Training and information materials on Vector Biology and Control
in the VBC Slide Set Series

Produced by
the WHO/FAO/UNEP/UNCHS Panel of Experts
on Environmental Management for Vector Control

PEEM Secretariat, WHO, Geneva

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1996

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Ordering information

Agricultural Development and Vector-borne Diseases
*Training and Information Materials on Vector Biology and Control, Slide Set Series*
Prepared by WHO in collaboration with FAO, UNEP, and UNCHS
1997, iii + 83 pages + 180 colour slides
Sw.fr. 250.-/US $225.00; in developing countries: Sw.fr. 175.-
Order no. 1660013
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Preface

At its 7th meeting at FAO, Rome in 1987, the joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control reviewed the effects of agricultural development in its broadest sense on vector-borne diseases. In addition to its traditional focus on water resources development for irrigation, the Panel focused its discussions on other aspects of agricultural development: cropping patterns, chemical inputs, the introduction of new varieties, mechanization and items pertaining to fisheries and forestry. A few years later, at its 1990 meeting, also in Rome, an in-depth review of the links between livestock management and human vector-borne diseases was carried out.

Several technical recommendations emerged from both meetings and, in particular, the collaboration with some of the CGIAR institutions was strengthened as a result. The WARD/PEEM/IDRC Research Consortium Project on the association between rice production systems and vector-borne diseases in West Africa would not have taken shape so fast without this review, and progress towards the implementation of health research activities in the Environment and Health Programme of the International Irrigation Management Institute in Sri Lanka would have missed an important impulse.

The information collected for and generated by the 7th PEEM meeting was published in the FAO publication *Effects of Agricultural Development on Vector-borne Diseases* (AGL/MISC/12/87). The Panel recommended that, in addition, a set of visual training aids be developed for use in awareness creation, training and education activities. The production of this slide set was commissioned in 1992. After review and further refinement, a final, prototype set was ready by 1994, but it was not until 1996 that, thanks to the financial support of the United Nations Environment Programme, a first batch of slide sets could be produced for marketing.

The health dimensions of the extensive environmental change we are witnessing in the last decades of the 20th century are complex and probably only matched by the health dimensions of the extensive social change occurring at the same time. In all parts of the world, policy and decision makers are grappling with a transfer from a strictly economics-driven development to true sustainable development. This slide set aims to help them and future professionals to visualize specific agro-ecotypes, relate them to their local conditions and develop effective preventive solutions to equally specific local health problems.

Robert Bos
Executive Secretary
PEEM
About PEEM

The Panel of Experts on Environmental Management for Vector Control (PEEM) was established in 1981 as a joint activity of the World Health Organization, the Food and Agriculture Organization of the United Nations and the United Nations Environment Programme. The Panel’s objective is to create an institutional framework for effective interagency and intersectoral collaboration by bringing together various organizations and institutions involved in health, land and water development and the protection of the environment, with a view to promoting the extended use of environmental management measures for disease vector control in development projects. The PEEM Secretariat is located in the Division of Operational Support for Environmental Health of WHO in Geneva, Switzerland.

In 1991 the three agencies were joined by the United Nations Centre for Human Settlements (UNCHS/Habitat) and the Panel’s mandate was expanded to include health issues relating to human settlements in the context of development and the provision of drinking water supply and sanitation, and urban environmental management for disease vector control. At the time of publication of this slide set, the global PEEM network consists of 40 experts and fifteen collaborating centres representing a range of relevant disciplines.

The WHO Slide Set Series on vector Biology and Control contains twelve sets, eight of which concentrate on a single vector or group of vectors. Of the remaining four, the present set and the set on Environmental Management for Vector Control have been prepared under the auspices of PEEM.
Acknowledgements

The production of this slide set was commissioned from Mr Tom H. Mather, CEng MICE, who designed the set’s structure, collected the slides and drafted the captions and accompanying text. Within the limited resources available, Mr Mather was able to successfully carry out his assignment, drawing on his many contacts dating back to his position as Service Chief, Water Resources, Development and Management in FAO, Rome. The photo libraries of both FAO and WHO proved valuable sources of material, but many others contributed and these inputs are individually acknowledged at the start of each section, where the slides are listed. The accompanying text was further developed by Hans Verhoef, at the time Associate Professional Officer in the PEEM Secretariat and currently Research Associate of Wageningen University in the Netherlands. Jacob Williams, Associate Professional Officer in the PEEM Secretariat at the time of publication of this set, assisted in completing the text with disease profiles and in its assembly.
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Glossary

Some of the explanations of medical terms in this glossary may not follow the precise wording of official WHO definitions. Wording has been chosen with a view to facilitating proper understanding by a non-expert audience.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aedes mosquitoes</td>
<td>type of mosquito that may transmit diseases like yellow fever and dengue</td>
</tr>
<tr>
<td>agricultural environment</td>
<td>environment which is defined by characteristics which have an important bearing on crop production or crop cultivation, e.g. water availability and soil characteristics (e.g. upland rice environment, seasonally flooded river banks)</td>
</tr>
<tr>
<td>agroecosystem</td>
<td>combination of ecosystem and cropping</td>
</tr>
<tr>
<td>Anopheles mosquitoes</td>
<td>type of mosquitoes that may transmit malaria and rural filariasis</td>
</tr>
<tr>
<td>arbovirus</td>
<td>an arthropod-borne virus, i.e. a virus that is transmitted by insects, ticks or mites</td>
</tr>
<tr>
<td>bilharziasis</td>
<td>see: schistosomiasis</td>
</tr>
<tr>
<td>cost-effectiveness analysis</td>
<td>a form of economic evaluation where all the costs are expressed in monetary terms but where some of the effects are expressed in physical units (e.g. life-years gained, cases detected, etc.) - as opposed to cost-benefit analysis, where all effects are expressed in monetary terms only.</td>
</tr>
<tr>
<td>cropping intensity</td>
<td>land use as expressed in the number of crops that are cultivated on a particular surface area per year or season</td>
</tr>
<tr>
<td>cropping system</td>
<td>social, political and economic environment which determines crop cultivation practices. Compare with: ecosystem, agrosystem</td>
</tr>
<tr>
<td>dengue</td>
<td>a disease caused by viruses that are spread by Aedes mosquitoes; dengue haemorrhagic fever (DHF): potentially fatal complication of dengue characterized by bleeding from nose, mouth, skin wounds and internal organs.</td>
</tr>
<tr>
<td><strong>economic evaluation</strong></td>
<td>a process whereby costs of alternative actions are compared with the consequences in terms of improved health, savings in resources and opportunities lost. Compare with: <strong>financial evaluation</strong></td>
</tr>
<tr>
<td>-------------------------</td>
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</tr>
<tr>
<td><strong>ecosystem</strong></td>
<td>physical and ecological environment that determines crop production potential. Compare with: <strong>cropping systems, agrosystems</strong></td>
</tr>
<tr>
<td><strong>ecotype</strong></td>
<td>see: <strong>ecosystem</strong></td>
</tr>
<tr>
<td><strong>encephalitis</strong></td>
<td>inflammation of the brain</td>
</tr>
<tr>
<td><strong>endemic</strong></td>
<td>a term referring to the continuous presence of infection in a given community. Compare with: <strong>epidemic</strong></td>
</tr>
<tr>
<td><strong>environmental assessment</strong></td>
<td>study to forecast the positive and negative effects of a particular project on the environment, and to recommend measures to mitigate possible negative effects.</td>
</tr>
<tr>
<td><strong>environmental management</strong></td>
<td>planning, organization, implementation and monitoring of activities for the modification and/or manipulation of environmental factors or their interaction with humans with a view to preventing or reducing vector propagation and reducing human-vector-pathogen contact. See also: <strong>environmental manipulation, environmental modification, human-vector contact</strong></td>
</tr>
<tr>
<td><strong>environmental manipulation</strong></td>
<td>a form of environmental management consisting of any planned recurrent activity aimed at producing temporary conditions unfavourable to the breeding of vectors in their habitat (e.g. weeding of irrigation canals for the control of snail vectors of schistosomiasis, regulation of water level in reservoirs, water salinity changes). See also: <strong>environmental management, environmental modification</strong></td>
</tr>
<tr>
<td><strong>environmental modification</strong></td>
<td>a form of environmental management consisting of any physical transformation that is permanent or long-lasting of land, water and vegetation, aimed at preventing, eliminating or reducing the habitats of vectors without causing unduly adverse effects on the quality of the human environment (e.g. drainage, filling, land levelling). See also: <strong>environmental manipulation, environmental management</strong></td>
</tr>
<tr>
<td><strong>epidemic</strong></td>
<td>the occurrence of disease or illness that attacks greater numbers of people in one place at one time than expected on the basis of data from the past. Compare with: <strong>endemic</strong></td>
</tr>
<tr>
<td><strong>filariasis</strong></td>
<td>a disease caused by parasitic worms which occur in the blood, lymph vessels and lymph nodes, and which may be transmitted by Anopheles, Culex, Mansonia and Aedes mosquitoes</td>
</tr>
<tr>
<td><strong>financial evaluation</strong></td>
<td>a process whereby costs or alternative actions are compared with the consequences in monetary terms. Compare with: <strong>economic evaluation</strong></td>
</tr>
</tbody>
</table>
### food security
conditions whereby people have both physical and economic access to food at all times

