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PANEL OF EXPERTS ON ENVIRONMENTAL MANAGEMENT FOR VECTOR CONTROL (PEEM)

Report of the Seventh Meeting
Rome, 7-11 September 1987

PART I: TECHNICAL DISCUSSION – Effects of agricultural development and changes in agricultural practices on the transmission of vector-borne diseases

PART II: GENERAL PROGRAMME AND POLICY

PEEM Secretariat
World Health Organization
Geneva, 1987

WHO FAO UNEP

JOINT WHO/FAO/UNEP PANEL OF EXPERTS
ON ENVIRONMENTAL MANAGEMENT FOR VECTOR CONTROL

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PEEM SECRETARIAT
World Health Organization
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OPENING CEREMONY

The seventh meeting of the WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control was held at the headquarters of the Food and Agriculture Organization of the United Nations, Rome, from 7 to 11 September 1987.

In his opening address, on behalf of the Director-General of FAO, Dr C.H. Bonte-Friedheim, Assistant Director-General and Head of the Organization's Agricultural Department, pointed out the significance of FAO headquarters being the venue of a meeting that had on its agenda a technical discussion addressing the relationships between agricultural development and vector-borne disease transmission.

Being aware that agricultural development and advancement might sometimes be attained only at the cost of some disruption to the social, cultural and environmental health status of people, FAO had, for many years, subscribed to collaborative efforts in the United Nations system to limit and mitigate such detrimental effects.

He recalled the fact that the Panel had already devoted considerable attention to the problems of vector control in agricultural environments, most recently by the joint sponsoring with IRRI and USDA of the workshop on research and training needs in integrated vector-borne disease control in riceland agro-ecosystems of developing countries. The workshop's conclusions and recommendations had emphasized the use of economical, agronomically compatible and socially acceptable approaches that confer dual benefits of sustained production and disease control.

In a broader framework and on a longer term, the overall benefits of development had to be mentioned: improved access to resources and services was one of the keys to a higher level of community health and inasmuch as this was associated with water and land development it had always formed a major element in the programmes of FAO. Sound policies for land tenure, and land use and management provided the required stability for sustainable development and these were, in turn, highly dependent on policies and plans for the development, use and management of water for the diverse sectors of agriculture, industry and domestic use.

The documents prepared for this year's technical discussion gave due prominence to all these issues, and the FAO looked forward to practical recommendations, followed by their effective implementation.

On behalf of the Director-General of WHO, Dr R. Slooff, Director of the Division of Vector Biology and Control, also referred to the strong focus of recent PEEM initiatives on the linkages between health and agriculture. He emphasized the need to bear in mind the farmer perspective: the feasibility of seemingly appropriate technology was often significantly reduced when it had to be applied at the farmer's level, either due to technical limitations or lack of social acceptance.

Another important aspect of the Panel's work during the past twelve months had been the promotion of innovative tools to support environmental management for vector control. The inclusion of a session on remote sensing in the agenda of this meeting and the Panel's support for the development of an Expert System prototype were two tangible examples in this connection.

Dr B.G. Waiyaki, senior programme officer of the environmental management services, addressed the Panel on behalf of the Executive Director of UNEP, and stressed his agency's belief that nowadays in many parts of the world vector control could not be carried out properly in isolation from agricultural pest control. He was therefore particularly pleased to welcome a representative of the FAO/UNEP Panel of Experts on Integrated Pest Control, whose participation would it was hoped, mark the start of an increased collaboration between the two Panels.

PART I. TECHNICAL DISCUSSION

EFFECTS OF AGRICULTURAL DEVELOPMENT AND CHANGES IN AGRICULTURAL PRACTICES ON THE TRANSMISSION OF VECTOR-BORNE DISEASES

The seventh annual PEEM meeting included a two-day technical discussion on the above theme, selected by the Panel at its previous meeting. Twenty working papers were presented, and served as a basis for the discussion. They included twelve papers on technical issues, five case studies and three reports from WHO staff on regional aspects. A summaries and issues paper served as a guide for the discussion. Titles and authors of the working papers are listed at the end of Part I of this report.

1. INTRODUCTION

The choice of FAO headquarters as the venue of the seventh PEEM meeting was a major factor in selecting the subject for discussion as it offered the opportunity for participation by various units of the Organization with interests in land and water development, crop production, fisheries and environmental aspects.

In planning for the discussion, the established objectives were:

(a) to analyze the effects of agricultural developments (in particular irrigation and more advanced agricultural practices) and changes in agricultural practices on the propagation of disease vectors and the prevalence and incidence of vector-borne diseases, and

(b) to recommend appropriate strategies and practices for vector control in agricultural development and specific land and water use practices for application at farm level.

It was noted that both beneficial and adverse impacts of agricultural developments and practices on the well-being of populations should be considered, and that only through a comprehensive approach could realistic recommendations be made on how to minimize adverse health impacts.

The working papers were arranged in three groups, dividing the discussion into three corresponding sections:

- Section A. Impact of agricultural developments and practices on the social, economic and nutritional conditions of rural and urban communities and the incidence of vector-borne diseases.

- Section B. Mechanisms of vector-borne disease transmission and epidemiological patterns associated with agricultural development and practices.

- Section C. Appropriate agricultural development strategies and practices to minimize environmental and health impacts, with special reference to environmental management for vector control.

As the discussion progressed, many issues of general importance and many of relevance to specific situations were identified, with various interrelationships among the above sections. This report has therefore been structured to reflect those themes and to illustrate the process leading to the formulation of the Panel's conclusions and recommendations. This includes a review of the impact of agriculture on the environment, ecology and health, with special emphasis on mechanisms involved in relation to vector-borne diseases, and trends in agriculture with their vector-borne disease implications and ways to mitigate or prevent them.

2. THE IMPACT OF AGRICULTURE ON THE ENVIRONMENT, ECOLOGY AND HEALTH

Agriculture is in essence a process of environmental management involving land and water resources, vegetation, naturally occurring fauna and human populations. The introduction of agriculture or any appreciable modification of existing patterns of cultivation must therefore present a likelihood of modifying the interrelationships among the many component factors and of creating an imbalance which will lead to a series of dynamic changes.

The theme of the discussion related agricultural development and practices to their effects on the transmission of vector-borne diseases. These relationships are systematically listed in table 1. In establishing such relationships, however, it is necessary to trace a variety of pathways linking physical environments with cultivation techniques and with vector habitat; modifications imposed or introduced in crop and livestock production; man/vector contact through economic and social activities; and the effects of a variety of direct interventions to control insect and other pests for the protection either of agricultural production or of human health. The epidemiologically relevant aspects of agricultural change are listed in table 2.

The two major forms of environmental modification involved in agricultural change are the opening up of additional land and the provision of increased or more controlled water for crop growth. Additional modifications, discussed below, are cropping patterns, pesticide use and social, organizational and institutional aspects.

Land use extension

Extension of land use brings about vector hazards, chiefly resulting from human intrusion into new ecosystems with disturbance of parasite life cycles that are maintained as zoonoses in the undisturbed environment. Leishmaniasis provides a clear example, both in the deforestation of the Amazon region where agricultural settlers are exposed to Leishmania braziliensis causing muco-cutaneous disease, and in the southern USSR where cutaneous leishmaniasis, transmitted by sandflies between huge populations of the colonial burrowing gerbil Rhombomys opimus, is a major hazard to farming settlement (Lainson et al., 1963). More lethal problems from sleeping sickness have resulted from agricultural resettlement or patchily cleared secondary forest in South Busoga, Uganda. The role of eco-tones, edge-effects between different ecosystems, is important in the epidemiology of vector-borne zoonoses and land use extension creates extended ecotones (Audy, 1968). Malaria outbreaks in Thailand due to Anopheles dirus (formerly called A. balabacensis), are principally of this type. The Panel reviewed in detail the interrelationship between the development of forest areas in Thailand and its effect on vector-borne disease epidemiology.

Anopheles dirus is the main jungle breeding vector of malaria in Thailand. It breeds in a variety of small pools, pits from gem mining, human and animal footprints, etc. all characterized by being well shaded in the forest. Population densities of this mosquito appear to depend primarily on availability of breeding sites, and so abundance peaks during the rainy season.

In Thailand, forest is disappearing rapidly in spite of the declaration of many areas as forest reserves (see table 3). The process of forest destruction tends to be gradual, starting with the cutting down of big trees which are burned for charcoal, followed by indigenous slash-and-burn agriculture and then plantations of tapioca, sugar-cane or rubber. The net result is a progressive reduction in the amount of surface waters, and elimination of shade, reducing the potential breeding sites for A. dirus. The annual parasite index (API) and other malaria indices in these areas have therefore declined substantially.

Although malaria attributable to A. dirus has declined when forest has been cleared, transmission by other species such as A. minimus has increased especially

Table 1. Major vector-borne diseases that may be related to agriculture

<u>Protozoa</u>	
Malaria	Anopheline mosquito vector may breed in standing water
Sleeping sickness	Tsetse-borne disease related to extending land use into forest
Chagas' Disease	Transmitted by bugs living in walls of houses, especially when livestock there
Visceral leishmaniasis	Sporadic, sometimes epidemic in semi-arid regions, sandfly transmitted
Cutaneous leishmaniasis	Rodent reservoirs disturbed in Asian land use
Muco-cutaneous leishmaniasis	Forest zoonosis of Amazon forests, to man during deforestation
<u>Trematodes and Cestodes</u>	
Schistosomiases	Major irrigation problems spread by aquatic and amphibious snails
Hydatid	Dog tapeworms, larva usually in sheep, harmful to man in sheep-herding areas
Other tapeworms	Problems where undercooked beef and pork concerned
Other trematodes	Transmitted by snails through undercooked freshwater animals
<u>Nematodes</u>	
Dracunculiasis (Guinea worm infection)	Transmitted through defective water supplies by water-flea type crustacean; big effect on agricultural productivity
Filariases	Transmitted by anopheline and culicine mosquitoes
Onchocerciasis	Transmitted by fast-water breeding <u>Simulium</u> species
<u>Other microbes</u>	
Relapsing fever	Tick-borne problem where man and livestock share accomodation
Yellow fever	Hazard at forest edge (and in urban areas)
Dengue, Japanese encephalitis, other encephalitides other arbovirus infections	Viruses transmitted by mosquitoes, mainly culicines, breeding in irrigated fields and standing water
Scrub typhus	Mite-borne zoonosis of the forest edge
<u>Non-vector-borne diseases</u>	
Leptospirosis	Especially a problem of marshy and irrigated agriculture
Rabies	Hazard of pastoral areas where dogs are used
Snakebite, leeches	Hazard in forest plantation agriculture

Table 2. Epidemiologically relevant aspects of agricultural change

	New or qualitatively changed	Increased quantitatively
PRIMARY AGRICULTURAL CHANGES		
ENVIRONMENT		
Water resources development	Reservoirs, dams, land drainage, irrigation schemes	Irrigation canals
Land use extension	Clearing, deforestation, extensive eco-tones	
ORGANISMS		
Plants	New high-yielding varieties, move to cash crops, intercropping	Multiple cropping
Livestock	New breeds	Increased animal husbandry
CULTURAL METHODS		
Chemicals	Pesticides, herbicides	Fertilizers
Machinery	Mechanization	
SECONDARY EPIDEMIOLOGICAL CHANGES		
People	Settlement, changes in seasonal patterns, nutritional status	Immigration
Vectors	Species changes	Population changes
Disease agents	Species changes, new introductions, new hosts acquired	Amplification by stock

amongst non-immune migrants settling in endemic areas to seek agricultural or mining work (see table 4). A. minimus breeds mainly in small streams around the new settlement areas. A trial of dripping abate[R] into these streams around one village significantly reduced A. minimus populations and reduced malaria infection rates to lower levels, but transmission was apparently maintained by imported cases from nearby forested areas.

Malaria risk in slash-and-burn agriculture in Thailand seems to produce a different picture from that in other countries, basically because of the different ecological requirements of different mosquito vector species with respect to their breeding habitats. In West Africa, for example, after cutting down the tropical rainforest for rubber plantations, the population of A. gambiae increased tremendously and so did the incidence of malaria (Livingstone, 1958). The explanation for this phenomenon is that

Table 3. Forest deterioration in Thailand over 21 years (1961-1982)

Region	Forest area km^2 1961	Forest area km^2 1982	Total deterioration km^2	Average per year km^2
North	116 275	87 756	28 519	1 358
East	21 163	8 000	13 163	626
Northeast	70 904	25 866	45 018	2 143
Central	35 660	18 516	17 144	816
South	29 626	16 442	13 184	627
Total	273 628	156 580	117 028	5 572

Source: Forest situation of Thailand in the past 21 years, Sept. 1983, Remote Sensing and Forest Mapping Sub-Division, Royal Forestry Department, Bangkok, Thailand.

Table 4. Composition of anopheline populations attracted to human bait at Khao Mai Kaeo, Bang Lamung district, Cholburi Province, over the period 1965-1985 (percentages)

Species	Year 1965	1969	1973	1978	1984	1985
A. dirus (balabacensis)	74.2	-	-	-	-	-
A. minimus	1.0	17.4	2.1	51.2	50.0	28.0
A. maculatus	14.2	78.3	14.6	44.4	44.4	12.0
A. barbirostris	5.6	-	35.4	-	-	22.0
A. hyrcanus	2.0	-	4.1	4.4	-	-
A. vagus	1.5	-	-	-	-	-
A. philippinensis	1.0	-	-	-	-	8.0
A. splendidus	0.5	-	-	-	-	-
A. aconitus	-	4.3	41.7	-	5.6	30.0
A. subpictus	-	-	2.1	-	-	-

Sources: 1965 - adapted from Scanlon, J.E., and Sanhinand, U., 1965.
1969-1985 - from Ministry of Health, Malaria Zone I, Region V.

cutting down of forest trees will lead to the creation of suitable breeding places for A. gambiae, which likes to breed in open, clean running water. With continued cutting of the forest, the soil loses its decayed materials and small tracks are formed which constantly fill with tropical rain water. Man's refuse and the environment of human settlements also provide more breeding places for mosquitoes.

A similar phenomenon was also observed in South-East Asia. In Malaysia, A. maculatus is the principal vector of malaria and it prefers to breed in slow-moving water exposed to sunlight. It has been observed that the population of A. maculatus and the incidence of malaria in Malaysia increased following the clearance of forest and vegetation on hilly land, whether for rubber plantation, tin mining, road or railway construction (Abbas, 1971). When the amount of rubber planting was compared with the malaria cases over 1900-1950, it was interesting to see that the increase of malaria cases was correlated with the increase in jungles being opened up for rubber planting.

The Panel noted that the effect of changes in land use in the foregoing cases may be either positive or negative in terms of vector breeding and disease transmission. This illustrated the importance of a clear identification of existing and potential vectors and a sound knowledge of their behaviour and likely preferences in a changed ecology which might lead to a prognosis of the process of species succession. Attention was drawn to the dynamics of change, especially in relation to the development of tree growth. In areas in Thailand where forest clearance was followed by planting of tapioca, the continued lack of shade discouraged the return of A. dirus, but with the increasing cover from maturing rubber trees, a return to conditions similar to the original forest could result in re-colonization by this mosquito. The need to consider both short and long-term changes was clearly spelt out, as also was the necessity for monitoring and surveillance, especially in the areas marginal to land use extension.

Water resource developments

Water resource developments have been much studied and may comprise impoundments of water in artificial lakes, sometimes of huge size, and irrigation systems to bring the water to the fields and plants. The resulting increase in availability and diversity of surface water both in area and in duration through the year tends to lead to increased populations of still-water vectors and intermediate hosts, particularly mosquitoes and aquatic snails. The torrent breeding Simulium vectors of onchocerciasis may have their habitats destroyed by inundation. The converse aspect of water management, drainage of swamps and waterlogged areas, will reduce breeding of mosquitoes and the amphibious snail hosts of Schistosoma japonicum. While increased surface waters with more vector habitats and increased vector populations tend to lead to more mosquitoes biting man, contact between snail-borne parasites and man will be dependent on the detailed changes in water availability; man/pathogen contact may even be reduced due to a dilution effect.

The Panel reviewed a number of case studies in this connection, starting with a status report from the WHO Eastern Mediterranean Region. In the 23 countries of this Region, agricultural development has been making continuous progress, but, together with improved prosperity, it has also increased the vector-borne disease problems. Table 5 shows that the main concern is malaria, which is considered to be of primary public health importance in eleven countries and of secondary importance in a further six. Schistosomiasis is of primary importance in four countries and secondary in five, and other diseases of secondary importance are the filariases, including onchocerciasis, and dracunculiasis. These diseases are all associated with water and, within the Region, water is the key to agricultural expansion in the arid and the semi-arid lands.

Examples of the intensification of the vector-borne disease problems are given for Egypt, Jordan, Pakistan, Somalia, Sudan and Yemen, but the blame is placed on poor standards of planning, design, construction and operation and not on the principles of water resource development for agriculture. The irrigation project in the Al Hassa Oasis in Saudi Arabia was referred to as an example which showed that sound engineering

Table 5. Relative significance of important water-associated vector-borne diseases in countries of the WHO Eastern Mediterranean Region

EMR countries	MAL	SCH	FIL	ONC	DRA
Afghanistan	A[1,2]				
Bahrain	B[2]				
Cyprus	C[6]				
Dem. Yemen	A[1,4,5]	B		C	
Djibouti	B[4]				
Egypt	B[5,7]	A	B		
Iran	A[1,2,3]	C			C
Iraq	A[2,3,6,9]	B			
Jordan	C[3,5,6]	C			
Kuwait	C[2]				
Lebanon	C[5,6]	C			
Libya	B[5]	C			
Morocco	B[10]	C			
Oman	A[1,2]	C	C		
Pakistan	A[1,2,5]				B
Qatar	C[2]				
Saudi Arabia	A[2,3,4,5]	B			
Somalia	A[4]	A	C		B
Sudan	A[4]	A	C	A	B
Syria	A[3,6]	B			
Tunisia	C[10]	B			
U.A.E.	B[1,2]				
Yemen	A[1,4,5]	A		C	C

A = Disease of great public health importance
B = Disease of comparatively low significance
C = Disease of minor significance

MAL = Malaria
SCH = Schistosomiasis
FIL = Filariasis
ONC = Onchocerciasis
DRA = Dracunculiasis

Malaria transmission by:
(1) A. culicifacies (2) A. stephensi
(3) A. superpictus (4) A. arabiensis
(5) A. sacharovi (6) A. sergenti
(7) A. pharoensis (8) A. fluviatilis
(9) A. pulcherrimus (10) A. labranchiae

practice can have a beneficial effect on malaria transmission. It had already been discussed by the Panel at its last meeting. In brief, irrigation canal lining, efficient drainage, elimination of marshland, and community water supply had succeeded in achieving the aims for agriculture and eliminating indigenous cases of malaria. On this last point, the Panel remarked that these desirable engineering approaches to vector control were, unfortunately, precluded on grounds of costs in many irrigation schemes in developing countries.

The history of irrigation development in Kenya, and the associated spread of schistosomiasis, provides a clear example of a major health problem which has increased in importance with agricultural development.

It is estimated that 10% of the Kenyan population suffers from schistosomiasis (Warren et al., 1979). This fact, coupled with the rapid population growth rate which now stands at 3.8%, suggests that the increasing population density will ultimately lead to intense transmission. The 1979 national census showed a population in excess of 16.5 million. Approximately 52% were in the 5 - 14 year age group. By 1988 it is projected that the population will be in excess of 23 million and by the year 2000 the population will be 38.5 million, again with roughly 52% of the population being in the 5 - 14 year age group (Jordan, 1985). Assuming that there is no change in the transmission pattern, by then nearly 3.9 million Kenyans will suffer from schistosomiasis.

Kenya's economic progress will, for the foreseeable future, largely depend on agricultural development. To this end it has been government policy to bring into productivity large tracts of idle land in Nyanza, North-Eastern and Rift Valley Provinces, through intensive irrigation and reclamation. At least 200 000 ha of arid and semi-arid land in Kenya can be made arable to perennial irrigation in order to increase food production and also release population pressure. While the potential benefits for irrigation are widely recognized, health problems which arise are also appreciated and, in the past, programmes have been mounted in the planning stages to assess health hazards in areas where schistosomiasis is endemic. No legislation exists, however, to enforce this.

This issue of legislation for health activities was recognized by the Panel as a particularly difficult, though important one, which raised problems of policing the proper observance of complex regulations, and devising means for penalizing any breaches of these. Where such legislation was already in existence, it was considered that it should support groups who were instrumental in proposing health interventions.

The case study of irrigation development in the Çukurova plain in Turkey was a revealing, well documented and fairly recent example of an outbreak of malaria associated with irrigation development.

