
The
Health Impacts
of
Peri-urban Natural Resource Development

BY M H BIRLEY AND K LOCK

International Centre for Health Impact Assessment
Liverpool School of Tropical Medicine
Pembroke Place
Liverpool L3 5QA
England
(E-mail: mhb@liv.ac.uk)
(Web page: <http://www.liv.ac.uk/~mhb>)



LIVERPOOL SCHOOL OF TROPICAL MEDICINE

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Copies of this book may be obtained from Dr Martin Birley, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, L3 5QA, U.K. [e-mail: mhb@liv.ac.uk; fax: +44 (0)151 708 7319] for £10.00 each, plus the cost of postage and packing.

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For Jo and Ben

Executive Summary

- All development projects have indirect impacts. They can be positive or negative and affect the physical and social environment and human health. Projects which adversely affect human health cannot be sustainable. Projects which ignore health impact simply transfer hidden costs to the health sector, which is, in general, poorly budgeted and unable to cope. If the health of producers or consumers is adversely affected then the productive potential is probably reduced.
- Non-health specialists form the intended audience for this review. They include the managers of natural-resource projects, researchers, and the recipients of development aid. The review provides the detailed reference material from which dissemination products can be constructed for each target group.
- Poor peri-urban communities live and work in a transition zone between rural and urban environments. They are confronted by both traditional and modern health hazards, in the worst of both worlds. Increases in natural-resource productivity carry the risk of increasing both kinds of health hazard. Transition theory provides an analytical framework.
- A chapter on each of the main, peri-urban, natural-resource themes is provided. There is also a chapter on common cross-cutting issues, such as labour migration and food safety. Each chapter begins with a summary of the health-hazard linkages identified. For example, enhanced agricultural production promotes health by alleviating poverty but the redistribution of wealth within the household can promote malnutrition. Diversion of surface waters for irrigation promotes production but, in Africa, it also promotes the vectors of malaria, schistosomiasis and filariasis. A range of chemicals is applied intentionally to crops, but poor methods of application cause poisoning. A further range is applied unintentionally, through wastewater re-use, at various rates of dilution and toxicity. Wastewater re-use, poor handling and storage can transfer pathogens to food products, causing diarrhoea, dysentery and various intestinal worm infections. Recent cholera outbreaks have been attributed to poor urban, agricultural practices. Increased use of fast-moving machinery for field preparation, harvesting and processing lead to increased injury rates as well as dust-induced lung diseases and other occupational diseases. Livestock is responsible for a range of communicable diseases, including brucellosis, tapeworm infections and salmonellosis. Psychosocial illnesses are created by change and stress, emphasising the social as well as physical environment.
- The report organises health issues into categories of communicable diseases, non-communicable diseases, injury, malnutrition and psychosocial disorder. Communicable diseases include malaria and diarrhoea. Non-communicable diseases include those attributed to toxic chemicals, dusts and moulds. Unintentional injuries from motorised transport have reached epidemic proportions in congested areas, while homicide is a leading cause of death in some age-groups. Malnutrition is associated with a transition from under-

nutrition to over-nutrition and changes in cropping patterns. Psychosocial disorders leading to stress, depression, suicide, domestic violence and substance abuse are associated with overcrowded and polluted, living and working environments.

- A method of prospective, health impact assessment is described that can help ensure that health safeguards are included in project design and operation. Assessments should consider the community, environmental and institutional risk factors. The community risk factors include physiological status and behaviour. For example, in some areas there is partial immunity to malaria and then women and children are the most vulnerable. The environmental risk factors include bio-physical and social factors. For example, the mosquitoes transmitting malaria require relatively unpolluted water. The institutional component includes the capacity, capability and jurisdiction of health-protection agencies. For example, irrigation managers control the flow of surface waters that provide mosquito-breeding sites.
- There are many opportunities for safeguarding health through improved design, operation and management of projects. A hierarchy of safeguards is apparent, from institutional through to personal. Specific techniques are described throughout the review. For example, vegetable produce is frequently contaminated with pathogens and requires careful control.
- An extensive literature on urban-health research is reviewed. Much of this literature concerns effective methods of supplying water and sanitation through community willingness-to-pay for participation in, and ownership of services. A recent trend within the Healthy Cities Programme is a focus on healthy marketplaces.
- The final chapters provide a synthesis of important linkages and list the researchable themes that require collective, natural-resource, social- and health-specialist inputs. Examples include: the effect of urban agriculture on psychosocial disorders; food-plant uptake of pollutants; integration of health issues in GIS overlays; occupational health and safety of using biomass fuels; post-harvest decontamination of food crops; safe aquaculture systems; the rural–urban transition in relation to various health risks, including malaria, respiratory illness and diarrhoea; and wastewater re-use.

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Acronyms

ARI	Acute respiratory infection
ASP	Activated sludge treatment plants
BOD	Biological oxygen demand
BSE	Bovine spongiform encephalopathy
CD-ROM	Compact disc with read-only memory
CGIAR	Consultative Group on International Agricultural Research
CJD	Creutzfeld–Jakob disease
DALY	Disability-adjusted life-year
DFID	United Kingdom Department for International Development (ex ODA).
DHF	Dengue haemorrhagic fever
DW	Dry weight
EHI	Environmental health indicators
EHP	Environmental Health Programme of USAID
EIA	Environmental-impact assessment
FAO	United Nations Food and Agriculture Organization
GIS	Geographical information systems
GTZ	Gesellschaft für Technische Zusammenarbeit [German overseas aid organisation]
HACCP	Hazard analysis critical control point [system for food-safety analysis]
HIA	Health impact assessment
HIV/AIDS	Human immunodeficiency virus/auto-immune disease syndrome
HPD	Health and Population Division of DFID
HYV	High-yielding varieties
IAP	Indoor air pollution
IDRC	International Development Research Council of Canada
IIED	International Institute for Environment and Development, London
IPM	Integrated pest management
KAP	Knowledge, attitude and practice
NGO	Non-governmental organization

NR	Natural resource
NRED	Natural Resources and Environment Division of DFID
NRI	Natural Resources International
NRSP	Natural Resources Systems Programme of DFID
ODA.....	Overseas Development Administration, see DFID
ORSTOM.....	Institut Français de Recherche Scientifique pour le Développement en Coopération [French institute for scientific and technical research for development]
PEC	Primary environmental care
PM ₁₀	Particulate matter of <10 µm
PU	Peri-urban
PUI.....	Peri-urban interface
SSA	Sub-Saharan Africa
STD	Sexually transmitted disease
TB	Tuberculosis
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization
WSP	Waste-stabilisation ponds

Chapter 1

Introduction

- The audience, context and purpose of the book are specified and terms are defined.
- The health-risk transition is proposed as a predictive model of health problems along the rural–peri-urban–urban continuum.

Objectives

The objectives of this book are to identify the kinds of health risks that are associated with the development of natural resources in and around cities and towns in economically underdeveloped countries, to describe how these can be assessed, to indicate what agencies are doing about them, and to suggest topics for future research.

The book is the third step in an exploration that started with vector-borne diseases and rural water-resource development (Birley, 1991) and continued with a general look at all development activities and their health impacts (Birley, 1995). The present book focuses on natural resources in the urban/peri-urban context and identifies their health impacts in relatively greater detail. The linking factor in this three-step exploration is a concern that the majority of decisions that affect human health are made outside the health sector.

Why should natural-resource specialists be concerned about health?

Natural-resource programmes seek sustainable increased productivity. A development project or programme cannot be sustainable if human health is adversely affected. Projects that ignore health impact simply transfer hidden costs to the health sector, which is generally poorly budgeted and unable to cope. If the health of producers or

consumers is adversely affected then the productive potential is probably reduced, although this link may not be quantifiable. The disbenefits are particularly important in vulnerable communities such as the landless poor, the elderly, children and women. All causes of ill-health reduce the productivity of farmers and farm labourers, reduce the educational achievement of children, increase the health-sector budget and thus produce a poor economic return on investment.

Many of the causes of negative health impact can be traced to poor management of the formal and informal peri-urban sectors. This, in turn, is due to lack of inter-sectoral collaboration, between municipal planning authorities and line ministries, and poor information. A timely prospective assessment of health impacts can safeguard and promote human health by encouraging small adjustments in project design or operation.

Audience and scope

The scope of this book was set by the commissioners in the Natural Resources Systems Programme (NRSP) of the U.K.'s Overseas Development Administration (Anon., 1994). They were concerned with energy, waste re-use, agriculture, livestock, and environmental degradation. The related health impacts are associated with: the handling and use of waste in agriculture; the effect of agro-chemicals on farm workers and

consumers; zoonoses and animal wastes; recreational/open space and stress related to urban change; settlements, communicable diseases and injury; and home gardening and nutrition.

There is a need to make information about the health impacts of environmental change available to the various non-health specialists associated with the natural-resource programmes. This audience includes project managers, researchers, extension services, municipal authorities, national planning departments, non-government organisations, CGIAR organisations, farmers, consumers and students. The information should be free of jargon, easily accessible by project type, and cross-referenced. The intention is to inform non-health specialists about health issues rather than to inform health-specialists about natural-resource issues. This book is not a textbook of tropical medicine. Those seeking such information should consult one of the many excellent texts available. For example, *Disease Control Priorities in Developing Countries* (Jamison *et al.*, 1993) should be comprehensible to a wide audience. In parallel with the preparation of this review, the WHO has recently published a book on environment–health linkages (World Health Organization, 1997a). This is a useful companion volume that provides a broader perspective on a number of relevant issues and is

highly recommended. Similarly, those seeking an overview of urban environmental problems should consult *World Resources 1996–97: the Urban Environment* (Anon., 1996a).

Some definitions (Table 1)

There are no universally accepted definitions of ‘peri-urban’, and a detailed definition is outside the scope of this review. Peri-urban settlements can be defined by what they lack as well as what they have. They frequently lack basic infrastructure and services and are found on marginal, inaccessible or fragile land. They have unreliable water supplies, low levels of sanitation services and high population densities. Municipal authorities frequently do not have jurisdiction over them and are unable to extend basic services to them (Varley *et al.*, 1996). There are conflicts over land uses, and urban industries move into the settlements to escape restrictions. The community is often heterogeneous with respect to ethnicity, income level, language and social norms. Misunderstandings between groups with different social customs are common. For all these reasons, peri-urban areas may be more complex than either rural or formal urban communities and present unique challenges.

Table 1. Definitions

Category	Definition
Peri-urban	A poorly planned and regulated mosaic of land, housing, agriculture and industry, in a state of rapid change, from which a city obtains some of its resources and to which it discharges some of its wastes. It is a transition zone between rural and urban.
Peri-urban interface	An area characterised by strong urban influences, easy access to markets, services and other inputs, ready suppliers of labour, but relative shortages of land and risks from pollution and urban growth (Anon., 1994).
Health (from WHO)	A state of complete physical, mental and social well-being and not merely the absence of disease or ill-health
Health hazard	A potential harm.
Health risk	The likelihood that a health hazard will affect a particular community at a particular time.
Health impact	A positive or negative change in health risk that is reasonably attributable to a planned or unplanned change in the bio-physical or social environment.

Peri-urban areas have high growth rates and may receive 70% of new migrants (Atkinson and Merkle, 1993). They are also characterised by a high degree of population mobility (K. Smith, pers. comm.), the level depending on whether residence is legal or illegal and the extent of residential mobility. Land ownership and land speculation at the edge of cities are also important driving forces that may impoverish farmers, displace them from their land, and extend agriculture into new and more fragile, rural areas. The same process may accelerate the rate of urban migration. The peri-urban commu-

nity grows from the addition of urban people moving outwards as well as from rural people moving inwards (D. Drakakis-Smith, pers. comm.). The outer boundary continuously expands into rural areas and the inner boundary becomes urban.

The outer boundary may also be defined as the limit of travel of daily market produce (J. Smit, pers. comm.). This limit varies according to the condition of the local roads, the methods of transport available, and the rate of deterioration of the produce. It varies for each crop.

Box 1. Health in a poor urban community in Nigeria

A report from Lagos (Akin Aina, 1990) paints a graphic picture of a poor urban community during the 1980s. This community is assumed to have peri-urban characteristics. The land included a linear strip either side of the railway line where the Railway Corporation had constructed and rented out metal shacks. Much of the remainder was owned by private landlords. The occupants were surveyed and disaggregated as those in formal employment as labourers and those self-employed (39%). Over 50% carried out their occupation in or near to the settlement. Sale of cooked and uncooked foodstuffs by petty producers was a common activity and involved about 3.5% of the self-employed. Artisanal activities such as tailoring were also numerous.

A land-use survey indicated that 66% of the 35.3 ha occupied by the community was officially commercial, 9% was public/government, 6% roads and 20% undeveloped or open land. Prevailing regulations, bye-laws and building codes were largely ignored. About 50% of the residents held their land on leaseholds of less than 5 years. This was regarded as unusual and the result of commercialisation and subletting. There was also a general sense of insecurity because of continuous threats of government acquisition of much of the land for development purposes.

Some of the land was in low-lying and swampy depressions and subject to serious flooding. Accommodation was very crowded and many households had less than 1 m² per person in their rooms. The majority of households shared a bathroom and toilet. Bathrooms had a soakaway for wastewater disposal. About 88% of toilets had a bucket-latrines and about 12% had a pit latrine. The number of latrines was inadequate and open defecation was common. About half the residents did not use a kitchen but cooked in corridors. Most cooked on kerosene stoves. Fire outbreaks were common. The neighbourhood scored high on a deprivation index: building structures were fragile; waste disposal was poor or absent; and drains were blocked. Drinking water was obtained from piped sources, wells and vendors in about equal proportion. About 80% of those surveyed did not have piped fittings that could be connected to public mains, although central pipe-borne-water systems had been installed in the area since the 1950s.

A survey of health-care provision indicated that there were few or no government services but plenty of private pharmacists and traditional-medicine sources within the community. The residents identified their most common illness as malaria, followed by measles and dysentery/diarrhoea. The respondents identified environmental improvements, such as flood control, as a health priority.

The report analysed the negative attitudes of those in authority towards poor settlements and the possibilities provided by local community organisation for community participation in various housing and habitat improvements.

No specific literature related to peri-urban health was identified during the course of our review, but many references to poor urban communities could probably be classified as peri-urban. Except where specifically indicated, references to peri-urban conditions are based on this assumption. Box 1 illustrates some of the linkages between natural resources and health in an urban community, as viewed from the health perspective. The relevant natural-resource issues are street foods, land tenure, flooding, water supply and sanitation, cooking fuels, traditional medicines, and municipal planning.

Organisation of the book

This book seeks to group human ill-health issues into a minimum set of categories that will assist readers to understand the linkages with natural resources and the kinds of interventions that are required. The book also explains how health issues can be assessed for a specific project and how the risks should be managed. Chapter 13 lists recommendations for future research on the interface between resource management and human health. A list of acronyms and a detailed glossary are included.

Theoretical framework

As countries develop they experience a process of transition which is related to their economic condition but affects their population birth and death rates, nutritional standards, environmental conditions, and health status (Kjellstrom and Rosenstock, 1990; Rossi-Espagnet *et al.*, 1991; Smith, 1991b, 1997; Bobadilla *et al.*, 1993; Anon., 1995a, 1996b; Popkin, 1996). This transition process provides a theoretical basis that will assist in the assessment of peri-urban health impacts. It can be viewed at three levels:

- between countries and regions;
- between cities; and
- between rural and urban communities.

Two major categories of ill-health can be distinguished: 'traditional' health hazards; and 'modern' health hazards. The traditional health hazards are largely communicable or associated

with under-nutrition. The modern health hazards are largely non-communicable or associated with over-nutrition, injury and psychosocial disorder. The health-transition theory predicts that traditional health hazards fall and modern health hazards rise during development.

BETWEEN COUNTRIES AND REGIONS

Evidence for epidemiological changes between countries and regions is most clearly visible at the regional level. Figure 1 illustrates the changing contribution of communicable disease, non-communicable disease and injury to morbidity in different regions, measured in disability-adjusted life-years (DALYs; World Bank, 1993). Communicable diseases are a dominant contributor in sub-Saharan Africa but are replaced by non-communicable diseases in other regions. Malnutrition contributes 14% of the burden of non-communicable diseases in Africa and this falls to 6% in China and 2% in established market economies. In contrast, cancers contribute 2% in Africa, rising to 24% in established market economies. Transport injuries contribute 12%–14% to the burden of injury in Africa and India, rising to 38% in Latin America and the Caribbean.

