appropriateness of DDT in areas where it continues to be used
- Efficacy and appropriateness of alternatives to DDT, including integrated vector management (IVM)

E. Advocacy

1. Provide background information on the POPs negotiations and on DDT to the health sector.

2. Ensure that the health sector’s views are known to delegations in the POPs negotiations.

WHO / PHE and Roll Back Malaria organised a number of advocacy activities during the POPs negotiations, and developed guidelines for vector control needs assessments in Member States which will be published early 2002.

DDT regulations

The regulations which effectively singled out DDT for exclusive use in vector control programmes in many countries significantly extended its lease on life as a vector control tool. As was subsequently shown, for example for carbamates in Central America (Georghiou, 1972, 1987), the wide-spread and intense agricultural use of pesticides may contribute importantly to an accelerated induction of insecticide resistance in disease vectors. Cotton-growing areas were notorious for their high environmental pesticide pressure and the negative consequences for susceptibility of disease vectors. Similar observations are now made in connection with synthetic pyrethroids. On the other hand, the regulatory measures banning DDT use for plant protection created the phenomenon of deviation of DDT from the health to

the agricultural sector. Through this illegal “leakage” some DDT continues to end up in agro-ecosystems and beyond. This phenomenon prompted the government of one southern African country to shift from DDT to synthetic pyrethroids for its indoor residual spraying programme, to avoid contamination of its tobacco crop with DDT and its residues, which would jeopardise access to important export markets.
In some cases, the concomitant sub-lethal dosage of the formulations used for indoor spraying has contributed to an accelerated induction of insecticide resistance. To complicate matters further, in many places DDT has become a generic name for effective insecticides and a range of compounds may be illegally traded under its name.

Coordinating IVM and IPM

In rural areas with important agricultural production systems and an environment receptive to vector-borne disease transmission, options exist, at least in theory, to achieve economies, of scale or otherwise, by better coordinating IPM and IVM.

Furthermore, as pesticide use in agriculture may cause resistance to develop in disease vectors, there is a need for intersectoral co-ordination of their use, and, more importantly, to limit their use to the extent possible. So far, there is only scarce experience in establishing co-ordination and co-operation between the agriculture and health sectors in the implementation of IPM / IVM activities, although there are various commonalities. The relatively long-standing experience in agriculture of applying integrated pest management, with a decision-making infrastructure for decentralised approaches that provide local solutions to local problems contrasts with the current state of vector control. From the IPM experience many lessons and opportunities can be derived for the development of integrated vector management strategies. A joint UNEP / WHO / FAO workshop held in Asia in March 2000 (UNEP, 2000) assessed options to promote environmental management for vector control through agricultural extension programmes. It concluded, *inter alia,* that the concept and strategies of Integrated Pest and Vector Management should be adopted by such programmes in their promotion of sustainable agricultural development and the health of rural communities. The inter-relationship between environment, agriculture and health is key to the identification and implementation of sustainable strategies for effectively protecting agriculture from pests, communities from diseases like malaria and ecosystems from hazardous chemicals.

IPM and IVM are both driven at the local level. There will therefore be new opportunities to establish beneficial institutional arrangements for their joint implementation. Economies can possibly be achieved through joint monitoring of insect populations, integrating IVM into the efforts of Farmer Field Schools, bearing in mind synergies between IPM and IVM interventions in the area of, for example, (irrigation) water management, elucidating the economic impacts of ill health on agricultural production and multidisciplinary ecosystem research that studies risks to both humans and crops.

Such opportunities should be seized to complement other vector-borne disease management approaches. Recently a System-wide Initiative on Malaria and Agriculture (SIMA) was started by the Consultative Group on International Agricultural Research (CGIAR) that should lead to a multidisciplinary research agenda and to research that expands our knowledge base on agriculture-health links.
The specific objectives of SIMA are :

- To create awareness on the links between health and agriculture and on opportunities for minimising malaria risks and enhancing human health through improved agro-ecosystem and natural resource management
- To promote applied field research for the development of control measures against mosquitoes and malaria parasites through improved management and utilization of natural resources
- To develop capacity for inter-disciplinary research and for the implementation of malaria control interventions based on improved management and utilization of natural resources in malaria-endemic regions of the world.

For information on SIMA visit their website www.cgiar.org/iwmi/sima/sima.htm.

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3.

Specific aspects of pest and vector management

This chapter provides information on a range of issues relevant to the task of reducing and/or eliminating the use of POP pesticides and selecting alternative approaches.

3.1. Pesticide policy reform in support of IPM and IVM[1]

Evidence has been accumulating for some time that pesticide use frequently is above its socially defined optimum, i.e. the benefits do not outweigh the costs (see also section 3.2.). This may be due to fundamental economic distortions, for example inappropriate subsidy and price policies (Repetto, 1985). Such policies will counteract efforts to introduce and sustain IPM and IVM approaches, and changes are therefore called for. The process of change should start with an analysis of national pesticide policies and should lead to the formulation of an optimal combination of policy instruments. A more recent phenomenon is the growing capacity of developing countries to produce pesticides locally. Often mainly first or second generation, highly toxic pesticides are produced, for local use or for export to countries with weak or poorly enforced policy/regulatory frameworks (WRI, 1999).

The first step towards policy reform is to establish a well-structured overview of the crop protection situation in the country following a framework of pesticide policy analysis (Agne *et al.,* 1996). Such a status report will give quantitative as well as qualitative indicators of the factors that drive pesticide use.

The development of a regulatory policy framework is an essential first step in the process of rationalising the use of insecticides.

The report can serve as a point of departure for the initiation of a dialogue aimed at building consensus for action. Experience has shown that workshops with participants from different disciplines are effective tools for raising awareness and improving the quality of the discussion. Changes in pesticide policy will often challenge existing structures and interest groups. Proponents of change must therefore be adequately equipped with well-founded scientific arguments. Support from international groups with experience in such debates is also essential.

In order to significantly enhance the probability that the introduction and strengthening of IPM/IVM activities and programmes be sustainable, the changed pesticide policy must be integrated into the mainstream of agricultural, economic and envi-

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[1] Partly based on a text generously provided by Professor Hermann Waibel, University of Hannover, Germany

ronmental policy-making. Policies promoting capacity building and resource allocation to ensure that the enforcement of pesticide regulations is carried out effectively are a crucial part of the overall framework.

In the health sector, schedules for in-door residual spraying became well-entrenched in many endemic countries at the time of the global malaria eradication programme. These rigid schedules were designed for quasi-military operations with maximum, sometimes redundant coverage, all geared towards the time-limited goal of eradication. When the global eradication effort was abandoned at the end of the 1960s, they continued to be the core of vector control programmes in many countries. Only in the 1990s could the start of a general shift towards targeted or selective spraying be observed, in the wake of the adoption of the new WHO Global Malaria Strategy at a summit meeting in 1992 in Amsterdam. Economic pressures played an important role in this process: donations of insecticides for vector control by industrialised countries were gradually phased out and the spread of insecticide resistance forced the introduction of more expensive products and formulations.

Health sector reform provides the enabling environment for a further evolution of vector control programmes. Decentralisation is a critical component of this reform and as decision making on interventions moves to the local level, the nature and frequency of chemical vector control may be further rationalised and optimised for specific settings. In countries where health sector reform has not yet led to changes in vector control policies and programmes, situation analysis, risk mapping and stratification, together with the development of improved decision-making criteria and procedures will be important steps towards a reduction in the reliance on insecticides.

3.2. The costs of changing pest control strategies – and the costs of not changing

It is frequently argued that banning, restricting or reducing pesticide use will come at considerable cost to individuals and society. This argument has been used against efforts to limit current pesticide use. Studies have analysed the effects of either banning or restricting individual pesticides without considering suitable alternatives, or sweeping statements have been made about the overall impact of more general reductions or restrictions on chemical inputs at large.

The costs of changing pest control practises are often exaggerated. The benefits can out-weigh the costs!

Although there obviously are economic consequences to any action taken (or not taken), predictions may be fraught with inaccurate assumptions and confounding factors. They often tend to overestimate costs of pesticide reduction and/or elimination.
A critical review of economic impact studies (Jaenecke, 1997) brought to light the most frequent shortcomings:

- The cost of "losing" the use of a pesticide is not weighed against the benefits to health and environment from its elimination. Although changes in yields and production costs may lend themselves more easily to economic estimation, the long-term impact of exposure may be more significant. Improvement of productivity resulting from better health, for example, has been shown to more than

compensate for the additional pest damage (Rola and Pingali, 1993; Antle and Pingali, 1994).
- No attention is given to the fact that reducing pesticide use will slow down development and spread of pesticide resistance, thereby conserving the efficacy of the pesticide for more urgent situations.
- The ability of farmers and other pesticide users to adjust to new circumstances is not accounted for. It is assumed that crop choices and cropping methods are fixed givens, while in real life they are flexible and subject to decisions that are part of adaptive management.
- It is usually fairly easy to compare the costs of different (alternative) pesticides being used for the same purposes, and in similar situations (see below). Changes towards integrated management methods require much more complex calculations, since a range of practices will be involved. They are therefore usually omitted. Excellent guidance on how such calculations can be made for vector control operations is provided by the joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM) (Phillips *et al.,* 1993). See the first case study in chapter 4 for an example from India, where exclusive reliance on non-chemical methods proved more cost-effective than DDT use.
- The capacity of researchers and industry, given clear incentives and policy signals, to produce innovation is underestimated. The faster-than-estimated global phase-out of chlorofluorocarbons (CFCs) and chlorine-bleached paper pulp can serve as encouraging examples of this.

A few studies in which external costs related to pesticide use have been included indicate that these costs can be very large. Cost items in a study on agricultural pesticide use in Thailand (Jungbluth, 1996) included for example:

- health costs (treatment, working days lost by those ill and by those taking care of the ill)
- costs of exceeded residue levels (leaving a proportion of produce unfit for marketing)
- costs related to pesticide resistance and resurgence
- pesticide-related research
- costs of pesticide quality control and residue monitoring
- costs of pesticide regulation
- costs of pesticide-related extension

These costs put together amounted exactly to the total value of pesticides sold in Thailand. The "true costs" of the pesticide would thus be double that of the chemical alone. Similar studies in Germany and the USA showed "additional costs" of 23 and 200%, respectively (Jungbluth, 1996).

The low cost of DDT is often used as an argument for its continued use. This may have been a relevant consideration in the past. Recent cost comparisons show, however, that the argument has lost much of its validity, as detailed below.
The product cost of, for example, synthetic pyrethroids may still be higher than that of DDT. When taking into account operational cost such as transport, storage and application, however, the overall cost of indoor spraying with alternative insecticides per house per six months will in several instances overlap with the cost of DDT. This is especially true for pyrethroids, as they are much less bulky than DDT, thus reducing transport and storage costs.

Table 2: Cost comparisons of insecticides for indoor vector control (excluding operational costs) (adapted from Walker, 2000)

Insecticide (SP = pyrethroid)	Dosage (grams of active ingredient per m^2) per spray	Assumed number of sprays per six month period	Product cost range (US$) per house per 6 months - 200 m2/house (based on 1998/1999 prices)
DDT	2	1	1.50 – 3.00
malathion	2	2	3.20 - 6.40
fenitrothion	2	2	7.70 - 15.40
bendiocarb	0.1 - 0.4	2	4.00 - 10.00
propoxur	2	2	28.00 - 56.00
lambda-cyhalothrin (SP)	0.02 - 0.03	1	3.75 - 4.50
deltamethrin (SP)	0.025 - 0.05	1	12.00 - 24.00
permethrin (SP)	0.125 - 0.5	2	2.8 - 13.60
cyfluthrin (SP)	0.02 - 0.05	1	2.20 – 5.50

3.3. Pesticide resistance

Resistance is a phenomenon whereby a pathogen, pest or vector population, through the selection of genetic traits or through mutations, gains the ability to survive treatment with a chemical at a dose that would originally have been lethal. It is a characteristic that is selected through the repeated use of the same pesticide. Resistance has its roots in genetic variation and natural selection, i.e. the least susceptible individuals in each generation are most likely to survive and reproduce, genetically conferring their lower susceptibility to their offspring. From this follow the principles that

- all pest and vector organisms will eventually develop resistance if current patterns of pesticide use are continued.
- any pesticide will eventually give rise to the development of resistance.

In reality, the speed with which resistance evolves varies greatly between species and ecosystems. Many mosquito vectors, for example, have developed resistance fairly rapidly, while no significant resistance has yet been detected in tsetse flies and triatomine bugs (vectors of Chagas disease). Insecticide resistance is a huge and costly problem in both agriculture and public health. It shortens the “effective life” of a substance. This leads to higher product costs. Increased resistance will usually also lead to increased use, at least initially, since farmers and other users will increase application rates and frequencies in an attempt to maintain pest

Pesticide resistance is a significant threat to the effectiveness of pesticides that may be needed in urgent situations – and a strong argument for IPM and IVM

and vector species under control. This translates into higher cost and a greater environmental impact. Widespread pesticide resistance causing uncontrollable pest situations has in fact been one of the main driving forces behind the development of IPM. The impact of agricultural applications of insecticides on resistance in populations of disease vectors has been covered in chapter 2.

Of particular concern is cross-resistance, whereby the use of one pesticide will induce resistance to other pesticides as well. This is most frequent among closely related substances (e.g. between pyrethroids), but can also occur between different pesticide groups such as organophosphates and carbamates. Different mechanisms may be at play at the genetic level. Of relevance to malaria control is the fact that cross-resistance can occur between DDT and pyrethroids through the expression of the so-called kdr genes. This has been observed in West Africa (Chandré *et al.*, 1999). In other parts of Africa, for example southern Africa, such cross-resistance has not (yet) been observed, because there pyrethroid resistance in anopheline mosquitoes is caused through other genetic mechanisms.