The history of malaria in Turkey over the past 30 years showed a decrease from an Annual Parasite Index (API) of 126 per 100 000 to 3 per 100 000 between 1957 and the early 1970s, as a result of the national eradication programme. At that point, malaria eradication, surveillance and control activities were considerably reduced, for financial reasons. In the 1970s the major irrigation project on the Çukurova plain, in the vicinity of Adana, became operational and the consequent agricultural and industrial expansion caused substantial migration, especially from eastern Turkey where malaria was still endemic.

A combination of poor irrigation management and inadequate drainage in this extensive low-lying coastal plain gave rise to a rapid increase of Anopheles sacharovi populations and a subsequent expansion of malaria transmission, with the national API reaching 278 per 100 000, and with 115 000 cases reported around Adana (compared with a low point of 49 cases previously). The development of vector resistance to organochlorine insecticides and refusal of many inhabitants to accept house-spraying with malathion complicated control measures, but a combination of drug distribution, larviciding, larvivorous fish and alternative residual insecticides reduced the API to 67 per 100 000. From 1978 to 1985 the number of cases in Turkey has fluctuated from 70 000 to 25 000, but the improvement has been less marked in the Çukurova plain than in the remaining part of Turkey.

The cause of the increase in malaria was clearly identified as poor water control in the irrigation scheme, and particularly in the drainage component, together with the seasonal and longer-term movement and migration of agricultural labour. The costs of remedial work have, however, so far prevented any major environmental modifications to the scheme as a vector control measure. This was particularly disturbing in view of the large irrigation developments now under construction to the east of Adana, which could replicate the malaria experience of the Çukurova plain unless early preventive actions were introduced.

The Panel identified the Adana case as one of several examples of the lack of proper drainage as a major factor in vector production and control, in the context of both irrigation and rainfed agriculture. In many countries, development was focussing on the use of swampland and valley bottom lands through drainage and improved water control and, here too, the quality of works and their operation and maintenance would determine the risks of vector-borne disease transmission in endemic areas.

In a setting of much larger scale, that of the Amazon region, drainage deficiencies were cited as one of the major causes of an explosion of malaria. Forest clearing and widespread development for agriculture had created erosion, and the resulting heavy sedimentation had led to the formation of stagnant pools in river beds. Engineering works for roads and structures had left undrained borrow pits. Due to migration and settlement, increasing numbers of people were exposed to malaria, and the local vector, A. darlingi, was changing its behaviour to adapt to the new man-made environment. Because this species was also highly exophilic, conventional chemical control by residual house-spraying was not feasible. The appropriate engineering measures to correct the drainage problems were well known, but the costs had apparently not yet been deemed to be justified.

Changes in crops and cropping patterns

As with the extension of land use, which is essentially a conversion from natural vegetation to some different form of cover, a change in crops (either in their management, or in cropping patterns) also has an impact on the environment which may have implications for disease vectors and disease transmission.

Some plants, for example abaca and pandanus, are preferred breeding sites for insect vectors in the Philippines. Water held in the leaf axils of these two plants provides a niche for the larval development of Aedes poicilius, the main vector responsible for transmitting human filariasis. Often grown close to houses, this poses a distinct health risk. Where there has been a change to banana crops, which do not offer such ideal breeding conditions and which are usually produced in plantations with strict cultivation practices and pesticide spraying, the vector breeding potential is reduced.

A subject of particular concern in the Panel's discussion was that of high-yielding varieties (HYVs) of crops, especially of rice. Several major characteristics of the HYVs of rice were recalled:

- The HYVs have shorter durations than most traditional varieties which may require 150 to 180 days to mature. This trait enables a farmer with access to irrigation water to grow two or three crops a year.

- The HYVs, unlike the traditional varieties, are insensitive to photoperiod or day length. This trait allows them to be grown during any period of the year.

- The HYVs tiller more, have shorter and stiffer stems, and bear heavier panicles without lodging. This is the characteristic that is mostly responsible for higher yields per unit of land use. Furthermore, it is important to note that as a result a rice field is almost completely shaded by foliage within about 40 days after transplanting.

- The HYVs are in general sensitive to water shortage or drought. Water stress at any growth stage may reduce yield, but the plant is most sensitive to water deficits from the reduction division stage to heading. Stress at this stage cannot be compensated by the plant and causes spikelet sterility (Yoshida, 1981).

- Most of the HYVs have various degrees of built-in resistance to a wide range of insect pests. Thus, they should require smaller amounts of insecticide application to avoid crop damage than traditional varieties.

There have been many instances where the introduction of HYV rice has been blamed for an increase in malaria. The case study from India, however, demonstrated the complexity of the cause-and-effect relationships and how apparent consequences may in fact be occuring strictly by coincidence following the massive introduction of new crop varieties.

In India, the green revolution began with the introduction of the HYV programme in 1966. Increased production required the introduction of high-yielding varieties, intensive agriculture, irrigation to minimize dependence on the monsoon, use of fertilizers and pesticides, etc.

The period of the green revolution was also the period of malaria resurgence. In 1965 there were about 100,000 malaria cases in the country, the lowest incidence since 1958, when the National Malaria Eradication Programme (NMEP) was launched. After 1965, however, malaria incidence increased in the country and reached a peak of 6.4 million in 1976. Insecticide resistance in mosquitoes was considered one of the important factors responsible for malaria resurgence. It was hypothesized by Chapin and Wasserstrom (1981) that "resurgence of malaria in Central America and India seems to have been parallel to intensified agriculture in these countries and the associated increased use of pesticides".

A critical study by Sharma and Mehrotra (1982a and b, 1983, 1986) of malaria resurgence in India revealed that the phenomenon was not linked with any aspect of the green revolution. Resurgence of malaria in India was largely the result of (i) the shortages of DDT throughout the period of resurgence, (ii) the fact that 96 units remained in persistent attack phase where the technique of residual indoor spraying had not been effective in interrupting transmission even after more than 12 to 14 years of spraying practice, (iii) malaria control in urban areas required intensive anti-vector measures which were lacking (and as a result transmission in towns remained uninterrupted and outbreaks of malaria were recorded as early as 1961 and 1962), and (iv) in many areas surveillance was not properly organized and health services were not mature enough to undertake monitoring in the maintenance phase. Further analysis of data revealed that malaria outbreaks preceded the true onset of insecticide resistance in malaria vectors and that usage of pesticides in agriculture did not induce resistance at a time when malaria resurgence was widespread.

Thus, malaria resurgence was fundamentally a phenomenon which occurred independently of the green revolution, but improved agricultural practices, irrigation development, expanded rice cultivation and migration of agricultural labour may nevertheless have had profound effects on the mosquito vector fauna. The changes in the mosquito fauna over the past 30 years are presented for several parts of India in table 6. These, in turn, will have affected the epidemiology of vector-borne diseases and, in particular, malaria transmission. The example illustrates the difficulty of ascertaining linkages between direct and secondary causes and effects of such major changes as the massive introduction of new crop varieties. The Panel noted that, here again, the management aspect of the greatly expanded system of agricultural water supply needed by HYV was implicated with respect to past and potential changes in malaria transmission patterns, as indicated by the following observations:

- Irrigation systems have made many areas more suitable for mosquito proliferation. Poor canal maintenance and untidy irrigation are responsible for creating mosquitogenic conditions. Major and medium size systems provide more untidy irrigation than minor schemes.

- There have been major changes in mosquito fauna as a result of the developments that have occurred in the last three decades or so. In areas affected by the green revolution or by intensified agriculture, succession of new species has frequently occurred, thus changing the malaria transmission potential of these areas (see table 6).

Table 6. Results of mosquito fauna surveys in India

NEW SPECIES RECORDED	SPECIES RECORDED EARLIER BUT FOUND ABSENT
1. ANDAMAN ISLANDS	
(Nagpal and Sharma, 1983)	(Christophers, 1912; Covell, 1927)
A. annularis	A. aitkenii
A. nigerrimus	A. umbrosus
A. nivipes	
A. karwari	
A. stephensi	
A. subpictus	
A. varuna	
2. UTTAR PRADESH, TERAI	
(Nagpal et al., 1983)	(Issaris et al., 1953)
A. aitkenii	A. karwari
A. lindesayi	A. minimus
A. kochi	
3. KUTCH + BHUJ	
(Neeru Singh et al., 1985)	(Afridi et al., 1938)
A. aconitus	A. barbirostris
A. nigerrimus	
A. pulcherrimus	
A. sundaicus	
4. ORISSA (continued)	
(b) Plain districts	
(Nagpal and Sharma, 1986)	(Watts, 1924)
A. aconitus	A. varuna
A. ramsayi	A. jeyporiensis
	A. theobaldi
	A. jamesii
(c) Hill districts	
(Nagpal and Sharma, 1986)	(Senior White, 1937; 1938)
A. kochi	A. moghulensis
A. ramsayi	A. majidi
	A. stephensi
5. NORTH-EASTERN REGION (ASSAM, MEGHALAYA, ARUNACHAL PRADESH AND MIZORAM)	
(Nagpal and Sharma, 1987)	(Vishwanathan et al., 1941; Mortimer,1946 and Sen et al., 1973)
A. majidi	A. balabacensis
A. theobaldi	A. aitkenii
A. nivipes	A. bengalensis
A. maculatus var willmorei	A. culicifacies
	A. lindesayi
	A. insulaeflorum
	A. umbrosus

- The most commonly encountered breeding sites of malaria vectors are the canals and fallow fields rather than the rice fields under cultivation *per se*. Rice cultivation may be harmful in certain specific situations but a study of the Indian scenario revealed that rice cultivation has a very weak or no relationship with malaria transmission. This conclusion is mainly based on information from regions which follow crop rotation and grow one crop of paddy per year. Surface irrigation is, however, creating changes in the agronomic practices, and in many Indian states, instead of rice and non-rice crop rotation, two or three crops of paddy are grown in one year. This may allow continuous breeding of vectors. Regular monitoring of vector breeding is required to be able to limit the impact of changing agricultural practices on mosquito abundance and consequent enhancement of disease transmission.

The reasons for the great interest in HYV rice in the context of irrigation and vector-borne disease transmission can be seen from Figures 1 and 2 which give an indication of the extent of land planted with HYV and the role played by these varieties together with intensified water management. But it must also be appreciated that there are limitations to the standards of water management imposed both at system and at farm levels, and that these will have an impact on crop production and on the creation of an environment which may or may not be conducive to mosquito vector propagation.

The Panel discussed farmer perceptions of crop/water management and accepted that these were often determined by technical, economic and social factors which were not compatible with system design and operation. This was particularly true where the reliability of water supply was low, causing the farmer to apply an excess when available, as an insurance. Synchronous planting and harvesting as a crop pest and vector control measure were only rarely applied, due to varying abilities of small-holders within large schemes, thus giving in the majority of cases a long carry-over of hydrological conditions suited to vector breeding. Here again the Panel recognized the need to incorporate demograpic and social factors into the design of vector-control interventions, even where these had an apparently clear technical base.

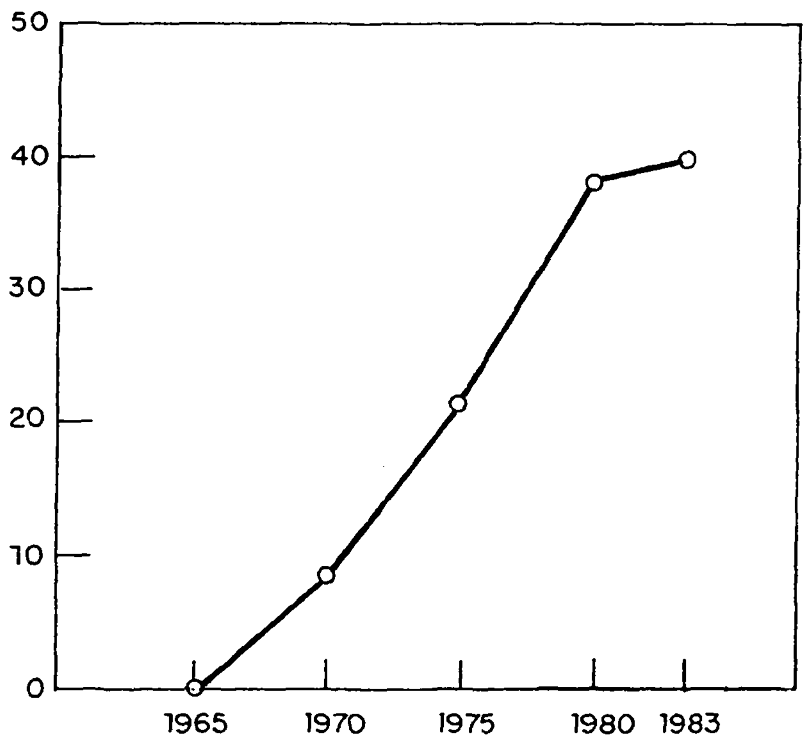

Figure 1. Area in hectares (x 10^6) planted with high-yielding rice varieties in selected countries in Asia (modified from World Rice Statistics, IRRI, 1985)

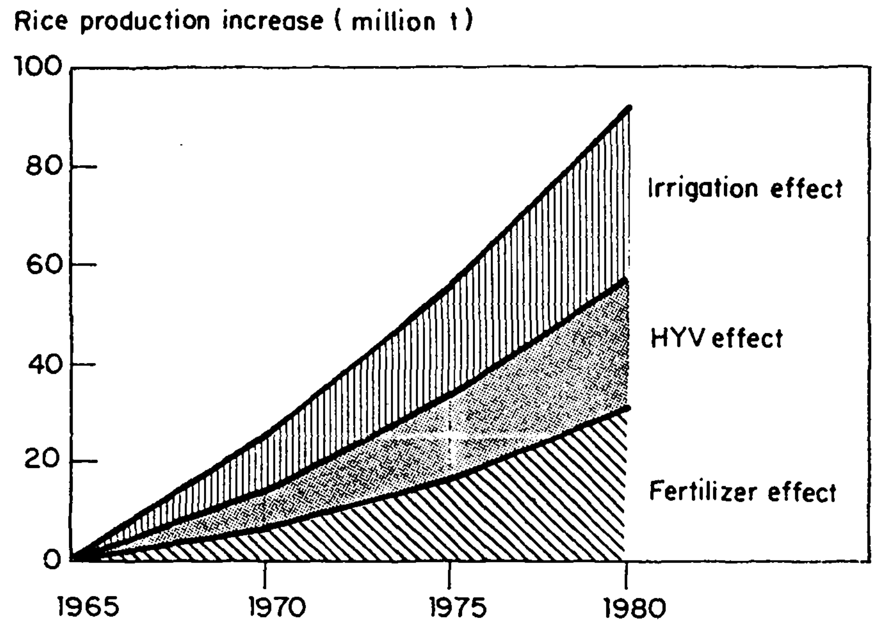

Figure 2. Estimated contribution of three different factors to rice production increases in eight Asian countries, 1965-1980 (modified from Herdt and Capule, 1983)

The Panel also considered the African situation in connection with the introduction of rice cultivation. There was a great variety in the effects of the introduction of rice cultivation on the transmission of malaria: in northern Cameroon, for example, malaria declined sharply from hyperendemic to mesoendemic levels in the Yagoua area after rice growing became established (Couprié et al., 1959), while in the Ruzizi plain of Burundi, on the other hand, there was an alarming increase in malaria following the extension of rice growing (Coosemans, 1985).

Studies in the Kou Valley in Burkina Faso provided some insight into the refined ecological mechanisms at play, which might explain differences in malaria transmission in rice growing and non rice growing areas. While in the former the vector populations throughout the year predominantly consisted of *Anopheles gambiae*, in the savanna area the classical sequence of maximum numbers of *A. gambiae* from June to August, followed by high densities of *A. funestus* from August to October could be observed. Here, the one-peak transmission pattern towards the end of the rainy season was distinctly different from the pattern in the rice growing area, which showed two peaks, coinciding with the rice harvests. In spite of the fact that the anopheline vector density was about three times as high as the level recorded in the savanna, malaria transmission was on average 2.5 times lower in the villages of the rice growing scheme than in those of the surrounding areas. A series of cytogenetic studies revealed that *A. gambiae* occurred as two sibling species, "Mopti" and "Savanna", and that the Mopti cytotype predominated in the centre of the rice growing area, while the Savanna form was proportionally better represented at the edges and outside of this area. Different vectorial capacities of the two sibling species might be the causative factor in this paradoxical phenomenon.

Pesticide use

Agricultural developments with their emphasis on higher yields through high-yielding varieties, fertilizers and improved water supply have greatly exacerbated many crop pest problems in the tropics, because host plant resistance has often been traded for yield potential in breeding progammes, fertilizers make plants more nutritious for pests, and irrigation permits continuity and hence build-up of pest populations. This has led to the increasing use of, and dependence on, chemical pesticides, which in turn

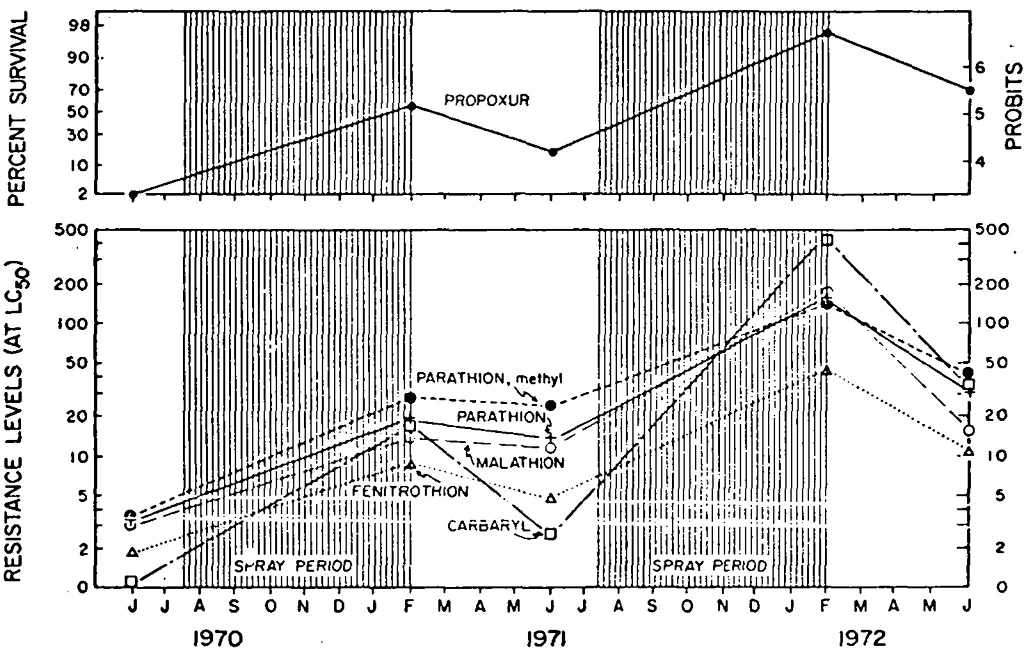

Figure 3. Fluctuations in resistance levels toward organophosphates and carbamates in Anopheles albimanus with reference to alternating agricultural spray and non-spray periods (after Georghiou et al., 1973)

has exacerbated problems through destruction of natural enemies and through direct effects on the host plant, making it more susceptible to certain insects. It is therefore inevitable that the massive increases in use of chemical insecticides against crop pests over the past 20 years will influence disease vectors that live in the sprayed habitats. Surprisingly, little critical work has been done on this problem. Georghiou et al. (1973) referred to observations since 1966 in Central America which suggested that the mosquito Anopheles albimanus was developing resistance from indirect exposure of the mosquito to agricultural insecticides. This classical paper on the subject (also: Georghiou, 1976) demonstrated induced mosquito resistance to a range of organophosphorus and carbamate insecticides associated with the agricultural spray period (August-January) on irrigated cotton fields, which declined somewhat during the non-spray period (figure 3). These changes were most pronounced with carbamate insecticides (e.g., propoxur). This work, as well as some evidence or assumptions from elsewhere (see table 7),suggested that agricultural pesticides, particularly those used in mosquito breeding areas such as rice paddies, could seriously jeopardize chemical control of some malaria vectors. The evidence had led to decisions, for example in 1977 in Sri Lanka, to restrict the use of malathion and fenitrothion to malaria control in an attempt to minimize development of resistance in malaria vectors that could be caused indirectly by their agricultural use, notably against insect pests of rice.

The density of the vector in sprayed areas relative to unsprayed areas is an important parameter for this phenomenon. In El Salvador, for example, the rise and fall of resistant Anopheles albimanus (figure 3) in spray and non-spray seasons, respectively, might suggest dilution by susceptible mosquitoes from unsprayed areas during the non-spray season. The general level of resistance, however, increased strikingly in successive years, associated with heavy selection pressure from up to 30 insecticide applications on cotton in El Salvador during the six-month season. Whilst indirectly induced resistance is a very serious hazard, it must also be appreciated that agricultural insecticides can drastically decrease vector populations locally, and perhaps usefully (figure 4; Hobbs, 1973; Service, 1977).