BETWEEN CITIES

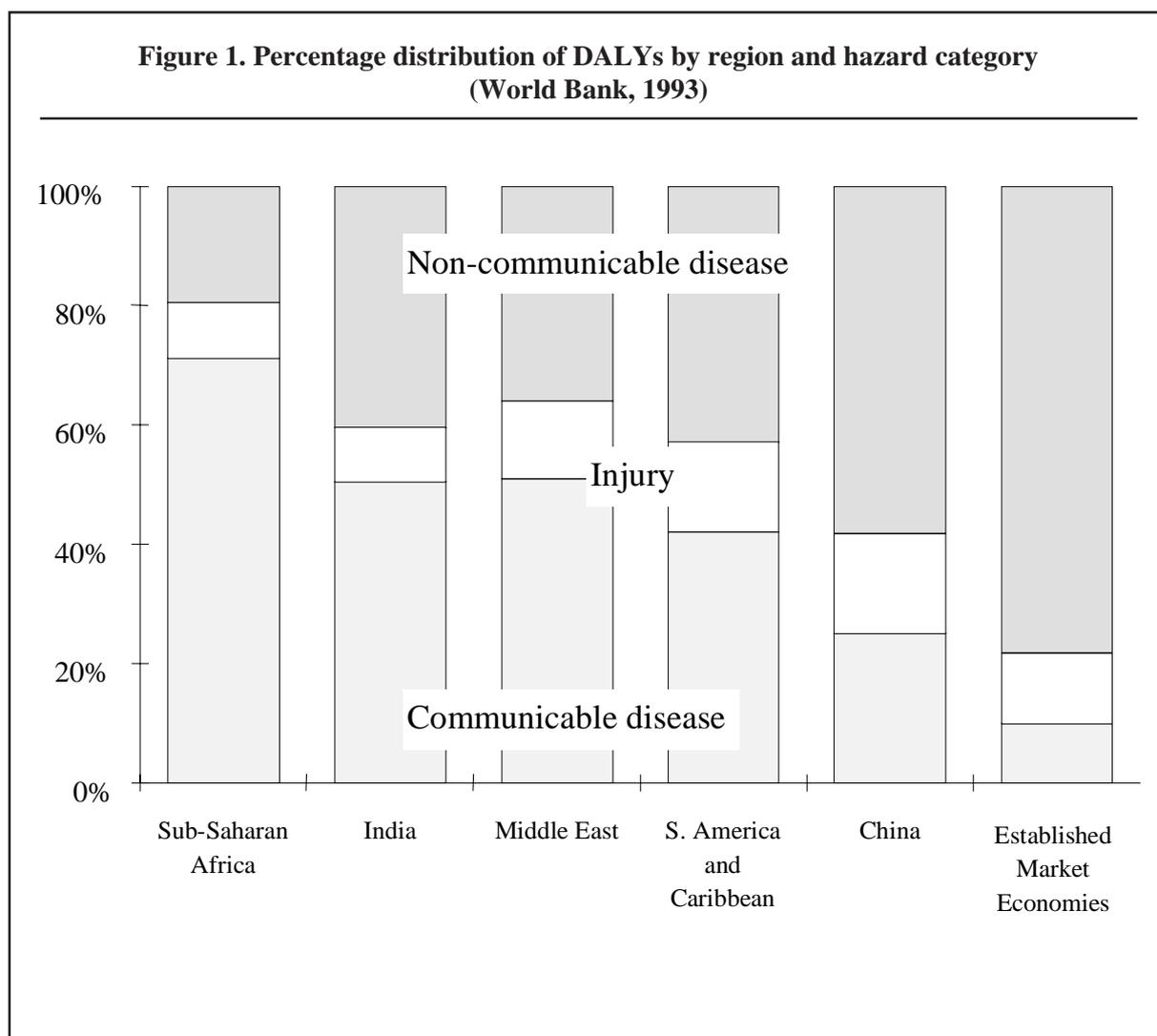
A similar transition has been observed between cities at different stages of economic development. Table 2 illustrates the changing pattern of mortality between two cities at different stages of development (Stephens *et al.*, 1994). The variation in infectious and parasitic disease is attributed to the shortage of water, toilets and solid-waste disposal and the reliance on biomass fuels in Accra (McGranaham *et al.*, 1996). The high rate of injury in São Paulo includes homicides and other intentional injury.

For their study, Stephens *et al.* (1994) divided the city of São Paulo into four socio-environmental zones. Almost half (44%) of the inhabitants lived in the worst zone, characterised by low education and income, relatively poor sewerage and water supply, and a high housing

density. The traditional and modern diseases varied intuitively between the zones, but there were also age-related factors. The study concluded that the urban deprived must first survive the unsanitary insults of poverty in childhood and then the psychosocial effects of poverty in adulthood that appear to result in high rates of traumatic and circulatory disease. One lesson from this study is that development projects need to manage the psychosocial as well as the more traditional infectious health hazards. *See also: urban health research in developing countries (page 121).*

Table 2. Comparative mortality in two cities at different stages of development (Stephens *et al.*, 1994)

Cause of death	% of deaths	
	Accra (metro)	São Paulo (city)
Circulatory	24	33
Respiratory	12	12
Infectious or parasitic	18	4
Injury	4	14
Other	42	37



BETWEEN RURAL AND URBAN COMMUNITIES

As Table 3 indicates, Harpham and Tanner (1995) observed similar differences in mortality between urban and rural communities in a single country, with a transition from communicable disease to non-communicable disease. In this data-set, respiratory diseases were 50% more frequent in urban areas. The analysis is limited by a lack of disaggregated data, but broad distinctions can be drawn between rural and urban areas. The authors suggest that particular features of the urban poor that differ from rural and affect health include:

- dependence on cash economy;

- settling on land that is environmentally hazardous;

- overcrowding;

- insecurity of tenure;

- breakdown of traditional family structure; and

- children working away from the family.

The case of Mexico has been analysed in some detail as an example of a middle-income country (Bobadilla *et al.*, 1993). The transition theory has been broadened to distinguish at least four models corresponding to: the Western model; the accelerated model (e.g. Japan); the delayed model, which describes the incomplete

Table 3. Selected causes of mortality in Mexico in 1990 (Harpham and Tanner, 1995)

Cause of death	Rate (deaths/100, 000)		Relative risk
	Rural	Urban	
Diabetes mellitus	17	38	2.2
Chronic lower respiratory disease	4	8	1.7
Congenital malformation	5	7	1.6
Heart disease	25	39	1.5
Malignant neoplasm	21	30	1.5
Nephropathy	8	11	1.3
Injuries	22	27	1.2
Liver disease	20	23	1.2
Septicaemia	3	4	1.2
Consequence of alcoholism	3	3	0.9
Asthma	14	11	0.8
Pneumonia	34	24	0.7
Malnutrition	20	12	0.6
Tuberculosis	9	6	0.6
Other anaemia	8	5	0.6
Acute lower respiratory infection	3	2	0.5
Gastro-intestinal disease	40	17	0.4

transition of many developing countries; and a protracted model. The last model takes account of the unequal distribution of wealth and health services, and the widening gap between different communities in the same country. It also seeks to take account of a counter-transition, to the re-emergence of epidemic diseases in areas from which they had been controlled or eradicated.

On the basis of the evidence presented above, a similar process of transition is postulated along the rural–urban continuum, at least for poor communities. The urban health hazards are typically non-communicable diseases associated with pollution, stress and diet, as well as injury and violence. They include diabetes, heart disease and chronic lung diseases. Rural health hazards are more typically communicable—such as diarrhoea, malaria and respiratory infection—but also include the consequences of under-nutrition and poor child-birth practices. Peri-urban communities face the industrial-pollution problems of developed nations at the same time as they face the lack of clean water and sanitation that developed nations have already overcome. They are in the worst of both possible worlds (Ashton, 1992). They are beset by the urban, or modern, health hazards on the one hand and rural, or traditional, health hazards on the other (World Health Organization, 1991b).

The health hazards faced by the urban poor can also be illustrated by comparing infant mortality rates. Table 4 indicates the differences observed, in these rates, between rural, poor urban and urban communities (Black, 1996). The low-income urban communities were not classed

as peri-urban but it is assumed that they may be so classified for the purpose of this review. The higher rates in the low-income urban group are striking.

The change in disease patterns from traditional to modern is due to changes in the underlying risk factors (Smith, 1991b, 1997). For some diseases the link is immediate and direct. For example, if there are no mosquitoes then there is no malaria. In these cases, monitoring changes in morbidity provides an indication of changes in the risk factors. However, when diseases have a long latency period, such as some cancers, the linkage is delayed and there are often cumulative effects. Many of the health outcomes do not have a unique cause. Cancers and cardiovascular disease are multifactorial in origin; there are additive and synergistic effects. It is then necessary to monitor the risk factors in order to predict the future changes in health patterns. Smith argues that risks which are delayed and non-specific are poorly perceived by human communities and cites smoking as an example.

The traditional health hazards are partly the consequence of local environmental hazards. These have an immediate and local consequence for health. In contrast, the modern health hazards are the consequence of widespread environmental hazards created by the more affluent. They have long time lags and wider consequences; lead pollution is an example. The priorities accorded to these two groups of hazards in 19th-century Europe and in modern developing cities have been analysed in terms of the political

Table 4. Infant mortality rates

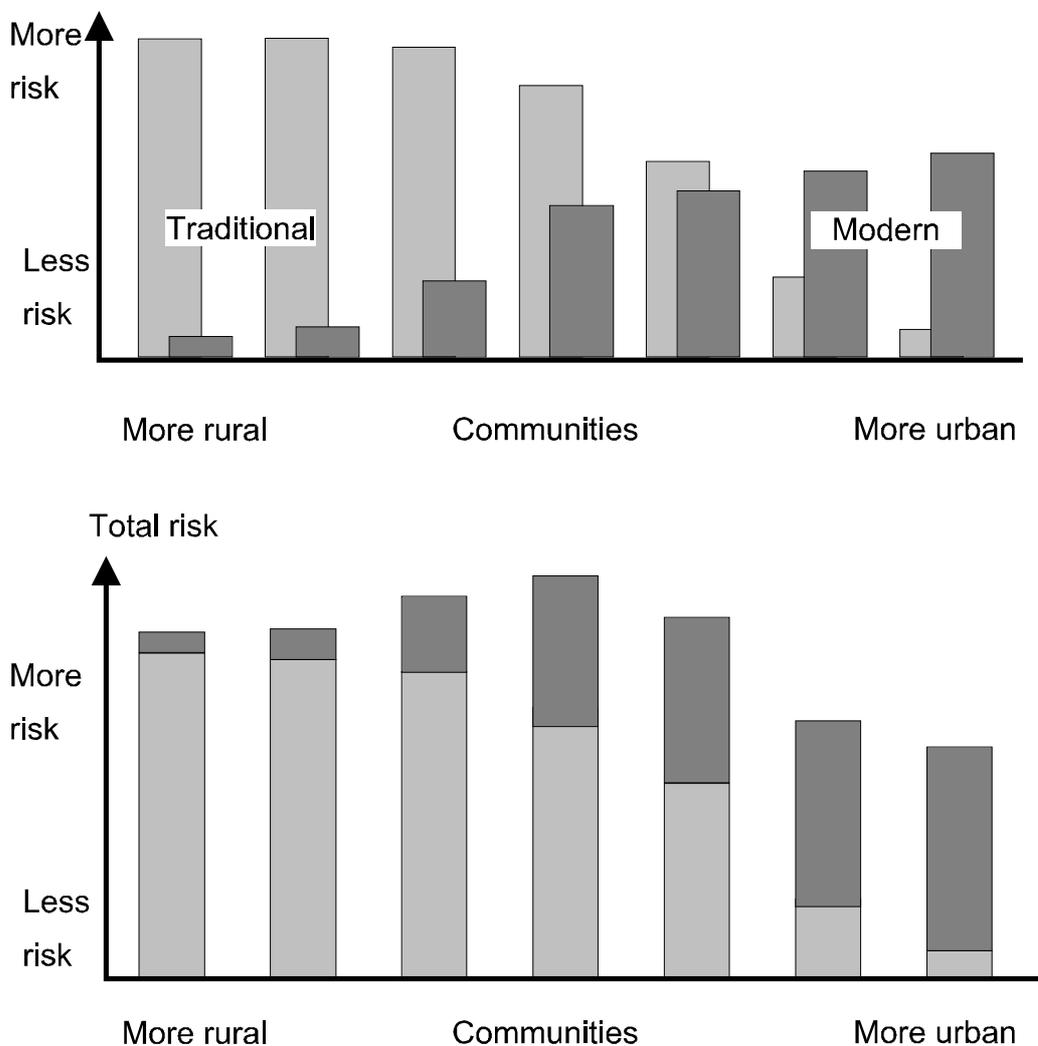
Region	Year	Deaths/1000 infants			
		Rural	Low-income, urban	Other urban	National
Dhaka	1991	93	142	68	116
Managua	1987	60	60	50	56
Port-au-Prince	1983	66	200		110
Karachi	1985		>95	32	120
SãoPaulo	1983		175	42	80

agenda of influential communities (McGranaham *et al.*, 1996). In the 19th century the proposed solution was public expenditure on sanitation. The solution proposed today is to treat water supply and sanitation as commodities and let a free market determine the price. Opponents of this solution suggest that, whereas privatisation

may increase efficiency, the free market is not always appropriate for managing common property resources without regulation.

The organising principle for peri-urban health is illustrated in Figure 2 (modified from Smith, 1991b, 1997). The peri-urban/urban environment consists of a mosaic of communities

Figure 2. A rural–urban health-risk-transition hypothesis (modified from Smith 1991, 1997)



with substantial differences, so the health-risk transition is represented in the figure as a set of communities in which health risks are distributed between traditional and modern. The communities on the left of the figure are poor and rural. Those on the right are wealthier and urban. Moving from poor rural to wealthier urban, traditional risks decline, modern risks increase, and each follows an S-shaped curve. The total risk is represented by the height of the columns and this also declines from left to right. The decline is not inevitable, as emergent diseases and public violence affect the urban community. In the peri-urban zone, the two sets of risks overlap and may do so synergistically so that the total risk rises. As we have noted before, this zone represents the worst of both worlds.

Projects may reduce traditional risks while simultaneously increasing modern risks. The net change in risk may be to higher or lower levels. There has been a tendency in risk-based impact-assessment studies to focus on modern risks. The risk-lowering and the risk-raising aspects of development should both be considered. The challenge for natural-resource specialists is to choose development technologies that lower both kinds of risk for the majority of the community.

Other examples of the transition process include demographic, nutritional and institutional. For example, in Peru, the overall popula-

tion growth rate in cities is 3.8% but the growth rate in informal settlements is 6%. World-wide, the urban population is expected to double in 10 years but the number of urban poor is expected to double in only 5 years (Anon., 1996b). The nutritional transition consists of a change from under-nutrition to over-nutrition: a switch from local staples containing complex carbohydrates to simpler sugars, fats and sweet drinks, as well as highly milled cereals and processed foods (Rossi-Espagnet *et al.*, 1991; Popkin, 1996). More foods are eaten away from the home and are purchased already prepared, often from street vendors. The institutional transition leads to increased intervention as the result of changes in organised social response. Environmental and occupational health hazards may continue to increase due to development activities, but the associated health risks may decline (Kjellstrom and Rosenstock, 1990; Bobadilla *et al.*, 1993). For example, the hazard of traffic injuries increases with the number of vehicles, but injuries per vehicle have declined in Europe because of increased use of seat belts, better maintenance, and defensive driving. Many services, including health, are more accessible in urban areas because they are closer and there is a wide choice of service providers.

Chapter 2

Health-hazard Classification

- A system of health-hazard classification is introduced (Table 5). The classes are communicable disease, non-communicable disease, malnutrition, injury and psychosocial disorder. Examples are provided for each class.
- The classes provide an organising principle for the issues identified in later chapters.
- The problems of prioritising health hazards are outlined.

Introduction

The classification of health hazards into ‘traditional’ and ‘modern’ has predictive value. However, in order to provide an organising principle

for this report, a more detailed classification system is required. One system of classification that has been used in urban-health research, but will not be used in this book, is summarised in

Table 5. Examples of health linkages to natural-resource production

Development category	Diseases		Malnutrition	Injury	Psychosocial disorder
	Communicable	Non-communicable			
Cross-cutting issues	Food handling and storage	Dust	Rural deprivation associated with labour migration	Traffic, occupational	Crowding, insecurity
Energy	Indoor air pollution	Indoor air pollution	Loss of subsistence crops and wild foods	-	-
Crop production	Vector-breeding sites	Agro-chemicals	Consequences of aflatoxins	-	-
Fisheries	Water-borne pathogens	Water-borne toxins	Loss of subsistence crops and wild foods	-	-
Livestock	Animal products	Dust	Loss of subsistence crops and wild foods	-	-
Recycling and waste	Vector breeding, sewage-borne pathogens	Hazardous chemicals	-	-	-

Box 2. An international system for the classification of diseases

A system based on the International Classification of Diseases (World Health Organization, 1977). The classes include:

- infectious and parasitic (communicable diseases);
- circulatory system (non-communicable diseases);
- respiratory system (includes both communicable and non-communicable diseases);
- mental disorders (including psychoses, conditions associated with drugs and alcohol, neuroses);
- external causes of injury and poisoning (including injuries caused by violence and traffic, drowning and many causes of poisoning including pollutants and pesticides); and
- endocrine, nutritional and metabolic diseases and immunity disorders (includes nutritional deficiencies or malnutrition).