### health impact assessment
part of an environmental impact assessment dealing with health issues relating to beneficiaries and non-beneficiaries of the project. A health impact assessment should address both adverse effects as well as opportunities to further improve health. See also: health opportunities

### health monitoring
part of project monitoring that evaluates the health impacts following project construction and implementation, the acceptability and the effectiveness of the mitigation measures that were carried out, as well as an assessment of the institutional, financial and legal arrangements in support of the implementation of these measures

### health opportunities assessment
study to evaluate how a particular development project can be used to promote health, either as part of the project, or through the concurrent implementation of a complementary health project

### health risk
probability of an unhealthy state (e.g. infection, disease, death, disability) occurring within a certain time period

### health hazard
a potential for causing harm to people’s health

### health sector
the sector that includes government ministries and departments, social security and health insurance schemes, voluntary organizations and private individuals and groups providing health services

### human-vector contact
direct contact between humans and vectors, which may therefore potentially lead to transmission of infection. Human-vector contact is determined by the distance between habitation and vector breeding sites, hygiene and personal protection measures, and provisions to divert humans and vectors from each other such as facilities for water supply and sanitation, mechanical barriers, zooprophylaxis, etc. The degree of human-vector contact is usually expressed as the number of vector mosquito bites per person per unit of time, the number or duration of contacts that a person has with snail-infected water per unit of time, etc.

### immunity
all natural ability to prevent infection, reinfection or superinfection, or to destroy parasites or to limit their multiplication, or which reduce the clinical effects of infection

### infection
the presence in the body of viruses or organisms such as bacteria, protozoa, fungi or helminths which multiply or develop, completing all or part of their life cycle within the tissues of an animal or human host (infection may or may not lead to a disease state); ~ rate: the number of infected individuals per total population (e.g. the proportion of infected mosquitoes)

### institutional
the administrative arrangements and procedures that formalize contacts
**arrangements**

between ministries and (semi-)governmental bodies involved in a project

**intersectoral collaboration**

the process of joint planning, construction, implementation and monitoring by ministries and authorities belonging to different public sectors, including sharing of resources in order to enable each ministry or body to carry out their responsibilities that were mutually agreed upon

**Japanese encephalitis (JE)**
an zoonotic disease caused by an arbovirus and which, due to the breeding behaviour of the mosquito vector, is strongly associated with irrigated rice cultivation in Asia

**leishmaniasis**
a zoonotic disease, caused by parasitic protozoa of the genus *Leishmania*, which is transmitted by sandflies. Its potentially fatal *visceral* form is also called Kala-azar

**malaria**
a disease caused by parasitic protozoa that are transmitted by mosquitoes of the genus *Anopheles*

**morbidity**

the state of being diseased (also used in an epidemiological sense to indicate the effect of disease, as quantified by the frequency, duration and severity of disease); ~ *rate*: proportion of sick people in a particular area or population per unit of time

**mortality**
death or the effect of death on a population; ~ *rate*: number of deaths in a particular area or population per number of people and per unit of time

**night storage water reservoir**

water reservoir constructed between a water source and irrigated fields to allow for the storage of water during the night time, so that the irrigating time is reduced and water can be saved by irrigating during the daytime only, when plants absorb water more efficiently

**onchocerciasis**
a disease caused by the parasitic worm *Onchocerca volvulus* that is transmitted by blackflies. See also: *river blindness*

**parasite**
disease-causing organism that live in another organism termed the host, from which it draws nourishment; ~ *rate*: proportion of people who are found to be infected

**project monitoring**

the continuous process of comparing the effects of a project with the predictions and plans that were made before project construction or implementation. See also: *health monitoring*

**resistance, insecticide ~**
an inherited ability in a population of insects to tolerate doses of an insecticide which would prove lethal to the majority of individuals in a normal population of the same species; developed as a result of selection pressure by the insecticide

**river blindness**
see: *onchocerciasis*
sandflies  tiny kind of flies that may transmit leishmaniasis

schistosomiasis  disease caused by the eggs of Schistosoma worms, which are transmitted by certain aquatic or amphibious snails. See also: bilharziasis

sector  distinct part of the economy e.g. health, agriculture, natural resources, economic planning, water resources, industry, private sector. Compare: health sector

severe disease  acutely life-threatening disease

transmission  passing of infection from person to person; ~ rate: frequency of transmission, measured as the number of infections per person per unit of time (e.g. the number of infected mosquito bites per person-month)

triatomine bugs  certain type of crawling bugs that may transmit Chagas disease (American trypanosomiasis)

tsetseflies  blood-sucking flies that may transmit African trypanosomiasis (sleeping sickness)

trypanosomiasis  a disease of animals and humans caused by Trypanosoma parasites, which are transmitted by tsetse flies in Africa and by triatomine bugs in South and Central America. In Africa the disease is referred to as sleeping sickness, as it affects the central nervous system. The parasite species found in the Americas affects smooth muscle tissue and causes chagas disease

vector  term used broadly here to refer to any animal that transmit human disease or plays an essential role in the parasite’s life cycle (e.g. anopheline mosquitoes of malaria, snail hosts of schistosomiasis, or rodent reservoirs of leshmaniasis)

zoonosis  infectious disease that under normal conditions occurs in vertebrate animals only

zooprophylaxis  the use of livestock or domestic animals to divert vectors from humans

1. Target audience, objectives, scope and structure

Target audience

The target audience of the present slide set is made up of those with technical, managerial or administrative responsibilities for planning, designing and implementing agricultural and natural resources development; for introducing changes in agricultural
practices; and, for the settlement or resettlement of rural populations. It is also intended for teachers and students engaged in training for such responsibilities.