Table 7. Cases of resistance to insecticides in mosquito vectors presumed to have been induced or aggravated by indirect selection pressure resulting from the agricultural use of pesticides

Species	Country	Crop	Insecticide resistance	Reference
Anopheles aconitus	Indonesia (Java)	various, incl. rice	dieldrin, DDT	Brown et al., 1971 O'Connor et al., 1974
A. albimanus	El Salvador, Nicaragua	cotton, rice	parathion, methyl parathion, malathion, fenitrothion, propoxur, carbaryl	Georghiou, 1972; Georghiou et al. 1971; Georghiou et al., 1973
	El Salvador	cotton	DDT	Rachou et al., 1965
	Mexico, Guatemala, El Salvador, Honduras, Nicaragua	cotton	DDT dieldrin	In: Brown et al., 1971
A. culicifacies	India (Andhra Pradesh, Madhya Pradesh)	various	malathion	Watal et al., 1981; WHO, 1973
A. gambiae	Côte d'Ivoire	coffee, cocoa	dieldrin	Hamon et al., 1963
	Nigeria	ground nuts	dieldrin	Elliott, 1959
	Ghana	cocoa	dieldrin	In: Hamon et al., 1963
	Mali	cotton	dieldrin	Ariaratnam et al., 1974
	Burkina Faso	cotton	DDT	Hamon et al., in: Brown et al., 1971
	Sudan, Ethiopia Togo, Senegal	various	DDT	WHO, 1973
A. maculipennis	Romania, Turkey	various	dieldrin	Duport, in: Brown et al., 1971
A. melanoon subalpinus	Turkey	various	dieldrin	Ramsdale, 1973
A. melas	Zaire	bananas	DDT	Hamon et al., 1961
A. pharoensis	Egypt	cotton	dieldrin	Zahar et al., in Brown et al., 1971
	Sudan	various	dieldrin, DDT	Haridi, 1966
A. quadrimaculatus	USA	cotton	dieldrin	Mathis et al., 1956
	Mexico	cotton	DDT, dieldrin	Martinez Palacios, 1959
A. rufipes	Mali	cotton	dieldrin	Hamon et al., in: Brown et al., 1971
A. sacharovi	Greece, Turkey	cotton, rice	DDT, dieldrin	Zulueta, 1959; Belios, 1961; Ramsdale, 1973, 1975
A. sinensis	China	rice	DDT, malathion	WHO, 1980
A. stephensi	Pakistan	cotton	malathion	Georghiou, 1986 (unpubl. data)
Aedes aegypti	Tahiti	cocnut	dieldrin	Mouchet et al., 1967
A. nigromaculus	USA	various	DDT, dieldrin, OP	various authors, in: Brown et al. 1971
Culex quinquefasciatus	USA	various	OP	Georghiou et al., 1975
C. tritaeniorhynchus	Rep. of Corea, Japan	rice	several	WHO, 1986

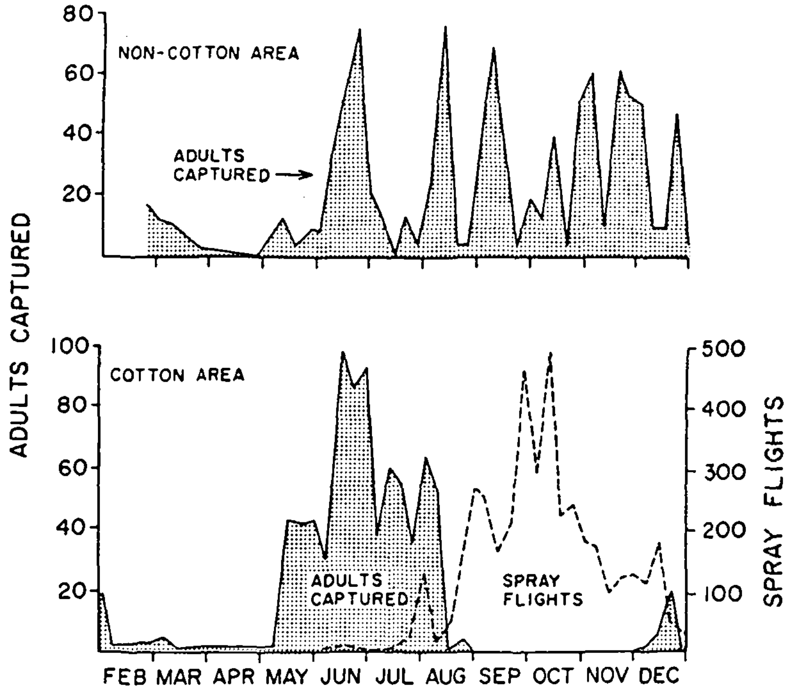

Figure 4. Adult densities of A. albimanus at Melara (cotton area) and Santa Emilia (non-cotton area), El Salvador, with records of cotton spray flights by week, in 1972 (data from Hobbs, 1973)

The Panel expressed concern at the conflicting statements in various working papers regarding the susceptibility of HYV rice to crop pests. In some cases, it was said that improved pest resistance was being bred into recent strains, while there were many other comments on the need for increased use of agrochemicals for HYV. As with so many of the issues under discussion, there is a wide range of factors affecting the crop in specific circumstances. Some HYVs have an improved resistance to certain crop pests, but the package of inputs for production, particularly assured water and fertilizer, creates a plant which is more attractive to pests. Breeding for pest resistance or for other features such as improved drought tolerance can usually be achieved only at some cost to yield characteristics which are generally the selected features for optimization.

It was accepted by the Panel that pesticides formed a vital component of the HYV input package, but that excessive application was all too common with resulting direct harm to people and the environment and the build up of vector resistance. Among various causes of over-use were unscrupulous sales practices, government subsidies (which make pesticides a cheap input to the farmer) and a lack of training and information for the user.

In these circumstances, traditional methods of pest control had been discarded in many places in favour of full reliance on chemical pesticides which tended to be applied with increasing frequency. One of the particularly serious results of this approach was the damage to natural enemies of the pests which sometimes were more susceptible to the pesticide than the target insects and were therefore unable to exert their normal control on pest populations. This effectively removed or severely restricted the potential for biological control through indigenous or introduced predator species of crop pests and has had the same effect on attempts at the biological control of disease vectors, especially affecting aquatic insect predators of mosquito larvae, and larvivorous and molluscivorous fish. This impact of pesticides was well illustrated by the following example of the brown planthopper.

Rice was not often seriously damaged by pests until the green revolution's introduction of a package of technology: high-yielding cultivars, artificial fertilizers and improved irrigation, which in some areas allows up to three crops a year and year-round continuous cropping. These inputs have greatly increased damage by insect pests, so chemical insecticides are also an essential part of the package. Insecticides have proved invaluable in protecting rice, but characteristically have also created resurgences and hence accelerated dependence on pesticides. In particular, a new pest, brown planthopper (BPH), Nilaparvata lugens, is now the most serious pest of rice in much of South-East Asia (Heinrichs and Muchida, 1984), although rice breeding for resistance to BPH has partly alleviated this problem in some areas.

It is evident that BPH, at any rate in the tropics, is normally kept under control by a large guild of generalized predators which also act against other potential pests. Different kinds of insecticides have caused rapid resurgences leading to major outbreaks of BPH through destruction of its natural enemies (figure 5; Kenmore et al., 1985) enhanced by the insecticide also directly altering the rice plant physiology, increasing its nutritiousness, and so encouraging pest multiplication rate beyond natural enemy control (Heinrichs and Muchida, 1984). The same considerations apply variously to other rice pests.

The Panel was informed of the activities in this area of the FAO/UNEP Panel of Experts on Integrated Pest Control. Impending disasters from green revolution technology led to rice being highlighted by FAO through this Panel which stimulated a Cooperative Programme on Integrated Pest Control in South-East Asia. This involves FAO/UNEP coordination of joint action by rice pest control specialists in major rice producing countries in South-East Asia and also publication of guidelines (FAO, 1979). As with all such control programmes, the vital first step had been to limit insecticide usage to when it is justified on the basis of an economic injury threshold (Kenmore, 1987). This included defining levels of pest numbers that if unchecked by chemical treatment would lead to losses greater than the value of the treatments applied. Such an approach not only prevented wastage of insecticide but also minimised harm to beneficial species. The definition and utilisation of economic injury thresholds for such pests, combined with the selective use of insecticide was considered fundamental to integrated control of crop pests (Way, 1977). The economic threshold concept seemed comparable to the cost-benefit approach in vector control where it seemed much less definable or applicable than the notably different concept of cost-effectiveness (WHO, 1986).

The FAO/UNEP Programme had established functional economic injury thresholds and had recommended suitable insecticides, its current priority being on their adoption by farmers (Kenmore, 1987). With reference to Mather and That's (1984) "problem of convincing agriculturalists that new ideas are viable" for vector control by environmental management, the enlightened approach of this programme (Kenmore, 1987; Kenmore et al., 1985) may provide insights on how vector control strategies might also be more effectively encouraged by government decision makers and adopted by farming communities.

The PEEM objective to promote environmental management for vector control is partly in response to the undesirable effects of pesticides on vector resistance, on the environment and on human health. In this connection, the Panel's attention was drawn to the International Code of Conduct on the Distribution and Use of Pesticides, prepared by FAO in conjunction with other international organizations, and adopted by the FAO Conference in 1985. This Code, with widespread support from governments, serves as a point of reference until such time as countries have established adequate national regulatory infrastructures.

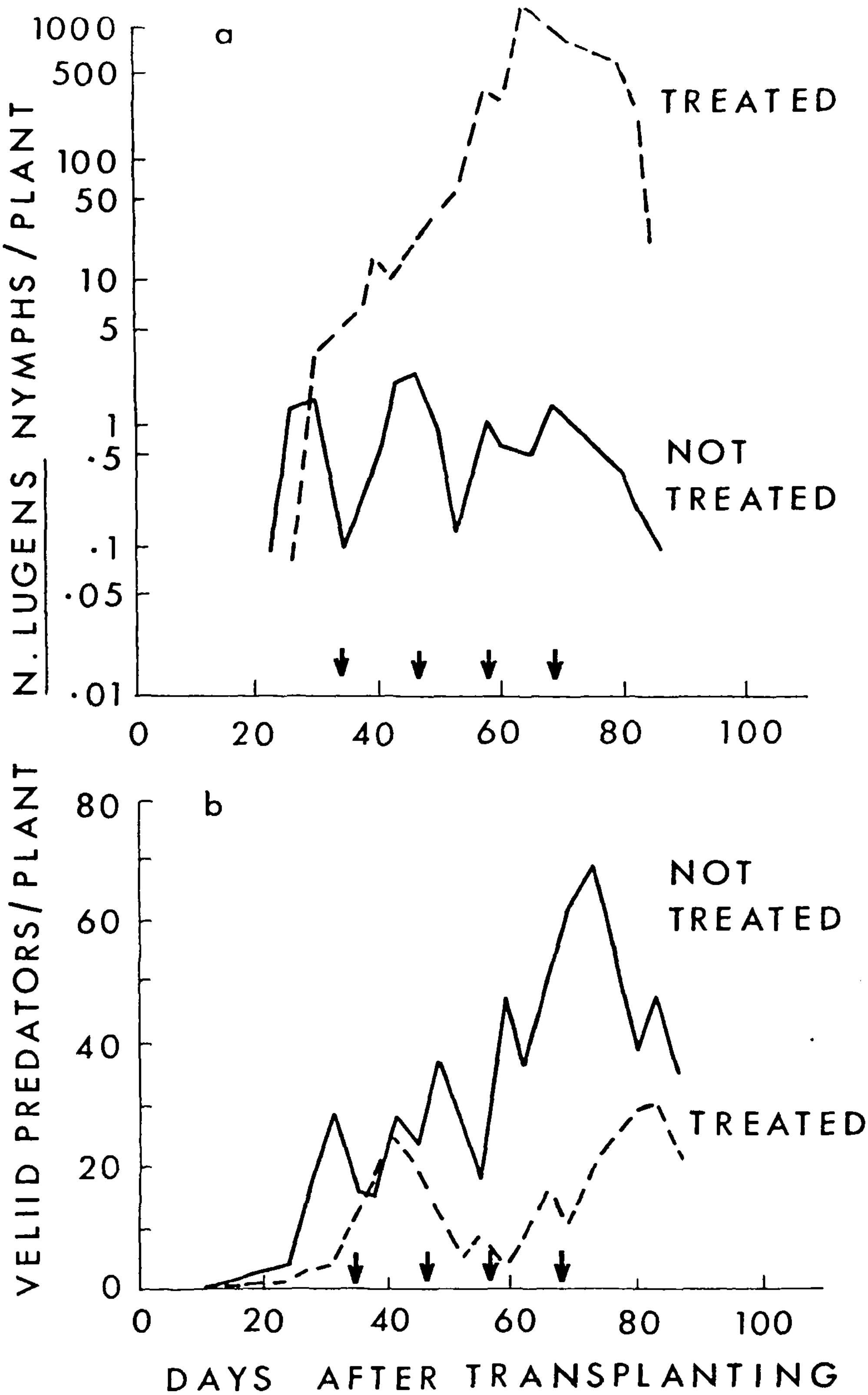

Figure 5. Population changes of the brown planthopper N. lugens and of its veliid predators in an untreated rice field and a field treated (arrows) once with the insecticide diazinon (OP) and the three times with deltamethirn (pyrethroid) (Kenmore et al., 1985)

Patterns of disease

The patterns of disease observed in different agricultural communities will depend upon the specific agricultural variables listed in table 2, above, together with the local features of climate, degree of socio-economic development, and a number of cultural variables. Certain broad patterns may emerge in different geographical regions, though the vector-borne diseases in particular will tend to show micro-geographical variations in both the types and prevalences of diseases encountered.

This was well illustrated by a case study from Côte d'Ivoire in which ethnic factors playing a role in the transmission of sleeping sickness were presented.

In Côte d'Ivoire, the only regional vector of African trypanosomiasis is Glossina palpalis which has spread in all cultivated areas. Fly populations remain plentiful in riverine woodlands; they have also proliferated around villages because of the presence of pigs, the preferred food-source for G. palpalis, and they have now occupied all biotopes modified by human activity. Nevertheless, the forest and riverine edges still represent the situation of greatest risk for man-vector contact.

Over the past 50 years, the agricultural economy of Côte d'Ivoire has become increasingly dependent on production of coffee and cocoa as cash crops. This agrarian change has been associated with extensive immigration of different ethnic groups, and the emergence of new social groups. Vector-ecological data alone are unable to explain why, at the local level in the plantation zone, greatly differing levels of prevalence of trypanosomiasis are to be found among ethnic groups sharing the same area and also among the various social and occupational categories within these groups.

In the Vavoua trypanosomiasis focus, between 1981 and 1983 prevalence was ten times higher among the Mossi than among the Baoulé and at least twice as high as among the indigenous peoples. In the Daniafla region, during the same period, prevalence was respectively 0.20 among the Mossi, 0.13 among the Baoulé and 0.07 among the indigenous peoples.

Incidence among the Mossi in 1981 was twice as high among village dwellers as among individuals living in the encampments within the plantations, and altogether accounted for 75% of the trypanosomiasis cases. The age group most affected was the one between 15 and 40 years, in which men were significantly more affected than women. In addition, 42% of the patients were temporary labourers, a group representing only 20% of the resident population. Sufferers were primarily individuals of working age in the plantations who were members of groups of people in which the parasite was able to circulate on a vast scale.

The Mossi tend to live in small encampments scattered within plantation areas, and they circulate freely within the lands of indigenous groups which are usually located close to river borders where rice is grown. In contrast, the Baoulé prefer to live in hamlets of 50-400 people and remain socially isolated from other tribes. The Baoulé have wells or pumps within their hamlets, whereas the Mossi obtain their water either from villages of indigenous groups or from communal pipes sunk into damp woodland bottoms where there is always a high density of tsetse flies. For these and other reasons, it appears that the Mossi tend to make more frequent journeys through their own and other peoples lands and so become more exposed to the tsetse flies. In contrast, the Baoulé spend less time in their fields and circulate much less amongst other villages and areas where tsetse fly populations are highest.

The Panel was particularly appreciative of this paper as human behaviour is increasingly recognized as a key factor in disease transmission. Studies of this type are difficult but should be encouraged because they have important explanatory and predictive power for epidemiological findings. It is, however, important to be able to quantify components and effects. This issue of quantification recurred throughout the discussion. With regard to the Côte d'Ivoire study it would call for an attempt to identify to what extent trypanosomiasis presence can be attributed to components such as social differences, genotype, diet, population structure, and water source. The demographic and socio-economic factors introduced in this study reinforced the Panel's desire to augment its number with members having background in these fields of expertise.

Another example of how agricultural development, by changing the human ecology, can affect an existing disease situation was presented by a case study from Japan. At the same time it demonstrated once more the difficulties of relating causes and effects in disease transmission in an agricultural community.

In Japan, cases of Japanese encephalitis (JE) dropped shortly after 1966 from 1-10 cases/100 000 during the preceding 20 years, to less than 0.01 cases/100 000 by 1976 (figure 6). Incidence rose slightly in 1978 but still remained below 0.1 cases/100 000. The sharp drop in incidence during the late 1960s coincided with the withdrawal of HCH as the main insecticide applied to paddy rice, and the withdrawal of organic mercury compounds as fungicides.

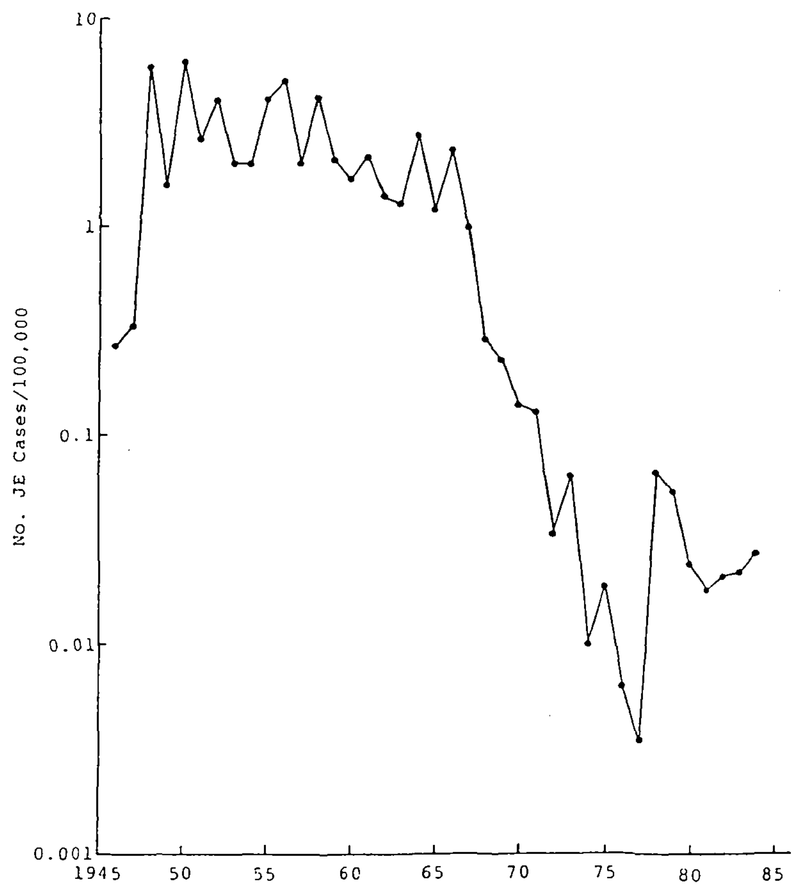

Figure 6. Annual incidence of Japanese encephalitis in Japan between 1945 and 1985

From assessment of numerous trends over the past 40 years, it is concluded that a decrease in populations of the JE vector Culex tritaeniorhynchus (which breeds mainly in rice fields) occurred in the late 1960s as a result of increased insecticide treatment and the switch from organochlorine insecticides (HC) - to which the vector had become resistant - to organophosphates and carbamates (see figure 7). At this time, vector populations declined by 90-99%. Although vector densities have since recovered, their infectivity rate has remained much lower, partly due to lower infection rates in pigs (the amplifying host) and in children (for whom an intensive vaccination programme expanded rapidly since 1965). By the late 1970s, vector populations had acquired high levels of resistance to organophosphates and carbamates, and had recovered to densities similar to before. Infection rates of pigs have also increased, but human infections remained low. This appears to be due to reduced man-vector contact because, as income levels have improved for farmers, they now tend to spend their evenings in air-conditioned, closed rooms with colour televisions and other recreation facilities, instead of spending evenings outdoors or in open houses during the hot and humid summer. Window screens are also more widely used now.