Susceptibility to a pesticide should be regarded as a resource to be maintained, since situations may occur where no other practical option is available. From a sustainability perspective, this is similar to cases of life-saving antibiotics that are rendered useless by careless over-prescription and use.

Intensive pesticide use in agriculture may increase the risk of resistance developing in vector populations. Spraying pyrethroids in rice paddies (where mosquito larvae breed) can, for example, reduce the effect of impregnated mosquito nets. This again underscores the need for a holistic, cross-cutting approach, consistent regulations and co-operation between different sectors.

Several strategies can be applied to slow down or even avoid the development of resistance. First and foremost among these is the reduction of pesticide use. This is yet another strong argument in favour of adopting the IPM/IVM approaches, with their priority reliance on environmental management and non-chemical control methods. Other possible resistance management strategies include:

- limiting the treated area to the most urgent foci;
- using pesticides with low persistence, especially in agriculture. (High persistence was previously considered a desirable property in a pesticide, e.g. for residual treatments, but it increases risks of selecting for resistance and of other ecosystem disruptions);
- leaving refugia untreated to conserve susceptible individuals in pest populations;
- using additives to enhance the pesticidal effect;
- monitoring for early signs of resistance. Resistance can sometimes be slowed if detected early;
- Within the context of IPM/IVM, installing a programme of pesticide rotation.

Using mixtures of unrelated pesticides has also been recommended as a resistance management strategy, but strong supportive evidence is lacking. There are reasons for caution: so-called synergistic effects may increase user hazards, as mixing pesticides can raise toxicity dramatically, and extensive use of such mixtures may create super-resistent pests.

In conclusion, close collaboration and frequent communication must be ensured between institutions responsible for health, environment and agriculture. Any ongoing or proposed control strategy will have implications for all these sectors, and it is vital that policies and strategies are consistent and mutually supportive. Effective collaborative arrangements are important for institutions and organisations at all levels, from local to international.

3.4. Pesticide stocks and the obsolete pesticide problem

Eliminating the use of POP pesticides is not only a question of providing viable alternative strategies, but also of removing remaining sources of POPs. Production of most POP pesticides has ceased, but remaining stocks are of utmost concern. A recent FAO estimate puts the total amount of obsolete pesticides of all types in non-OECD countries at between 400,000 and 500,000 tons (FAO, 2001). More than 20% of global stocks is of the organochlorine type - current or potential future POP pesticides. The amount in Africa and the Near East alone is around 47,000 tons.

Obsolete pesticides

- constitute an immediate threat to the health of humans and livestock, particularly since they are often stored in populated areas
- may sooner or later leak into and contaminate groundwater and the environment in general. Stores are often in deplorable condition, with defective containers, no rain protection, unfenced sites, etc.
- may find their way to the illicit pesticide market. This can lead to unacceptable residue levels in food and export crops

Stocks of obsolete pesticides are a huge threat to health and environment in many developing countries

FAO has assumed a lead role in organising and co-ordinating the disposal of obsolete pesticides. The Organization addresses the problem in a number of ways:

- mobilising resources and organising disposal operations together with governments, donors, non-governmental organisations and agrochemical companies
- monitoring compliance with international standards among contractors
- promoting methods that reduce reliance on pesticides (IPM)
- providing guidelines on ways to limit stocks to short-term requirements.
- recommending that pesticide purchases under aid agreements only be made from companies pledging responsibility for unused products

A pesticide disposal project specifically aimed at Africa and the Near East is currently being implemented by FAO, and a number of disposal operations have already taken place under its aegis (FAO, 1997). Although over 1200 tonnes have been disposed of, an overwhelming amount remains. Since it appears that a large part of the obsolete pesticides are organochlorines, disposing of this is of critical importance if POPs are to be successfully eliminated. Similar projects have been initiated in other regions together with UNEP and the Secretariat of the Basel Convention. WHO works closely with FAO in the area of disposal of stockpiles of obsolete public health insecticides.

In a number of countries, the use of existing stocks of pesticides has been restricted. Lack of resources and mechanisms to effectively enforce such restrictions is a matter of concern. In some cases, a total ban on the use of all remaining stocks may be more realistic and easier to administer.

Several countries continue to allow the use of DDT for public health purposes, either for regular indoor residual spraying, for targeted spraying or as an emergency response to disease outbreaks. The Stockholm Convention on POPs considers the use of DDT for vector control acceptable in cases where alternatives that are locally safe, effective and affordable are not available. Such use must follow practice and procedures recommended in WHO guidelines, which include the need to ensure that the insecticide is not diverted for other, illegal uses (WHO, 1995). The use of existing stocks of DDT in malaria vector control programmes is promoted as an acceptable disposal option in the WHO Action Plan (WHO, 2001). For this disposal option to be valid, the stockpiled DDT must meet WHO specifications (available from the WHO web site: www.who.int/whopes/specifications_and_methods.htm) Shipment of stockpiled DDT for its proper use in another country may contribute to a reduction in the need for its further production. Such shipments will have to be carried out in accordance with the rules laid down in the relevant international Conventions: the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (www.basel.int) and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (www.pic.int).

Stocks of obsolete pesticides may accumulate for a number of reasons:

- Excessive and unsolicited donations.
- Import (purchase or donation) of poor quality pesticides.
- Products have been banned and remaining stocks cannot be used.
- Inadequate stores and poor stock management. Products and containers may deteriorate, “first-in first-out” rules are not followed, etc.
- Unsuitable products, packaging and/or labelling.

Many of these problems have their roots in inadequate planning by recipient countries as well as in poor procedures for administration and co-ordination of donations. Aggressive promotion of pesticides by commercial interests may also play a role.

Preventing the accumulation of surplus quantities of pesticides in the first place is of prime importance. Countries with obsolete stock problems often lack disposal facilities and disposal abroad is extremely costly. Accumulation and eventual disposal of pesticides puts a tremendous burden on scarce resources. Therefore the following items of good practice must be considered:

- Each party (government, donor agencies, industry, users) must be fully aware of its responsibilities.
- Pesticide use must be minimised and IPM/IVM principles must be adopted in both policy and practice
- Overstocking of pesticides must be avoided. Stocks must be kept as low as possible.
- Accurate needs assessments must be made and distribution systems must be reviewed regularly.
- For imported products, including donations, clear acceptance criteria must be applied: suitable type and formulation, proper packaging and labelling.
- Proper handling, storage and stock management must be ensured. Donations of pesticides should only be made on the condition that this is complied with. Where necessary, training in these issues must be funded as part of the package and in advance of delivery of the pesticides.
- Procurement must only be made from companies taking full responsibility for unused products, pledging to take them back or have them safely disposed of.

3.5 Farmer Field Schools

A Farmer Field School (FFS) consists of a group of 25-30 farmers that will meet in the field regularly, usually one morning every week for the duration of the crop that is chosen for the FFS. It is organised at village level. A facilitator who has been trained in IPM will work with the group to facilitate the weekly meetings. The group will set up study fields of about 1000 m^2, to compare IPM practices and Farmer Practices (FP) common for the village where the FFS is organised. The FFS programme consists of carrying out a weekly agro-ecosystem analysis. Also, every week a special topic is selected for in-depth discussion, to strengthen knowledge on specific elements. The activities are carried out in such a way that they favour team building and positive group dynamics, to promote group bonding and to create an atmosphere conducive for learning and sharing of experiences between the group members (Gallagher, 2000).

Agro-ecosystem analysis

Farmers work in small groups of about five persons to observe their study fields on IPM and FP. The groups observe and record all elements in the field: the plants (height, number of green and yellow leaves), pest populations, natural enemy populations, disease incidence, weeds, water situation and weather conditions. After their observations the small group will analyse their findings by making a drawing. The drawing shows the crop, pests and natural enemies, diseases, weeds, weather and the water situation. The numbers observed are recorded on the drawing as well. In the small group farmers will discuss what would be the best management option for the IPM field, based on the observations of this week as well as previous weeks, and interactions between the different elements in the field. The management recommendation is recorded as well. Each small group will present their findings to the whole group. A discussion by the whole group will lead to a common decision on the management of the IPM field for the week to come.

Special Topics

Sessions addressing special topics are conducted every week. The selection of the topic will depend on the stage of crop development, and on specific problems encountered in the field. They reinforce knowledge about certain parts of the ecosystem.

Some examples:

◊ *Crop Development.*
During the season small groups of FFS members collect plants in a certain stage, observe and draw them. The FFS members discuss the requirements of the plants in this particular stage, leading to broader discussions on nutrient, soil and water management.

◊ *Crop compensation.*
Crops have the capacity to compensate for damage caused by insects eating leaves or tillers. Crop health and the development stage will influence the degree of compensation. To understand compensation better, and to make it part of decisions, farmers in a FFS set up small studies in their study fields.
At different stages of crop development they remove leaves (25% and 50%) in marked areas, or tillers (20% and 30%). The plants in the marked areas are observed regularly by the FFS during the season and measurements are taking of the crop development of treated and untreated plants. At the end of the season harvest data are collected for treated and untreated areas.

◊ *Effects of insecticides on natural enemies.*
Small groups carry out studies on the effect of insecticides on natural enemies. Natural enemies are collected from the field, and put into jars. Some jars will be sprayed with insecticides, others serve as control. Groups record their observations, and discuss what they mean for the agro-ecosystem.

◊ *Insect Zoo.*
FFS members set up small studies in caged pots to study life cycles of pests and natural enemies. They observe the different stages of development of an insect, and the duration of each stage. Also studies on predation are carried out. A certain predator is placed in a jar with a number of pest insects, and observations are made on the amount eaten daily. If unknown insects are found in the field small studies are set up to confirm the function of the insect in the field: eating plants, being a predator or a parasite. The group members show their zoos to others, and report on their results. At the end of the season the results of the insect zoo, as well as other observations, are used by small groups to draw food webs. These are discussed by the whole group.

An FFS aims at making farmers better decision makers in the process of managing their crops.

Many tools are available that are part of integrated management approaches, based on the principles of IPM. The choice of tools will depend on observation and analysis of the situation, possibilities to use them, and socio-economic conditions. Examples of IPM tools are presented in chapter 2 (page 29). Better knowledge on IPM allows farmers to reduce pesticide use while maintaining or improving yields.

Following are some results of FFSs on cotton in Pakistan: IPM plots were sprayed 1.4 times, while conventional plots were sprayed 5.4 times. Two FFS groups even managed to avoid spraying altogether. Beneficial arthropods were numerous in the IPM plots. Average yields were almost 10 % higher in the IPM plots compared to the conventional plots (1363 vs. 1245 kg/ha). In seven of the ten sites, IPM plots yielded better than conventional spraying. The savings in input costs (1974 vs. 6066 rupees/ha) increased the economic gain even further. Reduced pesticide use also lowered the health risk for farmers and the pollution load on the environment.

Farmers making informed decisions in their own fields can reduce pesticide use, increase yields and improve profitability

Successful IPM is driven by the actual users – mainly farmers. It is not a service provided from "above" – by a government service, a private company, a donor, or a foreign NGO. Full participation of the users is a prerequisite. Women have a crucial role to play – in many developing countries, the majority of farmers are women – and their training needs and other priorities are important.
An FFS is an entry point for farmers to take the lead in a range of other IPM related activities, such as:

- becoming trainers conducting FFS for others in their community,
- engaging in local research activities to optimise practices for the local situation,
- engaging in curriculum development activities with trainers and researchers
- taking the lead in local planning, implementation and evaluation of IPM activities at community level, including fund raising from local government, the farmer community or other organisations in their area.

3.6. Capacity building in intersectoral collaboration

Most developing countries have policies supporting expansion and/or intensification of their agricultural production systems, aimed at improved food security and better socio-economic conditions, in particular poverty alleviation. Certain types of agricultural development, however, may have negative effects on health, especially with respect to increased risks of vector-borne disease transmission. Agricultural development activities may cause changes in environment and ecology that favour vector development or prolong the transmission season. Often agricultural development is accompanied by demographic changes. Resettlement or informal migration may expose population groups with no

immunity to new disease organisms carried by vectors or new arrivals may introduce the disease into local communities where environmental receptivity (i.e. the presence of the vector) has increased through environmental change.

In principle, socio-economic benefits of agricultural development will translate into an improved community health status. Improved nutritional status will go hand in hand with better access to health services as local infrastructure improves. Increased purchasing power facilitates access to medicines and mosquito nets, and improvements in housing conditions. Some vulnerable groups, however, may not profit fully from the benefits and will be exposed to increased risks of vector-borne diseases. In the planning and design of agricultural development projects health issues usually are not sufficiently considered. Efforts from the different sectors are needed to ensure that in future agricultural and other types of development take health issues into consideration and that negative effects are avoided to the extent possible.

From past experience it is clear that a number of impacts on community health can occur that are of relevance in the context of the issues covered in this guidance document:

- changes in irrigation water management, land use patterns, cropping cycles and the introduction of high yielding crop varieties may all create conditions conducive to the propagation of disease vectors;
- increased or intensified use of pesticides for the control of agricultural pests may carry a range of health risks resulting from increased exposure to the compound itself or its residues;
- pesticide application in agro-ecosystems may lead to an accelerated induction of insecticide resistance in disease vectors, eventually rendering indoor residual spraying ineffective.

Such adverse effects on human health can be averted by submitting plans for agricultural development to an impact assessment. The method and procedures of health impact assessment (HIA) have been developed, tested and documented over the past fifteen years. They are described by Birley (1995) and WHO (2000). HIA is based on the principles of equity, environmental sustainability and economics. Critical steps in the procedure include screening and scoping, the formulation of HIA terms of reference, carrying out the assessment, appraisal of the assessment report and negotiating resource allocations for the implementation of recommended measures.

Capacity building in health impact assessment has three basic components:

- creation of an enabling policy environment that will facilitate the involvement of all relevant sectors at crucial decision-making moments;
- development of intersectoral decision-making skills among middle-level managers in different public sectors, and
- strengthening the environmental health unit in ministries of health so it can perform essential health sector functions related to HIA, including co-ordination with other sectors.