Secondly, it targets those working or preparing to work in public health to provide them with a clearer picture of the complexities of agriculture/health links

Objectives

The general objective of this slide set is to provide (future) professionals in the agricultural and natural resources sectors with relevant information so they become more willing to accept a joint responsibility with the health sector for solving health problems that are caused by land and water resources development for agricultural production.

More specifically, the set aims: a) to provide decision makers in the agriculture sector, at all levels, with a general understanding of the impact of agricultural development projects on vector-borne disease, b) to promote an awareness of the role of the agricultural sector in vector-borne disease prevention, and c) to give the target audience access to information, institutions and organizations that may assist in the incorporation of health safeguards into agricultural development and practices.

Scope

*Agricultural development* as used in this text refers not only to the development and management of crop production and cultivation, but also to irrigation, forestry and fisheries, land use and improvement and rural human settlements. The term vector-borne diseases is referred to in this slide set in its broad WHO definition, i.e. those diseases whose transmission vitally depends on primary and intermediate vertebrate and invertebrate hosts and animal reservoirs of pathogenic organisms. A summary description of each of the diseases is given in section 4.

Non-health professionals may easily be confused by clinical aspects and the epidemiological characteristics of the multitude of diseases that are covered in this slide set. Diseases have been grouped together as much as possible to avoid burdening the target audience with unnecessary details. Simplification has been unavoidable and it is recommended that in any case where professionals from the agricultural sector decide to work on human aspects of agricultural development, this is always done in close collaboration with health authorities and with the expert inputs of an epidemiologist.

Although the authors have tried to cover all major geographical areas of the world, there are admittedly gaps in the slide set due to the lack of available high quality slides. No attempt was made to illustrate all the topics that could possibly fit under the title of the set. Neither was it attempted to treat each discussed topic exhaustively, to discuss all vector-borne diseases or to prioritize vector-borne disease problems in relation to agricultural development.

The focus of this set is on health problems. Agricultural development, however, also provides many health benefits. The text accompanying the slides refers to these possible health benefits when appropriate.
**Structure**

Topic A (*Vector-borne diseases of relevance to agriculture*) provides a small reference slide collection showing the magnitude, distribution and symptoms of vector-borne diseases.

The development of environmental management measures should be systematically linked to specific vectors in particular agricultural environments and agroecosystems, in order to enhance the chance that they work effectively in a wide range of circumstances. This strategy is reflected in topics B (*Relevant disease vectors*) C (*Vector habitats*), with exclusive reference to schistosomiasis.

The remaining topics deal with the different components of agricultural development and their association with vector-borne diseases.

Topic E: Land use, vegetation and crops  
Topic F: Water use in agriculture  
Topic G: Cultivation practices  
Topic H: Influence of livestock  
Topic J: Plant protection, pest control and chemical inputs  
Topic K: Rural settlements

In the WHO Vector Biology and Control Slide Set Series, there are volumes for each disease which cover the epidemiological, clinical, curative and public health sector issues. A slide set on environmental management for vector control focuses on physical interventions, particularly, environmental modification and manipulation in irrigation and drainage systems. All slide sets can be ordered from *WHO Distribution and Sales, 1211 Geneva 27, Switzerland.*

### 2. How to use this slide set

**The integral set**

The slide set gives a complete overview of issues related to the association of agricultural development and vector-borne diseases. While the set as such can be presented in its entirety, following the same sequence and using the captions provided with each slide, users are encouraged to make a more creative use of this material.

**Target audience**

First, consider your target audience: Is it a group of decision makers with serious time constraints? Is it a group of middle level managers with a lot of field experience already? Or, will the subject matter be presented to students in the context of courses on natural resources management? The answer will determine the length of presentation, the focus of the presentation and, consequently, the number and selection of slides from the set.

**Objectives**

It is important to have a clear view of what you want to achieve with the presentation. For instance, if it is general awareness creation exercise for policy makers as part of a
debate on a new national water resources strategy, then slide materials should be selected highlighting locally important diseases and locally relevant situations. If the presentation is part of an environment and health risk appraisal by decision makers, then the organizers of the presentation may want to supplement the slide material with their own slides made in the project area.

The other important objective may be training and education. In that context, the material shown can address issues in much broader sense. At the same time, this objective implies an evaluation of the learning process, and ideas on that are further elaborated below.

Customize your presentation

Whatever the purpose of a presentation will be, it should be stressed that it will always be more convincing if the person preparing it will take the initiative to customize it to specific needs by (1) selecting the most appropriate slides of the set; (2) develop a narrative based on the information provided in this set and complemented by other relevant information, and (3) adding other visual training aids, i.e. slides from one’s own collection, overhead transparencies or videos.

Should it be decided to present the set integrally, then it is recommended to do so interspersed with course work on other relevant publications listed in this set. Nothing is as counterproductive in the learning process as slide presentation that lasts too long!

What should your students learn?

There are a number of key messages that professionals from the agricultural and water sector must assimilate to achieve the objectives of this slide set. These messages are contained in the set as six text slides, and they should be the most important topics for testing in examinations.

In addition, your audience must also have access to sources of information, institutions and organizations that may assist them further in the incorporation of health safeguards into agricultural development and practices. For this purpose, the set includes a short bibliography of selected publications and complementary training aids, and a list of addresses of organizations and institutions which can provide additional information and assistance. It is strongly recommended that you copy these two lists for distribution to your audience.

Use of slides

The psychology of learning has convincingly shown that students can remember subject matter more easily and use acquired knowledge better when they have the opportunity to elaborate on knowledge at the time of learning. Therefore, show a few slides at a time and discuss them thoroughly, rather than running through a large number of slides. Five or six slides may easily fill half an hour! Be selective, think ahead what you want to show and do not present slides for more than three quarters of an hour at a time.

Other didactic means
In mastering facts and concepts, it appears important that students learn and acquire the concepts while puzzling through a particular problem, rather than by ‘hammering’ it in through repetition. The task of the trainer is thus to present students with problems for which they have to find answers themselves (of course, with assistance of the trainer). Field trips, debates, discussions, essay writing all provide better opportunities to do so, and they are therefore more important learning forms than lectures, reading of literature or a slide show. Students benefit more if the use of the latter is embedded in an overall effort to solve a particular problem. For example, the slides may be used as an introduction to a learning exercise in which students will assess the health impact of a certain planned development project.

The multidisciplinary nature of the subject matter provides unique opportunities for discussions between professionals of different backgrounds, and this will significantly enrich the learning experience.

**Handling slides and slide projectors**

Store slides in a cool and dry place to prevent fungus growth, and away from chemicals.