This classification is primarily anatomical and illnesses are grouped by the organ system affected. Communicable diseases are the major exception and have largely been placed in a separate classification subdivided on the basis of causative agent. Bradley *et al.* (1992) proposed an alternative classification based on environmental causes such as shelter/built environment, water, waste and food.

Box 2.

In the current review, the following categories will be used, as these have proved to be useful in impact assessments in developing countries and to be easily comprehensible to non-health specialists (Birley, 1995):

- communicable diseases;
- non-communicable diseases;
- malnutrition;

Box 3. A typology of human urban migration and parasitic disease

- Infected persons enter non-endemic urban areas and provide a focus of infections. Examples include transmission of blood parasites by blood transfusion and transmission of soil geohelminths because of poor hygienic conditions.
- Infected persons enter non-endemic urban areas where vectors are present. Examples include the presence of *Anopheles* without malaria and vector snail breeding without schistosomiasis.
- Infected persons enter endemic urban areas. In this case there may be little change.
- Non-infected persons enter endemic urban areas. The susceptible migrant may experience acute and severe disease. Urban cutaneous leishmaniasis is cited as an example.
- Urbanisation of natural zoonotic reservoir. Leishmaniasis, giardiasis, *Cryptosporidium* infection and plague are cited as diseases which have animal reservoirs such as rodents that adapt well to dense human communities.
- Vectors enter non-endemic urban areas. Bugs, lice, fleas and aquatic snails may be transported in immigrants' belongings.
- Occupational exposure. The migrant must often work as a scavenger. Rates of intestinal parasitism in scavenger communities have been recorded that are higher than in neighbouring non-scavengers. Agricultural labourers in irrigated, peri-urban, vegetable gardens may be exposed to a range of water-borne and water-contact pathogens, including schistosomes, intestinal parasites, bacteria and viruses.

- injury; and
- mental and psychosocial disorders.

Communicable diseases

As explained in a previous section, the traditional health hazards associated with poor and rural communities are largely communicable, or infectious. In the peri-urban environment, these can be divided into several sub-categories:

- vector-borne, such as malaria;
- food-borne, such as salmonellosis;
- water-borne, such as cholera;
- air-borne, such as meningitis; and
- human contact, such as HIV.

The infectious agent or pathogen may be a parasite, bacterium, virus, rickettsia or mite. In some cases, partial or full immunity develops and the most vulnerable individuals are then children, migrants and the elderly. Human migration to the city (Rossi-Espagnet *et al.*, 1991) can have a powerful influence (see Box 3).

VECTOR-BORNE DISEASES

Vector-borne diseases (Table 6) are strongly associated with natural-resource management because modification of the environment frequently changes the habitat in which the vector breeds. In the following table, the first three rows are particularly important. The role of houseflies as mechanical vectors of diarrhoeal disease remains unclear; they are probably not the main transmission route but nevertheless important because of their large numbers (Esrey, 1991). A strong association has been observed in some areas (D. Chavasse, pers. comm.) and local communities sometimes associate flies with diarrhoea (Chavasse *et al.*, 1996).

Service (1989a) and Lines *et al.* (1994) have provided comprehensive reviews of the association between urbanisation and vector-borne diseases. Urban communities are exposed to a different spectrum of communicable disease than rural communities, by the nature of their environment. The urban environment is crowded

Table 6. Some vector-borne diseases

Disease(s)	Vector	Habitat in relation to natural-resource management
Malaria	Anopheline mosquito	Usually rural but also urban in India. Rural vector may find a niche in peri-urban environments
Filariasis	Often <i>Culex</i> mosquito	Commonly in heavily polluted water associated with overcrowding, poor drainage and blocked drains
Dengue, dengue haemorrhagic fever, and yellow fever	<i>Aedes</i> mosquito	Solid waste that can hold rainwater, and water-storage containers
Gastro-intestinal infections	Housefly	Organic refuse
Schistosomiasis	Aquatic snail	Irrigation channels and rivers where people bathe
Chagas disease	Triatomine bug	Associated with peri-urban livestock in Central America
Plague	Rat flea	Food stores infested with rats
Other arboviruses and typhus	Hard ticks	Imported livestock
Scabies	Scabies mite	Overcrowded human host
Epidemic typhus	Body louse	Overcrowded and unwashed human host
Leishmaniasis	Phlebotomine sandfly	Housing
Iron-deficiency anaemia	Bedbug	Housing

and brings susceptible and immune people into close proximity. There are less domestic animals to act as buffers between vectors and hosts but greater numbers of synanthropic rodents. The concentration of human waste creates a unique environment that certain vector and rodent species can exploit while other species are excluded. The spectrum of breeding sites is narrow but those types that do exist are in greater densities. Urban environments consequently have large populations of vectors and reservoir hosts but a smaller number of species and fewer natural enemies.

The most important vector-borne diseases are those transmitted by mosquitoes, particularly malaria, filariasis and dengue. Under favourable environmental conditions (of water and temperature), the populations of the mosquito vectors can increase in size very quickly. They avoid natural enemies by breeding either in transient water sources (*Aedes aegypti*) or in water too polluted for many potential predators (*Culex quinquefasciatus*). The peri-urban poor again get the worst of both worlds. In India, for example, they are exposed to malaria transmitted both by rural *Anopheles culicifacies* and by urban *Anopheles stephensi*.

Malaria

Malaria is the most common vector-borne disease, with several hundred million infections in some 100 countries. It is transmitted by anopheline mosquitoes; there are several hundred species of which about 50 are important vectors. In each locality there are usually only one or two important species, each species having a unique combination of breeding-site preferences and other behaviours. Broadly speaking, the vectors 'prefer' to breed in relatively clean water and therefore malaria is most common in rural and peri-urban areas. Peri-urban areas represent pockets of rural environment within the larger urban conurbation. During the dry season many towns and cities practise irrigated agriculture. Whether or not the associated surface waters are suitable for malaria-vector breeding will depend on their cleanliness. Malaria prevalence varies greatly from one district of a city to another, as a result of the mobility of the human population, the abundance of breeding sites for the mosquito,

and the quality of housing and services (Rossi-Espagnet *et al.*, 1991; Atkinson and Merkle, 1993).

Malaria mosquitoes have adapted to urban environments in India and to a lesser extent in the Middle East and Brazil. In India, the urban vector is *An. stephensi*, which has adapted to breeding in containers such as overhead tanks and garden ponds. In Brazil, some cities have expanded very quickly and retained several rural features, including the malaria vector *An. darlingi*. In the Middle East, *An. claviger* may have a similar role. In Africa, there are some signs of an adaptation to urban breeding sites but the main concern is with the rural pockets to be found in urban areas. These pockets result from urban agriculture or large tracts of swampy ground. The main vectors breed in relatively clean surface water such as rain puddles and vegetated pools. It has been suggested that African cities have relatively more open space, abandoned land and cultivation than the cities in any other endemic area (Lines *et al.*, 1994).

Many surveys in Africa have indicated an irregular gradient in malaria-vector densities, from the urban periphery, where they are high, to the centre, where they are very low. The main vector species are *An. gambiae*, *An. arabiensis* and *An. funestus*. The results of a study in The Gambia (Lindsay *et al.*, 1990) demonstrated that the prevalence of malaria in a coastal peri-urban settlement (2%) was much lower than that in rural areas (30%–90%). Most cases occurred on the periphery of the township and the vectors were probably breeding in garden wells and rice fields. Children who got malaria in this settlement tended to have more mosquitoes in their homes, which were made of mud and had bedrooms without ceilings, than children who had no malaria (Adiamah *et al.*, 1993). The differences observed could not be explained by consumption of medicines, such as chloroquine, and few people used bednets. Smoke-producing repellents were commonly used. In a transect study in Dakar, malaria prevalence was measured from the border of a permanent marsh to the centre of the city. Densities of the mosquito vectors fell

steadily along the transect, as did the prevalence of malarial infection in children (Trape *et al.*, 1992; Box 4).

Exceptionally, the malaria mosquitoes in Accra appear to have adapted to different breeding sites. Chinery (1984) traces the changes in these mosquitoes since 1911. In the early part of the century, larvae of *An. gambiae s.l.* were present in only 2% of all domestic water receptacles although there were many ponds and pools which were not surveyed. By 1969, such larvae could be found in 21% of domestic water containers and were almost as common as the larvae

of *Ae. aegypti* in such habitats. *Anopheles gambiae s.l.* was also breeding in polluted ground pools, including pit latrines, with *Culex quinquefasciatus*. Earlier this century, *An. funestus* was probably breeding in the few relatively clean streams in Accra. However, this species is now rare in the city as all of the streams are polluted.

In 1996, the Wellcome Trust, perhaps the most influential agency funding tropical-disease research, published a policy analysis of future options for malaria research (Anderson *et al.*, 1996). The most striking feature of this report

Box 4. Peri-urban malaria in Brazzaville, Africa

In Brazzaville the two main mosquito species were *An. gambiae*, the malaria vector, and *Cu. quinquefasciatus*, a nuisance mosquito (Trape and Zoulani, 1987). Five potential *An. gambiae* breeding-site categories were identified: the banks of river and streams; wells and installations for watering vegetable gardens and crops; ditches, gutters and puddles in ruts and car-tracks on the roads; borrow-pits and drainage wells in plots under construction and various building sites; and marshy hollows on non-urbanised ground.

The main breeding sites colonised by malaria mosquitoes were in the small fertile valleys, with clay soils watered by streams, where vegetable crops were planted. The sites were river banks, adjacent hollows and the diverse installations used for watering crops. Because of their high agricultural value, these valleys had held out against urbanisation. The low marshy banks of streams in zones of poor soils had little agricultural value and had been rapidly urbanised. Rainwater sites such as ditches, ruts and puddles were rarely used. These sites were frequently polluted and favoured by *Cu. quinquefasciatus*.

Further analysis indicated that each new area of human settlement initially favoured the multiplication of breeding sites and high densities of *An. gambiae*. Later, the canalisation of surface water, domestic pollution, and increased human density tends to eliminate breeding sites. Under high human densities the remaining *Anopheles* had low dispersal rates of under 500 m.

The following table summarises the main results.

	Rural	Peri-urban	Urban
% of mosquitoes represented by <i>An. gambiae</i>	0	37	0
% of mosquitoes represented by <i>Cu. quinquefasciatus</i>	0	63	100
Wet-season <i>Anopheles</i> biting rate (bites/person-night)	>50	7	0
Malaria prevalence in children (%)	75–90	50–80	<7
Human population density (people/km ²)	<50	150	200–250

was the almost total absence of reference to the environment or to environmental causes of malaria transmission. By placing research emphasis elsewhere, the report provides a window of opportunity for those who can work within a multi-disciplinary, environment, health and development arena, and who can command the necessary research resources. Malaria is pre-eminently an environmental disease, as its transmission depends on mosquitoes. All management, modification and manipulation of tropical and sub-tropical environments is likely to have either a positive or negative effect on mosquito production, contact or survival.

Studies of malaria on and off irrigation schemes in West Africa are beginning to confirm that there are complex changes in the ratio of two vector species, *An. gambiae* and *An. arabiensis*, following the development of the schemes, with consequent changes in malarial prevalence. One of these species is believed to be far more zoophilic than the other. Further work is required to determine whether there are more cattle in the vicinity of the irrigation schemes than elsewhere. The relative importance of entomological versus human behavioural factors has also to be assessed. A similar approach is required in the rural–urban transition. Additional factors in the peri-urban environment are likely to include the rapid turnover in susceptible, infective and immune communities, as a consequence of circulation between city and countryside.

Filariasis

About 100 million people are infected with filariasis. The most important urban and peri-urban form is bancroftian filariasis, caused by a nematode parasite which is transmitted by the mosquito *Culex quinquefasciatus*. This mosquito is prevalent in tropical Africa, India, parts of Asia, the Caribbean and along the eastern seaboard of Latin America but, exceptionally, does not transmit the nematode in West Africa. There are many areas where *Cx. quinquefasciatus* was considered rare before the 1940s–1950s but where it is now very common, as result of urbanisation. The mosquito breeds in water which is highly polluted with organic matter. Such water is characteristic of dense human settlement, where it occurs in wet pit latrines, blocked

sewage systems and drains, cesspits and septic tanks. Many of these structures have been poorly designed. Drains are frequently blocked by solid waste as a result of ineffective garbage-collection systems. Organically polluted, stagnant water accumulates behind the blockages. Because of the association of the mosquito with polluted water, there is sometimes an irregular gradient in mosquito density from high densities in the city to low densities at the periphery. A study in India (Cairncross *et al.*, 1988) demonstrated the relative importance of different kinds of breeding site within one coastal town and this enabled control activities to be prioritised. The study mapped the surface area of potential breeding sites and measured the mosquito production of each type of site. It revealed that, although there were large areas of flooded land, they were relatively unimportant. Small areas of soak pits were very productive for mosquito breeding. L-shaped drains were more numerous than U-shaped drains but the latter were more frequently blocked with rubbish and more productive for the mosquitoes. Filariasis control was not sustainable until other municipal problems, such as solid-waste management, could be solved in an integrated fashion.

Dengue

Dengue occurs in urban epidemics and there may be about 50 million cases per year. It is spreading rapidly as a result of urbanisation and travel. A severe form of the disease, called dengue haemorrhagic fever (DHF), is also spreading. As there is no effective treatment, control of the mosquito vectors is vital. The main vectors are *Aedes aegypti* and to a lesser extent *Ae. albopictus*. The rainwater and drinking-water containers in which the vectors breed include much solid waste, such as tin cans, coconut husks, rubber tyres, water-storage jars and buckets. Leaf axils may also be important and tree rot holes are probably the natural habitat. Important breeding sites may be the water-butts used by peri-urban horticulturists. Yellow fever is also transmitted by *Ae. aegypti* and is frequently fatal but a good vaccine is available and outbreaks are currently very sporadic.

Mosquito control

Solid waste contributes to the breeding sites of mosquitoes and houseflies. Consequently, solid-waste management has a uniquely important role to play in the management of urban and peri-urban diseases such as filariasis and dengue. The vectors of filariasis may also breed in various kinds of sewage-treatment plants, such as reed beds, and these need to be designed accordingly. In India, peri-urban malaria is associated with water tanks and with irrigation systems; both types of breeding site need to be well designed to minimise mosquito production in them. In Africa, there is a general concern about urban agriculture because it introduces pockets of rural land-use into the urban environment and may contribute to vector breeding, depending on water sources. Storage of clean water in any industrial enterprise or domestic environment is important. Peri-urban areas of low lying and marshy ground need to be removed as a matter of course and this can often be achieved by landfilling. If the water is required then another option is aquaculture projects. These may provide an effective method of mosquito control, provided that a range of fish species is included, ponds are restocked regularly, and marginal vegetation is cleared. However, there is still little or no literature on the cost-effectiveness of malaria control by fish.

Mosquitoes breeding in latrines and other enclosed, stagnant, polluted waters can be controlled efficiently by the use of expanded polystyrene balls (Lines *et al.*, 1994). Various chemical methods are available to control mosquito breeding. Microbial insecticides based on *Bacillus thuringiensis* and *B. sphaericus* fit well with IPM projects, the key research issue being the development of slow-release, floating formulations. A recent product from Iran shows promise (Moazami, 1994). Plant-based larvicides, such as Neem-tree extracts, may also have a role to play. Service (1990) provides an overview of urban mosquito control.

Adult mosquitoes can also be controlled by a series of measures (Lines *et al.*, 1994). The use of impregnated bednets has been shown to control disease transmission effectively in many circumstances. There is also a range of repellents containing natural or synthetic chemicals that are

rubbed on the skin or burnt. There is an opportunity to include plants containing these chemicals in natural-resource development projects.

Many mosquito-control measures are best undertaken by sectors other than the health sector. The health sector does not have the finance, the staff, the skill or the jurisdiction to manage solid waste, water storage or sewerage. There are important opportunities for collaboration between health and the natural-resource-management sector for vector control, which would contribute to a truly sustainable concept of development.

Chagas disease

Chagas disease (American trypanosomiasis) is well recognised as a serious public-health problem in Latin America. The World Health Organization (1991a) estimates that 16–18 million people are infected, with a further 100 million at risk, and the World Bank (1993) now ranks Chagas disease as the most serious parasitic disease of the Americas, with an economic impact far outranking the combined effects of all other parasitic diseases, such as malaria, leishmaniasis and schistosomiasis. Infection with the causative agent, *Trypanosoma cruzi*, is often contracted during childhood, but the debilitating effects of the chronic infection (e.g. cardiac arrhythmia or insufficiency and life-threatening aneurysms) tend to arise some 10–15 years later, in what should be the most productive age-groups. In spite of recent research developments, the infection remains incurable except during its very earliest stages, and vaccines are unavailable. Control therefore relies on halting transmission, by screening blood donors to avoid transfusional transmission, and by eliminating domestic populations of the insect vectors: large blood sucking reduviid bugs of the subfamily Triatominae (Schofield, 1994).