Problem-based learning can complement Farmer Field Schools as an adult learning approach aimed at improved decision making in pest and vector management.

The joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM) has developed and tested a capacity building package for the first two components. Seminars for senior government officials, aimed at incorporating health issues in the development policies of other sectors were held in a number of African countries. The training course to develop skills of middle-level managers was tested in three African countries, in the countries of Central America and in four States of India. For maximum benefits in adult education the course proposes a task-oriented, problem-based learning process. Recently, an analysis of the course development process was published (WHO/DBL, 2001). A detailed training manual will be published in 2002.

Impact assessment is an important first step towards the use of alternatives to POPs pesticides, because it requires different sectors to collaborate in a common framework. It should not be confined to human health, but should also consider issues in a broader environmental assessment approach. Without a proper impact assessment of development projects and programmes, it is likely that reliance on pesticides will be higher than strictly necessary. The experience of adult learning methods as a valid educational approach is not limited to HIA capacity building. Problem-based learning in a more formalised setting can complement the Farmer Field Schools approach by aiming at civil servants involved in plant protection and vector control policy making and in translating such policies into action.

3.7 Eliminating the use of POP pesticides against termites

One of the longest lasting uses for POP pesticides has been for the control of termites – mainly in construction, but also in agriculture. Preferred pesticides have been chlordane and heptachlor, but aldrin, dieldrin and mirex have also been used.

There are approximately 2500 different termite species in the world. Termites can for practical purposes be divided into four groups based on their living habits:

- *Dampwood termites* feed mainly on dead and deteriorating trees, stumps and other wood in the ground. They are virtually without importance as pests and provide useful ecosystem services.

- *Drywood termites* are common on most continents. They can survive in very dry conditions. They can attack and destroy structural timber, but generally do not cause damage in agriculture and forestry. They do not need contact with soil.

- *Subterranean termites* are the most common pests, and cause 95% of all termite damage to buildings. They build often extensive tunnel systems on and under the soil as protection against desiccation and enemies, and enter buildings from the ground, e.g. through openings in the foundation.

- *Mound building termites* can build mounds on the soil or in trees. They occur in Africa, Australia, South-East Asia and parts of South America. They contribute to building up soil.

In agriculture, termites are pests of intensification. Overgrazing or introduction of non-indigenous, more productive crops can be the cause for termites becoming a problem in an agro-ecosystem. Management measures should be based on understanding the biology and ecology of the termites.

In buildings and constructions, POP pesticides were used against termites because of their persistent character. As the negative aspects of using POP pesticides have become apparent, however, one country after another, has phased out their use for this purpose, turning instead to integrated approaches. Reference is made to the case study in section 4.7, with an example from Australia. Different construction methods are used to prevent termites from entering a building and structures are monitored regularly for termite activity.

UNEP and FAO are collaborating with termite experts on biology and ecology of termites and alternative approaches for management. More information is available on UNEP's POPs homepage (www.chem.unep.ch/pops).

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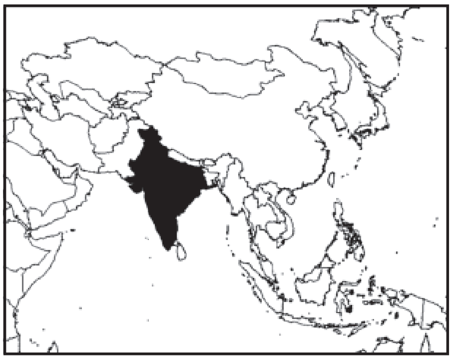
4

Case studies

This chapter provides examples of studies and experiences of relevance to the reduction and / or elimination of POP pesticide use. Some case studies touch on more general issues of concern in connection with pesticide use and alternative strategies for sustainable pest and vector management. The various pest or vector management measures presented are examples of what is possible in specific settings. They do not constitute universal recommendations. Each situation is unique and will require local assessment, site-specific considerations and local adaptations. The principles and decision-making criteria for IPM and IVM constitute the permanent core of this process.



4.1. Comparing bio-environmental management and indoor residual spraying for malaria control in India[1]

Malaria incidence in India dropped dramatically following the introduction of programmes for indoor residual spraying in the 1950s, but has resurged since the mid-1960s. Insecticide and drug resistance, financial constraints and decreasing community acceptance of spray programmes all contributed to this resurgence.

The challenge to find safer, more sustainable, community-based strategies led the Indian Council of Medical Research to support pilot activities on Integrated Disease Management. One of the pilot areas was the Kheda District in the State of Gujarat. The pilot activity was implemented between 1983 and 1989. The district is part of an area of low malaria endemicity: transmission intensity is low and seasonal, the population has little immunity to the parasite and there are periodic epidemic outbreaks of the disease, linked to particular weather patterns. Under these conditions, routine active case detection is not cost-effective, it is difficult to measure the impact of vector control interventions and making relevant comparisons between alternative vector control methods is a statistical challenge.

[1] Summarised from: Phillips, Margaret, A. Mills and C. Dye 1993. Guidelines for Cost-effectiveness Analysis of Vector Control. *WHO/CWS/91.4* PEEM Secretariat, WHO, Geneva, and
Khaware, Ray Kishor and Priti Kumar, 1999. Bioenvironmental Malaria Control in Kheda District, Gujarat, India in WWF, 1999 *Disease Vector Management for Public Health and Conservation*

Most people in the Kheda district are subsistence farmers, growing two rice crops every year. The extensive irrigation network and associated factors provide a favourable environment for mosquito breeding. By 1980, vectors had become resistant to DDT, HCH and malathion. Increasingly, citizens were refusing house spraying. The awareness of the communities on health issues, including malaria, was generally low.

The project in Kheda was designed to test an alternative, non-chemical malaria control strategy, combining enhanced health services with local ecosystem changes that discourage vector breeding. The strategy was preventive, aimed at avoiding epidemics of malaria by efficient treatment of people who could serve as reservoirs of the disease, combined with reduction of vector numbers through elimination of vector breeding sites. A stepwise implementation of the pilot activity started in 1983 with field work to monitor the impact of anti-larval and anti-parasitic measures. Project workers, including village level resident health workers, were hired by the project and received special training. An important step was to create community awareness on health-related issues as a basis for participation. Contacts were established with village councils, leading to growing local networks of staff, village leaders, teachers, and interested villagers. The project organised educational activities for villagers at the local facilities of the Malaria Research Centre and later in the communities themselves. Villagers could see for themselves mosquito larvae, adult mosquitoes and the malaria parasites through a microscope and learn about mosquito breeding around their houses and around the village. Group meetings for villagers were organised for open discussions and resolving doubts. Female health workers made house-to-house visits to involve women, whose decisions are important for water issues and uses. They taught women how to store and manage water in a way that would prevent the breeding of malaria vectors. They also encouraged interested women to expand their know-how to other women. These activities were important to motivate villagers to participate in the project.

Bio-environmental managament was cheaper than DDT in this study.

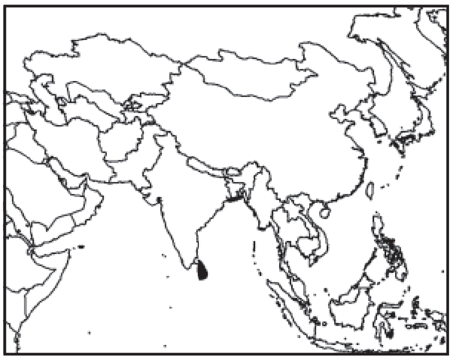
Village health workers carried out a weekly surveillance of malaria cases. They were trained to take blood samples from persons with fever, that were analysed by the project within 24 hours. Village workers treated persons with confirmed or suspected malaria.

Survey teams of entomologists, support staff, daily wage workers and volunteers from the village carried out extensive surveys of mosquito breeding sites. Most breeding sites were found within and around houses, and included irrigation canals. They also identified the two major species involved in malaria transmission and their preferred breeding sites. After the identification, breeding sites were eliminated or stocked with larvivorous fish. Weekly checks of the breeding sites took place. If mosquitoes were found in houses, their occupants were shown how to prevent further breeding. Guppies were found to be the most effective larvivorous fish. Hatcheries were set up in the project area to rear and distribute them.
The promotion of ponds to grow both larvivorous and commercially marketable fish was one of the community income-generating activities the project developed in collaboration with several NGOs.

The study covered six years and results at the end of that period showed that levels of malaria incidence under the conventional programme of indoor residual house spraying (IRS) and under the innovative programme of intensified case detection / treatment and bio-environmental vector control (EMVC) were very similar - about two cases annually per 1000 persons. A cost-effectiveness analysis was carried out in 1989, comparing the two programmes.

The per capita cost was Rs 5.5 in the IRS programme and Rs 4.5 in EMVC programme. The cost-effectiveness analysis took into account only the direct costs of the two programmes. Variables that could not be expressed in monetary terms, such as the environmental benefits of not using pesticides, were not included. Additional side benefits of the integrated programme, such as fish production, were not included, either. Including these benefits into the analysis would further enhance the cost-effectiveness of the the integrated approach of case detection / immediate treatment and bio-environmental management for vector control.

4.2. Water management for malaria control in Sri Lanka[1]



Sri Lanka is among six countries in the world, outside of Africa South of the Sahara, which share a third of the remaining global burden due to malaria. The number of deaths is relatively low, partly because of the quality of health services and partly because *P. vivax* still is the predominant parasite species, although the trend is towards an increased share of *P. falciparum* parasites. Transmission occurs in the dry (<2000mm rain / year) and intermediate zones (between 2000 and 2500 mm) with perennial transmission showing seasonal peaks linked to rainfall patterns. Great epidemics occur after droughts, when the southwest monsoon fails, because of the ecology of the local vector, which breeds profusely in rockpools remaining in dry rivers. The intensity of transmission facilitates conclusive studies on the effectiveness of different vector control options.

Malaria has been a serious public health problem in much of the North-Central Province of Sri Lanka for decades. A multi-disciplinary research team with expertise in vector biology and control, parasitology, health care, social science, economics and irrigation engineering (representing the International Water Management Institute, the University of Peradeniya and the Anti-Malaria Campaign of the Ministry of Health) spent five years investigating the malaria problem in the Huruluwewa watershed, located within the North-Central Province.

Water management schemes based on focused studies lead to reductions in vector incidence

The watershed has a 20 000 hectares catchment area of mixed forest and agricultural land, irrigated by an ancient tank-irrigation system, which more recently has also been receiving

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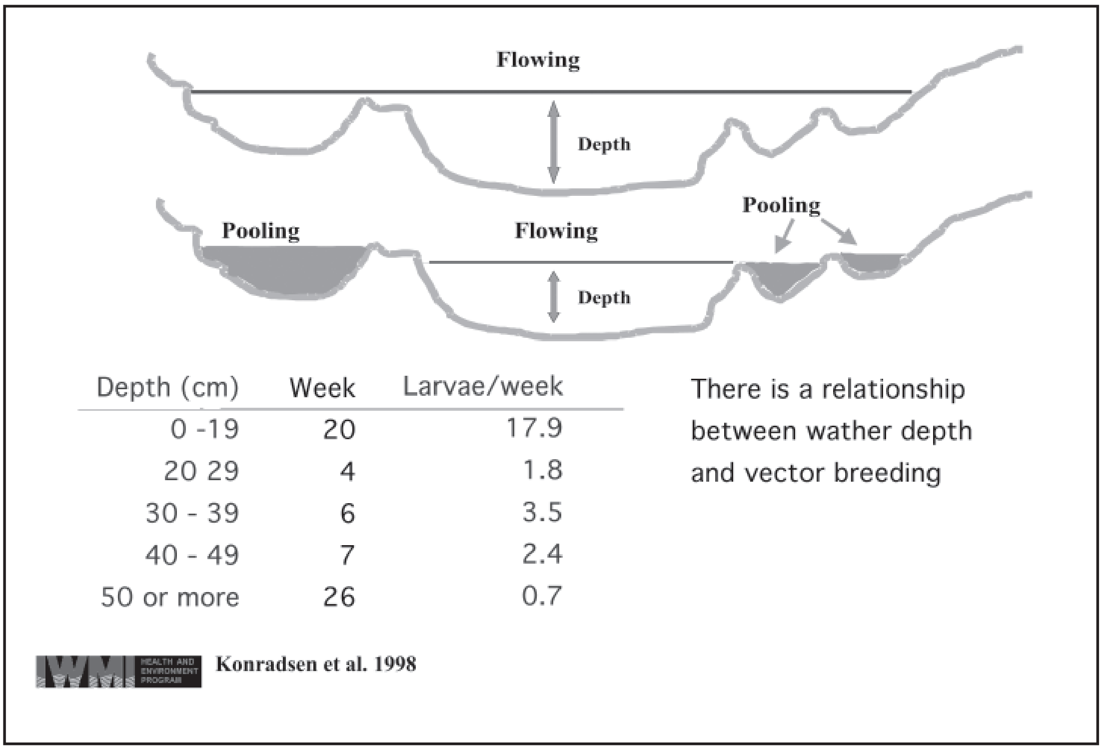
[1] Adapted from a contribution by Dr Felix P. Amerasinghe, Department of Zoology, University of Peradeniya, Sri Lanka; a useful up-to-date reference is Konradsen, F. *et al.*, 2000. *Malaria in Sri Lanka: current knowledge on transmission and control.* International Water Management Institute (IWMI), Colombo, Sri Lanka



Depth (cm)	Week	Larvae/week
0 -19	20	17.9
20 29	4	1.8
30 - 39	6	3.5
40 - 49	7	2.4
50 or more	26	0.7

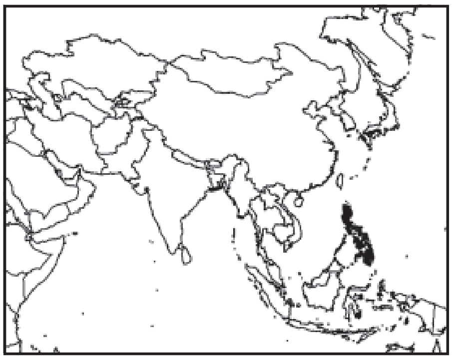
There is a relationship between wather depth and vector breeding

Konradsen et al. 1998

water issued from the Mahaweli System. The Yan Oya stream is the feeder canal to the Huruluwewa watershed. The main malaria vector in this area is *Anopheles culicifacies*. The main breeding habitats are the stream-bed pools that remain when water levels are low.

