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).

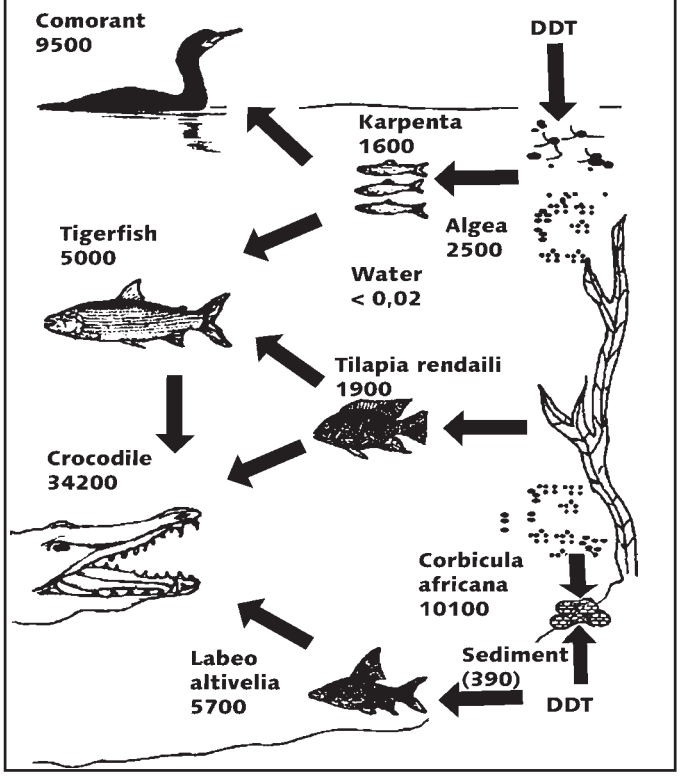
Effects of POPs on Health and Environment

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 insec-

ticides 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).

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.

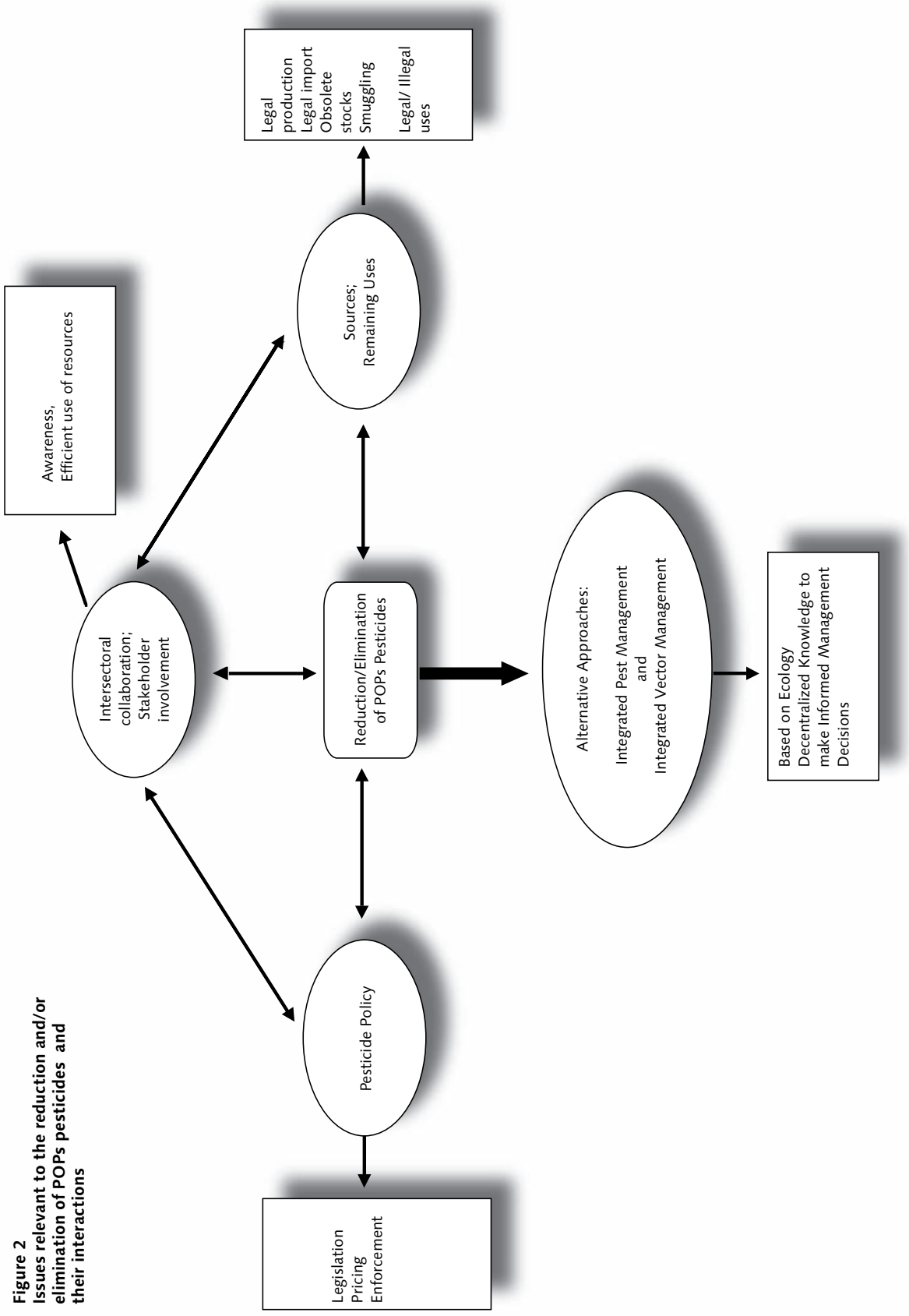


Figure 2
Issues relevant to the reduction and/or elimination of POPs pesticides and their interactions

- 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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