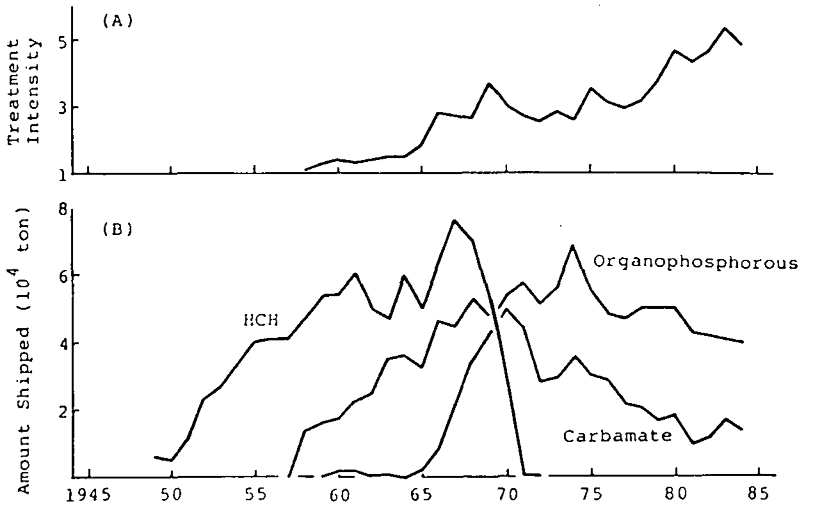

Figure 7. Treatment intensity of insecticides to paddy rice (cumulative area treated/area planted) (A) and the amount of main insecticides shipped for domestic use (B): organophosphorous insecticides include diazinon, disulfoton, EPN, fenitrothion, fenthion, malathion, and trichlorfon; carbamate insecticides include carbaryl, propoxur, BPMC, CPMC, MPMC and MTMC

In other areas, transmission of JE to man appears to occur when the mosquito vector switches hosts from pigs to man, possibly as a result of very high densities and some form of competition at the feeding site. As a result, JE outbreaks are often cyclic and associated with very high mosquito/pig density ratios. If this idea is correct, it implies that JE transmission to humans could be controlled by maintaining vector/pig density ratios low, and/or by restricting man-vector contact. In Japan, it appears that both these processes have happened in happy succession.

In terms of environmental management for vector control, however, two important points stood out from this case study. First, the area planted with paddy rice had decreased progressively since 1970 (figure 8), and transplanting time had advanced steadily over the past 30 years (figure 9), yet neither trend correlated at all with changes in vector abundance. This implied that vector densities were not, in this case, limited by available breeding sites, and raised the question as to the nature of the regulatory mechanism involved. Secondly, intermittent irrigation had been increasingly practised in Japan since the early 1960s, yet this also did not appear to have affected vector abundance. It remained unclear whether this was due to the presence of another important type of breeding habitat, or whether this was an example of a mosquito species whose density was limited by access to available hosts.

In conclusion, it was noted that the decrease in JE epidemics in Japan since the late 1960s probably resulted, in part at least, from unintended effects of environmental changes in addition to the vaccination programme. There may be other examples where

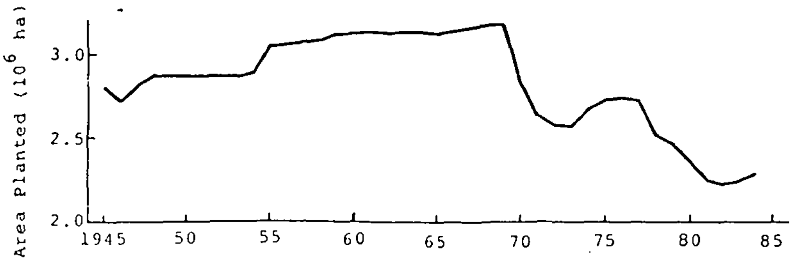

Figure 8. Total area in Japan planted with paddy rice

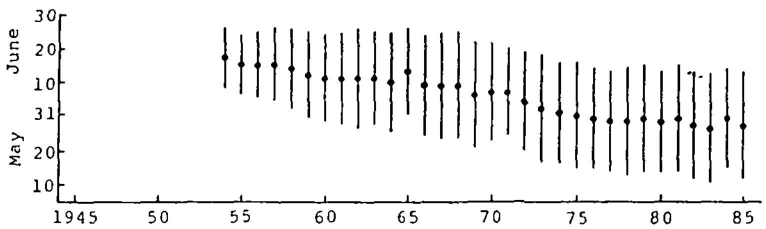

Figure 9. Mid-transplanting time. Mean and standard deviation were calculated from mid transplanting time in each prefecture except Okinawa where rice is cropped twice a year

vector-borne diseases decreased without continuous effective control operations. Overlooked or underrated factors may have worked under the general heading of successful control. An important element of integrated vector-borne disease control may be to identify and incorporate such factors intentionally into local development programmes.

Organization and institutional arrangements

Land and water development projects for agriculture not only increase agricultural production and change the environment but also have other substantial impacts on other aspects such as employment generation, education, health facilities, communication, energy availability in terms of fuelwood and electricity, domestic water supply, and women. These impacts take place through a series of interconnected pathways which are both direct and indirect and are not always easy to identify or predict. They may also vary substantially in terms of their nature and magnitude from one project to another. Unfortunately, holistic approaches to land and water management that consider all these issues are few and far between.

One of the most important reasons for this is the division of responsibilities among the ministries in any given country to look after the various sectoral areas of interest, including irrigation or water development, agriculture, health, environment, education, rural development and so on, while coordination and cooperation between ministries often leave much to be desired. And yet, in any large-scale land and water development project, all these issues must be integrated. The Panel recognized that it was easy to point out this necessity and it had, in fact, done so in the past. How it could be effected in reality was, however, a complex and daunting task. It had to be admitted that there were not many success stories. The promotion of intersectoral collaboration remained, nevertheless, a key-objective of the Panel, and the example it set within the United Nations system should continue to be a model for similar activities at a national level.

It was also noted that even if one single field like health was considered, there were many issues that should be reviewed but were generally not. Because of recent emphasis on negative impacts, health issues traditionally considered at present were the adverse ones, e.g., increases in vector-borne diseases. Indeed, it was rare to find projects where health considerations included improvements due to more assured and varied food supply available to the people in terms of increased agricultural production, fish catches in man-made lakes and livestock holdings. Improvement in health due to secondary factors like better transportation and communication in the project area, new education and health facilities and improved status of women were seldom considered. Yet, in terms of overall health of the people in the project area, these factors might be more important than increases in specific diseases only. Even for a single factor such as vector-borne diseases, information was at times somewhat anecdotal or at best unqualified and thus inadequate for decision-making processes.

This need for quantified information was continually stressed throughout the Panel's discussion. The multiplicity of agencies involved and their diverse disciplines, responsibilities and abilities made data collection and reporting an extremely complex task. It was considered that too little attention had been paid in the past to defining the factors on which data were required and the parameters to be observed initially and through subsequent monitoring and surveillance. A proposal was made for more precise definition of the purposes of data collection on physical, demographic, entomological, epidemiological and other relevant factors, and for a parallel attempt at identifying the "minimum information needs" to meet these purposes and to simplify an otherwise excessively complex task. As an accompaniment to this aim, it was also pointed out that the presentation or "packaging" of information to suit the needs of the various user agencies was of equal importance in order to obtain a desired response.

The role of public health units in agricultural development was illustrated by the rice growing project in the Kou Valley in Burkina Faso. This study also gives an example of other settlement and social aspects of development. The introduction and development of rice-growing in the Kou Valley is designed to fulfil three major objectives (Palé and Ouédraogo, 1985);

- to develop domestic rice production and to cut back on imports;

- to raise the wages and standard of living of agricultural workers; and, consequently,

- to reduce immigration to Côte d'Ivoire.

The area was settled by providing incentives for the transfer of about 10 000 volunteers, mainly from the Mossi Plateau, who were settled between 1970 and 1974 in six villages established entirely by and for the project, which today covers an agricultural area of 1050 hectares. These villages cluster around the traditional village of Bama, whose population is of the Bobo ethnic group.

The social structure is clearly defined: one hectare per family (this may be expanded up to three hectares), compulsory membership of the cooperative, which is the monopoly rice marketing organization and provides widespread and permanent supervision; social facilities: a market, a post office, a police station, two dispensaries, a school and a maternity clinic and community health centre at Bama.

A primary health care project was started in 1981-1982. The team of health workers comprises: two nurses and their assistants, one ambulant health worker (based in Bama), eight community health promoters (based at the Bama community health centre), two community health coordinators, four traditional birth attendants and two midwives (at Bama), eight primary health workers of the "secouriste" or emergency type in each village, who give first-aid (cuts and wounds, etc.) and also hand out aspirin and nivaquine[R] (for each attack of fever and in the correct dosage). The ambulant health worker organizes meetings and talks with the women in each village, emphasizing problems of hygiene (use of latrines,keeping clean the curb of the well, cleanliness in general) and parasitic diseases: schistosomiasis, intestinal parasitoses (dangers of faecal contamination), dangers of swampy areas, etc.

The community health promoters are mainly concerned with the problem of malnutrition, which is more serious than might be expected in this agricultural area. The nurse at Bama receives regular reports from all these health workers and makes a monthly report to the departmental Officer-in-charge at Bobo-Dioulasso.

The density of culicine and anopheline species in the Kou Valley rice-growing area is extremely high. The anopheline mosquitos bite throughout the year and in the rainy season they proliferate to the extent that people may receive as many as 150 Anopheles gambiae bites a night. When the major vector of human malaria is prevalent in such numbers, a catastrophic situation might be expected, with epidemic outbreaks among the human populations that were originally from low transmission areas and that have been resettled to the Kou Valley for rice-growing. Paradoxically, and very fortunately, this is not the case. Two of the many factors that help to account for this situation should be noted, and they are of an entomological and sociological order.

- In spite of the very high density of A. gambiae, transmission in the rice-growing area is relatively low (50 infected bites/person/year), i.e., three times lower than in the surrounding savanna villages. The underlying principles of this phenomenon have been mentioned above. Nevertheless, this level of transmission is such that no-one can escape malaria.

- Social and health supervision in general appears to function well and access to health care and basic drugs is facilitated by the existing infrastructure. Nevertheless, this rice-growing area in the Kou valley is more than "receptive" when the major vector is present in such quantities. Measures must therefore be envisaged at several levels to combat the potential risk of malaria, in particular: control of the disease through continuous improvement in diagnostic and general health services (basic health services, primary health care, etc.); and, permanent vector control activities to reduce the frequency of man/mosquito contacts and the longevity of vectors.

Considerations of health must inevitably introduce the question of funding. Sometimes there is a percentage allocation of project costs (in the order of 2% to 3%) for direct health care, but mainly for curative purposes through hospitals and clinics. The funding of other project compounds is more problematic. Some may have distinct benefits for health, although they have been primarily included for other purposes (examples being canal linings, provision of drainage and improved community services). The quality of housing is also closely linked to potential health status of the project population. Costs of these components may be relatively high, and in various African irrigation developments have been estimated at 25% to 30% of total costs.

Investment policies on the part of financing agencies, including governments, often make provision for funding direct health benefit costs outside the main project, and they are therefore excluded from calculations of the economic rate of return (ERR) which is a major criterion in appraising a project's viability. The Panel considered that more attention should be paid to the identification of health protection components and measures of projects and to quantifying both costs and benefits of these. Only in this way would it be possible to make recommendations for the introduction of the most appropriate interventions and to justify their financing from project or other funds.

Summarizing the Panel's discussion on the impact of agriculture on human health, vector-borne diseases in particular, it was clear that there were many areas where more and better information was needed. This was of course due in part to the specificity of the relationships between the environment, vectors and human health relationships, but it was also recognized that many more general fields of study had been neglected.

These related to sociological aspects, vector identification, vectorial capacity, sibling species, vector density/transmission relationships, procedures for monitoring and surveillance of changes in ecology and fauna and human health characteristics, pesticide impacts on vectors and their natural predators (indigenous and introduced), the possibilities of integrated systems of food production and vector control with fish and other aquatic fauna and various other related issues. The research recommendations arising from the PEEM/IRRI/USDA Workshop on Integrated Vector-borne Disease Control - Riceland Agro-ecosystems of Developing Countries were also cited as a useful reference in this respect. Finally, the subject of legislation received passing reference, mainly through questions as to how to approach legislation for health activities, how to achieve a satisfactory level of compliance and how to formulate legislation to support interventions aimed at health protection and improvement. In the absence of answers, it seemed that the Panel might benefit from the incorporation of some experience in this area.

3. TRENDS IN AGRICULTURE WITH IMPLICATIONS FOR VECTOR-BORNE DISEASE TRANSMISSION

In considering the future needs in land and water development for food production and their implications for the environment in general and for the vector-borne disease situation in particular, the Panel was cautious in its assessment of current attitudes and abilities to react to the trends and their implications for human health. It considered that there was a dearth of scientific and statistical data, from longitudinal studies starting with baseline conditions to the operational phases, on physical, demographic, social and other factors related to human health in its broadest terms.

Reference was also made to the unpredictability of health impacts resulting from various forms of agricultural development such as land clearing, irrigation, and the introduction of mechanization, and it was concluded that responses to such changes were strongly specific to the location and the local human and vector populations, both of which could be expected to show dynamic conditions of change as a result of the development process.

The broad range of possible links reviewed in chapter 2, which might even be contradictory when comparing one locality with the other, illustrates the difficulties inherent in relating trends in agricultural development to possible implications for health and particularly vector-borne disease transmission. A great number of factors might have some bearing on that relationship and, therefore, there is a need for continuous and detailed study in the specific environment where development and change are taking place. If the links are not immediately obvious and do not directly point the way to the selection of measures for the reduction of adverse impacts and the maximization of positive benefits, then the analysis of past experience should at least serve to identify the right questions to ask in an attempt to predict the probable outcome of agricultural change and the interventions most likely to be effective.

Changed land use

The potential risks of introducing new vector-borne diseases or the extent of the possible modifying effect on existing diseases depend on the changes to the physical environment of land, water and vegetation and thus on vector habitat, combined with changes in the susceptible human population and in the social and economic activities which condition exposure to disease. The specific examples cited in the previous section illustrate both positive and negative effects which may in fact occur sequentially due to progressive changes in agricultural practices and crops, with correspondingly different impacts on vectors and on a succession of species. Questions to be answered in such cases must be directed not only at a synoptic situation, but at a probable sequence of changes. The answers will be formed only through a continuing process of monitoring and surveillance which reflects the dynamics of development, not necessarily the initial plan which may often be modified due to inadequate forecasting or due to economic, social or political influences.

The Panel reviewed the possible implications of different types of agricultural development in the following order: mechanization, trends in irrigation development, crop and livestock changes, strategies for integrated pest management, and changes in people, pathogens and vectors.

Mechanization

It could be said in general terms that the move to highly mechanized advanced agriculture was accompanied by massive falls in the farming population, larger plots and more capital-intensive methods that usually tended to reduce the hazards of vector-borne disease. In the case of schistosomiasis, man/pathogen contact would tend to fall, even if snails continued to be present in the water bodies, and the main residual problems would be vector mosquito breeding if rice or similar crops were grown and health hazards from the influx of seasonal labour migrants where these were needed for harvesting. Mechanization and/or sophistication of technology were invariably involved with greater capital intensive production reducing labour demand and hence increasing rural unemployment, especially if alternative employment through rural or urban industrialization could not keep pace. This could further complicate the situation of poverty and disease.

When studied in more detail, however, the picture of the relationship between mechanization and the vector-borne disease situation would present itself with considerably more nuance. Mechanization could lead to (i) a change in the numbers of farm labourers or their re-deployment; (ii) increase in plot size or farm hectarage; (iii) increase in crop yields; (iv) more crops per year; (v) change of land usage, and (vi) decrease in farm livestock, as well as a variety of social and economic changes. It was, however, difficult to predict any of these changes as they would vary greatly according to local customs and traditions, as well as farm economy. For example, mechanization often led to a reduction of farm labour, but this was not a universal consequence. In Nepal and Indonesia, the introduction of mechanization in the form of tubewells and pump irrigation had increased the demand for labour throughout the year. In the Philippines, mechanization had caused a significant reduction of people needed for land preparation, although in fact the total labour force had been little affected due to redeployment (Aguilar et al., 1983). In Bangladesh, mechanization had not always altered the number of farm workers, although their employment often changed from that of labourers to plot owners. In one study in West Java, however, mechanization had resulted in less labour (Saefudin et al., 1983). Hidajat (1982) concludes that mechanization in Java initially reduced demand for agricultural labourers, but since 1978 several studies have shown that mechanized agriculture is being promoted because of an insufficient supply of farm labourers. Indications are that if mechanization leads to increased rice hectarage then there will follow a demand for extra labour.

Mechanization may also increase the size of plots and cause a reduction in the numbers of independent farmers, although this may be accompanied by a greater number of cooperatives. Duff and Kaiser (1984) discussed changes in rural labour associated with mechanization. Further information on the effects of mechanization on employment is given by Ahammed and Herdt (1984) and by Farrington et al. (1984), the latter publication containing many statistics, at least up to 1980, on the degree of farm mechanization in different Asian countries.

The classical example of the impact of mechanization comes from Guyana and was reported by Giglioli (1963). Prior to the 1960s malaria transmission in the coastal area of Guyana was almost exclusively by Anopheles darlingi, a highly anthropophagic and endophilic freshwater breeding mosquito. Although A. aquasalis was about as common as this vector, it was strictly zoophagic and exophilic. During the 1946-1950 malaria eradication campaign residual house spraying with DDT virtually eradicated A. darlingi, but it had no effect on the exophilic A. aquasalis. Malaria was eradicated in the coastal areas including the Demerara river estuary and spraying ceased in 1951. In 1961, however, malaria cases re-occurred. By then the ecology and the socio-economic status of the area had changed. For instance, the human population had increased and most available pastures and fallow lands were converted to rice cultivation, and cattle which formerly occupied them were displaced or eliminated. Mechanization replaced horses, donkeys and mules on the roads, while tractors replaced oxen for ploughing. Because of the lack of livestock the originally zoophagic A. aquasalis switched to feeding on man and was responsible for malaria outbreaks on the Demerara river estuary sixteen years after malaria had been eradicated.

In conclusion it could be said that there was generally little information on the impact that farm mechanization of rice and other irrigated crops has on the population densities of vectors, or the prevalence of vector-borne diseases. Furthermore, the diversity of economic, social and ecological consequences arising from the introduction of mechanized power make it extremely difficult to predict its effect on vectors. The following were, however, the types of questions that needed to be asked - and answered. Would farm mechanization in irrigation schemes result in (i) more or less standing water during land preparation, during rice growing and post-harvest; (ii) increased or reduced water contact by farm workers; (iii) more or less standing water following the introduction of tubewells and pump irrigation; (iv) increased or reduced rice hectarage; (v) increased number of crop cycles; (vi) marginal lands and forests being cleared, if so how would this affect vector species and their populations; (vii) a reduction of cattle, if so would vector populations increase or decrease, and (viii) improved social and economic conditions leading to better housing, and housing further removed from the paddy fields?

The answer to these and other relevant questions depends much on local circumstances and farm management practices.

Trends in irrigation development

The second half of the 1980s might well be a turning point in global agricultural policies with respect to irrigation development, and the Panel analysed the implications for vector-borne diseases of recent trends in this connection. The previous decade had been dominated by the growth of large surpluses of production in North America and in Europe. More recently, the grain production of South and East Asia, largely grown on irrigated land, had similarly increased. It had risen substantially faster than the population growth rate, and some countries of that region which had formerly been persistent importers of grain, now faced the different problems of identifying export markets for grain surpluses.

The implications for irrigation development of this relatively new situation remained uncertain for the time being. Initially, the rise of world-wide agricultural production levels had caused a slowing down of the rate of new irrigation developments. It was difficult to predict how long this phase would last, and there were (and would continue to be) substantial regional differences.

It, however, seemed reasonable to expect that the trends which could currently be observed would persist for some years yet, and they carried a number of implications for those concerned with the linkages between irrigation and public health.

Figure 10 shows how agricultural production has been increasing over the past two decades in some of the world's major regions. World-wide there has been an increase of about 61%, or some 2.5% per year, in the period 1965-84. Although the over-production in the European Community and North America are well known, the figure shows that it is in Asia that the greatest growth rate (3.45%/year) has been achieved. Latin America and Africa have also shown significant increases of total agricultural production during this time.

Figure 11 illustrates some salient differences, i.e., that the three continents of the developing world have been performing quite differently. In Asia, especially in recent years, per capita agricultural production has been moving ahead at rates that appear, by international standards, very satisfactory. Latin America, on the other hand, has a rather static record. Africa, in which the highest population growth rates have been combined with the slowest agricultural growth rates, has experienced a drastic decline in per capita levels.