A significant risk determinant of malaria transmission is the distance between houses and the stream. At a system-wide level, villages closer than 500m to the stream had higher vector densities and a higher incidence of malaria. The study showed a relation between the stream water depth and vector breeding. When water levels in the stream are low, more stream-bed pools form and once the water level is below 20 cm, the number of larvae increases significantly. Detailed analyses of the water dynamics of the entire watershed area followed. Models showed that with the current flow in the stream, water levels are low during two periods of the year, resulting in high densities of mosquito larvae. If the stream would be flushed regularly during these dry periods, breeding habitats of mosquitoes would be disturbed, reducing larval densities. The most viable management option was a redistribution of existing water flows in order to maintain a water depth sufficient to discourage the breeding of the vector.

Cost analyses were done comparing the water management measures with vector control interventions such as indoor residual spraying, mosquito nets and chemical larviciding, as well as with curative measures (hospitals, mobile clinics, village-level treatment centres) in the area. These showed that flushing streams through seasonal water releases from upstream reservoirs would be the most efficient malaria control measure.



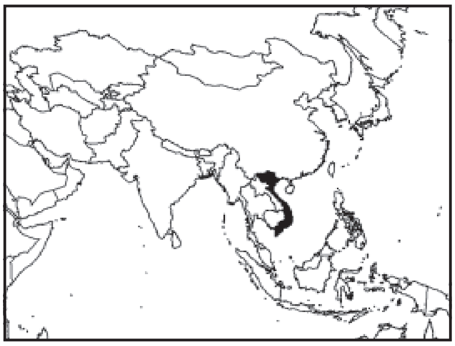
4.3. Malaria control in the Philippines[1]

After World War II, malaria control efforts in the rural areas of the Philippines relied exclusively on mass drug treatment and DDT for indoor residual spraying. In the 1980s these activities were complemented by active case detection to focus drug treatment and efforts to reduce breeding sites and densities of mosquito larvae. Across the board, malaria incidence was kept low through these measures, although fluctuations occurred. The use of DDT was banned in 1992, for environmental reasons.

Pesticide costs and malaria incidence have both dropped by 40% since DDT was banned

More recently, the National Malaria Control Service changed its strategy. Initially several pyrethroid insecticides were selected to replace DDT for indoor residual spraying. These were more expensive and posed higher risks to members of the spray teams because of their acute toxicity. In 1993, an external review of the Malaria Control Programme recommended that only one pyrethroid was to be used for residual house spraying. Based on results of pilot activities, it was also recommended to reduce residual house spraying and to increase the use of Insecticide Treated Nets (ITN). At present, periodic stratification of malaria endemic areas serves as the key criterion in the selection of area-specific measures. At the community level, Lead Contact Groups exist, composed of health officials, neighbourhood co-operatives, NGOs and community members. These groups are responsible for decisions on cost-sharing for ITNs, their proper use and maintenance.

The total cost of insecticides for malaria control in the Philippines has actually decreased 40 % since the banning of DDT - and malaria incidence dropped more than 40 % in the period 1993-96! Much of this significant success can be attributed to active community participation, and continued local involvement in a de-centralised structure will help sustain the positive situation.



4.4 Dengue control using copepods in Viet Nam[2]

Dengue fever was ranked as one of the most important public health problems in Viet Nam in the 1990s. Mosquitoes of the genus *Aedes,* mainly *Ae. aegypti,* transmit the disease. The main control strategy has, until recently, consisted of emergency interventions using synthetic insecticides against larval and adult

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[1] Summarised from: WWF. 1998. *Resolving the DDT dilemma: Protecting Biodiversity and Human Health.* Toronto and Washington, D.C.; and,
Matteson, Patricia. 1999. The Philippine National Malaria Control Programme in WWF: *Disease Vector Management for Public Health Conservation*

[2] Based on a text provided by Dr Brian H. Kay, Queensland Institute of Medical Research, Brisbane, Australia, in September 1999

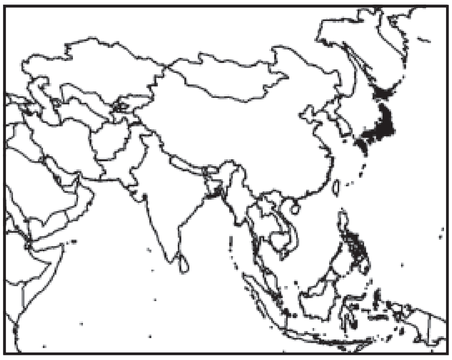
stages of the vector (these do not belong to the POPs category). This case study illustrates clearly to what extent biological control methods implemented by local communities can be effective.

In the mid-1990s, however, a review of the strategy was made with the assistance of Drs Brian Kay and John Aaskov and a national plan of action was formulated. A key component of this plan for disease prevention was to develop the use of copepods. Copepods are minute crustaceans that occur naturally in large and small water bodies. Certain copepod species are predators of mosquito larvae and can play an important role in controlling disease vectors. Ten species of the copepod genus *Mesocyclops* have been found in Viet Nam - all of them effective predators of *Aedes* larvae. Up to 30 % of local water tanks and wells contain *Mesocyclops*. Transfer of water from these sources to other water containers, wells, etc., to establish the copepods in the new places presented an opportunity for sustainable, locally managed disease prevention. A pilot project was carried out in 1994 in Phanboi village. With the collaboration of local households, all containers were inoculated. The effect was dramatic, and since this first trial, virtually all *Aedes* mosquitoes have disappeared from the community.

Community participation
+
enhancing natural control mechanisms
=
Success!

Extensive recycling of discarded containers such as plastic bags and plastic bottles reduces the number of potential breeding places for mosquitoes. Disease reduction becomes an additional benefit of this informal income-generating activity, and recycling thus also becomes an important component of the dengue control programme.

The programme is now being extended to other villages and provinces, and the positive effects are profound. Incidence of clinical dengue cases in “treated” areas during the extensive 1998 epidemic was less than one tenth of the incidence in neighbouring un-treated areas. The change from a curative to a preventative strategy is being facilitated by a substantial increase in funding.



4.5. Integrated management of Japanese encephalitis vectors[1]

Japanese encephalitis (JE) is a serious viral infection transmitted by mosquitoes of the *Culex vishnui* group, which breed by preference in flooded rice fields. It has a high fatality rate, especially among children, and those who survive clinical infection often suffer from lifelong mental disorders. A vaccine exists, but is expensive and cumbersome to deliver as two booster vaccinations are required at precise intervals after the initial vaccination, to achieve protective immunity.

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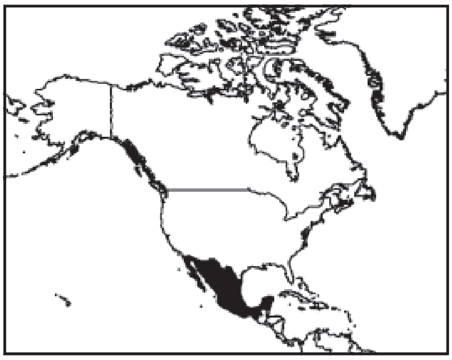
[1] Summarised from: IPM Working for Development - *Bulletin of Pest Management.*No 9, Sept. 1998. and Robert Bos, WHO (pers. com.)

Outbreaks of JE have occurred in recent decades in several countries in South and South-East Asia. This phenomenon can be linked to an expansion of areas under rice cultivation, particularly into more arid zones, an intensification of rice cropping (to two or three harvests annually) and an increase in pesticide use. Other elements in the rice production ecology contributing to outbreaks of JE are pigs (the amplifying host for the virus) and ardeid birds (herons, egrets), that transport the virus over larger distances. JE vectors have developed resistance to insecticides primarily used to control agricultural pests .

Research conducted in Tamil Nadu, southern India, has shown that using farm manure and green manure (including blue green algae) instead of artificial fertilisers will significantly reduce mosquito incidence. Introducing edible, mosquito-eating fish reduced larval populations by 80 % and increased total profits 2.5-fold.

Fish that eat mosquito larvae and other measures can play an important role in reducing vectors in irrigated rice systems

Water management (particularly alternate wetting and drying of rice fields) is another viable option to reduce vector breeding, particularly as water scarcity is forcing many farmers to adopt more cautious irrigation regimes anyway. The use of neem oil to reduce mosquito breeding has shown potential at the start of the cropping cycle. Improved pig husbandry, aimed at reducing pig-mosquito contact will contribute to keeping the virus out of circulation.



4.6. Mexico's action plan to eliminate the use of DDT in malaria control[1]

Malaria is a long-standing public health problem in Mexico. Sixty percent of its territory from sea level to 1,800 meters above sea level presents favourable conditions for transmission. Some 45 million people live in these areas. Ninety percent of all malaria cases occur in five States: Oaxaca, Chiapas, Sinaloa, Michoacán and Guerrero. These coincide with the distribution of two vector species: *Anopheles albimanus* and *A. pseudopunctipennis*. Behavioural aspects limit the impact of insecticide treated nets (ITNs) in Mexico: people generally tend to spend several hours of the early evening watching television, at which time they are exposed to biting anophelines.

In the 1940s and 1950s, malaria was one of the main causes of mortality, responsible for an average of 24,000 deaths annually and afflicting an estimated 2.4 million others. In recent years, the incidence of malaria had declined significantly, to less than 5,000 cases, and no deaths from malaria have been reported since 1982, indicating the success of the control program. However, the control of the disease had been highly dependent on DDT spraying (more than 2000 tons per year in the 1970s). Mexico continued the use of DDT in malaria campaigns until the 1990s, not only because of its effectiveness, but also because of its low cost and lack of acute toxicity for spray teams, compared to alternative chemical pesticides.

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[1] Adapted from a contribution by Bill Murray, Pest Management Regulatory Agency, Health Canada

In 1995, Mexico adopted a more integrated approach for malaria control, to substitute the heavy dependence on house spraying. For the reduction of transmission risks in the *A. pseudopunctipennis* areas, a successful community-based programme to clear algae from ponds was established with a dramatic effect on vector breeding. Furthermore, improved sanitation, surveillance and a minimum use of pesticides to control mosquitoes and larvae are considered key elements in this new approach. The reduction of DDT use, from 1260 tons sprayed in 1991 to 477 tons in 1997 was accelerated by a North America Regional Action Plan (NARAP) developed to reduce the exposure of humans and the environment to DDT and its metabolites. This NARAP was developed by Canada, USA and Mexico as parties to the North American Agreement on Environmental Co-operation (NAAEC), and was the result of Commission for Environmental Co-operation (CEC) Resolution 95-5 on Sound Management of Chemicals. New research on the human health effects of long-term exposure to DDT and the continuing need for an effective and comprehensive malaria control program in Mexico, provided additional incentives for regional action. DDT production in Mexico was stopped in 2000 and supplies of DDT are kept for authorised government use in malaria vector control only.

The objective of the NARAP is to reduce DDT use by 80 percent in five years and eventually phase it out completely for malaria control in Mexico. To achieve this goal, Mexico developed a national action plan with an initial geographical emphasis placed on areas with the highest number of cases. The general objective of Mexico’s action plan is to develop and assess local alternatives to DDT for the control of malaria at a national level and to assess the health and environmental impact of DDT and alternative pesticides. More specific objectives are:

- To strengthen the current integrated programme to control malaria in Mexico through assessment of the effectiveness of alternative control methods.

- To assess the cost-benefit / cost-effectiveness of all alternative control methods.

- To obtain general baseline information on current pesticide use, with emphasis on agricultural uses of pesticides proposed as alternatives to DDT in malaria control, and to update a Geographical Information System with datasets on this use as a decision-making tool.

- To monitor environmental levels of DDT and other pesticides used in the malaria campaign in water, soil, food, selected animal species and humans.

- To assess the health impact on human populations of DDT residues and alternative pesticides used in the malaria campaign.

The effectiveness of a number of alternative control measures have been assessed in the State of Oaxaca:

- field assessment of pyrethroid-impregnated mosquito nets as a complementary measure,
- field evaluation of deltamethrin and lambda-cyhalothrin as a substitutes for DDT for house-spraying, and
- establishment of a production facility for parasitic nematodes of mosquito larvae.

These three projects showed promising results. However, these were small projects that have

A national and regional action plan to phase out DDT is expected to give results

not yet been integrated into the national plan. A more holistic evaluation is under development. The studies in this phase will be used to develop and validate relevant methodology with alternative strategies and possible effects of alternative chemicals.

The use of DDT has been avoided during the most critical conditions for controlling malaria outbreaks during recent hurricanes and floods in the aforementioned states. DDT has been replaced by pyrethroids in these cases. New application techniques to reduce the quantity of pesticides used will be evaluated along with greater emphasis on community participation in the surveillance and treatment of cases.

Observations with respect to the above six vector control case studies

- Economic considerations are important when deciding on vector control programmes. Data must therefore be accurate and relevant. This includes opportunity costs of community participation and external benefits (such as commercial fish production linked to the production of larvivorous fish, or the gains from timber production where trees are planted to lower water tables).