Many presentations have been ruined by trainers who did not prepare themselves properly. As with other audio-visual material, get acquainted with your slide projector well before the actual session in which you present the slides, and check the following:

- Is there remote control of the projector? Does it have an auto-focus feature? If not, you may have to arrange for an assistant to switch slides and focus the slides.

- Is the slide projector connected to an active power supply?

- Can the room where the presentation is to be held easily be darkened? Is it dark enough for students sitting at the last row?

- Do you know where the on/off switch of is located on the projector?

- Is there spare light bulb available? Remember that the life span of a light bulb can be prolonged if it is switched off a few minutes before switching off the cooling fan in the projector!

- Do the slide trays match your slide trays? The slide contained in this set are thin and should preferably be used in matching trays.

- Can you project the slide to a size that is adequate for viewing by the audience in the back of the room? The size of the picture depends on the distance between the projector and the screen, and on the focal length of the projector lens. If you bring your own projector, remember that, the size of the room may require a different projector lens!

- **Very importantly, try out if you have put in your slides correctly in the tray!** The top of the slide should be down in the tray, and the front of the slide should face the back of the slide projector (so check how the slide tray should fit into the projector before putting the slides into the tray!)
3. Introduction to the subject matter

Health impact of agricultural development

The increasing world population, the desire to achieve higher levels of food production and the changing nutritional patterns of growing urban populations, have led to an intensification of agricultural production in most developing countries. Agricultural development policies usually aim to improve food security, socio-economic conditions and the quality of life. Unfortunately, agricultural development may also have adverse health effects, notably through the spread and intensification of vector-borne diseases which may invade new areas, increase transmission rate and/or season with resulting higher numbers of cases, or cause more severe disease symptoms.

How agricultural development determines health

There are several driving forces that determine the nature and magnitude of the health risks associated with agricultural development. These may be broadly categorized as environmental, ecological, demographic and socio-economic changes.

Environmental and ecological changes

Environmental and ecological changes induced by agricultural development may lead to the creation of new building sites for disease vectors and snail intermediate hosts; they may create micro climatic conditions that favour vector longevity; they may result in habitat simplification with the loss of vital predator species that keep vector populations under control; or, they may lead to an increased frequency of human-vector contact.

Many vector species have very precise breeding site requirements. This is part of their ecology. A few vector species, such as the malaria vector species complex of Anopheles gambiae in sub-Saharan Africa, can adapt to a broader range of breeding sites.

All mosquito vectors have an aquatic larval stage. Some species prefer shaded pools, and others, sunlit ones. Anopheline vectors of malaria as a general rule prefer clean water, while the culicine vectors of filariasis breed in organically polluted water. Vectors depending on terrestrial ecosystems, such as tsetse flies (Glossina ssp.), are often associated with specific types of vegetation. In agro-ecosystems species succession may occur in relation to the cropping cycle.

Vector longevity, i.e. the life span of the adult insect, is a crucial determinant of vectorial capacity. The longer a mosquito lives, the more bloodmeals it will take and the greater the chance of transmitting pathogens.

Irrigation schemes may significantly increase relative humidity in a large area, favouring vector longevity. The impact of this phenomenon on malaria transmission was clearly demonstrated in the development of irrigated rice production systems in the Ruzizi plains.
of Burundi. The forest species of malaria vectors in South-East Asia and the archipelagos of Indonesia and part of the Philippines (Anopheles dirus and A. balabacensis) are excellent vectors in their natural environment and in reforested areas and plantations - but where vegetation density is reduced and the relative humidity drops, vector longevity and vectorial capacity diminish accordingly.

Agricultural practices are important determinants of vector-borne disease transmission. Water management in irrigation schemes, the choice of crops and crop varieties, cropping patterns, chemical inputs (pesticides, herbicides and fertilizer), and animal husbandry and mechanization all have the potential to affect one or more of the variables of vectorial capacity. The present slide set aims to provide ample illustrations of these links. Another slide set in the WHO/VBC series (Environmental Management for Vector control) focuses on risk factors in the design and management of irrigation schemes specifically and on modification or manipulation measures for risk reduction.

Changes in human behaviour may be directly related to agricultural activities, but they may also be brought about by modification of the physical environment. Night storage dams in irrigation schemes, for example, provide a suitable habitat for the aquatic snail intermediate hosts of schistosome parasites. In most cases these reservoirs are likely to become preferred sites for agricultural workers to wash themselves or for children to swim in, thus creating ideal conditions for the transmission of schistosomiasis.

The role of domestic animals that are part of the agricultural production system and that serve as a reservoir host for some of the vector-borne parasites deserves special mention, because, like vectors and intermediate hosts, they play an essential role in the life cycle of disease causing organisms. Examples are pigs, the amplifying hosts for the Japanese encephalitis virus and water buffaloes, a reservoir of Schistosoma japonicum in the Philippines.

Demographic changes

Agricultural development is often accompanied by demographic changes, which may lead to large concentrations of vulnerable people being exposed to infection at times of peak vector-borne disease transmission. This is particularly evident where agricultural development leads to intensive cultivation. Irrigation projects, for example, frequently sustain double or triple the number of people of traditional systems and usually have a re-settlement component for farmer families. The cultivation of certain crops creates a seasonal demand for temporary agricultural workers, often during, or just after the rainy season when disease transmission is most intense.

New settlers, temporary agricultural labourers and construction workers share one important characteristic: they may be more vulnerable to some diseases than the autochthonous population. Migration from low transmission areas (e.g. highland areas, as in the case of malaria) implies an influx of people with an inadequate protective disease immunity; thus, infections may easily lead to life-threatening conditions resulting in death.

The increased mobility to and from agricultural development areas, as in the case of temporary labourers and construction workers, also carry the risk of further spread of disease. Construction workers coming from overseas may introduce exotic pathogens. Seasonal labourers may carry parasite species back and forth between areas of intense
agriculture and their home areas. A case in point is that of Madagascar, where malaria is much more common in the lowlands than in the highlands. Many seasonal workers engaged in rice cultivation in the irrigated lowlands carry malaria parasites back to the highlands from where they originate. When weather conditions in the highlands are favourable for transmission, this may occasionally lead to massive malaria epidemics in those areas. Because malaria does not occur with a high frequency in the highlands under normal circumstances, these epidemics hit highly vulnerable populations and usually result in many deaths. A similar phenomenon was observed in Ethiopia where schistosomiasis gradually spread from endemic areas in the provinces of Tigre and Wollo to new schemes in the Awash valley, mainly because of seasonal migration.

At the micro level, the siting of human settlements in relation to irrigation schemes can be of crucial importance in determining transmission risks: The distance between manmade mosquito breeding sites and human settlements may or may not be within the specific flight range. Easy access to irrigation canals may tempt villagers to have contact with unsafe water. On the other hand, siting of cattle between mosquito breeding places and human settlements may serve as a buffer and reduce human-vector contact. Studies in irrigated rice production zones in Philippines have shown that where long-term mass drug distribution to reduce the prevalence of schistosomiasis was carried out, each village reached a characteristic minimum level of prevalence rates, reflecting the specific environmental risks in its immediate surroundings.