Governments of the most affected countries now give high priority to the control of Chagas disease. The Southern Cone Initiative, a major programme designed to eradicate all domestic and peridomestic populations of the main vector, *Triatoma infestans*, throughout the endemic regions of Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay, was launched in

Box 5. The transmission of Chagas disease in Tegucigalpa, Honduras

Tegucigalpa, capital city of Honduras, is an expanding conurbation geographically constrained by surrounding hills. Broadly speaking, the richer residential areas occupy the valley floor, whereas the less well-off areas cluster over the surrounding hillsides. Expansion of the city correlates with the general rural–urban migration of people which has been widespread throughout Latin America over the last 20 years, although recent civil unrest in Central America has probably accelerated this general trend. Around 25% of the 5.6 million who live in Honduras now live in and around Tegucigalpa.

The results of studies carried out by the Central Reference Laboratory of the Honduran Ministry of Health over the last 10 years include reports of *Triatoma dimidiata* occurring throughout the hillside communities of Tegucigalpa, with frequent reports of bugs also captured in houses in the richer residential areas. From the cumulative reports, over one-third of houses are now considered to be (or to have been) infested (C. Ponce, pers. comm.). The source of these infestations is not entirely clear, although *T. dimidiata* is well known from rural areas throughout the Central American isthmus. Urban infestations are primarily attributed to passive carriage amongst the belongings of rural families migrating to the city.

A feature of the peri-urban communities is the clustering of houses and the complex networks of dry stone walls constructed by newly arrived families in order to enclose their domestic animals (mainly goats, chickens, and some donkeys and mules). These dry stone walls provide good habitats for rodents, and are widely infested with small *T. dimidiata* populations. The houses themselves are more usually constructed of wood or blocks; they are less frequently infested by *T. dimidiata* although true domestic infestations are sometimes quite heavy.

Control of *T. dimidiata* in the peri-urban communities is occasionally carried out in response to requests by the householders, by focal spraying with residual pyrethroid insecticides. There have also been programmes to encourage householders to reconstruct the dry stone walls using cement mortar to seal the cracks, although this is recognised to be a costly and long-term undertaking. Cement is expensive, transporting it up the hillsides is difficult, and there are now very extensive networks of dry stone walls. Rodent-control programmes have also been considered, with the idea of depriving the bugs of what are probably their main hosts, but there is a fear that this could provoke more frequent domestic invasions by hungry bugs searching for alternative hosts.

1991. Peru, where *T. infestans* is also the main vector in southern departments, joined the initiative in 1996. Elsewhere, similar initiatives are being developed for Andean Pact countries (mainly Colombia and Venezuela) and Central America (mainly Guatemala, Nicaragua, El Salvador and Honduras). In these regions the main target is *Rhodnius prolixus*, which is entirely domestic in Central America but may retain sylvatic foci in some parts of Venezuela.

The Chagas-control initiatives focus on rural areas where the infection is most prevalent, and have been highly successful, with the incidence of new childhood infections cut virtually to zero over wide tracts of previously endemic areas (Schmunis *et al.*, 1996). However, concern is now being expressed over urban foci of the disease, which may represent unusual problems

for the future. In general, this disease is not considered a predominantly peri-urban problem although there are peri-urban areas where transmission of Chagas disease by triatomine bugs is a matter of concern (C. Schofield, pers. comm.). For example, an important vector in Central America inhabits dry stone walls (see Box 5).

A study of Chagas disease in Bolivia identified a rise in prevalence in the peri-urban area of Cochabamba, although the rates there remained far lower than those seen in rural areas (Arata *et al.*, 1994). The study compared house infestation by the vector among new and old houses. The vectors were more intra-domiciliary than peri-domiciliary in the peri-urban areas and this was attributed to a lack of domestic animals. In southern Peru, the presence of *T. infestans* in various isolated towns, and in the southern

Table 7. Summary of the features of some common pathogens

Pathogen	Transmission	Symptoms	Environmental classification
Large roundworm (<i>Ascaris</i>)	Eggs ingested from soil, infective for months, destroyed by direct sunlight	Wasting at high doses	Latent, persistent
Hookworm (<i>Ancylostoma, Necator</i>)	Eggs hatch in soil, larvae remain infective for months, penetrate skin. Auto-infection occurs	Cause anaemia	Latent, persistent
Whipworm (<i>Trichuris</i>)	Eggs ingested from soil	Diarrhoea with blood, anaemia, wasting	Latent, persistent
<i>Strongyloides</i> worm	Eggs hatch in gut, larvae found in soil, penetrate skin. Auto-infection occurs	Often asymptomatic, sometimes wasting, diarrhoea	Latent, persistent
Beef tapeworm (<i>Taenia saginata</i>)	Eggs ingested by cow/camel during grazing. People eat raw or poorly cooked meat. Eggs survive months.	Rarely serious, no cysticercosis	Latent, persistent, animal host
Lesser tapeworm (<i>Hymenolepis</i>)	Person-to-person	Often asymptomatic, occasional diarrhoea	Non-latent, low infective dose
<i>Shigella</i> bacterium	Faecal-oral, food- and water-borne, flies, epidemic	Bacillary dysentery, with acute onset, fever and vomiting	Non-latent, medium to high infective dose
<i>Entamoeba histolytica</i> protozoan	Cysts excreted in faeces are ingested in contaminated water or food, flies are mechanical vectors	Amoebic dysentery, with gradual onset, no fever, blood and mucous in stools, sometimes liver abscess	Non-latent, low infective dose
<i>Giardia</i> protozoan	Faeco-oral, cysts	Giardiasis, with persistent diarrhoea, malabsorption of food	Non-latent, low infective dose
Pinworm (<i>Enterobius vermicularis</i>)	Person-to-person	Negligible public-health importance	Non-latent, low infective dose
Infectious hepatitis virus	Faeco-oral	Variable, can include jaundice	Non-latent, low infective dose
<i>Salmonella</i> bacterium	Faeco-oral and via food and water, seasonal, sometimes zoonosis	Diarrhoea, some species produce high fever	Non-latent, medium to high infective dose
<i>Vibrio cholerae</i> bacterium	Faeco-oral and via food and water	Many cases are mild, severe cases have acute fluid loss by diarrhoea and vomiting	Non-latent, medium to high infective dose
Pork tapeworm (<i>Taenia solium</i>)	Pork	Sometimes neurological (in cases of cysticercosis)	Persistent
<i>Cryptosporidium</i>	Human and other animal reservoirs, faeco-oral and via food and water	Diarrhoea, but often asymptomatic	Non-latent, persistent
Schistosomes (<i>Schistosoma mansoni, S. haematobium</i>)	Contact with infected water containing snail host	Bloody urine or stools, debilitating, damage to organs over long term	Latent, persistent, aquatic host

suburbs of Lima, is strongly associated with motor transport. *Triatoma infestans* was first recorded from Lima during the 1930s, in houses

around a market where lorries unloaded agricultural produce brought in from endemic rural areas in the south (Lumbreras, 1972).

Leishmaniasis

Visceral leishmaniasis is a severe parasitic disease transmitted by phlebotomine sandflies. In Brazil it is typically found in rural foci containing dogs and foxes as well as the vector. Rapid peri-urban expansion in north-eastern Brazil led to an epidemic in the city of Natal (Jeronimo *et al.*, 1994). The expansion took place in a sparsely populated sand-dune ecosystem about 15 km from the city where the disease was endemic. In one district, the population had increased from 485 in 1980 to 13,250 by 1991. The vegetation was cleared for housing. Most of the new cases were in children and there was clustering of cases within households. The mortality rate was 10%, mostly represented by malnourished and debilitated children. There were also many inapparent infections.

In parts of the Middle East and Asia there is urban transmission of cutaneous leishmaniasis, or oriental sore. The vector, also a phlebotomine sandfly, appears to favour high-density, low-quality housing and construction sites in dry cities and peri-urban areas. Cities from which it has been recorded include Kabul, Teheran and Aleppo. People are the main reservoir host and the parasite is probably imported by migrant workers (R. W. Ashford, pers. comm.).

WATER- AND FOOD-BORNE PARASITIC DISEASES

There are many water- and food-borne parasitic infections of importance at the peri-urban interface, each with its own age-prevalence distribution and severity. Table 7 summarises some

Table 8. Some clinical treatments for common pathogens

Pathogen	Treatment
Some helminths	Mebendazole
Tapeworms	Niclosamide
Protozoa	Metronidazole
Bacteria	Antibiotics
<i>Vibrio cholerae</i>	Fluid replacement and antibiotics
Some viruses	No specific treatment, but prevention by vaccination
Schistosomes	Praziquantel

relevant aspects of the transmission, symptoms and environmental classification of the most common of these infections (Feachem *et al.*, 1983). Note the environmental classification of latency, referring to a resting stage between excretion and infection, and persistence, referring to a period of survival in the environment. (The results of recent research indicate that there are two morphologically identical species of *Entamoeba*, one pathogenic the other not. This discovery is expected to lead to important changes in the understanding of the epidemiology of dysentery.)

Table 8 provides an indication of how some of these pathogens are treated.

Table 9. Some food-borne parasites (Murrell, 1995)

Disease	Source	Clinical features	Control
Toxoplasmosis	Pigs, sheep, cattle, poultry, cats, dogs	Congenital malformation	Cook or freeze meat, avoid faeces
Trichinosis	Pigs, horses	Diarrhoea, heart disease	Cook, freeze or cure meat
Taeniasis	Ingestion of infected beef or pork	Diarrhoea, weight loss	Cook or freeze meat
Cysticercosis	Ingestion of eggs	Brain damage	Avoid infective human faeces and food contamination, prevent scavenging

The poor disposal of organic solid waste and scavenging by domestic animals, such as cats, pigs and rats, are associated with a range of food-borne parasitic diseases. Table 9 summarises some of them (Murrell, 1995). *See also: food safety (page 110).*

Toxoplasmosis transmission is faecal–oral, congenital and through carnivory. Cats are the main reservoir and contaminate the environment through their faeces. Infected meat of other domestic animals may infect humans. Pigs may be infected by scavenging on faeces and dead animals. Babies born to infected women and immunosuppressed individuals are most vulnerable.

Trichinosis transmission is by consumption of infected meat. Pigs may be infected by scavenging on food waste and dead animals.

Tapeworm eggs contaminate the environment from faeces and may then be ingested by domestic animals. Pigs may be infected by eating human faeces directly. Use of under-treated sewage in agriculture can lead to transmission. Humans may then be infected by eating the meat of an infected animal. There are two main species of tapeworm affecting humans: the beef tapeworm and the pork tapeworm. The pork tapeworms are the most hazardous because humans may ingest their eggs and then serve as a host for the larvae that encyst, as cysticerci, in various organs. In some cases the brain is involved, causing a disease (neurocysticercosis) which is relatively common and frequently fatal or permanently disabling. In Mexico, for example, neurocysticercosis was estimated to cause 1% of all hospital deaths and 25% of all intracranial tumours, at an estimated annual cost of U.S.\$95 million (Murrell, 1995). In order to control the disease in humans, stringent abattoir regulations may be imposed. Condemning infected pig carcasses is an important source of losses to the meat market; in Mexico, the condemning of pork was estimated to cost the equivalent of 68% of the total investment in pig production.

ZOONOSES

New diseases from animal sources and other, ‘traditional’ zoonoses are of concern to both veterinarians and public-health specialists. *See also: livestock (page 81) and Table 9.* Emergent zoonoses can be grouped into three main categories (Meslin, 1992):

- those associated with changing farming practices, trade and consumer habits;
- those associated with changing environments which affect reservoirs, vectors or final hosts; and
- pathogens acquiring new properties through adaptation and mutation.

Food-borne enteric infections and intoxications have increased in both developed and developing countries (see above). These are associated with changing slaughterhouse practices. Infections with *Salmonella* and *Escherichia coli* are of particular concern and new pathogenic strains have appeared. The linkage between Creutzfeld–Jakob disease (CJD) and bovine spongiform encephalopathy (BSE) remains unconfirmed but is causing concern in many countries. Epidemics of Rift Valley Fever have occurred in several African countries in association with dam projects and livestock. There is speculation that influenza epidemics may sometimes have an animal reservoir. *See also: integrated aquaculture and the risk of influenza pandemics (page 77).*

Aquaculture is one of the fastest growing areas of peri-urban development in some regions. Table 10 lists some of the pathogens associated with aquaculture. Most of the pathogens listed in Table 7 are also important. *See also: aquaculture (page 74).*

ACUTE DIARRHOEAL DISEASE

Diarrhoea is a leading cause of infant and child mortality and morbidity. There are many sources of infection. Neighbourhoods with clean water supplies and functioning toilets tend to have

Table 10. Pathogens causing health hazards in aquaculture development (Cairncross and Feachem, 1993)

Disease	Common name	Pathogen	Transmission	Distribution	Water relation
Clonorchiasis	Chinese liver fluke	<i>Clonorchis sinensis</i>	Man or other mammal-aquatic snail-fish-man	South-east Asia	Water-based, ingested
Diphyllobothriasis	Fish tapeworm	<i>Diphyllobothrium latum</i>	Man or other mammal-copepod-fish-man	Worldwide	Water-based, ingested
Fasciolopsiasis	Giant intestinal fluke	<i>Fasciolopsis buski</i>	Man or pig-aquatic snail-aquatic plant-man	South-east Asia, mainly China	Water-based, ingested
Opisthorchiasis	Cat liver fluke	<i>Opisthorchis felineus</i> , <i>O. viverrini</i>	Cat or man-aquatic snail-fish-man	Thailand, former USSR	Water-based, ingested
Paragonimiasis	Lung fluke	<i>Paragonimus westermani</i>	Man or other mammal-aquatic snail-crab or crayfish-man	East Asia, Africa, South America	Water-based, ingested
Leptospirosis	Weil's disease	<i>Leptospira</i> spp.	Animal-man		Water-borne, through skin, mouth or eyes

lower rates of diarrhoea than those without. Contributory factors include early weaning and inappropriate treatment. Early weaning may be a function of the economic pressures on working mothers. The results of many studies indicate that, although mothers frequently know about oral rehydration therapy, they may not use it when their child is sick but turn instead to commercial medicines.

Table 11 provides an example of the variation in childhood diarrhoea between communities in the Greater Accra Metropolitan Area (Songsore and McGranahan, 1993). Several risk factors for childhood diarrhoea were identified. In the poorest economic groups about 48% of children defecated outdoors.

SEXUALLY TRANSMITTED DISEASES

Sexually transmitted diseases (STDs) are a major hazard associated with poverty and migration. They include HIV/AIDS. Poor women are often

forced into prostitution as a result of a lack of alternative means of livelihood in the urban environment. Sexual contact is still the major mode of HIV transmission, and prevalences of the infection are frequently higher in African cities than in the countryside (Rossi-Espagnet *et al.*, 1991). Infection rates in urban prostitutes are frequently as high as 75%. High infection rates in the active working population are likely to undermine economic development, health care, child survival and social structure. AIDS is also likely to aggravate other infections, such as tuberculosis. The urbanisation process may, itself, increase the average number of sexual partners and contribute to the rate of infection. Natural-resource developments which provide alternative economic activity and target poor women could therefore have an important, positive health impact.

Table 11. Urban and peri-urban diarrhoea and environmental factors in Accra (Songsore and McGranaham, 1993)

	Population					
	Rural fringe or peri-urban	High density, low class	High density, indigenous	Medium density, indigenous	Middle class	High class
Water source (% of population)						
Private	2	53	49	46	88	96
Communal	16	2	28	4	8	0
Vendor	50	20	19	2	4	4
Toilet (% of population)						
Flush	2	22	28	23	84	96
Pit/KVIP	92	46	46	55	9	2
Pan	0	29	25	13	4	0
Other/none	6	3	1	10	3	2
Diarrhoea						
2-week prevalence among children (%)	24	14	26	5	4	5

ACUTE RESPIRATORY INFECTION

Acute respiratory infections (ARI), including colds, sinusitis, tonsillitis, laryngitis, bronchitis, influenza and pneumonia, are an important cause of child mortality in both rural and urban areas. In developing countries, they represent 10%–30% of all mortalities in children aged less than 5 years. They include both upper- and lower-respiratory-tract infections and pneumonias caused by other infectious diseases such as measles, whooping cough and varicella. Measles represents an important percentage (Garenne *et al.*, 1992). The annual incidence of ARI in children tends to be relatively high in urban areas (Rossi-Espagnet *et al.*, 1991). There are also important intra-urban differences. For example, mortality in a shanty-town in Brazil was six times higher than elsewhere. Indoor and outdoor air pollution are likely contributing factors, as are overcrowding and poor ventilation. ARI deaths generally decline with development.