- Malaria transmission is often cyclical, following weather patterns. Vector ecology will also vary between areas. This must be considered when drawing conclusions from comparative studies on disease and vector management using conventional and innovative methods

- Community participation will be sustainable if there is real economic benefit for a large segment of the local population. NGOs can play an important role in ensuring this. Building on existing socio-economic structures and traditions can lead to greater success. The introduction of “new” activities such as fish production in areas where fish is not part of the traditional diet may be less sustainable and will need more coaching.

- Strengthening the regulatory role of the health sector is an important pre-requisite for the successful application of results from multi-disciplinary research.

- Improved formulations and innovative applications of new pesticides may seem to be more expensive than older types, but can in fact reduce the costs of vector control programme. This is particularly true where spraying programmes become better targeted and are supported by non-chemical interventions, as shown in the case of the Philippines.

- The degree by which the decentralisation of malaria control programmes supports IVM with reduced costs and improved levels of protection should be carefully assessed.

- Environmental management programmes are often more resilient and sustainable than service delivery programmes relying on regular spraying, case detection, drug treatment or vaccination. This is particularly important in times of social and political instability. An example: during the Iran-Iraq war, schistosomiasis was kept under control in Iran in irrigation schemes that included environmental modification measures, while it increased in schemes relying only on case detection and drug treatment, which were disrupted.

4.7. Controlling termites in Australia[1]

There are many harmful drywood and subterranean termite species in Australia, several of which can do great damage to houses and other buildings. Some are present in the whole continent, while others are found in the northern parts only. The most important are:

- *Cryptotermes brevis* - an extremely destructive drywood termite, introduced into Australia in the 1960s. It can cause severe damage to structural timbers, but generally not in agriculture and forestry.
- *Mastotermes darwiniensis* - a large subterranean termite found in the northern, (sub-)tropical part of the country. It can cause dramatic damage to buildings, and will also attack sugarcane and forest trees.
- *Coptotermes spp.* - species of this subterranean genus cause most building damage in Australia, and are also serious pests of trees.

A total ban on POP pesticides is in effect in Australia since 1997. The only exception is mirex, which is still approved for use as a toxicant in termite baits in orchards in northern Australia. National annual use is less than 10 kg.

Termite control in Australia has moved from relying mainly on persistent chemicals up to the late 1980s to a situation today, when physical methods have become useful complements to or replacements for pesticides. The physical methods are primarily used for new constructions, while existing houses are usually still protected with chemicals. House construction methods in Australia have changed over the last three to four decades, so that the majority of houses are now built on concrete slabs. Post-construction treatments can therefore in general not be applied, in contrast to the previous situation when it was possible to spray underneath suspended floors. The control principles, equally applicable in all countries, are: (1) minimise access from the ground; and (2) monitor for termite activity.

Responsibility for controlling termites now lies more with builders than with pest control operators. Australia is one of the few countries that has developed a particular building code on termite protection (Australian Standard 3660-1993), specifying measures to protect against (primarily) subterranean termites.

Building design measures being promoted and employed include

- reducing the amount of timber, particularly where inspection is difficult
- making inspection of the subfloor easy
- properly built concrete slabs to facilitate inspection and deter termites. Particular care must be taken around pipes and wires, and in wall cavities.

Annual or more frequent inspections against termite infestations need to be made,

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[1] Based on: Elimination of Organochlorine Termiticides. Australian Case Study. Prepared by the Agricultural & Veterinary Chemicals Policy Section Department of Primary Industries & Energy, GPO Box 858 Canberra ACT 2601 Australia for the IFCS Meeting on POPs, 17-19 June, 1996 in Manila, Philippines, and
Information on termite control in Australia received from Ian Coleman, Agricultural & Veterinary Chemicals Policy Section Department of Primary Industries & Energy and Michael Lenz, Division of Entomology, Commonwealth Scientific and Industrial Research Organization (CSIRO), in Canberra.

since no single method provides complete protection. Optic fibre techniques are nowadays being used to facilitate inspection in hard-to-reach building parts.

Measures directed against termites aim to deter their concealed entry into a building (popularly, though incorrectly, referred to as preventive measures) or they can be curative. Details are provided in the Australian Standard (AS) 3660 Termite management [1]. AS 3660 deals with "whole-of-the-house" protection while the Australian Building Code, which refers to AS 3660, is concerned with protecting the structural elements of a building.

Good building design and practices can greatly reduce the attractiveness of a building to termites. This includes drainage, adequate ventilation of areas under the floors and use of termite resistant materials. It will also facilitate inspection of structural elements (through, for example, removable skirting boards or slab edge exposure). In Australia, regular inspections, maintenance of buildings and of the integrity of a termite management system are considered critical to the long-term success of termite control measures.

Measures to deter concealed entry by termites into a building

- *Physical barriers*. For buildings with a raised (suspended) floor (with crawl space), the traditional method is to fit metal termite shields on top of foundation walls, supporting piers, etc. Termites attempting to cross the shields are easily visible and can be stopped. The same applies for termites crossing exposed sides of foundations. Vigilance on the part of the house dwellers and regular inspections are, of course, required.

  For buildings on concrete slabs (slab-on-ground constructions) two types of physical barriers are available: (1) sheet materials (stainless steel mesh; solid, but flexible stainless steel; marine grade aluminium) and (2) graded particles (crushed stone). These days most of the systems are no longer installed as full barriers under the entire slab area, but as partial barriers, i.e. across the wall cavity and around service penetrations and at joints in concrete slabs. This change became possible once AS 3660 (1995 edition) recognised that a so-called engineered slab, can form part of the termite barrier system.

  All major commercial physical barrier systems also provide shielding and barriers for service penetrations and can be readily adjusted to a range of construction practices. A growing number of specific devices are available just for the protection of service penetrations (pipe collars) .

- *Chemical barriers*. Specified areas of the soil under and around a building are treated with termiticides (handspray, rodding, trenching; reticulation systems) to create a barrier that will deter termites from gaining concealed access. While aldrin, dieldrin, heptachlor and chlordane were effective for periods of 20-30 years or more, replacement pesticides have a shorter residual effect.

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[1] Termite management AS3660, 2nd edition, 2000. Standards Australia, Sydney. AS 3660 states: The Standard includes methods to deter concealed entry by termites from the soil to the building above the termite barrier system. A termite barrier system constructed in accordance with this standard cannot prevent termite attack, as barriers may be bridged or breached. Where termites bridge barriers the evidence may be detected during inspections (Part 1, page 6).

Chlorpyrifos[1] and bifenthrin have been approved in Australia for pre- and / or post-construction treatment, although there are concerns about the shorter protection time provided. Retreatments have to be made more frequently than with organochlorines, and dosage rates must be strictly adhered to.

Presence of chlorpyrifos and bifenthrin is readily detected by termites which then avoid the barriers. Some modern termiticides cannot be detected by termites and these products have a somewhat delayed toxic effect. Hence, termites will enter soils treated with these chemicals and pick up the insecticide which they may transfer to their colony. One such product, imidacloprid, is registered for the protection of structures which can readily be retreated, for example buildings with suspended floors. Evaluation of other compounds with a similar mode of action is under way. Retreatments are facilitated if a reticulation system, consisting of interconnected tubes, is installed under the concrete slab.

Chemical barriers can also be created by applying the insecticide to a non-soil carrier, such as fibrous blankets or plastic sheeting which can be placed underneath concrete slabs or as a partial barrier in the wall cavity. One product commercially available in Australia which has deltamethrin as its active ingredient consists of a fibrous matting sandwiched between two layers of plastic. Other systems following the same principles are under evaluation.

- *Termite resistant materials.* Different types of termite resistant materials, including timber treated with compounds to preserve wood are also listed in AS 3660

Curative measures
Retrofitting or repair of physical and chemical barriers can be an option in certain situations. Otherwise, Australian authorities recommend the following curative measures:

- *Insecticidal dusts.* Dusts are commonly applied to termite-infested houses in Australia. Arsenic trioxide is the main agent. Recently, a new dust has been registered with the molt inhibitor triflumuron as the active ingredient. Other dust formulations are under evaluation. The effectiveness of dusting operations can be enhanced by first luring the termites into aggregation or trap devices, where exposure can be greatly increased. Several trap and treat systems are commercially available and many control operators have developed their own devices.
- *Biological barriers.* The potential of biological agents such as the fungus *Metarhizium anisopliae* and nematodes has not yet been fully explored. Spore formulations of the fungus have proven effective as dusts and in bait systems under certain circumstances. No registered fungal product for termite control is available.
  Much research is currently focused on the use of bait systems for managing active termite infestations. To date, only one system with the molt inhibitor hexaflumuron as active ingredient has been registered.

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[1] Immediately before this document went to print, the following information update was received from the United States of America: in accordance with EPA regulations, chlorpyrifos can no longer be used in the USA for residential use. Existing stocks must be off store shelves from January 2002. Post-application exposure risks were the main reason for this regulatory action. For the time being chlorpyrifos can still be used as a pre-construction termiticide, pending future risk assessment. Existing stocks of the compound can be used in post-construction situations until 2003 (Janice Jensen, USEPA, pers. comm).

A comparison of the costs of different control measures was made in 1994 (table 3). Although it is clear that the organochlorines compared favourably with chlorpyrifos, the integrated approach is obviously the most efficient strategy.

Table 3:
Costs (in Australian dollars) of termite protection measures in Australia in 1994

Control Method	Building under construction (170-200 m^2)	Retreatment	Comment
Integrated Termite Management Approach (involving a range of control measures)	\$200-\$300 (but may vary depending on building modification)	Variable up to \$500	Annual inspections necessary and may involve destruction of nest
Organochlorine	\$237-\$496	\$200-\$1500	Regular inspection advised. Annual retreatments are often done unnecessarily, may only be necessary every 5 or 10 years
Chlorpyrifos	\$480-\$715	\$290-\$2150	Regular inspection advised. More frequent retreatments may be necessary compared to organochlorines
Stainless Steel Mesh Barrier: Partial treatment (perimeter and entry points)	\$500-\$800	Not Required	Inspection of building for termite activity still required
Stainless Steel Mesh Barrier: Full slab underlay	\$3000-\$4000	Not Required	
Crushed Stone Barrier	\$800-\$1000	Not Required	Inspection of building for termite activity still required

In conclusion: the strategy for termite management in Australia described above clearly shows that moving from pesticide reliance, with its inherent hazards, to an integrated approach involves a range of measures. Some will be the responsibility of individuals: people living in houses will, for example, need to be on constant alert for early signs of termite attacks. Governments will have to develop building standards and standards for wood impregnation that are locally appropriate and based on research carried out in the concerned area. This is particularly important for developing tropical countries, as standards from temperate regions may be totally unsuitable. Architects and builders must pay greater attention to termite risk when designing and constructing houses, since the first line of defence must be buildings that are unattractive to termites.

4.8. Cotton in Sudan - IPM as a response to the pesticide treadmill[1]

The Gezira is a large fluvial plain south of Khartoum. A large scale irrigation system is in place covering over 800,000 ha. Cotton is grown by almost 100,000 tenants in rotation with other crops. They are actively engaged in most crop husbandry duties. Crop protection is, however, directly under the authority of the Gezira board, which decides on actions, selects and purchases chemicals and implements pest control actions, mainly aerial sprays. World-wide, cotton consumes more than one quarter of all chemical insecticides used in agriculture.

Before 1960 chemical pest control in Gezira was mainly limited to one single, early season spray of DDT, against cotton jassid, the main pest. In following years the control of jassids failed. On top of that two other insects, the American bollworm and the cotton whitefly caused increasing damage. These previously unimportant pests could become important due to the decimation of their natural enemies by DDT. The response was to spray more frequently, using other insecticides in addition to DDT, and using mixtures of different compounds. The pest situation continued to get worse despite this intensified pesticide use. The spray frequency reached up to nine applications per season.

In the 1978-79 growing season whitefly outbreaks occurred of unprecedented magnitude and caused heavy damage. Yield levels dropped from 1500 kg to 1100 kg of seed cotton / ha. Cotton growing was trapped in an insecticide treadmill: more and more treatments were made, with less and less results.

In 1979 an international group of experts convened by FAO and UNEP formulated a plan to alleviate the problem. The main elements were:

- Prohibition of further use of DDT
- Abolition of package deals between Scheme management and agro-chemical companies
- Initiation of research on possibilities for upward revision of treatment thresholds and substitution of broadspectrum for selective insecticides.

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[1] based on Kees G. Eveleens and Asim A. Abdel Rahman, 1993, *ILEIA Newsletter* Vol. 9, No. 2. Can Ol' King Cotton kick the habit?

Implementation of the plan led to positive results. Between 1981 and 1989 the average number of insecticide applications was reduced to 4-5 per season. Yields increased to 1500 kg of seed cotton / ha.

Period	No. of insecticide appl./season	Yields (kg seed cotton/ha)
1967 - 1975	4-6	1500
1976 - 1981	> 8	1100
1982 - 1989	4-5	1500

IPM was, however, not used to its full potential, while conventional crop protection was not completely replaced.

The main technical constraint to full operation of IPM is the timing of the first spray. As the group of international experts concluded: “...it is the first spray that does the most damage to natural enemies of pests and commits the manager to a season-long sequence of insecticide applications.” The first spray was postponed to some extent. However, mixtures of broadspectrum insecticides were still used as before. In 1992 the Agricultural Research Corporation decided to no longer use mixtures of compounds against a single pest. In the field natural enemies of more hardy species could be seen again in large numbers.

Successful IPM programmes are farmer-focused. An important non-technical constraint in IPM programmes is insufficient human resource development. In Gezira several factors worked against a farmer focus. The central management of the scheme had resulted in a hierarchical chain of command in which relevant information for farmers is passed as orders rather than extension that would allow farmers to increase their knowledge and to actively participate in decision making. Efforts to end this tradition will further encourage and strengthen IPM implementation.