Figure 12 shows the present extent of irrigated land in each of the three continents of the developing world. Figure 13 shows the rates at which these areas have increased.

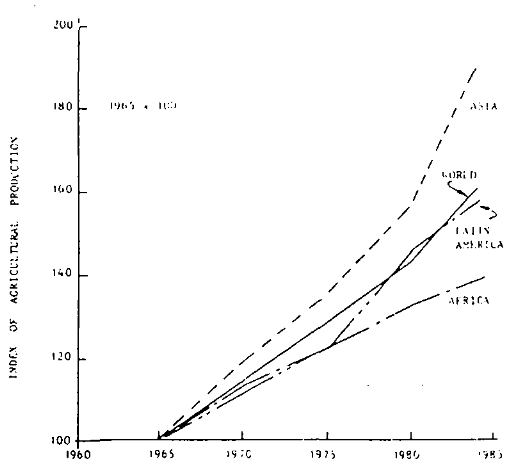

Figure 10. Indices of agricultural production

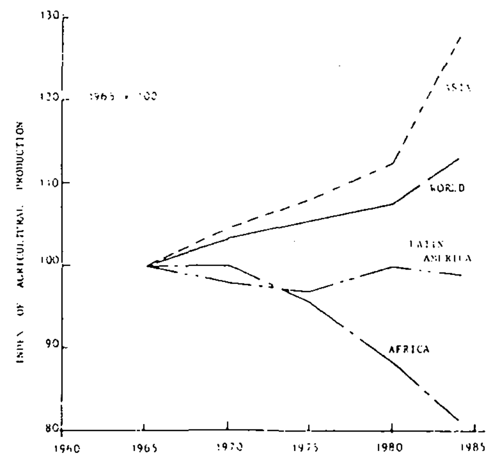

Figure 11. Indices of agricultural production per capita

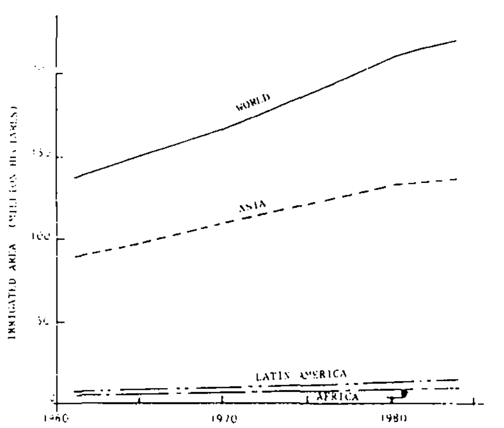

Figure 12. Extent of irrigated land

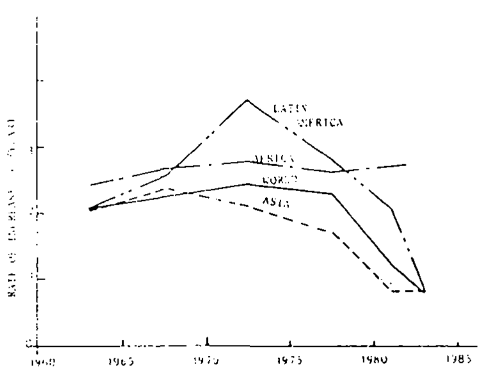

Figure 13. Rates of increase of the irrigated area

The 1960s and 1970s were a period of rapid expansion of irrigation, world-wide. More recently, the pace of new development has noticeably slowed down. It seems reasonable to suppose that there are linkages between these diagrams, i.e., that the success of irrigation development and other agricultural policies in enhancing food production has contributed to the slowing down of investment in new irrigation systems. In Africa, the diagrams seem to suggest a complementary trend: there, the rate of new irrigation development seems to have been sustained for longer, perhaps because the need for increased production is still present, and indeed is becoming more acute.

What should be inferred, from these facts, about the likely future course of irrigation development? Considering Asia, first, where both in absolute and in relative terms the largest irrigated areas of the world are found, it was observed that the pace of expansion had slowed down sharply, as figure 13 shows. The food situation of many countries is better than it used to be, and in several there is concern about the difficulty of finding export markets for agricultural surpluses. So it seems reasonable to expect that the rate of implementation of new projects in Asia will, in the foreseeable future, be much less than in the past.

On the other hand, there has been a growing recognition in recent years that many irrigation projects are performing below their potential. This perception is causing an emphasis on strategies for improving the performance of the existing systems, rather than installing new ones.

In Africa, matters are likely to be somewhat different. Figure 11 shows the need for special concern about Africa's agricultural performance. Well-known recent droughts in various parts of the continent, and the hydrologists' and meteorologists' difficulty in predicting the persistence or recurrence of these events, have led to a greater emphasis upon food security. The Mediterranean countries, Somalia and Madagascar already have a high dependence on irrigation and, because of the high population growth rates various other countries, led by Kenya, will soon exceed their capacity to grow their own food needs without irrigation.

Pressures of this kind probably mean that in Africa (and in some American nations, notably Brazil), the impetus to bring new land under irrigation will persist. As figure 10 shows, however, the areas involved will still be small in relation to irrigation throughout the world.

If the main emphasis in irrigation investment and project planning is moving towards the improvement of performance of existing systems, it is timely to consider what modes of project are likely to develop, and what the implications (and opportunities) may be for those concerned with vector-borne disease control, or with other environmental issues.

The project strategies likely to be pursued, for the purpose of enhancing irrigation performance, will generally emphasize rehabilitation and improved management.

In general, in Asia and Africa, and perhaps to a lesser extent in South America, a continuation of surface flooding can be expected as the predominant mode of irrigation. There will no doubt be some gradual shift towards well sources, especially as multiple demands begin to exhaust accessible river sources; but here again economic logic will play its part. The use of ground water implies an energy cost, which in most countries falls upon the end user, the farmer. He may get in return the important benefit of personal control over the time and quantity of water delivery, and he will value this benefit most highly in places where defective management conditions cause supplies from canal systems to be erratic and unreliable. Where management conditions are satisfactory, however, cost is likely to restrain the replacement of river sources by groundwater.

The latter phenomenon, which causes a low rate of adoption of new irrigation technologies in the developing countries, is somewhat unfortunate from the viewpoint of vector-borne disease control. Pumped and mechanized systems in general reduce the vector-sustaining environments, and also reduce human water-contact opportunities. But it should be recognized that mainly cost problems limit the introduction of these technologies.

The scale of irrigation systems is also relevant to vector control policies, and to various other environmental policies. There is at present a climate of opinion that seems to favour rather smaller project units than in the past. The reasons for this are somewhat diffuse or varied, and the data on which opinions have to be based are often imprecise, especially in regard to very small systems. In Africa particularly, however, there are good reasons for expecting that small schemes may predominate in the immediate future. These reasons include the generally low population densities (implying among other things thinner, more easily saturated markets); perceptions of low performance in state- or para-statal irrigation enterprises; and less frequent occurrence of the physical conjunction of large rivers and large alluvial soil deposits.

In parts of Asia, too, governments are having more success nowadays in finding ways of targeting assistance towards rehabilitation of village-scale irrigation systems, which often (for example, in Sri Lanka, or in the Tamil Nadu State of India) are of considerable age and embody a wealth of traditional practices.

None of this should be taken to mean that large projects are out of fashion. Facilitating very small scale irrigation effectively has, in practice, been found rather difficult to achieve, and the assessment of benefits from such policies is often obscure. But the inference that should be drawn (specifically in relation to vector control) seems to be that the amount of attention given to small and traditional systems should increase.

The trends outlined in this section, especially the search for improvements in water management and other aspects of irrigation management, offer scope for professional collaboration between the health and agricultural sectors, whose goals seem to require similar strategies.

Within this context, the need for research still exists, and two fields can be defined: first, the need for more quantitative analysis and predictive capacity in regard to the health impacts of alternative management and operational options. Management, in a multi-parameter activity like irrigation, often involves compromises between contradictory pressures, and managers require some predictive capacity if they are to make properly-balanced decisions.

Secondly, and for broadly similar reasons, there is a continued need for better cost/benefit guidance. The changing world food-supply situation is putting new stress on the economics of irrigation. Managers facing budgetary difficulties and designers planning rehabilitations need to be able to evaluate vector control options in financial terms.

Any movement towards smaller-scale projects and towards management devolution to farmers, such as have been discerned above, implies a greater need for preventive public health measures, of which education is probably the most prominent since in these circumstances there will not always be an active public-sector irrigation agency that can be asked to take on a vector control role.

The Panel was of the opinion that all of these fields were eminently suited to the sort of inter-disciplinary studies which it had the mandate to promote. The expected continuation of surface flooding as the main form of irrigation brought reference to intermittent water supply as a mosquito vector control measure in ricefields. The Panel wished to come to a definitive decision on its attitude to this practice. On the evidence of experience from various members and of information in the working papers it was agreed that the method be referred to in future as "alternate wetting and drying" which better described the process and that it be accepted as a suitable measure where land, soil, crop and water conditions were appropriate. As with many other control methodologies, it had to be realized that its use was constrained by site and vector characteristics.

The central questions of practical significance with respect to rice field water manipulation for vector control are: can rice fields be kept without standing water long enough without detrimental effects on yields? And: will such a method require more or less water than the standard practice? Basically two types of water regime manipulation are relevant in seeking a solution of the problem.

Alternate wetting and drying of ricefields. In this method irrigation water is withheld (or rainwater drained) with a planned regularity. In some literature, this method has been termed "intermittent irrigation", but, as pointed out above, the Panel considered the term "alternate wetting and drying" to be more appropriate because it expressed better what is done in the field and also because the other term could quite appropriately be used for such irrigation practices as delivering water intermittently, without necessarily creating dry conditions.

This approach should be highly effective in mosquito breeding control in rice fields provided the drying cycle is long enough to destroy the larvae and the wetting cycle short enough not to allow mosquitoes to multiply. A number of investigations were carried out in different countries using this general approach. The research findings may be summarized as follows:

- Significant water savings were achieved using this approach in comparison with the standard continuous shallow submergence practice (Hill and Cambournac, 1941; Sandhu et al., 1980; Jha et al., 1981; Luh, 1984).

- The reported effects on yields are varied. Only in the Chinese study reported by Luh (1984) were higher yields reported from the practice of alternate wetting and drying. In other cases, yields were either comparable or lower than those obtained under shallow submergence conditions. The reasons for the differing results are not clear. It is possible that differences in soil type, its mineral and organic matter content, temperature regime and their interactions may play a role.

- None of the reported research has determined the relationships of water management practices to the management of other inputs in the ricefields. The effects of alternate wetting and drying of ricefields on fertilizer uptake and weed control measures are especially important.

- In several studies, a very high degree of mosquito larva control was achieved with alternate wetting and drying of rice fields (for example, Hill and Cambournac, 1941; Luh, 1984), establishing that periodic wetting and drying is an effective means for control of mosquito propagation in rice fields.

From the practical implementation viewpoint, this method has the limitation that it requires a complete system of irrigation and drainage which is often lacking in the rice irrigation systems and it needs the services of well-trained irrigators. A more widespread problem is associated with unreliability in the supply of water to the various parts of the irrigation systems, especially in the tail-end.

Maintaining soil saturation. If this method can be practised properly it will eliminate mosquito reproduction in rice fields. Some research results from the Asian tropics indicate that rice yields under a saturated soil condition throughout the growth period are either slightly lower, often not significantly, or equal to yields obtained under continuous shallow submergence conditions.

Crop and livestock changes

The weakening of cereal prices and markets, which can be traced primarily to high levels of excess production in Europe and North America, is encouraging crop diversification policies, especially diversification away from rice, but the general difficulty of identifying alternative markets that will not, in turn, become swiftly saturated makes the outcome of this quite uncertain. The main trends for crop changes are, however, likely to be land clearance from forest cover for various agricultural uses, from range to plantation crops or peasant farming and the introduction of irrigation or its intensification.

Apart from such major trends, the choice of crops, mixtures and cropping patterns in many areas of the developing world may be dictated on a small scale and short term basis by local markets or by weather. Prediction of trends and their vector-borne disease implications is therefore difficult, even given specific circumstances, but general indications are given in table 2.

Changes in plants and animals for domestic use may affect vector-borne diseases, usually because they require changed cultural practices. Many of the high-yielding varieties of rice, which are the key feature of the green revolution, have requirements for water and fertilizer that prolong the period of available surface water for vector breeding.

The time scale of health impacts on agricultural change is both variable and complex. A common effect of water resource developments is to decrease seasonal effects by making irrigation water available in the dry season; as a result seasonal fluctuations in vector populations disappear and the pattern of disease transmission shifts from being seasonal to being perennial. Often the loss of seasonality will be accompanied by increased vector populations, but this will not always automatically mean that epidemiological changes are involved. Nor is perennial transmission by definition worse than seasonal transmission. The seasonal malaria of the savannah may be at least as harmful as the perennial transmission of the forest zone in West Africa. The degree of persisting seasonality will depend on small scale decisions. For example, with the multiple cropping of irrigated rice the fields may be planted synchronously, or they may be totally staggered with the consequence that there will always be rice present at the particular growing stage that provides the best habitat for a particular vector. The loss of seasonality may also remove the "hungry period" and its accompanying seasonal overwork and synchronous malaria transmission, that lethal combination which so raises the seasonal death rate in the savannah of West Africa and elsewhere.

Some changes will be of a secular type on a very long timescale. Thus the eutrophication sequence of lake Volta in Ghana is now settling after some 15 years, during which there were massive increases and now falls in the submerged macrophytes which acted as habitats for the snail intermediate hosts of urinary schistosomiasis (*Bulinus truncatus rolfsi*) (Obeng, 1975).

The trend towards multiple cropping which depends on both irrigation and appropriate crop varieties can, in the case of rice, increase threefold the period when the ricefields provide breeding habitats. Selection of crop rotations within the year can, however, reduce the time when free surface water is present.

Changes in livestock may affect vector-borne disease patterns in a complex manner. Increased animal populations may direct mosquito biting activity away from man, especially if the livestock pens are sited between the breeding sites and human settlements. On the other hand, the stock may act as amplifier populations, allowing a considerable proliferation of arboviruses normally transmitted at a lower level among wild birds or mammals. Subsequently the infection may spill over into the human population, as may occur with Japanese encephalitis virus, amplified in domestic pig populations. Livestock populations, by increasing food supplies for mosquitoes and tsetse flies, may also encourage larger vector populations than otherwise would be the case, but little quantitative data are available. In the case of *Schistosoma japonicum* schistosomiasis in East Asia, domestic animals are susceptible and may play a role in maintaining the parasite life cycle, as has been shown in the Philippines and elsewhere.

As agricultural activity and culture methods become more sophisticated and higher yields are systematically sought, a more evenly cultivated landscape will result. The eco-tones, patches of waste land and water will be reduced and many disease vectors will decrease. There may, however, be larger populations of a few vectors whose ecological preferences happen to coincide with the spreading pattern of agriculture.

Integrated pest and vector management

Integrated pest control or management based on integration of different methods has been adopted by agricultural entomologists as as rational approach replacing over-reliance, sometimes total reliance on synthetic pesticides. It is a broad ecological approach to pest (animals, diseases and weeds) control, using a variety of technologies compatibly. The fundamental principle is that, whilst chemical pesticides may be essential, they should be used to complement rather than jeopardize controls based on host plant resistance, cultural practices and use of natural enemies. Integrated control is now widely recognized in pest control in agriculture and public health as well as in all other situations where harmful organisms must be controlled. The basic principles are similar in all cases.

Admittedly, integrated pest control is practised only in relatively few crop pest situations (Way, 1977). A very large number of active programmes, however, have this ideal as an objective but are struggling with the earlier stages of practical application including use of economic injury thresholds, decision making on insecticide application and choice of methods of application.

Part of the problem stems from the fact that, in many of these projects, an interdisciplinary approach is not adopted. Such attempts to achieve improvements in integrated pest control are founded solely on biological integration rather than on integrating biological, technical, socio-economic and other important features of the farming or cropping system. Although the "farming systems" approach is helping to proselytize this idea, there is still a need for developing and applying more detailed and appropriate systems analysis techniques (Norton, 1987) to help implement the practical pest management approach. Here the philosophy is first to define the problem in terms of current farmer practices and then search for improvements within that context, a problem-oriented rather than a solution-based approach. This general approach would seem to be applicable to vector control.

In terms of biological approaches, cultural (environmental) controls are a vital part of many crop protection systems but integration remains incomplete, and the approach to biological control remains largely that of avoiding harm to naturally existing agents rather than simultaneously boosting their action, except in situations where biological agents are used essentially as biological pesticides (e.g., Bacillus thuringiensis, some virus diseases of pests and some inundation releases of arthropod natural enemies). In rice pest control, as in the FAO/UNEP programme, integrated manipulations of environmental controls and control by natural enemies are at an early stage of development, and are complicated by the fact that requirements differ in different localities so locally different tactics are needed.

The approach outlined by Schaefer and Meisch (1987) for integrated vector control fits closely with that adopted under the FAO/UNEP Programme for Rice Pest Control (e.g., Talib Majid et al., 1985). Schaefer and Meisch (1987) emphasise key problems for initiating integrated moquito control in rice fields including vector monitoring, definitions of tolerance levels and selective chemical controls when needed, all based on a better knowledge of relevant ecology of vectors and of co-existing biological control agents.

Much complementary research therefore remains to be done on crop pest/vector controls but, even so, there are already opportunities for practical application. The enlightened approach by the FAO/UNEP Programme to government and farmer acceptance and implementation of the early phases of integrated pest control in rice (Kenmore et al., 1985) has already been referred to as providing insights for those concerned with vector control, for example to help solve "the problem of convincing agriculturalists that new ideas are viable" (Mather and That, 1984). It would therefore be very desirable for vector control specialists to link appropriately with the FAO/UNEP Panel on Integrated Pest Management.

Changes in people, pathogens and vectors

Types of agricultural change are outlined above. Either in order to achieve them or following their introduction, substantial human population changes frequently occur. The most obvious are immigration of farmers to newly opened up or newly irrigated lands. Often they may come from over-populated hill areas where there is, for example, no local malaria transmission. Such immigrants suffer heavily; "malaria of the tropical migration of labour" is, for example, a well-known and named entity. The malnutrition which often occurs in the first years in a new site takes its toll and may exacerbate other diseases. The immigrants may precede the provision of health services. Unplanned immigrants, especially fishermen invading water resource developments, may suffer from vector-borne diseases such as schistosomiasis but benefit in economic terms (Pesigan, 1958). Even more unfortunate are indigenous inhabitants displaced by the agricultural innovations or the water resource developments. Their health problems are compounded by poverty and upheaval. Resettlement is usually inadequate and a health service to take particular care of new disease hazards is unavailable.

Where the agricultural shift is from subsistence to cash crops, family nutrition usually suffers, at least in the short run, from the loss of local cereals and pulses, sometimes from increased labour demand and less time for child-rearing. The effect of malnutrition on vector-borne diseases is complex and agent-specific, and does not necessarily have to be for the worse.

Patterns of settlement often change from scattered homesteads to compact villages. Health care can be made more accessible but some forms of disease transmission, such as hookworm and other geohelminths, the childhood virus fevers and other infectious conditions, may become more frequent. Common source disease outbreaks will be larger.

Many activities, and their health consequences, will tend to become less seasonal than before, and the "hungry season" that often coincided with maximal vector-borne disease transmision, may become less pronounced.

New pathogenic organisms may infect man: new in the sense that they were previously unknown in the locality. This may be because of the environmental changes due to changes in agricultural practice described above, introduction by immigrant farm workers, or amplification of zoonotic viruses by introduced livestock. Infections already present may become more prevalent, and in the case of helminthic infections the parasite burden may be increased, with a resulting risk in overt disease. Thus the Egyptian transition from annual flood irrigation to perennial irrigation in the Nile valley has led to a changed balance between schistosome species and a greater intensity of infection. Vector populations may increase in numbers, or in a few cases decrease, have an extended season of activity and undergo one or more of the many complex changes discussed above.

The emphasis here has been on the health effects of agriculture as mediated by change in the natural and biological environment but agricultural change has social and economic effects and their effect on human health may be yet more important. Effective agricultural development will raise aggregate income, with potential health benefits, but it often also increases disparities of income and the poor, usually landless labourers, may become yet poorer, and marginal farmers become worse off, with consequences for nutritional status and access to health services. Consequential inevitable urbanization of the poorest farmers, with its different health hazards, may be a consequence of agricultural change.

Development strategies involving both agricultural and industrial interventions are increasingly beginning to focus on those sections of society who do not adequately participate or benefit from the existing modes of development. While environmental and socio-economic changes in the community have been adequately documented, only in some limited specific cases have data about the health and nutrition effects of agricultural development been applied in impact evaluation. Much more needs to be done.

