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 co-operation 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 on-going 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 irri-gated 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 subtropical 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.

References - Chapter 2

Bos, R., 2001. Identifying opportunities to avert malaria risk across sectors, in the section: Working Though All Avenues\Enlisting the Non-Health Sectors. *Report of the 4th Global Partnership Meeting to Roll Back Malaria (Washington DC, 18-19 April 2001)*, CD-ROM produced by the World Bank, Washington DC

FAO, 1967. Report of the first session of the FAO Panel of Experts on Integrated Pest Control (Rome, 18-22 September 1967), Food and Agriculture Organization of the United Nations, Rome

FAO, 1987. Effects of Agricultural Development on Vector-borne Diseases, *Document AGL/MISC/12/87*, Food and Agriculture Organization, Rome

FAO, 1992. Pesticides selection and use in field projects. *FAO Field Programme Circular number 8/92*, Food and Agriculture Organization of the United Nations, Rome

Farah, J. 1994. Pesticide Policies in Developing Countries - Do They Encourage Pesticide Use? *World Bank Discussion Papers no. 238* The World Bank, Washington, D.C.

Georghiou, G.P., 1972. Studies on resistance to carbamate and organophosphorous insecticides in *Anopheles albimanus*, *Am. J. Trop. Med. & Hyg. 21: 797-806*

Georghiou, G.P., 1987. The effect of agrochemicals on vector populations. In: Effects of agricultural development on vector-borne diseases, *FAO document AGL/MISC/12/87*, Food and Agricultural Organization of the United Nations, Rome

IPPC Secretariat, 1996 International Standards for Phyto-Sanitary Measures. *Series 3: code of concuct for the input and release of exotic biological control agents.* Food and Agriculture Organization of the United Nations, Rome.

Litsios, S. , 1996. *The tomorrow of malaria,* Pacific Press, Wellington, New Zealand

Tiffen, M, 1991. Guidelines for the Incorporation of Health Safeguards into Irrigation Projects through Intersectoral Cooperation, PEEM Guidelines Series 1, *document WHO/CWS/91.2*, World Health Organization, Geneva

UN, 1992. *Agenda 21, Programme of Action for Sustainable Development,* United Nations, New York

UNEP, 2000. *Proceedings of a UNEP/FAO/WHO workshop on sustainable approaches for pest and vector management and opportunities for collaboration in replacing POPs pesticides (Bangkok, March 6-10 2000).* UNEP Chemicals, Geneva.

World Bank, 1997. Integrated Pest Management: strategies and policies for effective implementation. *Environmentally Sustainable Development Studies and Monographs Series number 13* The World Bank, Washington DC

WHO, 1983. Integrated Vector Control, seventh report of the WHO Expert Committee on Vector Biology and Control . *WHO Technical Report Series 688*, World Health Organization, Geneva

WHO, 1993. Implementation of the Global Malaria Control Strategy, report of a WHO Study Group on the Global Plan of Action for Malaria Control 1993-2000, *WHO Technical Report Series 839*, World Health Organization, Geneva

WHO, 1995. Vector Control for Malaria and Other Mosquito-borne Diseases, *WHO Technical Report Series 857*, World Health Organization, Geneva

WHO, 2001a. *The World Health Report 2001,* Mental Health: new understanding, new hope, World Health Organization, Geneva

WHO, 2001b. Action Plan for the Reduction of Reliance on DDT in Disease Vector Control, *Document WHO/SDE/WSH/01.05.* World Health Organization, Geneva

Recommended further reading on IPM for specific crops

Abdel Rahman, A.A. and K.G. Eveleens, 1979. *Cotton pest management in the Sudan*, FAO/UNEP Northeast African Programme for the Development and Application of Integrated Pest Control in Cotton, Wad Medani (Sudan), Agricultural Research Corporation, Gezira Research Station, 37 p.

Barducci, T.B., 1972. Ecological Consequences of Pesticide Used for the Control of Cotton Insects in Canete Valley, Peru, in: *The Careless Technology, Ecology and International Development*, edited by M. Taghi Farvar and John P. Milton. Anchor and Doubleday, New York

Conway, G.R., 1972. Ecological aspects of pest control in Malaysia, in: *The Careless Technology, Ecology and International Development,* edited by M. Taghi Farvar and John P. Milton. Anchor and Doubleday, New York

DeBach P. and D. Rosen, 1991. *Biological control by natural enemies*, Cambridge University Press

Dick, K.M., R.H. Markham and H.R. Herren *(eds.)*, 1990. Biological control of the larger grain borer in Africa: a component of an integrated pest management strategy, *Proceedings of an IITA/FAO Coordination Meeting*, Cotonou, Republic of Benin, 2-3 June 1989

Eveleens, K.G. and E.T.M. El Amin, 1981. Review of the current status of the FAO/UNEP African inter-country programme for the development and application of integrated pest control in cotton growing, *Report of the 10th session of the FAO/UNEP Panel of Experts on Integrated Pest Control.* Food and Agriculture Organization of the United Nations, Rome

FAO, 1983. Guidelines for Integrated Control of Cotton Pests, *FAO Plant Production and Protection Paper No. 48*, Food and Agriculture Organization of the United Nations, Rome.

Kenmore, P.E., F.O. Carino, C.A. Perez, V.A. Dyck and A.P. Gutierrez, 1984. Population regulation of the rice brown planthopper (*Nilaparvata lugens* Stal) within rice fields in the Philippines, *Journal of Plant Protection in the Tropics 1(1*): 19-37

Kenmore, P.E., K.D. Gallagher and P.A.C. Ooi, 1995. Empowering farmers: Experiences with Integrated Pest Management. *Entwicklung + Landlicher Raum 1*:27-28

Kenmore P.E, 1995**.** IPM rice case study, in: G.J. Persley (ed.) *Proceedings of the Bellagio Conference on Integrated Pest Management and Biotechnology*, Food and Agriculture Organization of the United Nations, Rome

Moscardi, F., 1993. Soybean integrated pest management in Brazil, *FAO Plant Protection Bulletin , 41(2)* : 91-100

Smith R.F., 1972. Effects of Manipulation of Cotton Agro-Ecosystems on Insect Pest Populations, in: *The Careless Technology, Ecology and International Development*, edited by M. Taghi Farvar and John P. Milton. Anchor and Doubleday, New York

Zadoks J.C., 1965. Epidemiology of wheat rusts in Europe, *FAO Plant Protection Bulletin 13, 5*: 97-108

Zadoks J.C., 1979. Wheat rust epidemiology in Ethiopia in relation to wheat breeding in Ethiopia, FAO-AGO—ETH/74/002, Food and Agriculture Organization of the United Nations, Rome

Zadoks J.C., 1989. Does IPM (Integrated Pest Management) give adequate attention to disease control, in particular at the farmer level?, *FAO Plant Protection Bulletin 37,4*: 144-150

Zelazny B., 1979. Loss in coconut yield due to *Oryctes rhinoceros* damage, *FAO Plant Protection Bulletin 27, 3*: 65-70

Zelazny, B., L. Chiarappa and P.E. Kenmore, 1985 **,** Integrated pest control in developing countries, *FAO Plant Protection Bulletin, 33,4:* 147-158