Socio-economic changes

Socio-economic change, in the wake of agricultural development, will have a dramatic impact on the health of communities affected. Most of these are positive, as one would hope for any development project. Local infrastructure improvements mean a better access to and by the health services. At the household level, additional buying power may translate in the purchase of protective tools (mosquito nets, screening of windows) or medicine. Surplus money at the community level can be used to install or improve water supply and sanitation.

Unfortunately, there is no guarantee that these benefits are equitably distributed over all community members. Also, within each community, there will be vulnerable groups whose increased risks are not adequately compensated by socio-economic advances. And finally, large scale agricultural development projects will, because of increased economic activity, attract large groups of new people. These unplanned settlers may, to some extent, benefit from the opportunities on offer, but by and large will end up as marginalized, vulnerable communities with no access to public services such as health care, drinking water supply or education. They become risk foci for the other communities and may adversely affect the improved health status gained.

Particular attention should be given to gender issues. The risk of pesticide-poisoning following occupational exposure or suicide attempts, for example, is usually different for males and for females. Also, men and women may engage in different agricultural activities, and agricultural development which results in changes in gender roles is likely to result in shifts in sex-specific health risks.

Implications for the agricultural workforce
The phenomena described above have tremendous consequences for human well-being. They also affect the agricultural and economic productivity of the people who are afflicted by these diseases. Infectious diseases such as malaria, schistosomiasis and hookworm are major causes of anemia, a condition affecting almost half of young children, and more than half of pregnant women worldwide. The consequences of anemia during pregnancy include an increased risk of maternal and fetal morbidity and mortality, premature delivery and low birthweight. Anaemia is estimated to be a causative factor in at least 20% of maternal deaths. Anemia causes developmental deficits, growth retardation, decreased resistance to infectious diseases and decreased physical fitness in children. Growth retardation in a child increases morbidity and mortality risks, decreases physical work capacity throughout his/her life span, and increases the risk of future reproductive complications for girls.

In addition to these direct impacts on the quality of life of large groups of people, the consequences for on the health services is substantial. The hidden cost of inadequately planned agricultural development is seldom considered in feasibility studies or the calculation of the Internal Rate of Return. These costs nevertheless represent an often substantial drain on the national economy.

Health mitigation measures

Methods exist to counter-act the adverse impact of agricultural development projects on vector-borne diseases. Part of the capital investments and project revenue can be used to finance the recurrent costs of extra health care for the farmer families concerned. It should be noted, however, that vaccines are not (yet) available for operational use for such major diseases as malaria and schistosomiasis. Investments in improved access to drugs and improved health care delivery are the least desirable of all possible health interventions, because they cure rather than prevent disease, they require long-term and recurrent funding, and the increased drug use will eventually accelerate the selection of drug resistant parasites. Nevertheless, improved health care delivery has a complementary role if and when other methods fail or if their combined use is not sufficient (which is frequently the case).

The use of environmental management

The concept of sustainable development places human livings at the center of the environment and development framework. It implies risk assessment and management as much for natural resources as for human health.

The effective management of risks of vector-borne disease transmission is best achieved through chemical, biological and/or environmental methods of vector control. Wherever feasible, environmental management is the method of choice because of its long-term effects, environmental friendliness, consistency with good agricultural practices and favourable cost-effectiveness in comparison with other methods. The implementation of such measures in agricultural development requires the involvement and active participation of the agricultural sector. Environmental management includes modification or manipulation of the environment and measures aimed at a reduction of human-vector contact (Table 1). Environmental modifications consist of permanent or long-lasting physical transformations of land, water and vegetation, aimed at preventing, eliminating or reducing the habitats of vectors without causing undue adverse effects on
the quality of the human environment. Environmental manipulation consists of any planned recurrent activities aimed at producing temporary conditions unfavourable to the breeding of vectors in their habitats.

Health safeguards can be built into agricultural development projects based on recommendations emerging from environmental assessments (see guidelines by Tiffen 1991, Birley 1991 and Phillips et al. 1993). Normally, the procedures include an initial health impact assessment, if necessary followed by an in-depth health impact assessment as part of the environmental assessment, an appraisal of the health impact assessment and an intersectoral action plan for health monitoring.

Formal procedures do, however, not normally exist for the use of such assessments in small-scale projects, nor will their use be economically realistic. For such projects, environmental management measures may be developed as a result of guidelines on procedures and standards of minimum requirements in the design, operation and maintenance of the project. Environmental management measures are only effective in specific ecological settings, for specific vectors and addressing specific epidemiological patterns. In the absence of a formal risk assessment, district level workers (health workers, agricultural extension workers and local engineers) will have to form a team to ensure the appropriate measures are designed and implemented.

Table 1: Examples of environmental management measures for vector control in irrigation schemes

<table>
<thead>
<tr>
<th>Component</th>
<th>Measure</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lay-out of irrigation scheme</td>
<td>• design of the scheme aimed at proper field drainage and minimum surface areas of standing water</td>
<td>MOD</td>
</tr>
<tr>
<td></td>
<td>• siting human settlements away from irrigated fields to reduce human-vector contact</td>
<td>MOD</td>
</tr>
<tr>
<td></td>
<td>• constructing latrines in the fields, laid out in a grid pattern, to provide farm workers with sanitary facilities while at work</td>
<td>MOD</td>
</tr>
<tr>
<td>Settlement design</td>
<td>• Provision of water supply and sanitation (piped water supplies, washing and communal laundry facilities, safe children’s swimming pools, latrines)</td>
<td>MOD</td>
</tr>
<tr>
<td></td>
<td>• screening of houses and better house design</td>
<td>MOD</td>
</tr>
<tr>
<td></td>
<td>• domestic animal pens at strategic sites to avert mosquito vectors away from humans</td>
<td>CON</td>
</tr>
<tr>
<td></td>
<td>• (insecticide-impregnated) mosquito nets, particularly for use by high-risk groups</td>
<td>CON</td>
</tr>
<tr>
<td>Reservoir design and operation</td>
<td>• avoid construction of night water storage reservoirs which may serve as vector breeding and disease transmission sites</td>
<td>MOD</td>
</tr>
<tr>
<td></td>
<td>• periodic drawdown to achieve water level fluctuation</td>
<td>MAN</td>
</tr>
<tr>
<td></td>
<td>• vegetation clearance to reduce vector breeding</td>
<td>MAN</td>
</tr>
<tr>
<td></td>
<td>• fishing facilities that prevent unnecessary water contact</td>
<td>MOD</td>
</tr>
<tr>
<td>Irrigation canal design and operation</td>
<td>• straight canals to eliminate standing pools suitable for vector breeding</td>
<td>MOD</td>
</tr>
<tr>
<td>Irrigation method</td>
<td>MOD: environmental modifications; MAN: environmental manipulations; CON: reduction of human-vector contact</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>• alternate wetting and drying of rice fields to minimize vector breeding</td>
<td>MAN</td>
<td></td>
</tr>
<tr>
<td>• sprinkler or trickle irrigation to reduce the amount of standing water</td>
<td>MOD</td>
<td></td>
</tr>
<tr>
<td>• scheduling of field irrigation that allows for periodic drying of canals and drains</td>
<td>MAN</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cropping system and other agricultural practices</th>
<th>MAN: environmental manipulations; CON: reduction of human-vector contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>• use of upland crops, at least once per cropping cycle, to prevent the establishment of vector species that need permanent water bodies for survival</td>
<td>MAN</td>
</tr>
<tr>
<td>• avoid double - or triple cropping to limit the vector breeding to the rainy season</td>
<td>MAN</td>
</tr>
<tr>
<td>• use of varieties with a short growing season to reduce the period that standing water is available</td>
<td>MAN</td>
</tr>
<tr>
<td>• Synchronization of cropping cycle in large areas of smallholder irrigated rice production, to ensure interruption of the availability of breeding sites</td>
<td>MAN</td>
</tr>
</tbody>
</table>