The analysis of health consequences of agricultural change has predominantly considered one disease at a time and traced the biological and behavioural determinants of transmission. Less often, a single change in agriculture or a single intervention has been considered in relation to all its health consequences, as when the effects of increasing irrigated rice fields or introducing piped water are considered. The farming family see their health as a whole in relation to themselves rather than a single agricultural change or occupational hazard. Moreover, the farming community is essentially a stratified community divided into different groups by socio-economic status, land ownership and wage relations. Agricultural change, whether single or multidimensional, affects different groups in different ways, quantitatively and qualitatively. There is a need for community based epidemiological studies that will consider agriculture as one of the many determining variables for health and measure its impact on the stratified agricultural community. This is needed not only to give a sense of proportion, but also to view the problems and thus seek solutions from the viewpoint of the farmer and the agricultural community.

4. CONCLUSIONS

In its conclusions, the Panel concentrated broadly on two main areas, information requirements (and their presentation) and applicable techniques.

Information requirements

The Panel recognized that future agricultural development will include new developments and modernization of existing ones. New developments require a prediction of health risk, for which prototype guidelines are under evaluation. In contrast, for modernization of existing programmes, the health and vector status may already be definable. In all cases, however, changes in existing land use represent the beginning of a dynamic process of ecological change associated with demographic changes and changes in vector species composition and abundance. Such changes are complex, occur over different timescales, must be considered in local context, and require appropriate monitoring and surveillance systems to provide the required information.

Recognizing the different needs and budgetary constraints specified by the overall size of each project, the Panel concluded that specific information requirements should include the following:

(a) Physical aspects of changes in land use. Physical changes within the agricultural context specifically alter the availability of vector breeding sites and the opportunities for human-vector contact. This seems particularly apparent at the margin between development and an established environment. Procedures for survey of such margins, and for monitoring changes in relation to vector and host behaviour, should be encouraged and, wherever possible, incorporated as part of a regular surveillance system.

(b) Demographic changes. Agricultural developments frequently involve human migration, seasonal labourers and changes in settlement patterns. Intrinsic cultural aspects, siting of settlements and migration can play a key role in the spread of parasites and vectors, and in defining levels of human-vector contact. Moreover, the Panel drew special attention to the need for detailed study of all strata of human populations, because of the diverse characteristics and perceptions of age-group, sex and occupation which can condition exposure and susceptibility to infection.

(c) Vectors and disease. Accurate identification of vectors, their habitats and their natural enemies was repeatedly emphasized by the Panel, especially where sibling species of different vectorial capacity may be involved. Accurate quantification of infection rates was also stressed, yet the Panel noted that considerable site, disease and vector specific variation exists in the quantitative relationship between vector abundance and parasite transmission. Three key areas for further study were therefore identified: methods for long-term enemies (including better information on natural enemy impact), accurate identification methods applicable to field situations, and the relationship between vector density and transmission. The latter was felt to be particularly important in relation to proposals for integrated pest management which require information about how any reduction in vector abundance will affect disease transmission.

(d) Organizational involvement. Agricultural development generally requires multidisciplinary interaction between several government and non-government agencies. Coordination of their activities can be difficult, especially because of communication problems and conflicting budgetary requirements, and requires careful identification of the institutions and personnel involved, noting their operational priorities, constraints and decision-making critera. Evaluation of institutional responsibilities within an agricultural development will help to define the specific levels of information they require, and how such information can best be presented.

The Panel stressed that while the quality of information was a key issue, its mode of presentation was of parallel importance and would influence the way the information would be used. It also stressed the need to identify clearly the institutional audience for each component of the information so that volume, form and level of interpretation could be presented in the most effective way.

The Panel noted that the policies of major investment agencies (including national governments) usually differentiate between the components of agricultural projects that have a primary production purpose and those with a clear social and health objective. Often, this allows separate consideration of the latter, even allowing the direct costs of investment for health to be excluded from estimates of the economic rate of return of the project. Nevertheless, some essential components such as housing and associated services can have a profound effect on the economic analysis (sometimes representing 25-30% of total project cost) and may therefore be provided at a standard inconsistent with good environmental health.

For this reason, the Meeting emphasized the importance of clear identification of specific project components, relating them to their association with health issues, their economic and social priority, and to the organizational responsibility for each component. PEEM should highlight those components essential to the aims of vector control and for wider community health benefits, indicating where feasible the relative benefits that may be derived from various components within specified budgetary constraints. Where several options seem available, PEEM should focus attention on those most compatible with sound environmental management for vector control.

Techniques

Impacts of agricultural pesticides

The PEEM objective to promote environmental management for vector control is largely in response to the undesirable effects of pesticides on vector resistance, on the environment and on human health. Agricultural development and changes in agricultural practices have shown a marked trend to increased use of pesticides, especially in irrigated agriculture where some vectors breed, with a known excessive use in many cases and often with considerable confusion regarding optimum applications. This overuse may sometimes be associated with pesticide subsidies which often make farm usage an inexpensive option.

The attention of the Panel was drawn to the International Code of Conduct on the Distribution and Use of Pesticides, prepared by FAO in conjunction with other international organizations, and adopted by the FAO Conference in 1985. This Code, with widespread support from Governments, serves as a point of reference until such time as countries have established adequate national regulatory infrastructures.

In view of the existence of the Code, and the complementary objectives of the FAO/UNEP Panel on Integrated Pest Control and Resistance Breeding, it was agreed that PEEM should collaborate closely with that Panel in joint efforts to encourage more rational pesticide use in order to reduce potential vector hazards and to promote control through environmental management measures where appropriate. To this end, PEEM should examine specific ways in which vector control can be included within Integrated Pest Management (IPM) strategies.

Impacts of high-yielding crop varieties (HYV)

The Panel recognized that the introduction of HYVs has a profound impact on agricultural practices, especially with regard to rice in Asia. The potential of such varieties can only be best realized under optimal growth conditions but does not necessarily require the high use of pesticides as is often assumed.

Discussion revealed that HYVs are not necessarily appropriate for all situations and are not always accepted by farmers for various physical, social and economic reasons. The Panel considered that the development of HYVs with lower water requirement would be highly desirable.

Agricultural practices for HYVs may not necessarily be compatible with the use of ricefields for fish production. Appreciating the advantages of HYVs for rice production, but also aware that fish may have the dual role of food protein and predators of disease vectors, the Meeting felt the need to investigate whether the higher pesticides input in HYV fields might have led to a lower fish yield as compared with that from ricefields under lower pesticides applications usually associated with growing traditional rice varieties. This could be a first step in the evaluation of integrated pest management strategies for vector control in rice fields.

Irrigation and drainage schemes

Irrigation development. The global trend in irrigation development is towards a reduction in the rate of expansion of new major schemes, greater emphasis on the rehabilitation and improvement of existing schemes and on changes in management methods and organizational arrangements as well as, in many countries, greater attention to small-scale irrigation projects. This was perceived as having implications for the Panel's work on forecasting guidelines which should respond to the different circumstances and for their treatment of operational aspects in addition to planning, design and structural elements.

Irrigation practices. The Panel adopted the use of the term "alternate wetting and drying" (AWD) to describe the vector control measure sometimes used in ricefields, rather than "intermittent irrigation" which also indicates a different practice of water supply.

The use of alternate wetting and drying of ricefields, which has received considerable publicity as a control technique, is accepted as a suitable measure where land, soil, crop and water conditions are appropriate but, as with many other control methodologies, its use is constrained by site and vector characteristics.

In general reference to water management practices applied as vector control measures in irrigation, it should be recognized that the ability of a system to control the supply of water to the farmer may not be accompanied by his ability or willingness to apply crop/water management techniques for vector control, especially where schemes are farmed by smallholders. This calls for dialogue with the farmers to identify possibilities and constraints of such methods.

Drainage. In irrigation schemes, in particular, but also in other agricultural development where excess water may pose a problem, drainage has been clearly identified as a major factor determining or controlling health risks. The same is also true in the case of rural and other settlements. The absence of a drainage system may cause problems through the accumulation and persistence of stagnant water on the land surface. Where an open drainage system exists, there may be different problems due to stagnant or slow-moving water, and weed growth in those drains. It is therefore proposed that this aspect be given greater emphasis and publicity by PEEM as a subject with special relevance in programmes related to environmental management for vector control. The WHO Manual on Environmental Management for Mosquito Control is a particularly relevant source of information.

Economics of health measures in irrigation. Because of the trend to reduction of investment in this relatively expensive form of agriculture and the consequent increased need to target the limited financial resources to best effect, the Panel reiterated the recommendations arising from the Sixth PEEM meeting regarding the necessity to identify and quantify potential health consequences due to irrigation and stressed the need for continuing with efforts to formulate methods for the application of cost-effectiveness and, where possible, cost-benefit analysis for the selection of the most appropriate methods of vector control in specific project circumstances.

Mechanization

The diversity of economic, social and ecological consequences arising from the introduction of mechanized power makes it difficult to predict its effect on vectors, and many possible influencing factors were cited. Among these were the direct effects of mechanization relating to vector habitat, such as an increase in cultivated area, greater number of crop cycles and changes in superficial water patterns which may affect large areas under irrigated agriculture or small depressions such as wheel nets, both of which have been known to have marked impacts on specific vectors. Also considered were the reduction in animal populations and usage; redeployment of labour force; reduced human/vector contact and, for some strata of the population, increased leisure time and improved standards of housing services.

5. RECOMMENDATIONS

Further to the above conclusions, the Panel formulated specific recommendations in order to promote the use of environmental measures to assist in the reduction of transmission of vector-borne diseases associated with agricultural development and changes in aricultural practices.

(1) The Panel should encourage the development of systems and techniques for monitoring and evaluating the effects of agricultural development and practices through the assessment of physical changes, demographic changes, alterations in vector species, their abundance and their natural enemies, changes in human diseases and in the social and organizational structure of the area under study.

(2) The Panel should investigate means of presenting information on health effects and appropriate environmental control measures associated with agricultural changes. These should be suited to the identified information needs of the various organizations involved in agricultural development programmes, and aimed at encouraging responsive action.

(3) A dialogue should be initiated between PEEM and the FAO/UNEP Panel of Experts on Integrated Pest Control and Resistance Breeding in order to promote ways to enable the incorporation of vector control considerations within integrated pest management strategies.

(4) Considering Article 12.7 of the International Code of Conduct on the Distribution and Use of Pesticides, PEEM should initiate a dialogue with the FAO Panel of Experts on Pesticide Specifications, Registration Requirements and Application Standards with a view to introducing specific mention of disease vectors within the Code and helping to make the content of the Code more widely known to vector control specialists.

(5) In view of concerns expressed regarding agricultural and ecological changes accompanying the introduction of HYVs in some rice growing areas, it is recommended to review information on vector abundance and the production of fish and other food sources associated with the cultivation of high-yielding and traditional rice crops, with the purpose of clarifying the role of integrated pest management under such conditions.

(6) The Panel strongly supported widespread evaluation and field testing of its draft Guidelines for Forecasting Vector-borne Disease Implications of Water Resources Development Projects in order to ensure their applicability and operational acceptability in accordance with predicted trends in such developments.

(7) The Panel should encourage the investigation of specific constraints and advantages associated with "alternate wetting and drying" in relation to site, vector and crop characteristics and to the perception of farmers and agricultural organizations.

(8) The common and close relationship between vector production and the adequacy and maintenance of drainage systems in agriculture and agricultural settlements is considered so important that the Panel proposes that it be given greater emphasis and publicity in programmes for agricultural development. The WHO Manual on Environmental Management for Mosquito Control should be listed Among relevant source material.

(9) Considering the various issues identified during the Technical Discussions as warranting further study and research, the Panel proposed that publicity be given to the research needs recommendations of the Workshop on Research and Training Needs in the Field of Integrated Vector-borne Disease Control in Riceland Agro-ecosystems of Developing Countries. While this PEEM/IRRI/USDA workshop gave specific attention to riceland ecologies, the resulting research recommendations also have general appliciation to the agricultural development and changed agricultural practices which form the subject of the present Technical Discussion, and the Panel therefore endorsed the Workshop's recommendations for research.

6. WORKING PAPERS PREPARED FOR THE TECHNICAL DISCUSSION[1]

Abernethy, C. Trends in irrigation development and their implications for vector-borne disease control strategies. PEEM/7/WP/87.10

Amerasinghe, F.P. Changes in irrigation techniques as a means to control disease vector production. PEEM/7/WP/87.11

Bhuiyan, S.I. and Sheppard, B.M. Modern rice technology and its relationships to disease vector propagation. PEEM/7/WP/87.3

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1 These papers may be obtained from the PEEM secretariat, Division of Vector Biology and Control, World Health Organization, 1211 Geneva 27, Switzerland

Biswas, A.K. Past, present and future needs in land and water development for food production : implications for rural development, environment and the vector-borne disease situation. PEEM/7/WP/87.2

Bown, D. Agriculture practices and their bearing on vector-borne disease transmission in the region of the Americas. PEEM/7/WP/87.8c

Bradley, D.J. and Narayan, R. Epidemiological patterns associated with agricultural activities in the tropics, with special reference to the vector-borne diseases. PEEM/7/WP/87.7

Carnevale, P. and Robert, V. Introduction of irrigation in Burkina Faso and its effect on malaria transmission. PEEM/7/WP/87.9a

Georghiou, G.P. Effect of agrochemicals on vector populations. PEEM/7/WP/87.13

Gratz, N.G. The effect of water development programmes on malaria and malaria vectors in Turkey. PEEM/7/WP/87.6b

Hervouët, J.P. and Laveissière, C. Ethnic factors in the transmission of sleeping sickness in the forest region of Côte d'Ivoire. PEEM/7/WP/87.9b

Imevbore, A.M.A. Vector-borne disease hazards in changing agricultural practices resulting from overall development in Africa. PEEM/7/WP/87.5

Mogi, M. Effects of changing agricultural practices on the transmission of Japanese encephalitis in Japan. PEEM/7/WP/87.12

Petr, T. Food fish as vector control, and strategies for their use. PEEM/7/WP/87.15

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Service, M.S. The linkage between mechanization of agricultural practices and vector-borne disease transmission. PEEM/7/WP/87.17

Sharma, V.P. The "Green Revolution" in India and ecological succession of malaria vectors. PEEM/7/WP/87.16

Sornmani, S. Malaria risks involved in slash-and-burn agriculture in A. dirus infested forests in Thailand. PEEM/7/WP/87.6c

Waiyaki, P. The history of irrigation development in Kenya and the associated spread of schistosomiasis. PEEM/7/WP/87.6a

Way, M.J. Integrated pest control strategies in food production and their bearing on disease vectors in agricultural lands. PEEM/7/WP/87.14

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PART II. GENERAL PROGRAMME AND POLICY

1. REVIEW OF ACTIVITIES, 1986-1987

1.1 Promotion

Publications. The Panel expressed its satisfaction with the expeditious publication of the report of the Sixth Meeting. It took note, however, of the constraints faced by the Secretariat in securing the publication of the PEEM Newsletter on a quarterly basis, and supported the remedies proposed, i.e., strengthening the Secretariat with an Associate Professional Officer, and a possible shift to desktop publishing. The improvement in the distribution of the Newsletter during the year under review, particularly by the inclusion of engineering schools in various parts of the world, was a positive development. The Newsletter's apparent failure to penetrate to field level was, however, also noted and considered important, especially in view of the Panel's intention to become more field-orientated. The Secretariat was asked to look into the matter, but the important role that Panel members could play in this respect was also emphasized.

After the thorough revision at the previous Panel meeting of the technical publications programme, it was gratifying to observe that considerable progress had been made during the year under review. The following technical documents had been published:

* Proceedings of the workshop on irrigation and vector-borne disease transmission (Sri Lanka, October 1985), by the International Irrigation Management Institute.

* Conclusions and recommendations of the workshop on research and training needs in the field of integrated vector-borne disease control in riceland agro-ecosystems in developing countries (Los Banos, 9-14 March 1987), by the International Rice Research Institute, Philippines.

* Guidelines for forecasting the vector-borne disease implications in the development of a water resource project (preliminary version), by WHO/VBC.

* Report of an informal consultation on proposed curriculum and syllabus on disease vector management in water resource development projects, for inclusion in engineering courses (Silsoe, 1-5 September 1986), by Silsoe College (UK) for WHO/VBC.

There was some additional discussion on the last three publications. The document containing conclusions and recommendations of the workshop held at IRRI was singled out as being particularly useful and well-produced and was fully endorsed by the Panel.
Dr Birley provided background information on his field testing of the forecasting guidelines in Zambia, and the modifications this had led to in the final document. His assignment report will be published shortly, subject to clearance by the Government of Zambia. The Panel was of the opinion that the field testing experience should be repeated in a country with different ecological and epidemiological conditions, preferably in Asia, and asked the Secretariat to explore possibilities for this. For the curriculum and syllabus developed at the Silsoe meeting, field testing in engineering schools in developing countries was proposed as a next phase. An ad hoc group was formed to set out the terms of reference for this field testing and its evaluation. Its conclusions are presented in Annex 1.

Progress in the publications programme. The Panel reviewed the status of its publications programme; the agreed steps to be taken and the revised target dates are presented in Annex 2. The guidelines for the incorporation of environmental management and other health safeguards in water resource development projects were the subject of an extensive discussion. It was obvious that, despite several admirable attempts by the International Institute for Land Reclamation and Improvement to produce these guidelines, neither the necessary multidisciplinary technical knowledge, nor the specific expertise in planning and decision-making processes were available in ILRI. The Panel considered that constraints imposed by inadequate institutional arrangements and intersectoral collaboration on the prevention and control of water resource development-associated health problems remained such as to justify the production of the guidelines. The Panel therefore called for a fresh approach by a policy analysis expert who would receive an extensive briefing on experience in the production of the guidelines so far, without having necessarily to build on the drafts produced by ILRI. The possibility of approaching the Institute of Development Studies at Sussex University was suggested. With respect to the report due from Anna University, Madras, the Panel decided to have that prepared as a case study for the next meeting's technical discussion. In view of the increasing output of PEEM's publication programme, the individual Panel members were reminded of their role in monitoring the impact of the documents in their own countries and reporting back to the Panel.

Meetings. The routinely scheduled meetings under PEEM's auspices aside, the Panel was informed of the results of a number of special activities carried out during the period under review. The most significant event had certainly been the workshop on research and training needs in the field of integrated vector-borne disease control in riceland agroecosystems of developing countries, jointly sponsored by PEEM, the International Rice Research Institute and the USDA Riceland Mosquito Management Program S-122. An evaluation of the workshop was presented by a member of the Steering Committee who stated that the workshop had achieved its original objective. In brief, the main vector problems of ricefield agriculture had been successfully reviewed. Two major innovations had been the venue of the workshop (in an international agricultural research institution) and the participation by agronomists in addition to those customarily present at such meetings. As a result, the range of disciplines had been increased and access had been gained to a new and more directly concerned audience. The sharing of research interests had been very effective and useful. The report of the workshop indicated priority areas for research which were likely to remain valid for several years to come. Although the workshop had been successful in bringing together vector-borne disease specialists and rice experts, it had been observed that the two groups tended to maintain a polite distance at the meeting, indicating that time and effort would be needed to reach agreement on successful operational solutions to vector control in rice production systems.

A workshop on the assessment of human health risk in irrigation and other water resource development had been organized by the World Bank in July 1987. PEEM representation at that workshop was a direct consequence of the continued collaboration between the World Bank and the Panel's Secretariat on the health risk assessment component of the Bank's study "Options and investment priorities in irrigation development". The workshop had focussed on the follow-up of assessment exercises and, more specifically, the need to strengthen the technical competence of national health services so that they could better cope with the required disease and vector surveillance activities.

Contacts with other organizations. The Panel considered the renewed interest of the International Federation of Consulting Engineers in establishing links with PEEM a valuable development which could facilitate the implementation of the recommendation made at the sixth meeting that environmental management should be incorporated in the codes of practice for civil, irrigation and agricultural engineers.

The Panel also expressed the hope that contacts with the World Bank, which had developed over the past years in relation to the Bank's activities in health risk assessment, would be maintained despite the fact that the studies of which that assessment was a part had come to an end.

Other promotional activities. A number of articles, either presenting PEEM, or focussing on one of its activities, had been published in international journals during the year under review. The Panel considered this an important contribution towards its promotional objectives which it hoped could be maintained in the next year. The objectives and work of PEEM had been presented by the Chairman of the Panel at a meeting of WHO's Regional Advisory Committee on Health Research in Rio de Janeiro. This had resulted in the adoption by the Committee of a recommendation to the Director of WHO's Regional Office for the Americas, asking him ".... to promote and stimulate in Latin America field research on different strategies, including environmental management, and the search for appropriate methods of prevention and control of the vectors of different tropical diseases associated with water development projects. This research should be carried out by interdisciplinary groups, who will take into consideration the biomedical aspects as well as the ecological and socio-economic problems involved". An immediate spin-off from this presentation was the production of a set of overhead projection slides for the presentation of PEEM, and the suggestion to provide each member with such a set was very much welcomed by the Panel.