CHRONIC RESPIRATORY DISEASES

There are intra-urban differences in the notification rates for chronic respiratory infections such as tuberculosis (TB), with higher rates among poorer people and poorer peri-urban areas (Rossi-Espagnet *et al.*, 1991). There are linkages between TB and HIV infection and severe malnutrition. Overcrowding and poor ventilation are important contributory factors. Other risk factors include alcoholism, drug abuse, homelessness and poor compliance with treatment.

MENINGITIS

Epidemics of cerebrospinal meningitis have been observed in the sub-Saharan area known as the meningitis belt. The belt includes parts of Sudan, Ethiopia and Chad. The epidemics are most severe in overcrowded urban slums and peri-urban areas, from which they tend to spread into formal urban areas (Rossi-Espagnet *et al.*, 1991).

Table 12. Some non-communicable health hazards associated with peri-urban natural resources

Source	Substance	Health hazard
Tanneries	Chromate	Cancer, ulcers, dermatitis, foetal damage
Food	Mycotoxins	Cancer, malabsorption, immune deficiency, liver disease
Crop protection	Pesticides	Neurological damage
Milling	Dust	Lung disease
Crops	Lead	Neurological damage
Biomass fuels	Gasses and particulates	Respiratory disorders
Waste water	Nitrates	Infant respiratory disorder
Fruit processing	Fruit acids	Dermatitis

Non-communicable diseases

Non-communicable diseases can result from the ingestion, inhalation or absorption of toxic chemicals, including pesticides (Figure 3 on page 93), minerals and heavy metals (Table 12). In addition to intoxication, they include maternal and perinatal mortality. They may be associated with air-, water- or food-borne pollutants, poor occupational safety, or poor domestic storage. The symptoms may be acute or chronic. Acute poisoning from pesticides can lead to acetylcholinesterase inhibition. The symptoms of such inhibition include dizziness, weakness and coma, severity depending on dose. Chronic neurological symptoms include blurred vision, dizziness, numbness or headache, and superficial or deep sensory loss (Amr *et al.*, 1993). Other chronic symptoms of non-communicable diseases include heart and lung disease, various cancers and foetal damage. The symptoms of chromate poisoning (associated with tanning) and of the ingestion of mycotoxins (associated with mouldy food) are discussed below. There is concern that industrial pollutants including lead may contaminate peri-urban crops and then poison consumers.

Vulnerability to pollutants is increased by malnutrition, communicable disease and human behaviour. In addition, pollution can increase susceptibility to communicable disease. Non-communicable diseases sometimes require long latent periods and may be associated with many

subacute exposures to toxic substances. The substances themselves may be associated with well-defined point sources such as pesticide stores or contaminated wells. Control may depend on a general reduction in levels of use, emission and exposure. Chemical pollution can damage the resource base and destroy fisheries, make water unsuitable for irrigation, or damage crop vegetation and reduce agricultural productivity. The consequential health hazard is then malnutrition due to food shortage.

AIR POLLUTION

Air pollution by industry, traffic, cooking fuels and thermal power stations contributes to chronic respiratory diseases such as bronchitis and asthma as well as acute diseases such as pneumonia. South American studies have documented the excess morbidity and mortality from respiratory disease attributable to air pollution (Rossi-Espagnet *et al.*, 1991). *See also: biomass fuels (page 51) and fossil fuels (page 53).*

The adverse health effects of air pollution have been associated with three major sources (Romieu *et al.*, 1990):

- sulphur oxide and particulates from fossil fuels, for example the London smogs;

- photochemical oxidants and carbon monoxide from motor-vehicles, for example the Los Angeles smogs; and
- miscellaneous pollutants, such as the hydrogen sulphide, lead and cadmium emitted by smelters, refineries, manufacturing plants and vehicles.

A dose–response relationship between 24-hour exposure to particulates and excess deaths has been derived. Certain community groups are particularly sensitive to sulphur dioxide plus particulates (which exacerbate the symptoms and frequency of asthma attacks). The effects of long-term exposure include cardio–respiratory disease. Intra-urban differentials have been measured. Associations with chronic obstructive lung disease are suspected but masked by the many other risk factors.

Photochemical smogs consist of ozone, nitrogen oxides, sulphates and other chemicals. There may be synergistic effects but ozone seems to be the most biologically active component (Romieu *et al.*, 1990). The effects include eye, nose and throat irritation, cough, pain, chest tightness, malaise and nausea, and increased frequency of asthma attacks. Nitrogen oxides have been related to increased respiratory infection in children. Lead has been associated with impaired neurological development of infants and older children. In Latin America, some 30 million children, 47 million adults (aged 15–59 years) and 4 million elderly were estimated to be exposed to air-pollutant levels that exceeded the WHO's guidelines (Romieu *et al.*, 1990). In Mexico City, the prevalence of upper respiratory infection in schoolchildren was found to be significantly lower in the centre than in the industrial periphery; this difference was attributed to outdoor air pollution.

ARSENIC AND GROUNDWATER

Arsenic poisoning is an example of contamination of natural groundwater resources with a serious poison. Arsenic in drinking water from wells (at a concentration of about 1 mg/litre) is

associated with skin lesions, cardiovascular lesions, and bladder and kidney cancer in several countries, including Chile, Mexico, Taiwan, India and Bangladesh.

Since the 1980s there have been reports of arsenic contamination of groundwater throughout Bangladesh. The use of contaminated tubewell water is considered a serious health hazard, with one third of the population estimated to be at risk of chronic arsenic poisoning. The exact cause has yet to be established but probable sources are thought to include the use of agro-chemicals (some of which contain arsenic), the large quantity of groundwater used for irrigation, and the fall in the Ganges water flow in recent years (which has affected the underground water level and probably mobilised naturally occurring arsenic in the aquifer). It is believed that simple education measures may go some way to alleviating the problem, by alerting the population to the problem. Other mitigation measures include testing tubewells regularly, preventing the use of contaminated water, and directing people to safe water (water from safe tubewells, surface water, or water passed through arsenic filters). In the long term, a national water policy is needed, to rationalise use of both surface and ground water for both agricultural and domestic use, and specifically to encourage construction of the deep tubewells which appear to avoid the problem (Anon., 1997a). *See also: groundwater (page 118).*

Injuries

Injuries can be sub-divided into intentional and unintentional categories. The unintentional injuries include burns and scalds associated with lack of protection from cookers and heaters. These causes are described, for example, by Hardoy and Satterthwaite (1997). Traffic injury is also of great importance, as are physical hazards from house siting. Improper use or improper maintenance of agricultural machinery may lead to both acute and chronic injury. *See also: agricultural labour and its effects on health (page 70).* Low standards of safety are commonplace. Unintentional injury appears to account for about 19% of all health problems, peaking in those aged 2–5 years.

Intentional injuries include homicides, suicides and violence. There is a world-wide epidemic of intentional injury and violent death that is responsible for approximately 10% of the crude death rate among young adult males (Bourbeau, 1992). In Latin American cities, homicides are particularly common. The rates tend to be higher among males than females, although females are often the victims. Many surveys have found a high incidence of wife abuse (Heise, 1992). For example, 40% of wives in one survey were 'beaten regularly'. In a study in Papua New Guinea, women also reported a high rate of beating: 60% among rural women, 56% among peri-urban women and 62% among the women of the urban elite. Rates in developed countries are similar, with about 40% of women surveyed in Texas reporting abuse after the age of 18 years. Child abuse is also thought to be a major problem, but the relevant data are poor.

Rates of suicides and attempted suicides are also high and increasing. There is considerable regional variation, with particularly high rates reported in Sri Lanka, Hungary and Finland (Diekstra and Gulbinat, 1992). In Sri Lanka and elsewhere, the drinking of pesticides is a common method of suicide. *See also: agro-chemicals (page 65)*. There are often intra-urban variations in rates of intentional and unintentional violent injury and a linkage with psychosocial disorder. Projects which affect the quality of life of disadvantaged groups in the peri-urban interface may affect the incidence of violent behaviour.

Malnutrition

All agricultural development projects are likely to have an impact on the food security and nutritional status of people living within and outside the project. The impact on nutritional status can be both direct and indirect. Indirect mechanisms include food production, food availability, workload, infection and feeding practices. Under-nourished people are more susceptible to communicable disease. The disease, in turn, may reduce their ability to assimilate whatever food is available. The results of several studies have demonstrated that under-nourished children are at increased risk of death (Rossi-Espagnet *et al.*, 1991).

The effects of under-nutrition include less than average weight or height, blindness, cretinism, anaemia and poor skin condition. Women and children are especially vulnerable because of differential entitlements within the household. Standard measures of under-nourishment are based on weight-for-age, weight-for-height and height-for-age indices. The FAO (pers. comm.) is working on a system of anthropometric measurement for adults, to provide an indication of energy under-nutrition. This may be useful as a tool in the study of the rural-urban continuum. It will provide information to supplement the more usual anthropometry that is applied to children.

There is plenty of evidence that urban dwellers still depend on self-grown food and access to agricultural land (Hardoy and Satterthwaite, 1997). Popkin (1996) has suggested that there is a process of nutritional transition that accompanies the processes of demographic and epidemiological transition. At its simplest, this consists of a change from under-nutrition to over-nutrition. Urban diets are considered to differ broadly from rural diets by showing trends towards:

- 'superior grains' such as rice and wheat rather than corn or millet;
- more milled and polished grains;
- food higher in fat;
- more animal products and sugar;
- food prepared away from home; and
- more processed food.

On the other hand, the diets of the urban and peri-urban poor may be worse than their rural counterparts. There are a number of published examples (Rossi-Espagnet *et al.*, 1991). A study in Thailand demonstrated increased under-nutrition in urban-slum children and adults compared with rural communities. The results of several studies in Latin America have demonstrated that infants that are breast-fed for less than 6 months have a greatly increased risk of dying. Working mothers often have to rely on artificial feeding provided by other child carers, so that reduced breast-feeding seems to be a feature of urbanisation. Opportunities for breast-feeding infants in the urban workplace are

**Table 13. Urban food problems and interventions
(from the FAO, as cited by Rossi-Espagnet *et al.*, 1991)**

Problems	Interventions
Price of food too high	Fair-price shops, simpler packaging, communal buying, consumer co-operatives
Prices of staples fluctuate at times of scarcity and prices in parallel markets soar	City food stocks in poor areas
Time shortage for breast-feeding, preparation of infant food, reduced child-care, nutritional problems of old	Day-care centres at work places, cheap weaning foods, communal kitchens
Unbalanced food intake, micronutrient deficiency, lack of household food safety	Urban agriculture, fish ponds, small-animal raising, cheap and nutrient-dense food mixes
Poor environment, scarce cooking fuel, insufficient sources of drinking water, poor health	Piped water at street outlets, urban wood-fuel lots
Long distance to markets	Establish controlled and serviced markets in poor areas
Lack of knowledge regarding nutrition	Education programme
Lack of statistics for planning	Surveys and monitoring
Scarcity of staff for programme implementation	In-service training
Insufficient nutritional aspects within existing community development programmes	Awareness-raising among decision-makers
Waste of resources and efforts due to lack of programme co-ordination	Establish co-ordinating mechanisms

limited. Some results indicate that height and weight deficits during the first years of life may frequently be associated with problems in pregnancy that are themselves the result of occupational or other behaviour.

Table 13 identifies a series of urban nutritional problems and possible interventions. Many are relevant for natural-resource-management projects. The FAO report on which this table was based also analysed some of the constraints limiting the interventions.

The International Food Policy Research Institute have prepared a draft review of urban challenges to nutrition security (Anon., 1996c). The institute's primary concern is maternal and childhood malnutrition. One of the causes of this is believed to be food insecurity. This is dependent on the availability of adequate food and the stability of food availability and access. Stability

is dependent on natural-resource management and environmental sustainability. A second cause of childhood malnutrition is believed to be inadequate maternal care (breast-feeding, food preparation and hygiene). A third cause is disease, which undermines nutrition and is often a function of environmental health.

The institute's review cites literature indicating that, on average, infant and child mortality rates and childhood malnutrition rates are lower in urban communities than in rural. The available evidence also indicates that urban diets are more diverse than rural diets and that the availability of both energy and micro-nutrients is greater in the urban diets. However, childhood morbidity is higher in urban areas in some countries and intra-urban differentials are very great. For example, malnutrition rates are much higher in poorer areas, and the differences

between poor and wealthy areas are larger than those between urban and rural. The review noted the importance of street foods: in some countries 25% of the urban-household budget was spent on these.

The review also considers determinants of urban food prices and purchasing patterns. It cites literature indicating that wholesale markets are often run-down, too small and badly managed. Small and scattered retail markets cater to the needs of the urban poor, who must make frequent purchases of tiny amounts. The price and availability of food often depends on transport of food to market, which in turn depends on the condition of roads, making these an important factor in natural-resource development. Finally, the review identifies a large number of research and policy questions that are relevant to peri-urban research. The results of a recent study from peri-urban Accra (Anon., 1996d), other reports, including those of the Food and Agriculture Organization (1995a) and Hutabarat (1994), and the discussion on food safety which appears later in this book are relevant here. The World Health Organization (1993a, 1996a, 1996b, 1996c) and Motarjemi *et al.* (1995) have collected and published a series of papers by Bryan and others on hazard analysis applied to street foods and similar issues. *See also: food safety (page 110).*

Mental or psychosocial disorders

Mental disorder has only recently started to receive concerted research attention in relation to urbanisation. The 1993 World Development Report attributed a substantial burden of non-communicable diseases to this source, with special emphasis on depression and anxiety in women (World Bank, 1993). Rates are about twice as high in women as men and the women who suffer are often victims of violent or alcoholic partners or family members. The economic cost of this burden is unknown but it is clear that it contributes significantly to lost productivity, hospitalisation, and early retirement. Other health consequences include violent injury, substance abuse and depression. *Urbanisation and Mental Health in Developing Countries*, edited by Harpham and Blue (1995), provides the most comprehensive available account of this category

of health hazard in the urban context, and the following points from this book are relevant to the present review.

A model of the association between social factors, urbanisation and mental disorder recognises a set of stressors or risk factors, including the following (Harpham and Blue, 1995; Blue and Harpham, 1996):

- a poor physical environment, including lack of open space, overcrowding, noise;
- a switch from subsistence to cash cropping;
- insecure tenure;
- participation of women in the labour-force;
- under employment;
- high levels of violence and accidents;
- rural–urban migration;
- a lack of control over events and lack of community support; and
- negative life-events, such as unemployment.

Numerous studies are cited that associate mental illness with economic status but the association can be in either direction. For example, schizophrenic disorders in the U.S.A. are more common among the poor but depression occurs more frequently among the wealthy. The evidence is mixed regarding differentials between rural and urban environments, as there are many confounding factors. However, urban living is regarded as an important determinant. In the chapter by Marsella, it is suggested that an important set of risk factors are life stresses in simultaneous interaction with lack of resources to resolve them. However, this is not to imply that only external events are relevant. The vulnerability of individuals is very variable. Many people show remarkable resilience and coping strategies when faced with extreme situations, and there are cultural aspects to the expression and resolution of emotion (see the chapters by Almeida-Filho *et al.* and Blue *et al.*).

There are only two chapters that refer to peri-urban (or suburban) environments. Cheng *et al.* cite evidence from Taiwan that the significant risk factors in the urban environment were finance and employment. The primary risk factor in rural and suburban environments was physical health. A chapter by Parry proposes a research methodology for mental disorder in the peri-urban environment but does not present results; the topic is new and the research is on-going.

In addition to the evidence presented above, there is anecdotal evidence to indicate that mental disorders increase as a component of 'modern diseases' in the health transition. For example, the ex-mayor of the Columbian city of Cali recounted the history of public health in a peri-urban area (Guerrero, 1996). The area was settled illegally during the 1980s and lacked running water and mains sewerage. A programme was started to help the people help themselves. By 1994, the incidence of communicable disease was greatly reduced. However, the incidence of violent crime had increased five-fold, to about 100 attacks per 100,000 inhabitants, and become an important source of death. There are also more analytical studies. For example, an analysis of determinants of maternal mental disorder in Rio de Janeiro indicated that the principle risk factors were very low income per capita, bad environmental conditions, lack of partner, and having more than three children (Reichenheim and Harpham, 1991). Migration seemed to be of secondary importance

Health priorities

The significance of a health hazard can be assessed objectively or subjectively. For example, irrigation projects in Africa often increase the prevalence of symptomatic schistosomiasis from less than 10% to more than 50%. Schistosomiasis, or bilharzia, is a communicable disease with symptoms that include blood in stools or urine. In later life, a small percentage of those infected suffer severe disease. The appearance of the blood causes alarm in naive communities but no alarm in communities with prior experience of the disease. Prevalence provides an objective measure whereas the degree of alarm in the

community provides a subjective measure. The significance of a health hazard is partly determined by its severity and frequency.