Environmental modifications and manipulations share a number of technical limitations with other methods such as larviciding or biological control of snails and immature mosquito stages. These methods can only be useful when aiming at public health protection through a reduction of disease transmission. Actions by individuals have little impact, even for personal protection. Also, environmental management measures may not lead to an immediate reduction of disease morbidity and mortality. Their effectiveness is site- and time-specific, and more applied research is needed to develop measures that are appropriate for particular agricultural environments and ecosystems. Larviciding and bio-environmental control require meticulous searching out of all breeding sites within mosquito flight range of the communities to be protected, and the large investments in labour or costs that are needed to carry out recurrent measures are prohibitive in areas with low population densities. Environmental modifications or
manipulations require intersectoral coordination, a top-down approach, a relatively high level of social organization and frequently high initial financial investments. The greatest chance of success in urban settings and in large, formal development projects, where a central management and farmer interest groups are present, and where a good level of control over the physical environment can be attained (e.g. irrigation projects). The chances of their sustainable use in poor rural communities, where most vector-borne diseases occur, are less.

Environmental management measures aiming at a reduction of human-vector contact, are usually cheaper, easier to apply and can be effectively used for personal protection of the individual or population groups at high risk. In certain conditions can also be used for the more ambitious goal of transmission control, for example by siting new villages away from breeding sites in the process of planning of irrigation schemes.

**Constraints to the use of environmental management:**

a) lack of intersectoral collaboration

Despite their obvious potential, environmental management measures remain insufficiently applied. We will briefly discuss a number of underlying reasons. The first is the lack of intersectoral collaboration (see guidelines by Tiffen, 1991). The agricultural and water sectors rarely consult the health sector in the planning of their projects. And even if they do, the health sector usually does not have the capacity to provide adequate inputs that can be readily taken up by the other sectors. The incorporation of engineering measures into the design, operation and maintenance of agricultural schemes is primarily a responsibility of the agricultural sector, but it requires close consultation with health experts to make a proper assessment of the possible health impact of a project, to get technical advice on appropriate measures, and to monitor the health status of temporary labourers and beneficiaries of the project. The health sector can only respond properly and timely when it is involved from the earliest stages of project planning.

b) financial constraints

The application of environmental management is furthermore hampered by financial constraints. Intersectoral collaboration should include sharing of resources. First, because sharing of resources avoids duplication of efforts and that are often initially required to apply environmental management measures. The health sector does not generate its own revenues, like some other sectors, and must therefore receive funds from other sectors, either at governmental level or at project level. In case agricultural projects create health risks, failure to share their revenues with the Ministry of Health is bound to result in inadequate provisions in health care and a poor health status of the agricultural labour force.

c) difficulties in economic analysis

The health sector often shows a reluctance and poor capacity to express health benefits economic terms. Health professionals often mistakenly assume that economic analysis requires the expression of health in monetary terms. Cost-effectiveness analysis, which is the type of economic analysis that is required to influence decision-making in agricultural projects, is based on a comparison of costs of different scenarios to contain
disease vectors to a certain degree. Guidelines on cost-effectiveness analysis of vector control have been developed by Phillips et al. (1993).

d) difficulties in forecasting health impacts

Health professionals should not be deterred by the difficulties in accurately forecasting the health impacts of a development project; nor should non-health decision-makers use these difficulties a pretext for inaction. At the United Nation Conference on Environment and Development in Rio de Janeiro in June 1992, there was agreement on the need to adopt the precautionary principle; its definition was set out in principle of the Rio Declaration on Environment and Development - “Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as an reason for postponing cost-effective measures to prevent environmental degradation.” There are good reasons to apply this principle in view of the frequent and dramatic examples of adverse health effects of agricultural development that have occurred in the past.

Priority actions by the agricultural and water sectors

In view of what is discussed in the preceding paragraphs, the agricultural and water sectors should make a number of adjustments to safe health in agricultural development:

• become willing to accept joint responsibility with the health sector (including a willingness to share resources) for solving health problems that are caused by agricultural and water resources development,

• become aware of the need to consult the health sector at the earliest stages of project planning in order to appraise the need for health impact assessment, either to be carried out independently or as part of environmental impact studies,

• develop a capacity for joint planning of health impact studies with the health sector, through the formulation of the terms of reference, to appraise the resulting reports, and to translate the recommendations of these studies into appropriate institutional arrangements and a plan of action for joint project monitoring,

• develop a joint strategy with the health sector for the development and promotion of guidelines and standards that should be maintained in small-scale agricultural projects.

Priority action by the health sector

The health sector should make the following adjustments:

• develop an understanding of the planning process that are used in agricultural projects, the actors involved and the critical times for health interventions in these processes.

• develop a capacity to use rapid methodologies for forecasting the health effects of development projects, and to translate the cost of vector control disease containment in economic terms,
• foster and coordinate intersectoral collaboration by maintaining formal and informal links with the ministries and (semi-)governmental bodies covering the following sectors: agriculture, rural development, irrigation and rural water supply, economic planning, livestock development, and river basin management.

• develop the capacity to carry out health impact assessment and/or foster links with specialized consultancy firms who can do so.

For more information, the interested reader is referred to the list of PEEM technical papers and discussions, and the bibliography which contains a selection of technical papers, publications and complementary training aids.

4. Brief description of major vector-borne diseases

• Malaria
• Lymphatic filariasis
• Schistosomiasis
• African trypanosomiasis
• Japanese encephalitis
• Yellow fever
• Leishmaniasis

**Malaria**

Malaria is caused by four species of *Plasmodium* (protozoan): *P. malariae*, *P. vivax*, *P. falciparum* and *P. ovale* and is commonly characterized by intermittent high fevers, shivering chills, body pains, headaches, fatigue, nausea and vomiting, diarrhea and anaemia. Severe conditions, caused by *P. Falciparum*, can lead to liver and kidney failure, brain damage and spleen enlargement, among others, and may be fatal.

It has been estimated (WHO, 1990) that about two billion people are at risk and over 270 million people are affected by the disease. Malaria is thought to be one of the leading causes of mortality and morbidity in the world with approximately 110 million clinical cases and between one and two million fatalities each year, primarily among children and pregnant women. The disease is prevalent in the developing world where it exerts a serious economic strain on already frail economies. In sub-saharan Africa, the average direct cost of a case of malaria has been estimated at $3.40, which is equal to the per capita health budget of many African countries.

The vector of malaria is the *Anopheles* mosquito. Sixty of the approximated 400 species worldwide are known vectors of malaria. Of these, 30 are considered to be of major importance. The disease is transmitted through the bite of the female mosquito.