4.9. IPM of the coffee berry borer[2]

Coffee is an important cash crop for many farmers and plays an important role in the economy of entire nations. It also suffers from attacks by several serious pests and diseases, such as the coffee berry borer (*Hypothenemus hampei*), the white stem borer (*Monochamus leuconotus*), the coffee mealybug (*Planococcus kenyae*) and coffee berry disease (*Colletotrichum coffeanum*). Pesticide use in coffee is extensive in many places and applications are often made according to a fixed schedule. This has several negative effects and causes excessive costs. Natural regulation is disrupted when natural enemies of the pests are killed, increasing crop vulnerability to future pest attacks. Frequent pesticide applications have also caused resistance. The coffee

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[2] Mainly based on material received from the Pesticide Trust (UK) and Internet information available from CABI

berry borer in New Caledonia has, for example, developed high levels of resistance to endosulfan, the most commonly used insecticide in coffee in many countries.

Biological control can be a way to control difficult pests such as the coffee berry borer

Several IPM strategies to control the coffee berry borer can be considered:

- The pest survives from one season to the next in berries left on the trees or on the ground. Picking up and destroying these berries will effectively break the life cycle and limit damage the next season. This method is obviously very labour intensive, and studies are now underway in Colombia to make it less demanding.
- Direct biological control using parasitic wasps has been carried out in Latin America. Two species of parasites are already established, and research continues on two more. The aim is to make mass production more economical.
- The insect-pathogenic fungus *Beauveria bassiana* will infect and kill borers in the berries. It is produced commercially, and the spore-containing formulation can be sprayed like a pesticide. The effect is better under humid conditions. Although the fungus occurs naturally, the effect can be greatly enhanced if direct treatments are made, and this method is used by some farmers in Colombia.

4.10. Phasing out methyl bromide - an on-going parallel process

The POP pesticides are not the only issue of global environmental concern; ozone depletion is another one and has led to agreements under the Montreal Protocol to control the use of methyl bromide, a pesticide used for soil fumigation as well as in the food industry. Production and consumption were frozen at the 1995 level (2002 level for developing countries), and a schedule for stepwise reductions has been agreed on. The phase-out will be faster in industrialised countries, while developing countries will have more time. The former shall have achieved 100 % elimination by the year 2005, while the latter will have another ten years to reach the same goal.

To make the elimination of methyl bromide possible for all but critical uses, alternative control strategies and methods are developed and promoted. Technical committees and working groups have been set up in several countries, addressing specific areas of use.

Examples:

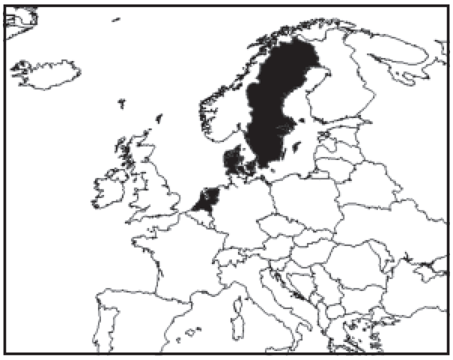
- The Canadian Methyl Bromide Industry / Government Working Group Subcommittee on Alternatives for the Food Processing Sector, has developed a guide for IPM in the food industry.
- The US Environmental Protection Agency (EPA) has set up the Methyl Bromide Phaseout Web Site, giving information on the process and providing many concrete case studies of successful alternative methods and strategies.
- UNEP has set up the Methyl Bromide Technical Options Committee (MBTOC).
- Many organisations, such as UNIDO, UNDP, the World Bank and UNEP are currently involved in a large number of demonstration projects to promote alternatives to methyl bromide in different countries and crops.

Some countries have already taken a lead in reducing methyl bromide use.
The Netherlands, which is the world's major producer of cut flowers and plants,

used to be a major consumer of methyl bromide for soil fumigation. Early concerns about the dangers to health and environment led to its elimination as a soil fumigant during the 1980-1991 decade. At the same time, production of horticultural crops actually increased.

The transition away from methyl bromide involved alternative direct control methods such as soil sterilisation with steam instead of fumigation, but also changes in cultivation methods - for example, using non-soil substrates that do not need fumigation. In addition to stricter regulations, adequate funding to investigate and introduce the new methods has been a crucial factor in the successful transition.

The process to phase out methyl bromide shows that international action is possible and effective



4.11. Pesticide reduction schemes in Europe[1]

Concern over environmental contamination and loss of biodiversity in the 1980s prompted political decisions in several European countries to reduce the use of pesticides in agriculture. Three countries in Northern Europe - Denmark, Sweden and the Netherlands - have mandated and made drastic cuts in pesticide use.

Although the preconditions were very different, a common feature of the three programmes was a combination of government measures and voluntary farmer involvement. All three countries have achieved significant reductions in pesticide use. Key features of the programmes include:

- A coherent strategy for achieving the target was set up
- Specific taxes on pesticides were imposed (on value, amount active ingredient and / or differentiated according to hazard)
- Stricter registration and re-registration procedures were introduced, leading to restrictions and removal of less desirable products from the market
- Training and certification of applicators was made mandatory. More hazardous pesticides are only sold to certified applicators.
- Certification of new application equipment was made mandatory and testing of existing equipment was subsidised.
- The use of pesticides in sensitive areas (e.g. along streams) was restricted.
- It was made mandatory (or voluntary) to keep records of pesticide applications and the environmental effects of pesticides.
- Increased and targeted research on IPM , IPM components and the environmental fate of pesticides was funded.
- The plant protection extension service was strengthened to provide farmers with better decision support.
- Ecological (organic) agriculture was given specific support.

National schemes to reduce pesticide use can give results if a coherent policy is applied

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[1] Adapted primarily from: Matteson, P.C. 1995. The "50% Pesticide Cuts" in Europe: A Glimpse of Our Future? *American Entomologist*, Winter 1995: 210-220

4.12 Obsolete pesticides and associated contaminated materials in Ethiopia.

In 1997 an FAO Project Task Force was established, with Swedish support, to comply with a request of the Ethiopian Government to evaluate the scale of the problem of obsolete pesticides in that country.

The Task Force is composed of experts from a variety of relevant disciplines and fielded a first mission to Ethiopia in 1998 to verify the inventory of obsolete pesticides of the Ministry of Agriculture and to assess the suitability and acceptability of options for their complete and environmentally safe disposal.

The use of local cement kilns for the destruction of obsolete pesticides was considered as a first option and rejected as technically unsuitable. The Ethiopian authorities themselves were not in favour of this option, either.

High Temperature Incineration (HTI) at a licensed hazardous waste incineration facility was considered the only acceptable disposal option. Such facilities are only found in industrialized countries. Full ratification of the Basel Convention, which regulates the transboundary movement of hazardous waste, including obsolete pesticides, was therefore called for.

The project document prepared on the basis of this mission made an initial estimate of 1500 tonnes of obsolete pesticides, areas of heavily contaminated soil, and unspecified numbers of pesticide contaminated containers and equipment such as sprayers in over 450 sites. The cost of disposal was estimated at US$4,5 million. The USA, Sweden and the Netherlands pledged support towards this task.

Delays in project initiation were caused by lack of additional funds forthcoming, but field operations eventually started in April 2000 under the supervision of a full-time resident Project Manager. Main activities completed in the first eighteen months include:

- Meeting with representatives of donors, ministries concerned, NGOs and IGOs to discuss the project goals and to secure the necessary pledges for financial and political support.
- Setting project objectives in consultation with local Ministry of Agriculture (MoA) counterparts and senior Ministry personnel.
- Designing a realistic project plan in consultation with the MoA and other parties.
- Training of forty selected federal and regional MoA personnel during a 5-day training programme in inventory taking.
- Establishing a National Project Coordination Committee where all project stakeholders are represented. This forum allows all parties to be kept fully informed of project activities and to comment on plans for the coming months. It affords full project transparency and involvement of parties concerned with the decision making process.
- Completion of a nation-wide re-inventory exercise. This process identified over 940 sites and more than 2,800 tonnes of obsolete pesticide stocks. In addition, it specified the amount of heavily contaminated soils at 1000 tonnes and empty drums and contaminated spray equipment at 350 tonnes.

- Review of the local formulation plant to assess its capacity to reformulate products found in Ethiopia. Unfortunately the current lack of Environmental Impact Assessment data and the observed poor management of the plant mean that this option cannot be considered. Work undertaken by UNIDO may address the problems and allow a re-appraisal of the situation in future. Re-formulation may help prevent future accumulation of obsolete pesticides.
- Commissioning of existing laboratory equipment and training of MoA personnel in the use of the equipment. It was also necessary to provide pesticide standards and other essential laboratory chemicals.
- Sampling of obsolete stocks to determine the amount of material which could be reformulated or given an extension to the manufacturers two-year shelf life.
  In total approximately 400 tonnes of stocks were identified which could be used as a strategic stock for the control of migratory pests such as desert locust and armyworm.
- Review of current IPM initiatives in Ethiopia and the sponsorship of the first national IPM workshop. This has allowed a National IPM Framework to be completed by the Ministry of Agriculture (MoA) which will be presented to the donor community for support in the years to come. This should assist in the prevention of future accumulation by decreasing the reliance on chemical pesticides.
- Review of existing Pesticide Registration initiatives. Ethiopia has robust registration procedures. This will help prevent import of unnecessary and unlicensed pesticides into Ethiopia in the future.
- Review of existing Donor programmes for agricultural inputs, including pesticides.

Next, FAO opened an international tender for bids for the disposal of obsolete pesticides and the clean-up of contaminated sites in Ethiopia. Under the ensuing contract for the removal of 1500 tonnes of obsolete pesticides, the Finnish disposal contractor started repackaging operations in May 2001. By September 2001 some 300 tonnes had been repackaged, and the endeavour is expected to be completed by June 2002. All waste will be shipped to Finland for environmentally sound disposal.

The biggest challenge facing the project remains the securing of the external support still necessary for the outstanding disposal tasks. This highlights the need to enlist pesticide manufacturers to support and contribute to the disposal process.

Annexes

Annex 1

Table A1:
Residues found in various organisms in the northern parts of North America and the Arctic region[1]

Pesticide	Residues found in	Levels (ppb dry weight)
Chlordane	Falcons	100-2500
	Fish	3-220
	Polar bears	1810-7090
	Terrestrial herbivores (fat)	2-7.4
	Whales (blubber)	620-2380
	Zooplankton	10
DDT	Falcons	1650-63000
	Fish	0-29000
	Polar bears	5-1190
	Terrestrial herbivores (fat)	5-55
	Whales (blubber)	670-6830
	Zooplankton	6
Dieldrin	Falcons	80-3450
	Fish	0-750
	Terrestrial herbivores (fat)	0.07-2.2

Table A2: Half life in soil of POP pesticides[2]

Pesticide	Approximate half life
Aldrin	5 years[1] in temperate soils
Camphechlor (toxaphene)	3 months - 12 years
Chlordane	2 - 4 years
DDT	10 - 15 years
Dieldrin	5 years in temperate soils
Endrin	up to 12 years
HCB	3 - 6 years
Heptachlor	up to 2 years
Mirex	up to 10 years

Table A3: Residue levels in freshwater fish[4]

Pesticide	Region	Number of samples	Mean levels (ppb dry weight)
DDT	USA and Europe	80	2270
	Africa	190	5450
Dieldrin	USA and Europe	56	90
	Africa	74	2890

1) Ritter, L., Solomon, K.R., Forget, J., Stemeroff, M. and O'Leary, C. 1995. *A review of selected persistent organic pollutants.* Report for the International Programme on Chemical Safety (UNEP/ILO/WHO) December 1995

2) *Substance profiles.* Background Report for the International Experts Meeting on Persistent Organic Pollutants: Towards Global Action. Vancouver, June 1995.
Ritter, L., Solomon, K.R., Forget, J., Stemeroff, M. and O'Leary, C. 1995. A review of selected persistent organic pollutants. Report for the International Programme on Chemical Safety (UNEP/ILO/WHO) December 1995

3) for dieldrin, to which aldrin is rapidly converted

4) Wiktelius, S. and Edwards, C.A. 1997. Organochlorine Residues in African Fauna: 1971 – 1995. *Rev. Environ. Contam. Toxicol.*151: 1-37.