The costs of ill-health include the costs of health care and treatment, lost production, educational under-achievement, individual suffering and labour substitution. Disability-adjusted life-years (DALYs), defined in the *World Development Report 1993* (World Bank, 1993), provide a comparative measure of severity. The relative contribution communicable diseases, non-communicable diseases (including, *inter alia*, malnutrition and neuro-psychiatric disorder) and injury make to the burden of ill-health in different regions is illustrated in Figure 1. When disaggregated to take account of urban, peri-urban and rural differences, such data may assist in the identification of priorities.

Listorti (1996) ranked the top five causes of disease in Sub-Saharan Africa using various data (see Table 14). Together, these diseases contributed about 50% of the total burden. Such data are only indicative because there are major differences between communities. Peri-urban areas are most likely to be under-represented because they are informal and poorly served by government health centres.

Listorti reorganised the data to indicate which diseases would be most affected by improvements in infrastructure and how (Table 15). He concluded that 44% of the disease burden would be strongly affected by infrastructural interventions.

Not all of the health issues listed above are of equal concern to peri-urban natural-resource-project managers. In Table 16 we have tried to separate the health hazards into those that are likely to be associated with peri-urban conditions and affected by natural-resource management and those which are not. We have also included an intermediate category for hazards that may fit into either of the others.

Table 14. Rank and share of the burden of disease in sub-Saharan Africa

Rank	Among females		Among males	
	Disease	Share (%)	Disease	Share (%)
1	Malaria	11	Injuries	13
2	Respiratory infections	11	Respiratory infections	11
3	Diarrhoeal diseases	10	Malaria	11
4	Childhood cluster	9	Diarrhoeal diseases	10
5	HIV and other STDs	9	Childhood cluster	10

Table 15. Infrastructural interventions for common urban diseases in Africa (Listorti, 1996)

Disease/condition	Type of infrastructural remedial measure
Respiratory disease	Improved housing and air-pollution abatement
Malaria	Vector control, drainage
Diarrhoeal diseases and intestinal worms	Improved drinking-water supply and waste management
Childhood cluster	Health care and education
Injuries	Reduction in household and traffic accidents
Tropical cluster (including schistosomiasis and filariasis)	Vector control, sanitation and drainage

Table 16. The health concerns of natural-resource (NR) managers and other managers

Hazards clearly associated with peri-urban areas or NR-related?		
Yes	No	'In between'
Communicable Diseases		
Associated with water: water-borne, water-related, water-washed, water contact, including re-use of waste water	Communicable diseases of children preventable by vaccination	-
Zoonoses associated with domestic animals	Sylvatic zoonoses	-
Non-communicable Diseases		
From agro-chemicals	Poisoning from poorly stored medicines and household chemicals	-
Heavy-metal contamination of food crops or occupational exposure through tanning	Other occupational exposure to heavy metals	-
Associated with Food Safety		
Industrial pollution damaging the NR base, such as fish stocks	Industrial pollution in air which is directly inhaled	-
Injuries		
Household burns and scalds from use of biomass fuels	Household burns from electricity	-
Injury from house siting	Occupational injury in non-NR industries	Traffic injury
Malnutrition		
Associated with lack of access to agricultural land	Associated with inequalities in entitlement	-
Psychosocial Disorders		
Associated with overcrowding, lack of open spaces, insecurity of land tenure, and leading to violence, substance abuse and depression	Occupational	Associated with lack of control of events, noise

Chapter 3

Management

- Methods for prospective health impact assessment are described. The preferred method is based on community risk factors, environmental risk factors and institutional risk factors.
- The completion of a summary health-assessment table, such as Figure 4, is advocated.
- Opportunities for health-risk management in development projects are outlined.

Figure 4. Summary health-assessment table

Health hazard	Community groups	Community risk factors	Environmental risk factors	Institutional risk factors	Change in health risk attributable to the project
Communicable diseases					
Non-communicable diseases					
Injury					
Malnutrition					
Mental disorders					

Health impact assessment

Health impact assessment is a management tool. It consists of three general steps that are common to many management problems. Within the health sector, similar steps are encountered in studies on food and occupational safety. The three steps are:

- identification of health hazards;
- assessment of health risks; and
- implementation of health safeguards and mitigation measures.

Identification of health hazards requires detailed reviews of known issues. This forms the bulk of the report. The assessment determines whether the health hazards identified may lead to changes in the health risks associated with a project. The assessment should be prospective: it should indicate the future changes that are expected (Birley, 1991, 1995).

The health-risk assessment process consists of an examination of the component risk factors. These have no unique designations. The following designations are proposed:

- community risk factors—the socio-economic and physiological risk factors that determine the vulnerability of specific community groups to specific hazards and which depend on physiology, education, behaviour and poverty and other forms of vulnerability (the community groups, or stakeholders, associated with the project must be identified);
- environment risk factors—bio-physical and social environment risk factors that determine the exposure of communities to health hazards and which depend on vectors, poisons, machinery, food supply, alienation, unemployment, violence and stress; and

- institutional risk factors that determine the capacity, capability and jurisdiction of responsible services to protect the communities from the hazards.

COMMUNITY RISK FACTORS

These factors are characteristics of the vulnerable human community. The factors include poverty, immunity, education and occupation. Other determinants include individual or household ability to afford health care, to make appropriate emergency responses, to take time off to recover from illness or injury, and to re-arrange household activities, and the availability of a support network to draw on (Hardoy and Satterthwaite, 1997). Social roles, including occupation, may determine the duration and severity of exposure to hazards (Satterthwaite, 1993). Movement from rural environments is also associated with a range of lifestyle changes which are linked to a variety of urban health problems (Rossi-Espagnet *et al.*, 1991). The particular environmental and community risks for children are reviewed by Satterthwaite *et al.* (1996).

A similar system of community risk factors was used in British Columbia to assess the impact of public policies and projects on health (Frankish *et al.*, 1996). The risk factors considered were income and social status, social-support networks, education, employment and working conditions, biological and genetic endowment, personal health practices and coping skills, and healthy child development.

Gender differences are frequently an important determinant of vulnerability. Survival strategies of poor women in urban Africa are described by O'Reilly and Gordon (1995). A recent anthology explores the linkages between gender, health and environment (Sims, 1994). A paper by Oruwari, cited by Sims, examined housing needs in poor communities in Port Harcourt. The survey revealed that women funded 55% of household expenditure through their own micro-enterprises, usually the retailing of foods. The paper discusses how the associated stresses may undermine women's health. An associated theme was the inappropriate allocation

of housing to male rather than to female household heads. Other papers cited by Sims are concerned with domestic energy and indoor air pollution and occupational hazards. The report reviews the complex relationship between domestic energy shortage and women's health. For example, there are references to pneumococcosis in women, caused by a combination of smoke from biomass fuel and maize grinding, and to lung cancer in Chinese women caused by a combination of passive smoking and use of poor-quality coal. A section on occupational hazards reported a number of comparisons between male and female workers and between exposed and unexposed groups. Of particular interest was a study by Restrepo *et al.*, cited by Sims, on pesticide exposure among female floriculturalists in Bogota. Large numbers of pesticides were being used in the flower-growing industry. The study detected significant differences in foetal loss, prematurity and congenital malformation among women according to their exposure. A study by Ferrar reported on exposure of women working in the cassava-processing industry to hydrogen cyanide; no results were given but a simple indicator test-paper had been developed which could be used by women to monitor their exposure to this dangerous gas.

Definition of community groups by less obvious factors than gender and age may be difficult in peri-urban areas. People dwelling there may have a weak sense of their own community, as a result of mobility and breakdown of traditional family ties, changing gender roles, and ethnic diversity. New definitions of community may be emerging based on common perceived hazards.

In general, several diverse communities may be identified but there will rarely be sufficient demographic data to determine the size of each group.

ENVIRONMENTAL RISK FACTORS

Environmental risk factors include the biophysical and social environments in which the community are exposed to the hazard. The biophysical environment includes access to infrastructure, such as water supply and sanitation, as

well as the natural environment. Access to the physical requirements for good health is strongly skewed within the urban and peri-urban environment. For example, the richest 20% of the urban community may consume 80% of the public services such as water supplies (Hardoy and Satterthwaite, 1997).

A natural-resource development project may promote a succession of plant and animal communities, including those of disease vectors (e.g. mosquitoes and snails), animal reservoirs of disease (e.g. rodents and pigs) and agricultural pests and weeds. For example, mosquitoes may breed in the seepage pools associated with water-resource development.

There are problems of contamination of water supplies with human faeces, inadequate sanitation, drainage and solid-waste disposal. Chemical pollutants are transported through water, soil and air. Geographical factors which can affect risk include topography and zonation. In the working environment, injury is caused by fast-moving machinery and poisoning by exposure to hazardous substances. Noise is a common problem of both the work and domestic environment. In general, the external environmental risk factors can be categorised as focal or dispersed, frequent or infrequent, near or distant.

Risk or industrial-hazard assessment is a component of health assessment that focuses almost exclusively on the environmental factors. It often involves an engineering analysis of the concentration of an unintended release of energy or chemical at various distances from a point source and the probability of that release occurring. Environmental impact assessment (EIA) also generally focuses on the external environment and pays little attention to host risk factors.

INSTITUTIONAL RISK FACTORS

Protection of human health is the responsibility of many agencies in addition to the national Ministry of Health. For example, the Ministry of Labour or of Employment may oversee occupational health and safety, Public Works may be responsible for drinking-water quality and sanitation, Transport may control traffic move-

ment and safety, and Agriculture may limit access to communal and forest lands, irrigation water and agro-chemicals. The division of responsibility between project proponents and local government is often not clear. Local government may lack the capacity to discharge their responsibilities. Health activities are also undertaken by a range of non-governmental organizations, and the private sector is often an important source of health care.

The assessment should determine whether these agencies have the capacity, capability and jurisdiction to prevent exposure of the vulnerable community to the identified health hazards or to care for them after they are exposed. This is akin to the institutional analysis undertaken in social-impact assessment. Capacity refers to resources in terms of staff, equipment, communications and transport. Capability refers to the skills of the staff to use their resources. For example, a health centre may not be able to cope with an influx of 30,000 immigrants without additional staff, infrastructure, drug supplies, environmental and health-education officers, primary-health-care facilities, and mosquito control. If the project creates new or unusual health risks the staff will need additional training on how best to respond. The assessment should determine whether a multi-sectoral approach is taken towards planning. For example, are there any formal or informal linkages between the Ministry of Health and the project proponent? Jurisdiction refers to the limits of responsibility of each agency. Urban services each define their own boundaries and jurisdictions and these may be poorly defined, overlap or have gaps (Silimperi, 1995). This makes it difficult for urban citizens to mobilise needed services or to obtain maximal assistance. Informal and peri-urban communities are frequently perceived as having no legitimate rights to urban services.

In the system used in British Columbia, the importance of assessing the 'policy environment' was also stressed (Frankish *et al.*, 1996). The intention was to find indicators that measured the very presence of a healthy public policy. The process consisted of:

- the identification of social organisations and institutions engaged in policy-making;
- the identification of policy-making processes and outcomes;
- a description of policy directions; and
- analysis of past, present and future trends.

This process provides an opportunity to identify health-protection agencies and to consider their past, present and future capacity, capability and jurisdiction.

The role of institutional factors in the improvement of household environments is discussed by McGranahan (1992).

COMPLETING THE ASSESSMENT

The analysis seeks to gather information under the headings discussed above. The results can then be summarised in a matrix, such as Figure 4. This matrix provides a useful summary of the assessment for readers who do not wish to examine the details. It should be supported by summary paragraphs and these, in turn, should be supported by detailed evidence.

The evidence gathered will vary considerably in quality. A recent health assessment (Will *et al.*, 1994) separated evidence into four classes, as follows:

- calculable—strong, easily quantifiable relationships that can be precisely calculated, such as relative risk;
- estimable—strong relationships where impact can be estimated in percentage or rank terms;
- definite but not measurable—relationships that can be described but not measured; and
- speculative—observed or theoretical relationships which are at present unproven or for which the biological mechanism is unclear.

A different approach to evidence was used in a method referred to as comparative risk assessment (Brantly *et al.*, 1997). The method distinguished different levels of reliability in the evidence and sought to determine whether a potential environmental-health problem was significant. If both the environmental cause and the public-health outcome were documented then the evidence was considered to be good. If, however, only one or the other was documented, the risk might exist but the conclusion could be reached with less confidence. *See also: comparative risk assessment (page 131).*

Implementation

The third and final component of the management process consists of the implementation of health safeguards and mitigation measures. These are sometimes referred to as health-risk management (Birley, 1995). Affordable solutions are frequently available. Programmes often fail because of weak government-implementation capacity, market imperfections, and lack of inter-sectoral collaboration. In this section we focus on safeguarding health in natural-resource development projects.

Health-risk management is first and foremost about prevention and about seeking opportunities within the project to safeguard and enhance human health. It is not simply about

providing extra services such as health care, health education, and more medicine. In many cases, modification to project plans and to operating or maintenance procedures will simultaneously improve the efficiency and sustainability of the project and safeguard human health. Box 6 provides examples of environmental-management measures that have been used effectively to control vector-borne diseases.

There are many opportunities for health-risk management and they can be grouped according to whether they place responsibility with the individual or the society. In many cases, a societal component is required to balance that of the individual. For example, avoidance of traffic injury is not only the responsibility of the driver; the need for safer vehicles is widely accepted. Shortage of resources in developing countries sometimes dictates a transfer of responsibility from society to the individual: malaria control has shifted from mass spraying to individual use of bednets; and single disease-control programmes have been replaced by horizontal approaches that depend on the support and empowerment of local communities. Passive measures that do not require the active and continued co-operation of the community have to be included in project designs. Examples include infrastructure that prevents the accumulation of waste water and contact with contaminated water, traffic regulators, pollutant-emission controls and new agro-chemical formulations.

Risk-management techniques employed at societal level include the following, in order of priority:

- avoiding or eliminating the risk, by prohibiting the use of a substance or activity, such as control of agro-chemical imports;
- regulating the use so as to reduce adverse health effects, such as by zonation;
- reducing vulnerability of people by using personal protective devices, such as helmets, masks and boots;

Box 6. Examples of environmental measures for the control of vector-borne diseases

Malaria and yellow fever control were essential for the success of the Panama canal project at the beginning of the 20th century. Control was achieved by simple drainage, filling and screening measures. At the same time, sub-surface drains helped control malaria in Malaysian plantations. More recently, manipulation of reservoir levels has been instrumental in controlling malaria in America, while spillway redesign has helped control the blackfly vector of river blindness in Africa, drain improvements have helped control urban filariasis in India, and house inspection has helped control dengue fever in Singapore.

- developing mitigation and recovery procedures after the event, such as medical centres and emergency services; and
- instituting schemes to reimburse and redistribute losses, such as insurance.

In order to be effective, health-risk-management measures must also be socially acceptable to the community, reasonably costed and of proven efficacy. The agencies responsible for implementation must be specified and the capacity, capability and jurisdiction of these agencies must be sufficient to undertake the task. The community's own perception of health risk

is likely to be different from, and more important than, that of the outside observer. For example, a study of slum dwellers in India identified flooding as a primary concern (Anon., 1996a). Action taken by the municipal government to control flooding included installation of covered drains. Paradoxically, this increased the risk, as the community could no longer monitor the water level and have warning of potential flooding.

The emphasis should be on health opportunities and not only impacts. Each project can strengthen and be strengthened by the incorporation of measures that contribute positively to human health.

Chapter 4

Energy Efficiency

-
- Indoor air pollution from burning biomass fuels is an important cause of respiratory illness, heart disease, eye disorders and low birthweight.
 - Little is known about the occupational health problems of workers using biomass fuels in cottage industries.
 - Burns and scalds are a hazard of using poorly designed cooking stoves.
 - Muscular and skeletal industries are associated with long-distance portorage of fuelwood.
 - Malnutrition is associated with loss of land for subsistence crops, to fuel crops.
 - Fossil fuels are responsible for much ambient air pollution.
 - Hydropower reservoirs promote vector-borne-disease transmission, pollute downstream drinking water, and may disrupt fish stocks.
 - See Table 17.
-

Introduction

Provision of energy has many direct and indirect benefits to health. For example, electricity is used in refrigeration of food and medical supplies, including vaccines, and fossil fuel is used in fertiliser manufacture to enable increased food production. There are several major reviews of the negative health impacts of the energy sector (World Health Organization, 1983, 1992a; Cooper Weil *et al.*, 1990; Smith, 1993). The following four priority areas were identified:

- indoor air pollution from biomass and coal combustion (respiratory diseases associated with air

pollution have become as important as diarrhoeal diseases as major sources of morbidity and mortality);

- exposure of large urban populations to high levels of ambient air pollution;
- serious injuries associated with extraction, storage and power generation; and
- global climate change (outside the scope of this review).