Transmission is dependent upon a number of factors relating to the parasite, the human host, the vector’s ecology and the social environment. The important role of environmental factors in sustaining malaria transmission is typified in the developing world where there has been dramatic changes in incidence patterns as a result of the intense economic activities brought about by rapid population pressure. The resultant deforestation, land exploitation, dam-building and irrigation has, in turn, led to the creation of vector habitats and movement of nonimmune people into malarious zones.
The situation has led to the resurgence of the disease in many areas. The once primarily rural disease is now a growing problem in cities and peri-urban areas as a result of the trend towards urbanization.

Eradication measures have proved unsustainable and control measures have not yielded the expected goals, as prevalence has not changed in recent years. It has been estimated that about 474 million people now live in areas where no specific control measures are applied.

Options for malaria control include chemotherapy, vector control with chemical, biological and environmental management components. The development of drug and pesticide resistance by parasite and vector, respectively, have proved a severe impediment to the control of the disease. Other constraints to control measures include prohibitive costs and high trained manpower requirement. In spite of the progress made in vaccine research, an effective vaccine is still years away. Experience over the last two decades point to an integrated control approach as the best control strategy where a combination of all complimentary control methods are used.

The WHO Global Malaria Control Strategy advocates the following four points:

- to provide early diagnosis and prompt treatment
- to plan and implement selective and sustainable preventive measures, including vector control;
- to detect early, contain or prevent epidemics; and
- to strengthen local capacities in basic and applied research to permit and promote the regular assessment of a country’s malaria situation, in particular the ecological, social and economic determinants of the disease.

**Lymphatic filariasis**

Lymphatic filariasis is caused by three nematode species, *Wucheraria bancrofti*, *Brugia malayi* and *Brugia timori* with *W. bancrofti* (bancrofian filariasis) being the most widespread. Humans are the only reservoir for *W. bancrofti* and *B. timori*, but *B. malaya* is also found in monkeys.

The disease is characterized by recurrent fevers, inflammation of the lymph nodes and vessels with transient swelling of the limbs as early clinical symptoms. Later symptoms include scrotal swelling and permanent swelling of the limbs (a condition commonly referred to as *elephantiasis*) as a result of the collections of fluid in cells, tissues, or body cavities brought about by adult worms residing in the nodes and vessels of the lymphatic system and restricting the flow of lymph. In hypersensitive individuals, immunological reactions may result in an asthma-like condition called tropical pulmonary eosinophilia (TPE), characterized by bouts of wheezing and coughing at night and shortness of breath.
Vectors of the disease include a number of mosquitoes of the genera *Culex*, *Aedes*, *Mansonia* and *Anopheles*: *C. quinquefasciatus* is the vector in urban and semi-urban areas worldwide, while species of the other genera have a more restricted geographic distribution. Strict ecological requirements by the vectors tend to make the distribution of the disease both patchy and focal. The parasite is transmitted an infected mosquito takes a blood meal.

Foci for the disease can be found in a number of countries in South-East Asia, Pacific island groups, several Caribbean countries, most African countries and limited areas of Central America and northern South America. Conservative estimations put the number of people living in endemic areas at about 905 million, out of which about 91 million are actually infected by the parasite. Two-thirds of the infected people live in India, China and Indonesia. There is a strong correlation between infection and low socioeconomic status.

There has been an increasing incidence of bancroftian filariasis in Asian and African countries; poor sanitary conditions, i.e., polluted water, blocked open drains, roadside ditches, broken septic tanks and accumulation of sewerage effluents, which often accompany rapid urbanization have created conducive breeding habitats for the vector *C. quinquefasciatus*.

Disease control methods include vector control (reduction of breeding sites, control of vectors at breeding sources, and interruption of transmission by adult mosquitoes), reduction of infection in the human reservoir (chemotherapy) and personal protection. While some countries in the Western Pacific Region have more or less eliminated the disease, other countries, including the African countries, still have poorly developed control programmes.

Future priority areas for disease control include multidisciplinary research efforts, an intersectoral approach to vector control, strengthening of primary health care and surveillance systems.

**Schistosomiasis**

Schistosomiasis is caused by five species of schistomes: *Schistosoma mansoni*, *S. japonicum*, *S. haematobium*, *S. mekongi* and *S. intercalatum*. It is a chronic debilitating disease affecting an estimated 200 to 300 million people in 79 countries. About 600 million are thought to live in endemic areas.

Schistosomiasis is primarily a rural disease associated with daily activities related to water use, such as farming, fishing, bathing, recreation, washing clothes and kitchen utensils, and personal hygiene. However, urban and peri-urban transmission of schistosomiasis is becoming a serious problem in some developing countries, due in part to the migration of infected persons from the countryside to areas of the cities or their suburbs that do not have adequate sanitary and health care facilities. Thus, the disease may have probably escaped detection in many localities where health services and disease surveillance are not well developed. Other factors contributing to the changing endemicity pattern of the disease include increasing irrigation projects, intensive water resources development activities and environmental destabilization.
Fresh water snails of the genus *Biomphalaria, Bulinus and Oncomelania* serve as species specific intermediary host of the parasites. The infective larvae penetrate the skin of humans who enter snail infested water. Thus infection does not require physical contact between man and snail.

The onset of the disease may be characterized by itching and rash, sometimes by shortness of breath and cough and on rare occasions by a fatal immunological reaction known as Katayama syndrome. The disease has two forms; urinary schistosomiasis caused by *S. haematobium* and intestinal schistosomiasis caused by the other four species. The former has a conspicuous early symptom of blood in the urine, and is as a result of major pathologic lesions in the walls of the urinary bladder often extending to the ureter, kidney, urethra and genitalia. It is accompanied by incontinence, and constant and increasing pain upon urination. There is also lower abdominal pain, bladder colic and weakness. Intestinal schistosomiasis is characterized by major pathological lesions of the intestine, particularly the colon, caecum and rectum as a result of worm-eggs passing through or calcifying in the tissues. Dysentery, accompanied by abdominal pain, enlargement of spleen and liver as well as arterial obliteration in the lungs are symptoms of severe cases.

Schistosomiasis control strategies have shifted away from the elimination of infection or interruption of transmission toward control of the human disease with chemotherapy. Snail host control should be a supportive part of an integrated control activities. The best strategies must be community-based and should include primary health care, especially as relating to health education, food and nutrition, water supply and sanitation, maternal and child health and drug distribution.

**African trypanosomiasis**

**(Sleeping sickness)**

Sleeping sickness is endemic in 36 countries in Africa. Estimates put about 50 million people at risk with at least 25,000 new cases yearly. The disease is caused by a protozoan parasite of the genus *Trypanosoma*. There are two forms of the disease recognized in man: an acute infection caused by the more virulent *T. brucei rhodesiense* (the Rhodesian sleeping sickness) found in the savannah areas of eastern and South-Central Africa, and the chronic *T. b. gambiense* (gambian sleeping sickness) found in the riverine, lake and humid, forested areas of West and Central Africa.

Infection is man is through the bite of an infective tsetse fly of the genus *Glossina*. *G. mortisans and G. fuscipes* transmit *T. b. rhodesiense* which is associated with occupations that expose humans to tsetse fly bites in areas with abundant game animal populations. The animals serve as parasite reservoir and source of infection to the tsetse fly during blood meals. The *G. palpalis* group of flies and their subspecies transmit *T. b. gambiense*. It is, however, believed that a peridomestic transmission cycle including pigs, dogs and cattle also exist.