1.2 Establishment of an International Information System

National water resources development coordination boards. The Committee for Inter-institutional Collaboration in Ethiopia continued its intersectoral efforts towards the improvement of the health conditions of populations in irrigation schemes. It had formulated a comprehensive proposal for intervention research in the Wonji Sugar Estate which had been submitted to the Panel, and is further referred to in section 3.4 below. The Panel noted the initiatives of its new member in the Philippines, Ms Peralta, to introduce environmental management for vector control as an element in the national agrarian reform programme which is being undertaken by the Government of the Philippines. It was felt that this and similar activities by other members should be strongly encouraged. From Sri Lanka a communication had been received concerning the establishment of an inter-agency committee for the control of vector and nuisance mosquitos, the members of which were directly appointed by the Prime Minister.

Collaborating Centres. The Panel noted with satisfaction the activities carried out by the various institutes in the framework of their collaboration with PEEM, but had no specific comments to make.

International Reference Centre for Environmental Management (IRCEM). Lack of progress in the establishment of this centre at WHO headquarters and in the further development of an information exchange network with the Collaborating Centres was very much regretted. The proposal to strengthen the Secretariat with the services of an Associate Professional Officer was, however, considered to be constructive in this context also.

1.3 Research activities

After a thorough revision based on the comments received on an earlier draft, the final report of the study on the nature and magnitude of vector-borne disease problems related to small-scale irrigation projects in Nigeria had been received by the Secretariat. The collection of data had resulted in a useful, country-wide inventory of small-scale water resource developments and in information on some of the health aspects associated with these in one part of Nigeria. The project had, moreover, been a valuable exercise in intersectoral endeavour from which practical lessons had been learned. As a tangible result, the Nigerian Subcommittee on Irrigation and Drainage had agreed to implement certain of the study's recommendations.

The Panel indicated that it would be regrettable if the circulation of reports of such studies were restricted to the country where the study had been carried out. Obviously the data obtained would be of immediate use for the national authorities, but the reports also had a promotional value at a global level, and the Secretariat was asked to explore the possibility of their broader dissemination. Another case in point was the study carried out in Sri Lanka, the final report of which was being revised for submission to the Secretariat before the end of the year.

In general, the importance of focussing on small-scale water resource development schemes was stressed. There were thought to be many such schemes, although no complete inventory of them existed. Aerial surveys would probably reveal that their number was under-reported, while their informality was almost certain to lead to a negligence of their potential health risks. Contrary to large-scale developments, which tended to be unique in their ecological impact and consequent effects on health, methods of vector control which proved successful in a small-scale scheme in a particular area could immediately be replicated in other such schemes in the same area.

Progress was reported in the demonstration project on community-based environmental management for vector and rodent control in Saint Lucia. The magnitude of the solid waste problem in Saint Lucia and its relationship to vector and rodent problems were clarified in a slide presentation. The most tangible result from this activity had been the reduction of the Aedes house index in the two selected communities, from 45% to 0%. The project had also been significant in terms of health education and community involvement in relation to vector control. Several neighbouring communities had requested extension of the project to include them, and there was also a possibility of that vector control approach being incorporated in a Primary Health Care project underway in Saint Lucia.

Professor Lu Bao Lin had finalized his laboratory studies on the effect of Azolla on mosquito vector breeding and in his report had also presented some rather inconclusive results of a few preliminary field trials. The Panel's response to a proposal for continued research, focussing on the possible role of Azolla under field conditions, is given in section 3.2 below.

A number of research projects endorsed by the Panel at previous meetings but which had so far not received external donor support were brought to the attention of the Panel. Some of these had indeed elicited donor interest and were undergoing scrutiny and modifications, such as the proposal to study the effectiveness of environmental management for malaria vector control in Nepal, which was being considered for support by the International Development Research Centre in Canada. For others, however, no progress had been made towards funding and implementation. The Panel felt that the latter group of proposals should not continue to be listed in the programme of recommended activities.

The concept of PEEM functioning as a technical clearing house for research proposals in the field of environmental management was discussed by the Panel. It was recognized that this would not be of great practical value to researchers as long as the Panel's endorsement did not give direct access to financial support. Individual donor agencies had their own proposal review mechanisms by which they would scrutinize proposals irrespective of a PEEM endorsement.

1.4 Training activities

Visual training aids. The final phase in the preparation of visual training aids on environmental management for vector control had been completed, and the Panel expressed its appreciation for this valuable contribution made by its collaborating centre in Zurich. The training aids were to be made available on the same conditions as other visual training aids marketed by WHO's Division of Vector Biology and Control. The accompanying brochure would therefore need some further adaptation to standardize its format. The Panel asked the Secretariat to give the highest priority to this work in order to have the training aids available as soon as possible.

The follow-up by the WHO Regional Office for Europe of the Panel's recommendation, made at its sixth meeting, to proceed with the organization of courses on environmental health impact assessment for water resource development projects, to be held in the French and in the Portuguese languages, met with approval. It was noted that the courses were to be organized as a global activity by the WHO European Regional Office, in collaboration with WHO headquarters.

Dr Birley reported that a course on "the assessment of environmental health effects of development proposals" would be held at the Centre for Environmental Management and Planning of the University of Aberdeen, from 13 to 19 September 1987, during which he would present lectures on, inter alia, the work of PEEM.

Professor Imevbore reported on a successful workshop on water resource development-associated health problems held at Obafemi Awolowo University in Ile-Ife in March 1987, in which 28 managers and professionals of resource development projects participated.

1.5 Remote sensing

A special session of the Panel, held in the FAO Remote Sensing Centre on the afternoon of Thursday 10 September 1987, was devoted to the topic of remote sensing.

After being welcomed by the Director of the Centre, lecturers from FAO and guest lecturers from NASA and WHO familiarized the Panel with the principles of remote sensing, its current applications in the field of agriculture, including locust control, and approaches to using its potential for public health activities.

The work of the FAO Centre in assisting project development and implementation, training and technical support were described, together with the new ARTEMIS monitoring system designed for the African Region.

The interest of WHO in exploiting the opportunities offered by remote sensing in the areas of geographical reconnaissance, epidemiological and operational stratification, programme planning and also in possible monitoring and epidemic forecasting was emphasized.

Facilities for obtaining and processing data, including remotely sensed data, which are provided by UNEP through the Global Resource Information Database (GRID) as part of the Global Environment Monitoring System (GEMS) were described.

Activities of NASA in the application of remote sensing to vector control were presented to the Panel, among which activities in the ongoing pilot work in Californian ricefields were of particular interest.

The afternoon was rounded off by a most interesting guided visit to the various sections of the FAO Remote Sensing Centre.

The Panel was thus able to appreciate the importance of closer examination of the potential of remotely sensed information and related data processing in contributing to planning of vector control operations and monitoring of environmental conditions, as they arise in water resource development, that may be favourable to vector propagation and lead to the introduction or increase of vector-borne disease transmission.

2. REPORT OF THE STEERING COMMITTEE

The Steering Committee had met twice since the Sixth Meeting of the Panel: on 16 and 17 March 1987 at the WHO Regional Office for the Western Pacific in Manila and on 6 September 1987 in Rome.

In its report, it presented the following decisions and recommendations, which were endorsed by the Panel:

(a) The Steering Committee considered five proposed subjects for the technical discussions of the eighth PEEM meeting (1988), and selected "Education, training and information exchange for planning, design and implementation of environmental management for vector control". The Secretariat was requested to prepare a proposal for a programme of work for this technical discussion, to be submitted to the Panel at its seventh meeting.

(b) The Steering Committee took note of the invitation by the Brazilian authorities to hold the ninth PEEM meeting (1989) in Brasilia. It decided to accept this invitation in principle and asked the Secretariat to explore the possibilities for obtaining additional financial support for the organization of this meeting. It also decided to offer to the Brazilian authorities the technical expertise of the Panel members attending the meeting to assess some of the typical water resource development-associated vector-borne disease problems that Brazil faces. Both issues have been followed-up by the Secretariat.

(c) The Steering Committee reviewed progress in the PEEM publication programme and decided that work on position papers be kept pending for the time being and that the Newsletter be further improved by including a regular section on collaborating centre activities.

(d) The Steering Committee took a number of administrative decisions concerning the redesignation of Panel members and collaborating centres. With respect to the latter, the extension of TVA (Knoxville) and ETH (Zurich) was agreed on unanimously. The Secretariat is in the process of following up this decision as well as an earlier one to designate the International Irrigation Management Institute as a Collaborating Centre.

(e) In view of the agreed policy of rotation of meeting venues between the headquarters of the three sponsoring agencies, it is recommended that UNEP headquarters, Nairobi, be selected as the venue for the eighth PEEM meeting in 1988.

(f) In connection with the Panel's role in the promotion of research, it was recommended that, as a first step towards a more dynamic role of individual Panel members in fund raising activities, members from donor countries could investigate the exact priorities and procedures of their national bilateral assistance agencies. Following up this recommendation, the Secretariat has prepared a first initiative to approach the European Common Market through the Chairman of the Steering Committee.

(g) With respect to the redesignation of the Ross Institute as a PEEM collaborating centre, the Steering Committee came to the conclusion that, though the contributions made by the institute had been of excellent quality, there were limitations on the volume of work it could be asked to do. It was therefore recommended that the number of collaborating centres in tropical medicine be increased to five, each with its own specific focus. The following institutions were proposed:

   (i) London School of Hygiene and Tropical Medicine, Division of Communicable and Tropical Diseases, London, U.K., with special reference to the epidemiology and control of vector-borne diseases and to health economics (redesignation);

(ii) Mahidol University, Faculty of Tropical Medicine, Bangkok, Thailand, with special reference to community action in health monitoring and environmental management.

(iii) Liverpool School of Tropical Medicine, Department of Entomology, Liverpool, U.K., with special reference to health risk assessment of resource development;

(iv) Queensland Institute for Medical Research, Unit of Vector Biology and Control, Brisbane, Australia, with special reference to environmental management for the control of arbovirus vectors;

(v) Oswaldo Cruz Institute, Rio de Janeiro, Brazil, with principal investigator and area of special reference still to be determined.

The Steering Committee also reported on its detailed discussion of training, which had taken place at the mid-term meeting. In brief, there had been a consensus among the members of the Steering Committee that, although some activities had been successful (reference was made to the preparation of training aids and the informal consulation as well as to a training course organized in Belgium by the WHO Regional Office for Europe), a general assessment of the training component of the Panel's programme of work showed that activities had been rather haphazard, with too much emphasis on the organization of training courses, without enough prior consideration of training needs, course design, target audience or materials needed.

The Steering Committee felt that it was time to bring the experience gained and materials developed together in one international course on environmental management for vector control, to be implemented on a regional basis with a considerable input from the collaborating centres. It suggested to the Panel that a proposal be developed along these lines and that, as a first step, the Panel should redefine training needs and identify target groups. The conclusions and recommendations regarding training formulated at the IRRI/PEEM/USDA workshop of March 1987 would provide useful guidance and would form the basis on which the Secretariat could develop a detailed proposal, to be submitted to the Steering Committee and the Panel. Consideration of this proposal could be part of the 1988 Technical Discussion. The example of the DANIDA-supported VBC courses could be relevant as regards implementation, i.e., that courses need to have an international core group that works alongside national or regional professionals.

In the subsequent discussion by the Panel, the question was raised of whether the issue was indeed needs in training or needs to keep the trained in their positions. Although this was recognized as a real problem, it was also felt that the latter issue did not make the need for training redundant. Careful identification of target groups and a clarification of their training needs in view of the competences which needed to be developed were basic requirements. The expertise available in the three organizations in this connection should be tapped. It was also clear that in training in this particular field, convergence was needed; not only should engineers be made aware of health issues, but the reverse was also true. Keeping those considerations in mind, the development of a course along the lines proposed by the Steering Committee was felt to be a good suggestion, and was endorsed by the Panel.

3. PROJECT PROPOSALS

The Panel reviewed the project proposal submitted by the Secretariat for its consideration. The Panel's conclusions are given below:

3.1. Development of guidelines for cost-effectiveness analyses of vector control programmes

Following the recommendations of the Panel at its sixth meeting, Ms A. Mills and Ms M. Phillips (Evaluation and Planning Centre for Health Care of the London School of

Hygiene and Tropical Medicine) proposed to develop practical guidelines which would enable non-experts to carry out cost-effectiveness analyses providing adequate information for the medium-term planning of vector control operations. A detailed description of the format of the document and the proposed programme of work of the authors was presented.

The Panel recognized this as an important initiative, fully in line with its earlier recommendation. It was noted that, as part of the preparatory work, field trips would be made to a number of countries to collect information for case studies to be attached as annexes and to field test the usefulness of concepts developed in the first draft. This was considered a most valuable element in the proposal. Although countries had not yet been selected, Nepal was likely to be included in view of Ms Mills experience in that country. Obviously, once countries had been selected, the assistance of any a local PEEM members would be sought to optimize the effectiveness of the visit.

The Panel endorsed this activity as part of its programme of work.

2. Field studies on the effect of Azolla on mosquito breeding in rice fields

Laboratory studies by Professor Lu Bao Lin in 1986 had shown that the coverage of water by Azolla fuliculoides can act as an oviposition barrier to culicine mosquitos, including Culex tritaeniorhynchus, the major vector of Japanese encephalitis, and can also reduce the rate of emergence of Anopheles sinensis, one of the important vectors of malaria in China. A preliminary study in small plots of rice seemed to show that larval densities were greatly reduced after complete coverage by Azolla was achieved. These results indicated that the effect of the application of Azolla as an environmental management measure may be significant; however, the effectiveness and practicability of this method had to be further confirmed through a series of field studies.

The objective of the current proposal was to evaluate the effectiveness of Azolla under natural conditions in the reduction of mosquito vector breeding, with a view to its potential use by the farmer community as a means of vector control, through experimental cultivation of the fern in rice fields and studies of larval populations both in experimental and control fields.

The Panel carefully reviewed the methodology proposed. It was noted that the objectives of this proposal were relevant to the research needs identified by the workshop held at IRRI. Several issues, however, were raised on which the principal investigator would have to elaborate before the proposal could be endorsed. For instance, would agricultural pesticides be used in the experimental rice fields? What was the exact timing and the practicability of an approach which might have to start off with high Azolla coverage? Was there a need to use light traps for mosquito sampling? There was also a reminder that the original objective of studying Azolla had to do with its possible toxicity, and tests should be carried out on what the effect of macerating the fern has in that respect. It would be desirable if the National Azolla Institute in China would become involved.

The Panel decided to keep the proposal pending until these and a number of other issues were clarified. Dr Kay would visit China in December and discuss the proposal.

3.3. The development of a computer-assisted procedure for the rapid assessment of the health impact of irrigation schemes and man-made impoundments

A prototype Expert System for forecasting the vector-borne disease implications of water resource development had been constructed and was demonstrated by Dr Birley, after a more general introduction on Expert Systems. These computerized knowledge-based decision-making systems were built on such rule-of-thumb statements as could be found in the forecasting guidelines.

It was now proposed to establish a knowledge engineering laboratory with the following objectives:

(a) To complete development of decision-support software suitable for the rapid appraisal of environmental impacts of water resource development projects that may adversely affect human health;

(b) To undertake field testing of rapid assessment procedures by field visits of approximately one month, at the request of collaborating institutions or donor agencies;

(c) To provide advanced training in environmental health impact assessment and decision-support systems;

(d) To provide consultancy on health impact assessment;

(e) To transfer the knowledge and methodology of rapid assessment and environmental impact assessment to developing countries.

Though the potential usefulness of this approach for consulting engineers, project planners and the like was recognized, its value for managers of irrigation schemes in the developing countries was questioned as they would not have access to the necessary computer hardware. The required level of knowledge of health sciences by engineers was also discussed, but it was recognized that the main characteristic of an expert system is to give non-experts access to expert knowledge. Such a system would simplify the scrutiny requirements faced by project developers.

The proposed project was beyond the financial capabilities of the three participating agencies, but the Panel endorsed the proposal as being relevant to PEEM's objectives.

3.4. Integrated schistosomiasis and malaria control at the Wonji Sugar Estate in Ethiopia

This proposal had been formulated by the members of the Committee for Inter-institutional Collaboration in Ethiopia, and its objective was to carry out comprehensive epidemiological, malacological and entomological assessments of the nature and magnitude of schistosomiasis and malaria transmission and prevalence in the Wonji-Shewa Sugar Estate, followed by the planning and implementation of a cost-effective control programmme based on primary health care strategies.

The Panel noted that this was a highly comprehensive proposal, with many components ranging from sociological baseline studies, to water supply and sanitation, environmental management and selective drug treatment. It was therefore felt that the limited time available for discussing proposals at the meeting would not do justice to this particular proposal. It was decided that the full proposal document would be distributed to a number of Panel members for their detailed review, and that comments thus obtained would be communicated to the group in Ethiopia.

3.5. Evaluation of agronomic practices in ricefields in relation to the production of mosquito vectors, with special reference to neem

It has been suggested that extracts from the kernels of the neem tree, *Azadirachta indica*, could be used for the control of phytophagous insects. The tetranortriterpenoid, azadirachtin ($_{35}H_{44}O_{16}$) from the neem tree is a powerful antifeedant, has insecticidal growth retarding properties and recently was shown to be an oviposition deterrent for the sheep blowfly, *Lucilla cuprina*.

Scientists at IRRI, Los Banos, have shown that leaf extracts of the Asian neem tree can be used as safe, inexpensive alternatives to commercial pesticides, and can often meet the crop protection needs of Asian and African rice farmers. Neem leaves have been used as a natural insecticide for more than 1000 years. Rice plants (strain IR 42) treated with neem oil (NO) or combined with neem cake-urea (NCU) generally had low green leafhopper populations, consistently low tungro virus infection and good yields. Neem in NCU prolongs fertilizer life by delaying bacterial breakdown. Neither the effect of neem oil nor neem cakes has, however, been assessed with respect to their effect on mosquito production.

In the light of the suggested mode of action of azadirachtin, the hypotheses to be tested are as follows:

(a) With respect to the NUC application, that larval colonization will be delayed; used with HYV rice strains which give shade early, that numbers of the major Japanese encephalitis vector, Culex tritaeniorhynchus, may be reduced significantly;

(b) With respect to the NO application, that densities of immatures will be depressed and that adult oviposition activity will be suppressed.

To determine differences in survival rates between treated and untreated paddies, age specific regressions for immatures, in the presence and absence of predators, will be correlated. Any growth retardation in the treated paddies will be analysed by comparison with average developmental time of each stage by Student's t-test.

Supplementary laboratory trials will be done with caged C. tritaeniorhynchus (and other species if possible) to examine fully the potential repellency of neem with respect to oviposition. This will be explored with both NCU and NO preparations, with adequate replication.

Operational studies. When the dynamics of mosquito colonization, the toxicity and persistence of neem, and any detrimental effects on predator populations have been established, these will be compared with the dynamics of agricultural rice pests in order to establish any time overlaps. It seems possible that, with knowledge of both medical and agricultural entomology, minor changes in the timing of neem applications may serve a dual control purpose.

If time permits, and in conjunction with the Associate Professional Officer to be seconded to IRRI, the various agricultural practices on trial at IRRI will be examined with respect to their effect and the numbers of mosquitos and aquatic organisms in the rice paddies. Such studies will not only help bridge the gap between agricultural and medical entomologists but may also have practical benefits in reduction of disease.

The Panel fully endorsed this proposal for implementation under the Panel's programme of work.

3.6. Environmental management using livestock for the reduction of malaria and Japanese encephalitis virus transmission in the Mahaweli Irrigation Scheme, Sri Lanka

The overall plan, to be accomplished in several phases, will not only see the utilization of a rational livestock policy to reduce malaria and Japanese encephalitis transmission, but will also consider village design (200 families/village) and alternate cropping or planting of botanicals said to have repellent or insecticidal properties (e.g., neem, citrus, and lemon grass). All of these measures are capable of producing practical benefits apart from vector control and therefore are most likely to be socially acceptable at community level (IRRI Workshop 1987).

In conjunction with the Mahaweli Authority and the Sarvodaya movement of Sri Lanka (a community participation movement), the first phase phase will involve:

(a) Vertebrate infection studies to define the Japanese encephalitis (JE) virus amplification status of cattle, goats, sheep against a pig (the accepted major vertebrate reservoir host) standard using C. tritaeniorhynchus mosquitos and low passage level virus isolated from Sri Lanka;

(b) Defining the vector competence of C. tritaeniorhynchus against other accepted vectors, C. gelidus, C. pseudovishnui and C. fuscocephala, all common in Sri Lanka;

(c) Defining host preference per se using closely spaced magoon traps and linking with data on host feeding patterns gathered as part of other studies, currently underway with BOSTID funding;

(d) Through Dr Silva, a sociologist and a leader of the Sarvodaya movement, exploring social and practical issues at the outset and immediately initiating involvement at the village level;

(e) In relation to the relative attractiveness of the animals and their amplification status, and taking into consideration the results of (d) above, initiating a pilot study to determine the diversion achieved and to monitor serological conversions to JE, malaria incidence and work days lost; a village with livestock introduction will be compared with an unmodified village.