Respiratory ailments are strongly associated with fuel use and energy efficiency. An energy ladder is recognised in which cheaper fuels are more polluting. As income increases,

Table 17. Summary of health linkages to energy use

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Biomass fuels	Indoor air pollution	Indoor air pollution	Petroleum substitution	Occupational injury during collection and use
Fossil fuels	-	Indoor and outdoor air pollution	-	Occupational, explosion
Water reservoirs	Vector-breeding sites, water pollution	-	-	-
Power lines	-	Potential proximity cancer risk	-	-

people tend to move up the energy ladder. However, there is a time lag during which they tend to continue to use the same cooking fuels as when they were poorer.

Research on fuel efficiency has not always aimed to reduce pollution. In the period 1984–1994, some 1.3% of spending in sub-Saharan Africa was devoted to improving efficiency of cooking stoves but it was done for ecological not health reasons (Listorti, 1996a). There is a widespread agreement that a more integrated approach is required that considers improvements in kitchen conditions more generally, and this should include indoor air pollution as well as stove improvement (Figure 5 on page 93).

There are a number of linkages between fuel and food preparation. Food vendors may extend their cooking times and hence their exposure to air pollutants. Working women may shorten their cooking times, producing under-cooked foods that are less safe.

NRI commissioned a review of energy utilisation in peri-urban production systems (Anon., 1996e). The following points from that review are pertinent:

- energy expenditure occupies a prominent place in poor households and the poorest households tend to spend a higher proportion of income on energy (e.g. in Kenya, very-low-

income communities spent 30% of their income on food and 10%–30% on fuel);

- fuelwood is a preferred source of energy for a range of social and dietary reasons;
- households under energy stress employ a range of management strategies which affect their nutrition and food safety;
- energy transitions are not unidirectional and, under economic pressures or fuel shortages, people may revert from commercial fuels back to traditional fuels. Fuel use can show seasonal variation. Purchased fuel is supplemented with gathered fuel. The energy transition can be represented by two crossing histograms, similar to the health transition: traditional energy sources decline and modern energy sources increase in the transition from rural to more urban;
- different fuels are not equally useful for the same purposes (e.g. wood stoves may focus heat more effectively on cooking pots than kerosene stoves);

- women dominate household energy collection, production and use in the peri-urban environment but gender issues have received little attention;
- an increasing percentage of time available is spent on fuel gathering because of increasing scarcity; and
- transportation systems for moving fuels from the rural fringe to the urban fringe are sometimes poorly developed (a transport transition model was proposed similar to those of energy and health transitions).

Biomass fuels

INTRODUCTION

Biomass fuels are the primary fuels for most domestic users in poor communities. They include wood, logging wastes, animal dung, and crop residues. Wood for fuel is one of the safest crops to grow with wastewater because it minimises the danger of contamination with pathogens or hazardous chemicals. However, there are important health hazards associated with the collection and burning of biomass (World Health Organization, 1992c). These include the respiratory disease caused by smoke and the eye disease caused by intense heat as well as smoke. One solution is to improve cooking stoves and kitchens to reduce indoor air pollution. The WHO set an agenda for this purpose, which included epidemiological research, dissemination and social studies, but little of this agenda has been completed (N. Bruce and other key informants, pers. comm.).

Work on improving biomass stoves has been on-going for many years, primarily for environmental and economic reasons. In recent years more attention has been placed on health but few studies have been funded. Improved cooking stoves may reduce particulate concentrations by 50% but only to levels which are still substantially higher than those commonly considered as acceptable (N. Bruce, pers. comm.). Acceptable levels may be reachable with well-made, installed and maintained stoves but there is

insufficient research-based evidence. The levels of PM_{10} around open fires are greater than $1000 \mu\text{g}/\text{m}^3$. Improved stoves may reduce the level to $500 \mu\text{g}/\text{m}^3$, or even to $80\text{--}150 \mu\text{g}/\text{m}^3$ following careful installation. However, morbidity effects may still be detectable at levels of $30\text{--}50 \mu\text{g}/\text{m}^3$.

A recent research proposal (N. Bruce, pers. comm.) seeks to establish a relevant resource centre and to promote better links between natural-resource and health researchers. It identifies priorities in health and implementation research. Key health-research issues are:

- obtaining more robust evidence of the causal association between indoor air pollution and pneumonia in young children and low birthweight;
- quantifying the effect, on key child and adult health outcomes, of reducing exposures across the range of achievable exposure levels; and
- developing simple, inexpensive, and valid measures that can be used to assess the health impacts of different exposure levels.

Key implementation-research issues are:

- assessing the applicability of measures to assess the health impacts of exposure in a range of settings;
- further research on emissions and the fuel efficiency of interventions; and
- evaluating integrated, community-based approaches to improving kitchen environments.

A key informant at FAO suggested that, in addition to domestic air pollution, relatively little work has been done on the occupational health and safety of workers in cottage industries, other industries, and institutions that use biomass fuels. Industrial examples include brickmakers and ceramic factories while institutions include schools and hospitals. The Intermediate Technology Development Group also has an active interest in cooking stoves and indoor air pollu-

tion. In an unpublished review, members of this group discussed the relative costs and benefits of chimneys versus hoods and summarised their own work in this field. The members of the group do not appear to have a peri-urban focus at present.

COMMUNICABLE DISEASES

Presence of indoor air pollution from biomass fuels is a risk factor for acute respiratory infection (ARI) in children. For example, baby girls in The Gambia who were carried on their mothers' backs during cooking were found to have six times higher risk of ARI than those who were not (WHO, 1992). The World Bank (1993) attributed 50% of the burden of disease in poor countries to indoor air pollution. Most of this was through acute respiratory disease in children and chronic obstructive lung disease in adults.

NON-COMMUNICABLE DISEASES

Exposure to smoke causes respiratory and eye irritation and associated diseases such as:

- chronic obstructive lung disease;
- heart disease (especially cor pulmonale which is secondary to lung disease);
- low birthweight (due to maternal exposure), which is associated with a range of perinatal and infant ill-health;
- eye disorders (conjunctivitis, blindness); and
- lung cancer (due to long term exposure to smoke; Mutere, 1991, Smith, 1991a).

Women and infants are the most vulnerable groups. Household cooking on an open fire has been described as the largest single occupational health problem of women in the world (Smith, 1987; World Health Organization, 1992a). Measurements in the kitchens of Indian villagers indicated particulate levels 100 times above recommended standards, and levels of a

carcinogen equivalent to smoking several packets of cigarettes per day (Leitmann, 1991). The results of a study in Nepal in 1986 indicated that improved cooking-stoves were effective in reducing the cook's exposure to health-damaging particulates by approximately two-thirds. The stoves also reduced carbon monoxide concentrations in kitchens by three-quarters, in comparison with neighbouring kitchens with traditional cooking-stoves (Mutere, 1990). In a recent study in India, Dutt *et al.* (1996) observed better lung function in women using fuels other than biomass fuels.

Urban (and peri-urban) poverty may reinforce exposure to pollution at the household level. The results of a study in Rio indicated that the poor do not have access to less-polluting technologies (Leitmann, 1991). The poor may pay far more for fuel than the more wealthy. They also live in areas more affected by industrial or traffic pollution. The total pollutant emissions from one large, remote, fossil-fuelled power station may be less than the pollution from a large number of small, woodburning plants (Leitmann, 1991).

INJURY

Biomass stoves are often at floor level causing injuries, especially burns to children, and jeopardising food hygiene (World Health Organization, 1992a; Listorti, 1996a).

Fuelwood often has to be transported long distances on heads and backs promoting occupational injury. For example, between 1966 and 1981 the distance travelled in northern Uganda to find fuelwood increased from an average of 0.9 km to 4.4 km (Hamilton, 1984). Women are specially vulnerable.

MALNUTRITION

Petroleum substitute fuels are produced by the fermentation of food crops such as sugar cane, cassava, corn and sweet sorghum. Sugar cane is the most efficient in terms of net energy yield. The large scale use of such crops to produce fuel could seriously deplete the food supply in local

communities. Even crop residues could be more valuable to local farmers as a soil conditioner than fuel produced from the residues. Removal of large quantities of biomass from a given locality will produce changes in soil, forestation, groundwater recharge, surface run-off and aquatic biota that could adversely affect the productivity of fisheries and farms (Lee, 1985, Leitmann, 1991). This degradation casts an 'urban shadow' over the peri-urban areas, especially along transportation routes (Leitmann, 1991). However, a Zambian study suggested that only 12% of woodland clearing could be attributed to fuelwood, the majority was converted for cropland.

A study in India suggested that the energy cost of collecting fuelwood, water and other domestic chores represented one third of a woman's daily energy expenditure (Cooper Weil *et al.*, 1990). In several African cities, poor families have to spend 20%–30% of their income on charcoal, reducing the sum available for food purchase (Harrison, 1987).

Fossil fuels

Coal is promoted as a household fuel to reduce the effects of deforestation. But coal tends to produce more air pollution.

NON-COMMUNICABLE DISEASE

Fossil fuels (coal, gas, and oil) account for most of the global industrial energy sources. The health hazards of fossil fuel use can be classified according to time of onset of the potential illness or disability or according to the stage in the fossil fuel cycle. The long term mutagenic and carcinogenic effects are the most serious and most uncertain.

The pollutants emitted by the combustion of fossil fuels have an impact on the health of nearby communities and are also dispersed over large areas. They include sulphur dioxide, nitrogen dioxide, carbon monoxide, particulate matter, ash and carbon dioxide. Carbon monoxide accumulates in buildings when combustion chambers and exhaust ducts are not properly sealed. It impedes oxygen transport in the human body leading to neurological, physiological and

cardiovascular impairment. Nitrogen dioxide impedes respiration. Oxides of nitrogen react with hydrocarbons to produce photochemical smog that causes eye irritation and acute respiratory disease. In London, 1952, when the atmospheric concentration of sulphur dioxide and suspended particles exceeded 1000 µg/m³ the total daily mortality rate doubled. Similar effects have been reported from Japan (World Health Organization, 1979b). A rapid increase in upper respiratory infection was reported in the vicinity of a new coal-fired power station at Batangaas, Philippines (Anon., 1990). In China, burning high fluoride content coals contributes to endemic fluorosis affecting large populations (Anon., 1991a).

High concentrations of sulphur dioxide and particulates increase respiratory disease and can increase mortality. Hydrogen sulphide exposure is an occupational hazard and in high concentrations causes acute intoxication and eye ailments (World Health Organization, 1981). In Mexico, 1950, an oilfield flare malfunctioned releasing hydrogen sulphide; 320 people were hospitalised and 22 died (World Health Organization, 1981).

The relative health risks of coal- versus oil- based electricity generation are complex. The occupational risks of deep coal mining are well established and include injuries and respiratory disease. The by-products of coal and oil processing include chemicals that can cause skin tumours and dermatitis. The ash residue from coal burning contains concentrated toxins such as heavy metals. The emissions from coal-fired plants are harder to contain than those from oil-fired power stations. Small to medium-sized power stations are more dangerous to the immediate population than large ones because they have lower stacks.

The emissions from petrol or diesel engines are an important source of air-borne pollutants and contribute to photochemical smog. Urban air pollution from burning fossil fuels regularly exceeds the health-related guidelines established by WHO in over half of the cities that are monitored (World Health Organization, 1992a). Burning domestic fuel generates about half of Delhi's air pollution, according to one

estimate. Some cities in Central and Southern Africa suffer from thermal inversion smogs made worse by the extensive use of wood and coal for domestic purposes. In southern Africa these smogs are associated with the spread of tuberculosis and other respiratory diseases (Meakins, 1988).

INJURY

Noise and vibration are occupational hazards of power plants that affect general well-being, hearing and vision. The transportation of fuel by road and rail increases the risk of traffic crashes and collisions. Fires and explosions are hazards of fuel combustion in power stations. Burns and scalds may occur at various stages of the process. Gas-pipeline explosions killed 508 people in São Paulo, Brazil, in 1984, and 58 people in Mexico in 1978 (Covello and Frey, 1990). Gas released in a tank explosion in Mexico, in 1984, left 452 dead, over 4000 injured, and 300,000 requiring evacuation (LaDou, 1992).

Water reservoirs

Reservoirs constructed in peri-urban areas are likely to be for domestic water supply rather than hydro-power generation, although both are possible. There are important health hazards associated with the large bodies of water that are stored, diverted and discharged during dam construction and operation. Land-use changes occur and many people are resettled, with health consequences. *See also: labour mobility and resettlement (page 114)*. Large construction projects such as dams entail occupational injury, while drowning of children can be a cause for concern when the reservoir fills.

COMMUNICABLE DISEASE

The communicable diseases most often associated with reservoirs are malaria, schistosomiasis and onchocerciasis. Large engineering projects involving rivers have frequently led to explosive malaria epidemics during construction. The main cause is the increase in water-filled excavations and diversions. Erratic downstream flows pro-

mote stream-pool breeding of mosquito vectors while spillways, in some regions, support breeding of the blackfly vectors of river blindness. The natural flow in the upper reaches of the Mahaweli river, Sri Lanka, was interrupted by dams and diversions. Stream pools, in which malaria vectors bred, formed in the dry river-bed. A reservoir of infection was created by human circulation between lowland resettlement sites and riverine villages (Wyesundera, 1988).

Mosquitoes which transmit malarial parasites often breed in the shallow, sheltered margins of reservoirs. However, there is much variation between regions. In Africa, malaria-mosquito breeding is also associated with draw-down that exposes numerous puddles on gently sloping shores. In Asia, downstream pools in the river bed tend to be more important. A small dam was built to regulate flow to the Edea hydro-electric plant in Cameroon. The shallow waters behind the dam soon contained abundant vegetation and larvae of the mosquito *Anopheles funestus*. The prevalence of falciparum malaria was high in surrounding villages and decreased with distance from the lake (Ripert and Raccurt, 1987).

Schistosomiasis and, to a lesser extent, dracunculiasis are commonly reported hazards of reservoir construction. The large reservoirs usually associated with hydro-power have many sheltered, shallow inlets where aquatic vegetation thrives. An increase in schistosomiasis has been observed across most of SSA where water development has taken place. Informal settlements of fishers are frequently vulnerable. The increases in prevalence have often been dramatic and the intense haematuria in children has caused public alarm (Hunter *et al.*, 1982). Urinary schistosomiasis was locally of low prevalence before the Akosombo Dam was built in Ghana. The reservoir attracted some 150,000 lakeside residents and there was an explosive increase in prevalence. Prevalence of the disease fell rapidly with distance from the lake shore, due to decreasing dependence of the lake for water needs (Hunter *et al.*, 1982). In Asia, by contrast, schistosomiasis is contained within small endemic foci and dam development has often proceeded without outbreaks of the disease.

In South-east Asia and countries of the former U.S.S.R., *Opisthorchis* (human liver fluke) infection is associated with reservoir construction (World Health Organization, 1992a).

Reservoir outflow is often polluted by decomposing plant material. Pollution reduces access to potable water for downstream communities that rely on the river, promoting transmission of water-borne diseases. Reduced stream flows alter the replenishment rate of aquifers, affecting domestic water supply, and promoting saline intrusion on to irrigated lands. Reduced nutrient flows disrupt fisheries and reduce food

security. When groundwater rose in Lower Egypt, as a result of the Aswan Dam, wastewater disposal was disrupted and aquifers became polluted (Egboka *et al.*, 1989).

Power lines

There is current concern about the effects of electromagnetic radiation from high-tension power lines, but little conclusive information. Exposure to electromagnetic fields may increase the risk of some cancers, in particular leukaemia, lymphoma and nervous-system tumours (World Health Organization, 1992a).

Chapter 5

Crop-production Intensification

- The most direct link between peri-urban agriculture and health is via nutrition. Promotion of subsistence crops is likely to benefit the nutritional status of the poorest people.
- Agricultural intensification, especially of cash crops, introduces health hazards such as poisoning from agro-chemicals, injuries from machinery, posture and physical demands, and communicable diseases associated with surface water.
- Changing labour practices can lead to loss of livelihood, subsistence crops and within-household entitlements to food, and hence to malnutrition.
- Changing labour practices can reduce the time available for child-care, including cooking, feeding and social interaction, and so increase childhood malnutrition, infection and injury.
- Peri-urban agriculture often uses hazardous waste products that contain pathogens and poisons that affect occupational safety.
- Food crops may be contaminated by chemical uptake from air, water or soil media that affect consumers.
- Pesticides are often misused and there is scope for reducing their use.
- There are uncertainties about the effectiveness of post-harvest decontamination of food crops by washing, cooking or other treatment. Post-harvest processes can themselves be hazardous.
- The waste products from agriculture can be hazardous, contaminating air, soil and water media.
- See Table 18.