The disease, in both its domestic animal and human forms, is a major deterrent to economic development in parts of Africa. The cost of disease treatment is very high - about $140 per patient for drugs and a long period of hospitalization.
Both forms of the sickness can be invariably fatal if untreated. It is characterized by intermittent fevers, headaches, swollen glands, intense itching and general malaise, drowsiness, somnolence and eventually a comatose state.

Disease control strategies are based on active or passive surveillance of infection in persons or populations, treatment and, if appropriate, vector control. The most promising and environmentally acceptable method of vector control is through the use of insecticide-impregnated fly traps.

Priorities for future actions for the control of trypanosomiasis will be on ecological studies for effective trap distribution and efficiency; the possible role for communities; the use of Geographical Information Systems and remote sensing data in the identification of high risk transmission areas and targeting of control affairs; serological and parasitological diagnostic techniques.

**Japanese encephalitis**

Japanese encephalitis (JE) is caused by a virus and occurs as epidemics in the rice growing areas of eastern and South Asia. The disease has a fatality rate of about 20 percent in children and up to about 50 percent in adults above the age of 50.

Disease symptoms include fever, headache, prostration, stiff neck and neurological disorders, including encephalitis. Some degree of mental impairment can be demonstrated in 30-40 percent of convalescent patients between the ages of 5 and 40.

The rice-field breeding mosquitoes, *Culex tritaeniorhynchus*, *C. gelidus* and *C. fuscocephala* are the most important vectors of the disease. Pigs are the major vertebrate amplifying hosts (they carry the virus without showing disease symptoms) in the northern areas of the disease distribution. While there has been marked reduction in disease incidence in Japan and Republic of Korea, countries such as Bangladesh, Burma, India, Nepal, Sri Lanka, Thailand and Viet Nam have recorded increases. Changes in the epidemiology of JE in many countries may be the result of increased rice paddy cultivation and pig rearing.

Disease control strategies include immunization of children and vaccination of all pigs in high-risk areas. In most countries immunization Campaigns are hampered by poor logistics and pig vaccination is economically not feasible. Therefore, vector control is an important disease control method. Since the vector is linked with rice production, water management in rice fields and changes in agricultural practices hold the key to the success of any vector control efforts. Chemical control of vectors has proved to be very expensive and not a very feasible method. Changes in pig-rearing practices form another important disease control tool.

**Yellow fever**

Yellow fever is a viral disease characterized in man by a sudden onset of fever, headache, backache, prostration, nausea and vomiting, and haemorrhagic symptoms and jaundice. The virus exists in two cycles: an urban cycle involving human-to-human transmission through *Aedes aegypti* and a jungle cycle involving forest primates and forest canopy mosquitoes, with accidental human infections.
Yellow fever is endemic in tropical Africa (15 degrees north - 15 degrees south) and in the northern and eastern South America and parts of central America. Worldwide incidence has been rising and the risk of the disease has increased in many parts. About 3,172 fatalities were reported worldwide out of 5,395 cases between 1986 and 1988.

Several species of *Aedes* mosquitoes are involved in the transmission of yellow fever. However *A. aegypti* is thought to be the main epidemic vector in the domestic form of the disease. Recent evidence suggests possible transmission from one mosquito generation to another via uterus as an additional mechanism responsible for maintaining the virus in circulation.

While vaccination seems to be the most important form of disease prevention, environmental management for the control of the disease vectors remains a cost-effective option in an overall integrated control strategy. This relates directly to efforts at reducing vector breeding sites, especially in the urban and peri-urban areas where inadequate sanitary conditions create favourable vector breeding sites.

**Leishmaniasis**

Human leishmaniasis is caused by a complex of protozoan parasites (at least 14 species and subspecies) of the genus *Leishmania* and transmitted through the bite of female phlebotomine sand flies. There are about 600 known species serving as vectors of the disease. Leishmaniasis has a worldwide distribution although it occurs mainly in tropical and subtropical areas. Endemic regions include Latin America, the Mediterranean, Africa, India and China, and along the borders of Texas and Mexico. The disease is on the increase largely because forest clearing and cultivation projects, large water resources schemes, and colonization and resettlement programs are increasing contact between humans, vectors and reservoirs. About 12 million people are afflicted with the disease worldwide, with 400,000 new cases annually. Epidemic outbreaks in the Bihar region of India, is reported to have killed 75,000 people in a period of just three years.

There are many mammalian reservoirs of the disease, both wild and domestic. They include domestic dogs, wild canines such as foxes, and man. The primary reservoir sources, however, are rodents and other wild animals such as sloths.

There are three main forms of the disease: visceral, cutaneous and muco-cutaneous. Visceral leishmaniasis, also known as kala-azar, is an acute, often deadly form of the disease resulting from parasites multiplying in the spleen, liver and bone marrow. The disease is usually fatal if untreated. It is characterized by fever, enlarged spleen and liver and decreased white blood cell count. Visceral leishmaniasis a significant threat to child survival. Cutaneous leishmaniasis occurs in the form of one or more skin lesions that are usually self healing but can be seriously disfiguring. The mucosal form occurs when *Leishmania* invades the mouth, nose and throat, causing severe destruction and permanent disfiguring of the nose, lips and larynx.

Disease control measures usually takes the form of an integrated program of chemotherapy, vector control, vaccination and elimination of reservoirs. House spraying with residual insecticides to reduce domestic transmission, the cutaneous form is probably the most effective vector control measure. Insecticides used include dieldrin,
malathion and chlorophos. Where occupational exposure is a problem, education on avoidance of sand fly bites through protective clothing is useful.
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**International Irrigation Management Institute**, P.O. Box 2075, Colombo, Sri Lanka. *Focal point* - Mr. Flemming KoNrdadsen. (In 1997 a new health and irrigation programme coordinator will be appointed)

**Institute for Land Improvement and Water Management**, Swiss Federal Institute of Technology, EHT Hönggerberg, Zurich, Switzerland. *Focal point* - Professor Martin Fritsch

**London School of Hygiene and Tropical Medicine**, Keppel Street, London WC1E 7HT, United Kingdom. *Focal point* - Professor David Bradley

**Malaria Research Centre**, 22 Sham Nath Marg, Delhi 110054, India. *Focal point* - Dr V.P. Sharma

**National Water Research Centre**, Fum Ismaila Canal, P.O. Box 74, Shoubra El-Kheima, Cairo, Egypt. *Focal point* - Dr Mahmoud Adu-Zeid.

**Tennessee Valley Authority**, 400 West Summit Hill Drive, Knoxville, Tennessee 337902-1499, USA. *Focal point* - Dr J. Cooney.
The International Centre of Insect Physiology and Ecology, P.O. Box 30772, Nairobi, Kenya. *Focal point* - Dr Hans Herren.

The Queensland Institute of Medical Research, The Bancroft Centre, P.O. Royal Brisbane Hospital, Queensland 4029, Australia. *Focal point* - Dr Brian H. Kay.

West Africa Rice Development Association, 01 BP 2551, Bouaké, Côte d'Ivoire. *Focal point* - Dr P. Matlon