Because the Sarvodaya has 52 village groups throughout Sri Lanka and because the Mahaweli Authority controls development, the results of this pilot study will be implemented as broadly as possible. The second phase will consider the addition of botanicals to what essentially will be the building up of an integrated pest management approach using environmental methods. This may not, of course, be done to the exclusion of other cost-effective methods (e.g., impregnated bed nets, and environmental sanitation).

The Panel considered the proposal very relevant in the light of the research needs identified at the workshop at IRRI, and endorsed it for implementation under the Panel's programme of work.

4. PROGRAMME OF WORK AND ESTIMATED BUDGET FOR 1987/1988

4.1 Programme of work

Next meeting of the Panel. The Panel decided to hold its eighth meeting at the headquarters of UNEP in Nairobi, from 5 to 9 September 1988. The number of members to be invited for this meeting would be maintained at between 10 and 14. The tentative agenda for the meeting was amended in view of the discussion on the Panel's future direction in the light of the agencies' responses to the recommendations of the external evaluators; it was decided to replace the proposed agenda item 7 (Progress report on the survey of relevant policies in multi- and bilateral donor agencies and development banks) by "Follow-up of the external evaluation of the Panel". The proposed agenda for the eighth meeting is given in Annex 3.

The Panel reviewed the proposed programme for the technical discussion on "Training, education and information exchange for the planning, design and implementation of environmental management for vector control". It was decided that a field visit of one entire day to Mwea Tabere would be more feasible than a morning visit, and that possibilities should be explored for some on-site presentations and discussions, involving representatives from the Kenya Medical Research Institute and the National Irrigation Board. In order to provide sufficient time, it was decided to delete the information exchange section from the programme and to adapt the title accordingly. The Secretariat was asked to modify the section on training so that working papers would not reflect a teacher-centred approach but rather a focus on competence development. It was also proposed to approach the training section of the

Central Water Commission in India and request a relevant contribution from them. The involvement of UNESCO was considered important for the development of better links with that Organization. The Secretariat would redraft the technical discussion programme and circulate it for final comments before proceeding with the invitations for working papers.

Organization of the next Steering Committee meeting. The tenth meeting of the Steering Committee was tentatively scheduled to be held in the third week of March 1988, and would, on the invitation of the Chairman of the Committee, be held in the Netherlands.

Secretariat meetings. Two meetings of the Secretariat members from the three participating organizations were scheduled: one immediately after the seventh Panel meeting and the second in conjunction with the tenth Steering Committee meeting. The expenses incurred for these meetings would be covered by the participating organizations.

Workshop on the state-of-the-art in forecasting methodologies. A workshop was tentatively planned to be held in June 1988 in the USSR. The Panel endorsed its proposed objectives and scope. The objectives included:

(a) A review of the current state-of-the-art of health risk assessment methodologies, with special reference to irrigation and other water resources development projects;

(b) A review of forecasting methodologies applied in fields other than health and a determination of their usefulness for the further refinement of health risk assessment methodologies;

(c) An analysis of the response to the preliminary version of the guidelines for forecasting and, based on this analysis, proposals for modifications to the manuscript before final publication;

(d) A definition of research priorities for the development of new forecasting, monitoring and evaluation techniques and for the further development of health risk assessment methodologies.

Establishment of an International Information System for Environmental Management. The Panel fully agreed that efforts towards the establishment of the proposed International Information System should continue along the same lines as in previous years. Networking with the PEEM collaborating centres would be a first priority, with identification of specific tasks for each participating institution. It was recognized that progress in the creation of an International Reference Centre on Environmental Management would largely depend on the successful recruitment of an Associate Professional Officer to strengthen the Secretariat. Developments at the national level (i.e., the establishment in Member States of national water resource development coordinating boards) would continue to be monitored and, whenever possible, direct contact would be made with such intersectoral bodies.

Development of guidelines for cost-effectiveness analyses of vector control programmes. The technical details of this activity are summarized in section 3.1 above. The Panel wholeheartedly endorsed this activity.

Field studies on the effects of Azolla on mosquito breeding in rice fields in China. The Panel raised a number of questions with respect to this proposal, (see section 3.2 above) and it was decided that this activity would be maintained in the programme of work, on the understanding that the comments of the Panel would be incorporated in the proposed studies.

Field testing of the proposed curriculum and syllabus on environmental management for vector control in water resource development projects, for inclusion in engineering courses. A number of engineering schools in the developing countries would be asked to implement the proposals formulated at the informal consultation, and to evaluate their feasibility and effective use, within the terms of reference outlined in Annex 1.

Technical publications. The approved revision of the Panel's publication programme is contained in Annex 2.

Publication of the PEEM Newsletter. Continued publication of the Newsletter was considered a major activity. Introduction of desktop publishing would result in a more reliable publication frequency, and more flexibility in the Newsletter's format. The budget estimate presented below reflects costs of translation, printing and distribution, and the purchase of the desktop publishing software.

Strengthening of the Secretariat The Panel agreed that a similar provision (as detailed below) be made for 1987/88 as in previous years. The cost of strengthening the Secretariat with the services of an Associate Professional Officer would be added over and above these expenditures, but would be borne by the donor-country recruiting the Associate Professional Officer.

4.2. Estimated budget

*(a)	Organization of the eighth Panel meeting	US$ 52 500
*(b)	Organization of the tenth Steering Committee meeting	US$ 7 500
(c)	Secretariat meetings	-
**(d)	Forecasting workshop	US$ 50 000
(e)	International Information System	US$ 10 000
(f)	Cost-effectiveness guidelines	US$ 12 500
***(g)	Azolla studies in China	US$ 6 250
(h)	Curriculum/syllabus field testing	US$ 10 000
(i)	Technical publications	US$ 5 000
(j)	Newsletter	US$ 12 500
(k)	Strengthening Secretariat	US$ 25 000
		US$191 250

* For these activities funds are available from the regular annual contributions by the three participating organizations. For the other activities financial support will have to be sought from possible additional contributions by WHO, FAO or UNEP, or from outside sources.

** The possibility will be explored of obtaining support from the TDR programme for Social and Economic Research (SDR)

***Subject to clarification by the principal investigator to questions raised by the Panel.

5. FUTURE OF THE PANEL

The Panel was informed that one of the three participating organizations, FAO, had formulated its response to the report of the external evaluators. The reaction of the other two Organizations was expected in the next few months, and the Panel would be given full information once these had been received. The Panel was informed that FAO's response was, in principle, favourable toward the evaluators' recommendation for continued support of this interagency collaborative effort, within the terms of reference originally agreed in the establishment of PEEM. The recommendation that PEEM become more field-oriented was also supported, but the question was raised and addressed to the Panel of the possible mechanisms for achieving this objective.

There were several aspects to the recommendation for a field orientation. First, the current mandate of PEEM was in the area of promotion and awareness creation; even if the mandate were changed to include direct field implementation of research and training activities, the three participating agencies could not realistically be expected to provide the additional financial support required. On the other hand, if the Panel were to continue to restrict itself, as in the past, to the mere endorsement of proposals, and possibly to assistance in channelling endorsed proposals to potential donors, the visibility of PEEM at the time of their implementation was likely to be less than satisfactory. Such a technical clearing house function would, moreover, not elicit the submission of very many proposals, as their endorsement by the Panel would not give direct access to donor support, and they would still have to go through a scrutiny by the donor agency in question.

Yet another consideration was that, although the annual Panel meetings were important events for establishing and maintaining a dialogue between professionals from various relevant disciplines and different sectors, and although the reports of these meetings, and more particularly the technical discussion sections of them, had proven effective tools in awareness creation and promotion of environmental management, many of the topics in the field addressed by PEEM had been extensively covered. This had resulted in a great number of recommendations requiring follow-up through field activities. The stage was being reached where the purpose of a further compilation of recommendations without adequate follow-up was becoming questionable. Of course, this did not mean that the monitoring of trends and developments in the field of environmental management for vector control and disseminating information on them would not continue to be important components of the Panel's work.

The idea was put forward by the Secretariat that the collaborating centres could be the key to an increased level of field orientation. They could develop research and training activities along the lines of PEEM recommendations and seek external donor support, facilitated by PEEM endorsement of proposed activities. Many of the collaborating centres had networks in their own area of work, which reached down to field level. A mechanism to implement the process of field orientation through the collaborating centres could be to change from the current pattern of annual Panel meetings to a pattern of alternating Panel meetings one year, and meetings of representatives of collaborating centres the other. Such a shift would not require additional financing by the three agencies; it would maintain the promotional, monitoring and dialogue functions of the Panel intact, and it would guarantee PEEM's visibility in field activities. It would also greatly facilitate the implementation of interdisciplinary research and training efforts.

The Panel considered the ideas outlined by the Secretariat very interesting and constructive, but it was felt that the right procedure would be to await the replies from WHO and UNEP to the evaluators' report, and to discuss the question of mechanisms to achieve field orientation at the next Panel meeting. The Panel suggested that the Secretariat prepare a documented proposal, which should also assess how far the policy advising tasks of the Panel, set out in its terms of reference, had been fulfilled. There was still an apparent lack of coordination and dissemination of knowledge between the three participating agencies. A self-evaluation on the basis of the terms of reference should be on the agenda of next year's meeting. It was considered appropriate, meanwhile, that the Steering Committee address the subject of research and field orientation at its mid-term meeting.

The issue of how to achieve a reflection of PEEM's policies in the programme of work of the three organizations was indeed an important one. It was reported that, as a result of PEEM's efforts, one of the targets of the disease vector control programme of WHO had become that by 1991 a majority of Member States would have implemented policies to ensure that health safeguards be incorporated in water resource development projects. In conclusion it was felt that the Panel's success in fulfilling the objectives stated in its terms of reference should be documented in three areas: policy making, research and training, at the global, regional and national level.

ANNEX 1

REPORT OF THE *AD HOC* GROUP ON ESTABLISHING TERMS OF REFERENCE FOR THE FIELD EVALUATION OF THE PROPOSED CURRICULUM AND SYLLABUS ON HEALTH ASPECTS OF WATER RESOURCE DEVELOPMENT FOR INCLUSION IN ENGINEERING COURSES[1]

The *ad hoc* group, consisting of Professor J.K. Olson, Professor Santasiri Sornmani, Professor W.A. Schmid, Dr R. Bos, Dr D.A. Muir and Dr C. Schofield, met on 9 September 1987.

The mandate of the group was to provide guidance for the terms of reference to be established for the field testing of the proposed curriculum and syllabus proposals resulting from the informal consultation held at Silsoe College.

The group considered the inclusion of lectures on health aspects in engineering courses, with the primary aim of sensitizing engineers to the possible health implications of engineering work, and achieving a certain level of understanding of the cause-and-effect relationship between engineering and human health. Once a critical level of awareness had been achieved, it would be useful to provide engineers with information on approaches and tools to apply to prevent or mitigate possible adverse effects on health or on with whom they should liaise to clarify health issues. The objective was certainly not to turn engineers into health experts.

It was therefore agreed that the field testing of the proposed curriculumshould focus on the courses of short and medium duration; the 205 hour course was generally considered to be too ambitious, and to go beyond the objectives outlined above, and it was thought to be unrealistic to aim at its implementation at any other than post-graduate level.

The group felt that a progressive implementation of courses of different lengths would be the most desirable approach in the field testing of the proposed curriculum. This meant that a short (five or ten hour) lecture series would be included in the training programme as an obligatory course, followed by a medium length course offered as an option. Such an approach would have a built-in evaluation component: the short course would aim merely at awareness creation, and the follow-up course would cover engineering interventions and intersectoral linkages. It was also agreed that these courses should be included towards the final year of the training programme.

The field evaluation should also try to aim at determining the perceived interest of the students. It was therefore felt that, although making the medium length course a diploma course would be an incentive for students to enroll in it, this might obscure the real level of motivation for being informed on the subject matter and was therefore not desirable at the field testing stage. If such a course were institutionalized at a later stage, then its participants should certainly be awarded a diploma upon satisfactory completion of it.

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1 Proposed curriculum and syllabus on disease vector management in water resources development projects for inclusion in engineering courses, document VBC/87.1, World Health Organization, Geneva.

In the selection of engineering schools to participate in the field testing exercise, prestige and reputation at the national level should be an important criterion. The impact of having such institutions incorporating a health component in their curricula would be very advantageous. Another important criterion would be the question of whether or not a sanitary engineering component was already part of the curriculum. Inclusion of a series of lectures on environmental management for vector control would be facilitated if it could be linked to a sanitary engineering component. Similarly, an environmental assessment component, which had been incorporated in the training of engineers in those countries where environmental impact assessment (EIA) was legally mandatory, would provide a suitable entry point.

Teaching of the environmental management course should, in principle, be carried out by an engineer, with professionals from health disciplines giving guest lectures and participating as expert witnesses. Evaluation of the teacher's experience would be as important as evaluation of the students' experience. It was suggested that a course to train the trainers be organized first, once the engineering schools participating in this field trial had been selected. This would also contribute to the standardization of the various trials, a factor which the group considered crucial for proper evaluation. The trainers could agree on materials and on the details of the final evaluation. The bias resulting from the variation in quality of teachers should be minimized to the greatest possible extent. Whenever possible, universities should involve internal evaluation experts to make the exercise more meaningful.

Finally, the group stressed again that certain components in the proposed course contents needed reconsideration. There was no need to go into the details of clinical aspects of the vector-borne diseases concerned, or of drug-treatment. These issues should be dealt with only to acquaint engineers with the complete picture of health interventions, and should be presented accordingly.

ANNEX 2

PROPOSED REVISION OF THE PEEM PUBLICATION PROGRAMME

Title	Current status	Planned action	Pub. date as targetted in 1986	Revised target pub. date
(1) Guidelines for forecasting vector-borne disease implications of water resources development projects	Prelim. version published May 1987; limited distribution for feedback	Review comments June 1988; finalize	July 1987	Oct. 1988
(2) Guidelines for incorporation of environmental management and other health safeguards in water resource development projects	Undergoing major revision	Submission next draft Aug. 1988; circulate for comments	Dec. 1987	July 1989
(3) Proposed curriculum and syllabus on environmental management for vector control in water resource development projects for inclusion in engineering courses	Prelim. version published June 1987	Field testing during 1988	Final version 1989	1989
(4) Report evaluation incorporation health component in engineering courses (India)	No progress reported by the Eng. School of Anna University	Prep. report as working paper for 8th PEEM mtg.	1987	Delete from programme
(5) PEEM introductory brochure	2nd draft submitted and under review	Final draft by end 1987	Sept. 1987	May 1988
(6) Case studies on environmental management for vector control	2nd draft submitted and under review	Final draft by end 1987	End 1987	May 1988
(7) Selection working papers prepared for previous PEEM technical discussions	New item; text being made print-ready	Print-ready by end 1987	New item	Jan. 1988
(8) Position paper: feasibility of EM under different ecological conditions	Assignment not accepted by suggested author	Delete	Sept. 1987	Delete from programme
(9) Nature and magnitude studies in Nigeria and Sri Lanka	Final report Nigeria study received; draft report Sri Lanka under revision	Prep. articles for the PEEM Newsletter	Early 1987	Delete from programme
(10) Proceedings of the riceland mosquito workshop*	New item; prelim. proceedings published by IRRI June 1987	Finalize acc. to agreed schedule	New item	March 1988
(11) Proceedings of the technical discussion seventh PEEM meeting	New item	Finalization by FAO	New item	March 1988
(12) Guidelines for cost-effectiveness analysis	New item	Start prep. in 1988	New item	1990

*These proceedings will be published by the International Rice Research Institute (IRRI)

ANNEX 3

PROPOSED AGENDA FOR THE EIGHTH MEETING OF THE JOINT WHO/FAO/UNEP PANEL OF EXPERTS ON ENVIRONMENTAL MANAGEMENT FOR VECTOR CONTROL

1. Opening of the meeting
2. Election of Officers
3. Adoption of the agenda and approval of the tentative programme of work
4. Review of the Annual Report
5. Report of the outgoing Steering Committee
6. Composition of the new Steering Committee
7. Follow-up of the external evaluation of the Panel
8. Proposed programme of work 1988/1989
9. Project proposals
10. Technical discussion
11. Arrangements for the next meeting
12. Other business
13. Approval of the report
14. Closure of the meeting

ANNEX 4

COMPOSITION OF THE PANEL

Dr Mahmoud Abu-Zied, Chairman, Water Research Centre, Ministry of Irrigation, Cairo, Egypt

Dr A. Adames, Rector, University of Panama, Panama

Dr Awash Teklehaimanot, Head, Malaria and other Vector-borne Diseases Control Service, Ministry of Health, Addis Ababa, Ethiopia

Dr S.I. Bhuiyan, Head, Irrigation water management Department, International Rice Research Institute, Los Banos, Philippines

Dr M.H. Birley, Lecturer, Department of Medical Entomology, Liverpool School of Tropical Medicine, Liverpool, UK

Professor D.J. Bradley, Chairman, Department of Communicable and Tropical Diseases, and Professor of Tropical Hygiene, London School of Hygiene and Tropical Medicine, London, UK

Dr R.H. Brooks, Assistant Director, Division of Air and Water Resources, Tennessee Valley Authority, Knoxville (TE), USA

Dr P. Carnevale, Head, Medical Entomology Section, Antenne ORSTOM auprès de l'OCEAC, Yaoundé, Cameroon

Dr A.A. El Gaddal, Project Manager, Blue Nile Health Project, Ministry of Health, Wad Medani, Sudan

Dr M.D. El Khalifa, Director, Institute of Environmental Studies, Khartoum, Sudan

Dr M. Falkenmark, Executive Secretary, Committee for Hydrology, Swedish Natural Science Research Council, Stockholm, Sweden, Member of the Board of the International Water Resources Association

Mr D. Goe, Project Manager, Bong County Agricultural Development Project, Monrovia, Liberia

Dr Chamlong Harinasuta, Coordinator, SEAMEO-TROPMED Project, Tropmed Central Office, Bangkok, Thailand

Dr L. Herath, Chairman, Dairy Development Foundation, Colombo, Sri Lanka

Professor M. Holy, Director, Institute for Irrigation and Drainage, Technica University, Prague, Czechoslovakia

Professor A.M.A. Imevbore, Director, Institute of Ecology, Obafami Awolowo University, Ile-Ife, Nigeria

Dr B.H. Kay, Head, Vector Biology and Control Unit, Queensland Institute of Medical Research, Herston, Brisbane, Australia

Mr M. Jafer Kazem, Director, South Asia Cooperative Environment Programme (SACEP), Colombo, Sri Lanka

Professor S.O. Keya, Dean, Faculty of Agriculture, University of Nairobi, Kenya

Professor W.L Kilama, Director-General, National Institute for Medical Research, Dar es Salaam, Tanzania

Mrs G. Knight, General Manager, Urban Development Corporation, Kingston, Jamaica

Dr R.J.H. Kruisinga, Member of the Senate and Chairman of the Senate Committee on European Affairs, The Hague, Netherlands

Professor E. Laing, Chairman, Health Committee on Water Resources Development, University of Ghana

Professor Lu Bao Lin, Director, Department of Vector Biology and Control, Institute of Microbiology and Epidemiology, Beijing, China

Mrs G. Peralta, Former Head, Special Projects Group, Environmental Management Bureau, Quezon City, Philippines

Dr R. Rabinovitch, Scientist, National Institute for Diagnostics and Research in Chagas' Disease, Buenos Aires, Argentina

Professor Santasiri Sornmani, Dean, Faculty of Tropical Medicine, Mahidol Univerity Bangkok, Thailand

Professor M. Sasa, Toyama Medical and Pharmaceutical University, Toyama City, Japan

Professor W.A. Schmid, Institute for Land Improvement and Water Management, Federal Institute for Technology, Zurich, Switzerland

Professor Leslie E. Small, Agricultural Economist, Cook College, Rutgers University, New Brunswick, (NJ), USA

Dr P.L. Tauil, Parliamentary Advisor, Health Area, Federal State, Brasilia Brazil

Mr C.L. Tech, former administrator, National Irrigation Administration, Quezon City, Philippines

Mr Fekade Tsegaye, Head, Public and Environmental Health Planning Department, Water Resources Development Authority, Addis Ababa, Ethiopia

Dr R. Zeledón, Minister of Science and Technology, San José, Costa Rica