Table A4. Hazard classification and health risks of POP pesticides and pesticides included in the PIC procedure/Rotterdam Convention

Pesticide	Type	POP	PIC	Acute toxicity[a]	WHO[b]	USEPA[c]	IARC[d]	Examples of other effects of concern
1,2-dibromoethane (EDB)	fumigant		yes	146	n/a	B"	2A	Possible endocrine disruption
2,4,5-T	herbicide		yes	500	II	-	2B	Teratogenic, possible endocrine disruption
aldrin	insecticide	yes	yes	83 (humans) 38	Ib	B2	3	Immunotoxicity, chronic liver effect, male reproductive system impact
camphechlor (toxaphene)	insecticide	yes		30 (humans) 40	II	-	2B	Nervous system effects
captafol	fungicide		yes	5000	Ia	B2	2A	
chlordane	insecticide	yes	yes	25 (humans) 250	II	B2	2B	Endocrine system impact, reproductive disorders
chlordimeform	acaricide		yes	340	II	B2	3	Possible endocrine disruption
chlorobenzilate	acaricide		yes	700	III		3	Male reproductive system effect, eye irritant
DDT	insecticide	yes	yes	113	II	B2	2B	Immunotoxicity, interference with estrogenic system, Possible endocrine disruption
dieldrin	insecticide	yes	yes	37	Ia	B2	3	Immunotoxicity, chronic liver effect, male reproductive system impact
dinoseb and dinoseb salts	herbicide		yes	25	Ib	C	-	Reproductive system effects
endrin	insecticide	yes		7	Ib	-	3	
fluoroacetamide	rodenticide		yes	13	Ib			
HCB	fungicide	yes	yes	>10000	Ia	B2	2B	Effects on nervous, thyroid and reproductive systems
HCH (mixed isomers)	insecticide		yes	100	II		2B	
heptachlor	insecticide	yes	yes	147	II	B2	2B	Possible endocrine disruption, reproductive disorders
lindane	insecticide		yes	88	II	B2	2B	Possible endocrine disruption , effects on reproductive systems
mercury compounds	fungicides, insecticide		yes	1-210	Ia-II			Irreversible nervous system damage
methamidophos (certain formulations)	insecticide		yes	30	Ib			
methyl-parathion (certain formulations)	insecticide		yes	3	Ia			
mirex	insecticide	yes		306	-	B2	2B	Teratogenic
monocrotophos (certain formulations)	insecticide		yes	14	Ib			

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[1] Data mainly from
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- Greenpeace. "Dirty Dozen" Chemical Profiles. Prepared by Greenpeace International, Washington, D.C. October 1995. 22 pp.
- Substance profiles. Meeting Background Report for the International Experts Meeting on Persistent Organic Pollutants: Towards Global Action. Vancouver, June 1995.
- Commission for the European Communities (CEC), DGVIII/Pesticides Trust. 1998. Progressive Pest Management: Controlling pesticides and implementing IPM. London
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Annex 2
Selected bibliography, grouped by subject

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Agne, S., Waibel, H., Jungbluth, F. and Fleischer, G., 1995. Guidelines for Pesticide Policy Studies. *Pesticide Policy Project Publication Series no. 1,* University of Hannover

Commission for the European Communities (CEC), DGVIII / Pesticides Trust, 1998. *Progressive Pest Management: Controlling pesticides and implementing IPM,* London

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UNEP, 2000.
Report of the UNEP/FAO/Global IPM Facility Termite Biology and Management Workshop
(Geneva 1-3 February 2000), United Nations Environment Programme, UNEP Chemicals, Geneva

Pesticide labelling

FAO, 1995.
Guidelines on Good Labelling Practice,
Food and Agriculture Organization of the United Nations, Rome

Pesticide disposal

FAO, 1995. Guidelines on prevention of accumulation of obsolete pesticide stocks. FAO Pesticide Disposal Series no. 2. Food and Agriculture Organization of the United Nations, Rome.

FAO, 1996. Pesticide storage and stock control manual. Food and Agriculture Organization of the United Nations, Rome.

FAO, 1996. Disposal of bulk quantities of obsolete pesticides in developing countries. Provisional technical guidelines. Food and Agriculture Organization of the United Nations, Rome

GIFAP (GCPF). 1991. Disposal of unwanted pesticide stocks: guidance on the selection of practical options. Global Crop Protection Federation (Now: Crop Life International), Brussels

Annex 3

Selected international organisations and networks

Organisation	Acronyms	Description	Web Site	Postal address	Telephone (T) Fax (F)
Basel Convention		The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal aims to control the transboundary movement of hazardous wastes, monitor and prevent illegal traffic, provide assistance for the environmentally sound management of hazardous wastes through cooperation and Technical Guidelines. The secretariat of the convention is located at UNEP, Geneva.	http://www.unep.ch/basel	Secretariat of the Basel Convention Geneva Executive Center 15, Chemin des Anémones, Building D CH-219 Châtelaine, Switzerland	+41-22-9178218 (T) +41-22-7973454 (F)
CAB International	CABI	An international organisation providing expert service in agriculture and human health. Areas include entomology, parasitology and biological control	http://www.cabi.org	Wallingford, Oxon OX10 8DE UK	+44-1491-832111 (T) +44-1491-833508 (F)
Commission for Environmental Cooperation	CEC	Established under the North American Agreement on Environmental Cooperation (NAAEC). Develops Regional Action Plan on POPs and other substances of mutual concern under its "Sound Management of Chemicals" programme.	http://www.cec.org	393, rue St-Jaques Ouest Bureau 200 Montreal, Québec H2Y 1N9 Canada	+1-514-350 4300 (T) +1-514-350 4314 (F)
Codex Alimentarius Commission		Jointly operated by FAO and WHO, the Commission makes recommendations for maximum residue limits in food and fodder	http://www.fao.org/waicent/faoinfo/economic/esn/codex/Default.htm	Secretariat of the Joint FAO/WHO Food Standards Program Via delle Tere di Caracalla 00100 Rome, Italy	+39-6-57051 (T) +39-6-57054593 (F)
Consultative Group on International Agricultural Research	CGIAR	A global network of agricultural research centres, covering different areas and crops. A Systemwide Programme on IPM aims at further strengthening IPM coordination between the participating institutes.	http://www.cgiar.org/	1818 H Street W Washington DC, 20433 USA	+1-202-473 8951 (T) +1-202-473 8110 (F)
Consumers International		An international consumer organisation monitoring use of and trade in hazardous chemicals, including POPs	http://www.consumersinternational.org/	24 Highbury Crescent London N5 1RX United Kingdom	+44-171-226 6663 (T) +44-171-354 0607 (F)
Food and Agriculture Organization of the United Nations	FAO	The FAO has a central role in promoting IPM, sound pesticide management practices, disposal of obsolete stocks, etc. The Code of Conduct on the Distribution and	http://www.fao.org/	Via delle Tere di Caracalla 00100 Rome, Italy	+39-6-57051 (T) +39-6-57053152 (F)

Organisation	Acronyms	**Description**	**Web Site**	**Postal address**	**Telephone (T) Fax (F)**
		Use of Pesticides is supervised by the FAO.			
Global Crop Protection Federation (now: Crop Life International)	GCPF	Formerly known as GIFAP, GCPF is the global organisation for agrochemical industries. Promotes safe and responsible management of pesticides in industry and by users, e.g. through "safe use of pesticides" projects.	http://www.gcpf.org/	143, Avenue Louise B-1050 Brussels Belgium	+32-2542 0410 (T) +32-2542 0419 (F)
Global IPM Facility		An internationally supported unit specifically promoting farmers' participation in IPM development.	http://www.fao.org/ag/agp/agpp/ipm	c/o FAO/AGPP Via delle Tere di Caracalla 00100 Rome, Italy	+39-6-57051 (T) +39-6-57053152 (F)
Greenpeace International		Monitors and campaigns on environmental issues such as pesticides and other chemicals	http://www.greenpeace.org	Keizergracht 174 1016 DW, Amsterdam The Netherlands	+31-20-523 6222 (T) +31-20-523 6200 (F)
Intergovernmental Programme on Chemical Safety	IPCS	The International Programme on Chemical Safety or IPCS established in 1980, is a joint programme of three Cooperating Organisations, ILO, UNEP and WHO, implementing activities related to chemical safety. IPCS is an intersectoral coordinated and scientifically based programme. WHO is the Executing Agency of the IPCS.	http://www.who.int/pcs/	WHO CH-1211 Geneva 27 Switzerland	+41-22-791 3588 (T) +41-22-797 4848 (F)
International Agency for Research on Cancer	IARC	The International Agency for Research on Cancer (IARC) was established in 1965 by the World Health Organisation. IARC's mission is to coordinate and conduct research on the causes of human cancer	http://www.iarc.fr/	150, cours Albert Thomas F-69372 Lyon Cedex 08 France	+33-4 7273 8485 (T) +33-4 7273 8585 (F)
International Centre for Insect Physiology and Ecology	ICIPE	The centre carries out research on important agricultural pests and disease vectors, aimed at developing sustainable control methods suitable for developing countries.	http://www.icipe.org/	PO Box 30772 Nairobi, Kenya	+254-2-861 686 (T) +254-2-861 690 (F)
International Centre for Pesticide Safety	ICPS	The centre provides training, information and other assistance on issues concerning occupational pesticide safety. Located at the University of Milan, Italy	e-mail: occupmed@imiucca.csi.unimi.it	Via Magenta 25 20020 Busto Garolfo MI Italy	+39-3-31 586 091 (T) +39-3-31 586 023 (F)
IPMEurope		A European network of organisations aimed at improving the adoption of IPM in developing countries through better coordination of policies and activities.	http://www.nri.org/IPMEurope/homepage.htm	Central Avenue Chatham Maritime Kent ME4 4TB United Kingdom	+44-1634-883054 (T) +44-1634-883377 (F)
IPMForum		Uniting a wide range of international organisations, the IPMForum promotes IPM adoption in developing countries with a focus on	http://www.nri.org/IPMForum/index.htm	Central Avenue Chatham Maritime Kent ME4 4TB	+44-1634-883054 (T) +44-1634-883377 (F)

Organisation	Acronyms	Description	Web Site	Postal address	Telephone (T) Fax (F)
		NGOs		United Kingdom	
International Water Management Institute	IWMI	One of the Centres belonging to the Consultative Group for International Agricultural Research (CGIAR: home to the secretariats of the Dialogue on Water for Food and Environment and of the System-wide Initiative on Malaria and Agriculture	http://www.cgiar.org/iwmi	127 Sunil Mawatha Pelawatta Battaramula 10200 Colombo Sri Lanka	+94 (1) 787 404 (T) +94 (1) 786 854 (F)
Organisation for Economic Co-operation and Development Pesticide Programme	OECD	The OECD Pesticide Programme produces Guidance Documents for pesticide registration	http://www.oecd.org/ehs/pesticd.htm	2, rue André-Pascal 75775 Paris Cedex 16 France	+33-1 45 24 16 75 (F)
Panel of Experts on Environmental Management for Vector Control	PEEM	This joint WHO/FAO/UNEP/UNCHS panel promotes the extensive use of environmental management in disease vector control in the sectors covered by the involved agencies.	(no specific site – some information available at http://www.who.org)	Avenue Appia 20 1211 Geneva 27 Switzerland	+41-22-791 2111 (T) +41-22-791 0746 (F)
Pesticide Action Network	PAN	PAN, which has five regional centres, organises individuals and groups monitoring pesticide use and pesticide trade, and advocates alternative pest management approaches	North America: http://www.panna.org/panna/ Europe: http://www.gn.apc.org/pesticidestrust/ Asia-Pacific: http://www.poptel.org.uk/pana/	Pesticide Action Network North America 49 Powell St., Suite 500 San Francisco, CA 94102, USA The Pesticides Trust (PAN Europe Eurolink Business Centre 49 Effra Road, London, SW2 1BZ United kingdom PAN Asia/Pacific P.O. Box 1170 10850 Penang, Malaysia	+1-415 981-1771 (T) +1-415 981-1991 (F) +44-171-274 8895 (F) +60-4-657 7445 (F)
Pesticide Policy Project		Based at the University of Hannover, Germany, the project does research on economic and political factors influencing pesticide use.	http://www.ifgb.uni-hannover.de/institut/projekte/gtz/ppp.htm	Institut für Gartenbauökonomie Herrenhaeuser Str. 2 D 30419 Hannover Germany	+49-511-762-2666 (T) +49-511-762-2667 (F)
Rotterdam Convention on the procedure for Certain Hazardous Chemicals and Pesticides in International Trade	PIC	International agreement to increase exchange on information on particularly hazardous pesticides. Jointly implemented by FAO and UNEP. PIC is being replaced by the Rotterdam Convention, signed in 1998.	http://www.fao.org/waicent/faoinfo/agricult/AGP/AGPP/pesticid/PIC/pichome.htm	FAO Joint Secretariat to PIC Via delle Tere di Caracalla 00100 Rome, Italy	+39-6-5705 3441 (T) +39-6-5705 6347 (F)

Organisation	Acronyms	**Description**	**Web Site**	**Postal address**	**Telephone (T) Fax (F)**
System-wide Initiative on Malaria and Agriculture	SIMA	An initiative in the framework of the Consultative Group on International Agricultural Research (CGIAR) to promote multidisciplinary research on determinants of malaria in agro-ecosystems; Secretariat in IWMI, South AFrica Office, Pretoria	http://www.cgiar.org/iwmi/sima		
United Nations Environment Programme	UNEP	UNEP is instrumental and catalytic in international environmental activities. UNEP Chemicals is the division responsible for maintaining and updating information on toxic chemicals in international trade, providing services to the Rotterdam Convention and the interim Secretariat for the STockholm Convention on POPs..	http://www.unep.org http//chem.unep.ch http://www.pic.int	PO Box 30552 Nairobi, Kenya UNEP Chemicals 11-13 chemin des Anémones CH 1219 Châtelain, Switzerland	+254-2-62 1234/3292 (T) +254-2-62 3927/3692 (F) +41 22 979 9193 (T)
United Nations Industrial Development Organisation	UNIDO	UNIDO strives to assist developing countries to improve industrial production, including pesticides	http://www.unido.org/	Vienna International Centre PO Box 300 A-1400 Vienna, Austria	+43-1 26026 (T) +43-1 2692669 (F)
World Health Organisation	WHO	The WHO has a crucial role i.a. in establishing international standards related to pesticide safety, and in combating diseases world-wide. Particular programmes include: Programme for the Promotion of Chemical Safety (PCS)	http://www.who.ch/ http://www.who.ch/programmes/pcs/pcs_new.htm	Avenue Appia 20 1211 Geneva 27 Switzerland	+41-22-791 2111 (T) +41-22-791 0746 (F)
World Wildlife Fund International	WWF	Focusing on nature conservation, WWF also supports efforts to improve pesticide management and reduce risks	http://www.wwf.org	Avenue du Mont-Blanc CH-1196 Gland Switzerland	+41-22-364 9111 (T) +41-22-364 5358 (F)

Annex 4
Internet resources on specific issues

The Internet sites listed below were active and up to date at the time of publication. The Internet is by nature very dynamic, and new highly interesting and relevant sites are continuously being developed. The sites presented here will in any case provide entrance points for further exploration.

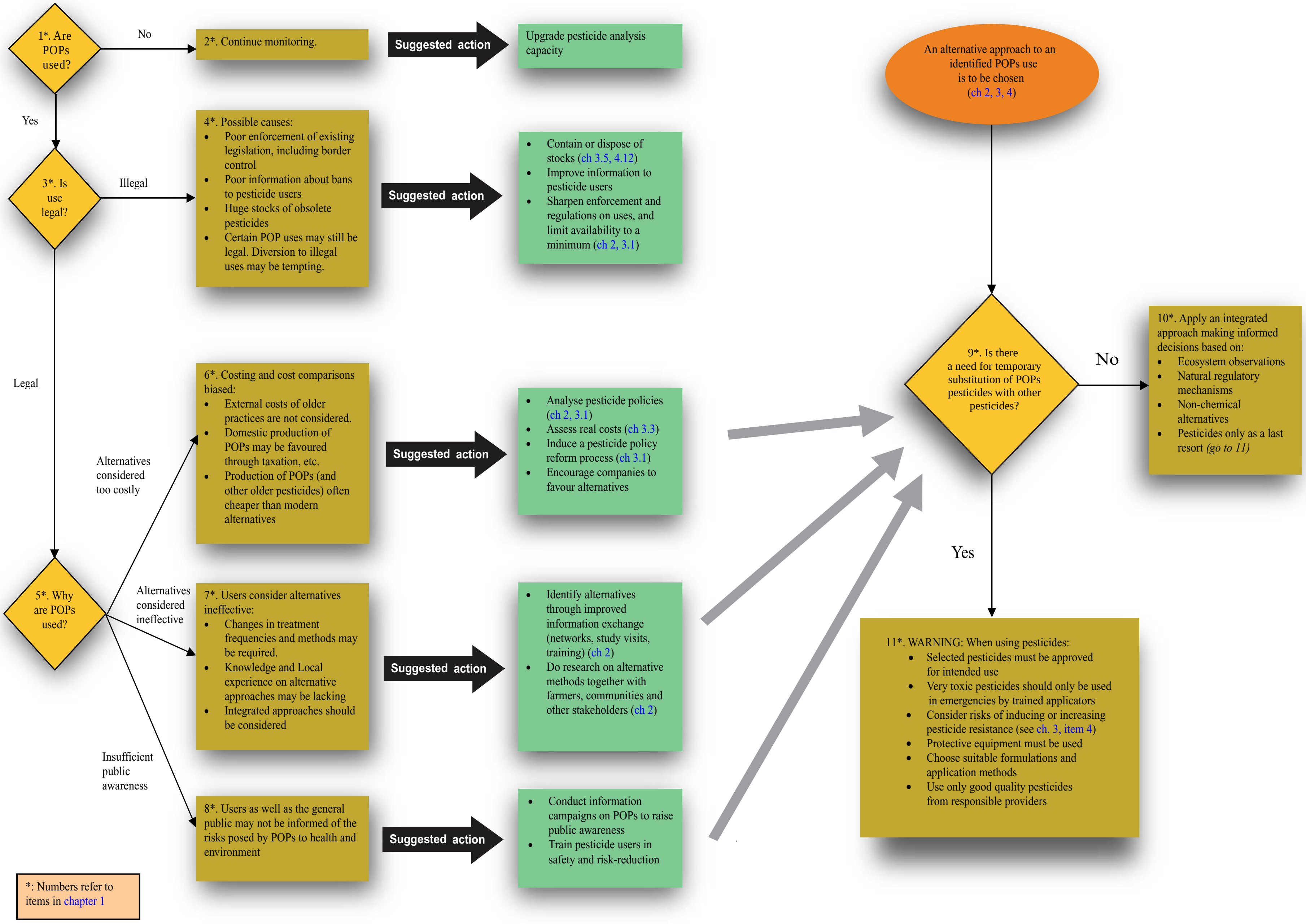
Issue	Description	Internet address
IPM	IPMnet is a network under the auspices of the Consortium for International Crop Protection. Among its activities is the publication of an electronic newsletter, IPMnet News.	http://www.ipmnet.org/
	Pest Management Resource Centre – provides extensive information on a range of pest management issues. Public and private sponsors.	http://www.pestmanagement.co.uk/
	FAO provides information on IPM programmes and FFSs	http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/IPM
	The FAO Intercountry Programme for Community IPM in South and Southeast Asia provides information on IPM activities in Asia.	http://www.communityipm.org
	The CGIAR task force on Farmer Participatory Research for Integrated Pest Management (FPR-IPM) maintains a forum for people and institutions interested in fostering farmer participation in research and development of Integrated Pest Management.	http://www.ciat.cgiar.org/ipm/index.htm http://www.ciat.cgiar.org/ipm/index.htm http://www.ciat.cgiar.org/ipm/index.htm
Malaria and other vector borne diseases	The Malaria Database site is run by the Department of Microbiology, Monash University and the Walter and Eliza Hall Institute of Medical Research, Melbourne, Australia. Funded by: UNDP/World Bank/WHO. This is an information resource for scientists working in malaria research	http://www.wehi.edu.au/MalDB-www/who.html
	Malaria Foundation International – various private and public sponsors aim to promote coordination between different malaria networks and give access to malaria – related databases.	http://www.malaria.org/
	The Roll Back Malaria Initiative was established in November 1999 by WHO, UNICEF, UNDP and The World Bank. It aims to half the global burden caused by malaria by 2010.	http://rbm.who.int
	ACTMALARIA: Asian Collaborative Training Network for Malaria: focuses on malaria in the countries of South-East Asia.	http://rbm.who.int
	The official web-site of the EC Regional Malaria Control Programme in ambodia, Lao PDR and Viet Nam	http://www.mekong-malaria.org
	A reference directory on malaria transmission research.	http://www.anopheles.com
	London School of Hygiene and Tropical Medicine Malarial Centre: focusing on malaria research networking and capacity building.	http://www.lshtm.ac.uk/centres, malaria/introduction.htm
	The USAID sponsored Environmental Health Project, based in Arlington, Virgina, USA, publishes monthly literature summaries on malaria research.	http://www.ehproject.org
Methyl Bromide	Methyl Bromide Phaseout Web Site (USEPA)	http://www.epa.gov/ozone/mbr/mbrqa.html

	UNEP Ozone Action Programme – a clearinghouse that assists developing countries to phase out ozone depleting substances.	http://www.unepie.org/ozonaction
	The Ozone Depleting Substances Phase out Project in German Technical Cooperation.	http://www.gtz.de/proklima
Pesticide disposal	FAO Pesticide Management Prevention and Disposal of Obsolete Pesticide	http://www.fao.org/WAICENT/Faoinfo/Agricult/AGP/AGPP/Pesticid/Disposal/default.htm
POPs	The UNEP POPs and Stockholm Convention site provides, inter alia: • Updated information on the negotiations of the Stockholm Convention on Persistent Organic Pollutants • Reports, documents and case studies • Data on POPs and their alternatives • A collection of studies and action plans to reduce/eliminate releases of POPs • Discussion forums on specific POPs related topics • Contacts to expertise • Calendar of events	http://www.chem.unep.ch/pops/ http://www.chem.unep.ch/sc/
	International POPs Elimination Network (PEN) is a network of public interest organisations united in a POPs Elimination Platform.	http://www.ipen.org
Termites	UNEP/FAO/Global IPM Facility Expert Group on Termite Biology and Management provides information and guidance on options for management of termites in construction and agriculture through specific web-pages and workshop reports.	http://www.chem.unep.ch/pops/
	Cal Termite Page provides general biology, detection and control information for termites in California and the Pacific Coast and contains answers to common questions about termites, papers and video. University of California.	http://nature.berkeley.edu/lewis
	Termites – Urban Entomology Program Website provides information on termite species and biology for North-America. University of Toronto, Canada.	http://www.utoronto.ca/forest/termite/termite.htm
	Online Termite Database is a taxonomic database of all living termites of the World. It is complete for the Nearctic and Neotropical regions including synonym and taxonomic information, geographical distribution, pest status, bibliography.	http://www.unb.br/ib/zoo/docente/constant/catal/catnew.html
	Termite Control: Answers to Homeowners; Protecting your home against termites; Termite baits: a Guide for Homeowners. University of Kentucky	http://www.uky.edu/Agriculture/Entomology/entfact/struct/ef604.ht http://www.uky.edu/Agriculture/entomology/entfacts/struct/ef605.htm http://www.uky.edu/Agriculture/Entomology/entfacts/struct/ef639.htm
	TAMU Termite Web Site provides information on the different termite species, (Drywood, Subterranean, Formosan Subterranean).	http://termites.tamu.edu/

Glossary and selected acronyms

Agrochemicals	Chemicals used in agricultural production systems including fertilizers, herbicides and pesticides
Arbovirus	An arthropod-borne virus; human diseases caused by arboviruses include dengue, Japanese encephalitis, yellow fever and West-Nile encephalitis.
Arthropod	Class of animals that includes insects, mites and spiders.
Bio-accumulation	Increase in the concentration of a pollutant in an organism compared to its direct environment or food.
Bio-magnification	Increase of the concentration of a pollutant as it moves from one trophic level to another through the food chain.
Biological control	Using a living organism (natural enemy) to control a pest. The biological control agent can for example be an insect, a fungal disease, a bacterium or a virus.
Carbamates	Group of synthetic pesticides
Carcinogenic	Causing cancer
Ecology	The science of relationships between communities of organisms and their environment
Endocrine system	The hormonal system, regulating numerous bodily functions
FAO	Food and Agriculture Organisation of the United Nations
Food chain	The links between food organisms and consumers (e.g.: from plankton to fish to fish-eating bird); more correctly: food web.
Formulation	The pure pesticidal substance can seldom be used as it is. It is therefore formulated with solvents, dispersants and other additives.
IARC	International Agency for Research on Cancer (WHO).
IDM	Integrated Disease Management.
Incidence	The number of new (disease or infection) cases over a given period, usually a year.
IPM	Integrated Pest Management
IVM	Integrated Vector Management
LD_{50}	Measure of toxicity – the dose that will kill 50% of a population. The unit is usually mg (toxin)/kg (body weight).
Malaria	A parasitic disease caused by organisms of the genus *Plasmodium*, transmitted by mosquitoes of the genus *Anopheles.*
Mutagenic	Causing mutations
Organophosphates	Group of synthetic insecticides
PEEM	Panel of Experts on Environmental Management for Vector Control (WHO/FAO/UNEP)
Pheromone	A substance (odour) used for communication between individuals of the same species. Vital for locating mates for many insects.
POP pesticides	The POPs which are pesticides (nine of the twelve).
POPs	Persistent Organic Pollutants – chemical substances with the characteristics listed in the introduction of this document; this group includes the twelve substances identified for reduction and elimination under the UNEP Governing Council decisions 18/32; 19/13C; 20/24; and 21/4 and covered by the Stockholm Convention.
ppb	Parts per billion.
ppm	Parts per million.
Prevalence	The number of (disease or infection) cases divided by the total number of people at risk at one particular moment in time.
Pyrethroid	Group of synthetic insecticides that are toxic to insects also in low doses.
Resistance	The capacity of an organism to withstand the killing effect of a chemical or drug, usually linked to a genetic trait that is propagated in a population because of selection pressures.
Sp.	Species (singular)
Spp.	Species (plural)
Teratogenic	Causing foetal damage.
UNCED	United Nations Conference on Environment and Development, held in 1992. Also known as the Rio Conference.
UNEP	United Nations Environment Programme.
USEPA	United States Environmental Protection Agency.
Vector	Organism – often an insect- transmitting an infection from one person to another or from an infected animal to a person.
WHO	World Health Organisation.

Reducing/eliminating persistent organic pesticides



1*. Are POPs used?

No

2*. Continue monitoring.

Suggested action

Upgrade pesticide analysis capacity

Yes

3*. Is use legal?

Illegal

4*. Possible causes:
- Poor enforcement of existing legislation, including border control
- Poor information about bans to pesticide users
- Huge stocks of obsolete pesticides
- Certain POP uses may still be legal. Diversion to illegal uses may be tempting.

Suggested action

- Contain or dispose of stocks (ch 3.5, 4.12)
- Improve information to pesticide users
- Sharpen enforcement and regulations on uses, and limit availability to a minimum (ch 2, 3.1)

Legal

5*. Why are POPs used?

Alternatives considered too costly

6*. Costing and cost comparisons biased:
- External costs of older practices are not considered.
- Domestic production of POPs may be favoured through taxation, etc.
- Production of POPs (and other older pesticides) often cheaper than modern alternatives

Suggested action

- Analyse pesticide policies (ch 2, 3.1)
- Assess real costs (ch 3.3)
- Induce a pesticide policy reform process (ch 3.1)
- Encourage companies to favour alternatives

Alternatives considered ineffective

7*. Users consider alternatives ineffective:
- Changes in treatment frequencies and methods may be required.
- Knowledge and Local experience on alternative approaches may be lacking
- Integrated approaches should be considered

Suggested action

- Identify alternatives through improved information exchange (networks, study visits, training) (ch 2)
- Do research on alternative methods together with farmers, communities and other stakeholders (ch 2)

Insufficient public awareness

8*. Users as well as the general public may not be informed of the risks posed by POPs to health and environment

Suggested action

- Conduct information campaigns on POPs to raise public awareness
- Train pesticide users in safety and risk-reduction

An alternative approach to an identified POPs use is to be chosen (ch 2, 3, 4)

9*. Is there a need for temporary substitution of POPs pesticides with other pesticides?

No

10*. Apply an integrated approach making informed decisions based on:
- Ecosystem observations
- Natural regulatory mechanisms
- Non-chemical alternatives
- Pesticides only as a last resort *(go to 11)*

Yes

11*. WARNING: When using pesticides:
- Selected pesticides must be approved for intended use
- Very toxic pesticides should only be used in emergencies by trained applicators
- Consider risks of inducing or increasing pesticide resistance (see ch. 3, item 4)
- Protective equipment must be used
- Choose suitable formulations and application methods
- Use only good quality pesticides from responsible providers

*: Numbers refer to items in chapter 1