Introduction

An extensive review of agriculture–health linkages identified four components of agriculture in which health impacts can occur (Lipton and de Kadt, 1988; see also Table 18):

- inputs, such as land, water, agro-chemicals, draught power and labour;
- technologies (hydraulic, mechanical, biological and post-harvest);

Table 18. Summary of health linkages to crop production

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Urban and peri-urban agriculture	Animal husbandry, vector-breeding sites	Agro-chemicals	Increased food supply	-
Choice of crop	Vector-breeding sites	Agro-chemicals, plant poisons, bio-accumulation of poisons	Loss of subsistence, inappropriate crops	-
Agricultural labour	-	-	Loss of subsistence crops	Postural injuries, heavy labour and carrying
Mechanisation	Loss of alternative hosts for vectors	Noise	Loss of income	Heavy and fast-moving machinery
Agricultural processing industries	-	Dust- and mould-induced lung disease, and eye and skin irritation	-	-

- structures of work and ownership (including assets, customs and laws); and
- outputs (such as choice of crop, food safety).

The agricultural-nutrition chain constitutes the main set of links between agriculture and health. The objective of agriculture ultimately is not production but improved nutrition. Agricultural projects in urban areas can be major determinants of food intake, energy requirements for work, and susceptibility to some infectious diseases. Children's health is particularly affected by the interaction of malnutrition and infection. Healthier farmers and workers may be more productive and more careful. Yet health considerations play little or no part in most decisions either by farmers about production or by government about agricultural policies.

Future increases in agricultural production will mainly come from further intensification of agricultural production on land that is already devoted to crops and livestock. This intensification could cause adverse environ-

mental changes such as water logging, salinisation and groundwater contamination, which all have associated health impacts.

The agricultural changes that affect health can be grouped into three categories (Ruttan, 1994):

- changes in specific agricultural techniques are likely to have a single main health effect. Examples are the introduction of a new piece of machinery, a new fertiliser or a new pesticide. The consequences include occupational injury and poisoning. Work-related injury is a particular area needing more analysis. These events can be monitored using survey techniques.
- changes in farming systems are likely to have many complex and indirect health effects. An example is a shift from subsistence to cash crops. The impact may be non-specific, by increasing or reducing the

distribution of disposable income (Cooper Weil *et al.*, 1990). There may be increased incidence of pre-existing local diseases.

- changes in land and water-resource use are likely to affect vector-borne diseases. Examples include the creation of irrigation projects and deforestation for agriculture. Land-use changes may alter the breeding sites for vectors of malaria, schistosomiasis, Japanese encephalitis, sleeping sickness and leishmaniasis.

Urban agriculture

It is estimated that 25%–100% of urban food demand is met through urban horticulture, aquaculture and livestock production. Of particular importance are perishable foods, which benefit from short transportation and storage times between harvest and market. Urban and peri-urban agriculture includes both formal and informal scales of production and diverse locations. Between 25% and 80% of urban families may be engaged in some form of urban agriculture. Most farmers practising urban agriculture are poor and farming on land which they do not own. Urban agriculture is considered to be a contributor to sustainable development, providing an economic method of recycling urban solid waste and domestic wastewater. Urban agriculture also has a role to play in the improvement of living conditions in urban slums. It converts derelict land to productive use and provides an incentive to collect and re-use organic wastes as fertiliser or irrigation water. It may also provide the incentives for infrastructure development.

Many international organizations have urban agriculture programmes, including DFID, USAID, IDRC, GTZ, the World Bank and many NGOs. For example, IDRC have a strong interest in urban agriculture through the Cities Feeding People programme. One current project is assessing peri-urban agricultural production on available land and co-ordina-

tion with re-use of waste in Santiago de los Caballeros in the Dominican Republic (Anon., 1996f).

The special problems of urban agriculture include the following:

- lack of policies and regulation, or inadequate institutional frameworks, means most cities do not manage urban agricultural activities to ensure environmental protection, health and safety;
- there is limited access to agricultural inputs such as wastewater, solid waste and land; and
- political and socio-cultural biases mean that planners view urban agriculture as an inappropriate activity to take place in cities, and it is often banned.

Urban agriculture is being vigorously promoted at present, through the activities of the urban agriculture network and others (Smit *et al.*, 1996). For the purposes of this review, no distinction need be made between peri-urban and urban agriculture. The benefits and disbenefits of urban agriculture are only relevant to this review in so far as they have either a direct or indirect linkage to human health. Some of the negative health linkages, listed by Smit (1996), are as follows:

- malaria associated with cereal crops (but see below);
- infections caused by contaminated food sold in unregulated markets;
- tuberculosis from cattle;
- trichinosis and swine 'flu' from pigs;
- compost attracting rats which may be reservoirs of diseases such as plague;
- hepatitis and heavy-metal poisoning from fish;

Box 7. Urban agriculture in Harare

The report of an ODA-funded study of urban agriculture in Harare contains a number of observations related to health impact (Bowyer-Bower and Drakakis-Smith, 1996). Two kinds of cultivation were investigated: home gardens with leafy vegetables and tomatoes; and illegal plots on public land with maize and groundnuts. The main concern of the study was the effect of cultivation on soil and biodiversity. Field measurements indicated a reduced rainfall infiltration rate of 28% and a 3.5-fold increase in surface run-off, leading to increased flooding and reduced groundwater recharge. The large surface flows and rainfall impacting on bare soil produced considerable soil movement, which blocked surface and underground drains. During the dry season there was an increase in wind-borne soil. A range of pesticides and fertilisers was used in the cultivation. Crops produced were consumed by cultivators or marketed.

Communicable diseases

There were no references to communicable diseases such as malaria and enteric infections; Harare is at a relatively high altitude and malaria transmission is limited. The report indicated a high level of destruction of maize crops by slashing, possibly as a malaria-control measure. The report does not indicate whether increased surface pooling resulted from cultivation practices. Tap water was used to irrigate home gardens whereas illegal crops depended on rainfall. There was no indication of water storage. Blockage of drains from whatever means tended to lead to standing water. Mosquitoes could breed in this water: either *Culex quinquefasciatus* (if the water is heavily contaminated with organic materials) or the vectors of malaria (if the water is relatively unpolluted but muddy). There was some use of organic and artificial fertiliser but no reference to the use of nightsoil or sewage that could contaminate leafy vegetables with enteric pathogens.

Non-communicable diseases

The report suggested that there may be a link between increased dust levels, eye irritation and asthma. It also recommended further research on the following health hazards which have implications for poisoning:

- agro-chemical run-off into the surface water bodies used for domestic purposes;
- heavy-metal and toxic-chemical content of crops cultivated on land polluted by industrial effluent (especially in a valley beyond an industrial area);
- lead-uptake from vehicle fumes in crops grown along transportation routes.

About 40% of respondents used pesticides in their home gardens, except for those in the poorest groups. On illegal plots less than 10% used pesticides. The methods of use, storage and disposal of pesticides were not discussed.

Malnutrition

For almost 25% of those interviewed, some 60% of food consumed came from self-production. The report recommended further studies on the nutritional gains to households from consuming their own produce.

Injury

Small hammer-mills for grinding maize had proliferated with the rapid increase in urban agriculture and were used by both maize purchasers and sellers. Such technology is likely to ease the burden of manual maize pounding and be beneficial. There is an associated problem of occupational injury from poorly guarded machinery.

Psychosocial disorders

There were several factors which could be associated with loss of well-being, insecurity and stress. Many of the interviewees had lost part of their crops due to slashing or stealing and there were intra-urban differentials. Loss rates were much lower in low-density suburbs. The report noted important reductions in recreational open space and loss of biodiversity, especially of the large animals valued for their aesthetic qualities. The report mentions an increasing crime rate, with mature maize crops provide hiding places for muggers. Such a link is unlikely to be causal, as muggers could find alternative locations, but may further reduce the sense of well-being. The institutional response to urban agriculture appeared to be generally unsupportive.

- heavy-metal and other poisoning from vegetables grown close to industries;
- insecticide poisoning from intensive use on vegetables;
- water pollution from animal remains;
- infection and pollution from informal slaughtering;
- agricultural waste and chemicals polluting water supplies and soils;
- insecticidal sprays causing air pollution;
- planting on roadsides increasing traffic accidents; and
- wandering domestic animals increasing traffic accidents.

Many of these health concerns are discussed elsewhere in this review. As Smit suggests, once the concerns are identified, appropriate solutions can be sought. Many of these hazards carry a similar risk in both rural and urban environments. The list above is clearly incomplete and it should be noted that there are many other zoonoses and vector-borne diseases associated with a range of crops. *See also: vector-borne diseases (page 23), and zoonoses (pages 31 and 83).* Overall, the potential negative health impacts of urban agriculture seem to have received little attention among its promoters.

In many parts of Africa the production of cereals such as maize has been prohibited in cities for many decades, because of an irrational fear that the plants breed the mosquito vectors of malaria (see Box 7). A more recent reason for prohibition is that tall crops provide hiding places for criminals. Intentional violence and criminal behaviour may be regarded as a public-health issue, and an analysis of the benefits of crop destruction versus crop promotion, in changing the prevalence of criminal behaviour, would be instructive. Although malaria is generally considered to be a rural problem in sub-Saharan Africa, it occurs in towns and cities where pockets of

countryside are incorporated through urban agriculture. During the dry season many towns and cities practice irrigated agriculture. As detailed elsewhere in this review, agricultural practices which require the diversion and storage of surface water can promote the breeding of mosquitoes and disease transmission. *See also: vector-borne diseases (page 23).* Whether or not the associated surface waters are suitable for the breeding of malaria vectors will depend on the cleanliness of the water. Frequently such water may be too polluted. Vector breeding is a serious issue and it can be largely prevented by environmental management (Figure 6 on page 93). The proponents of urban agriculture need to be informed about appropriate environmental management.

Urban agriculture has a potential to contribute to the food and nutritional requirements of many urban and peri-urban communities and is promoted for this purpose. Smit (1996) discusses this production in terms of nutrition, food security and health benefit, especially for the very poor. He cites examples that indicate that the children of urban farmers have a better nutritional status than those of non-farmers who have similar or even higher incomes. Social benefits include community well-being and employment opportunities. For example, in Dar es Salaam, urban agriculture was the second largest source of employment after petty trading and labour. Smit (1996) suggests that poor urban farmers can contribute substantially to improving the environmental-health conditions of their neighbourhoods through their activities. For example, about 27% of all garbage in Khartoum is said to be consumed by urban animals, and mature garbage dumps in Calcutta produce substantial quantities of vegetables.

Table 19 provides a useful overview of the nature of urban farming systems in which health linkages must be sought.

Table 19. Urban and peri-urban farming systems (Smit, 1996)

System	Product	Location or technique
Aquaculture	Fish and seafood, vegetables, seaweed, fodder	Ponds, streams, cages, estuaries, sewage, lagoons, wetlands
Horticulture	Vegetables, fruit, compost	Homesites, parks, rights-of-way, roof-tops, containers, hydroponics, wetlands, greenhouses
Livestock	Milk, eggs, meat, manure, hides, fur	Zero-grazing, rights-of-way, hillsides, coops, open spaces
Agroforestry	Fuel, fruit, nuts, compost, building materials	Street trees, homesites, steep slopes, vineyards, greenbelts, wetlands, orchards, forest parks, hedgerows
Other	Houseplants, medicines, beverages, herbs, flowers, insecticides	Ornamental horticulture, roof-tops, containers, sheds, beehives, greenhouses, rights-of-way, urban forests

Choice of crop

COMMUNICABLE DISEASE

Rice cultivation is nearly always associated with an increase in malaria. However, as transmission of malaria in sub-Saharan Africa is sometimes already at saturation level, increases in vector breeding may have no effect. The irrigated fields in some areas of West Africa are colonised by a mosquito subspecies that appears to be a poor malaria vector (Service, 1989b). However, the reduction observed in malaria prevalence in these areas may also have been associated with changes in human behaviour. There is a succession of different mosquito species in rice fields, as sun-loving species are replaced by shade-loving species when the rice grows. The large amounts of fertiliser and pesticide used with HYVs may deter certain malaria vectors.

There is a range of communicable-disease hazards associated with irrigation of food crops using wastewater in the peri-urban environment. (Figure 7 on page 93). *See also: recycling and waste re-use (page 89).*

NON-COMMUNICABLE DISEASE

There are special occupational hazards associated with particular crops (Ghosh *et al.*, 1979; Nag Anjali, 1986). The agricultural tasks associated with these crops may tend to be gender-specific. For example, women may be employed for tea and tobacco picking. Teapickers are exposed to high levels of pesticides used in tea growing. Tobacco cultivation is very labour intensive and requires labour in short-duration peaks, which disrupts employment patterns and child-care (Brott, 1981).

Certain varieties of crops, such as cassava, contain toxins. Promotion of these varieties may be associated with a real risk of poisoning among consumers. Production and consumption of the grass-pea is increasing in India, Ethiopia and Bangladesh. Over-consumption of improperly cooked grass-pea leads to lathyrism, a neurotoxic disorder, common in young men (Haimanot *et al.*, 1990). The grass-pea is especially tolerant to drought, poor soils and pest attack. It can be intercropped and is useful for nitrogen fixation. These characteristics make it attractive to poor peasants, especially during times of stress. In an Ethiopian study, consumers were aware of its toxic potential but found it preferable to starvation (Haimanot *et al.*, 1990).

In a recent review, Listorti (1996a) suggested that pesticide hazards appeared to receive less attention than low-level hazards such as pollution by nitrates. He also pointed out that malnutrition had received far more attention than contamination of the food chain.

MALNUTRITION

Food security means physical and economic access to food for all people at all times. Lack of food security is associated with poor nutritional status, particularly in young children (Dearden and Cassidy, 1990; Payne, 1990). The malnourished child is more susceptible to communicable disease. Food insecurity is a concrete manifestation of poverty that may be more meaningful than income levels.

Changes in household food security and nutritional status can occur, for example, when projects affect food production, food availability, purchasing power and workload. Urban and peri-urban agriculture is considered an important way of improving nutrition for the urban poor. The produce is used directly and indirectly by the household to obtain food and income. However, not all low-income households benefit equally from food-production activities. Cash from high-value vegetable crops may be controlled by male members of the household, who do not use it for the benefit of the elderly, women and children. Transitory food insecurity can be associated with seasonal shortages or, for example, a shift from subsistence to cash crops.

The type of crop grown is also important in terms of nutritional benefits. Crop-development programmes may neglect staple root crops and coarse grains in favour of high-protein or fine-grain export crops. Promotion of export crops (often associated with structural adjustment programmes) may adversely affect production of food crops through competition for productive resources, but the available evidence is mixed (Cooper Weil *et al.*, 1990). Changes from subsistence to cash crops may reduce the income or security of vulnerable groups, reduce the production of

foods for home consumption or increase the price of purchased foods so that income may be insufficient to buy food in local markets. Crops with a high value, high yield and high protein content may represent a health hazard to poor farmers by paradoxically increasing malnutrition (Lipton and de Kadt, 1988). Such crops may not meet the needs of poor people for the following reasons. The poor need:

- subsistence rather than cash crops;
- extra energy rather than extra protein;
- reliable yields rather than high yields;
- stable market demand rather than extreme price fluctuations; and
- varieties that are resistant to drought and disease and easy to store, and that require limited labour.

The effect of cash-crop production on income and nutrition is mixed, as the following examples illustrate (Fleuret and Fleuret, 1980; Fillmore and Hussain, 1984; Longhurst, 1988).

- Change from subsistence to cash cropping is usually accompanied by a reduction in crop diversity. The simplification of traditional diets can lead to nutritional imbalance and increasing malnutrition.
- In Kenya, sugar production was significantly associated with malnutrition, as was a switch from traditional weaning foods to commercialised food substitutes (Fillmore and Hussain, 1984).
- Smallholder tea growing in Kericho district, Kenya, was associated with a serious reduction in home-produced food (Fillmore and Hussain, 1984).
- A positive change in nutritional status was observed on a paddy-rice development scheme in Sri

Lanka. It was noted that rice was a traditional crop which had cultural and nutritional importance in the community. The scheme provided a surplus of the traditional crop which could be stored, against seasonal fluctuations, or sold (Holmboe-Ottesen *et al.*, 1989).

- The nature of the land and the market may ensure a more stable employment (and hence food purchase) from an export than from a staple food crop, in the case of plantation crops such as tea.
- In Africa, it has been suggested that change to modern varieties of crops may be less harmful than no change at all (Lipton and de Kadt, 1988).
- The poor usually obtain more of their sustenance from vegetables than from animals. Animal-development projects may divert land from producing staple crops and reduce the food supply of the poor.

One of the main problems of urban agriculture for the poor is insecurity of land tenure. Much urban agriculture occurs on unused land to which farmers have no legal rights. There is a constant risk that loss of land and crops could occur at any time, with devastating effects on livelihood (Dennery, 1996). A strategy of poor urban people is to grow and sell high-value vegetables which have a short growing cycle on land for which they have transitory access, and to use the profit to buy low-value staples which could not be produced on the same land.

INJURY

The cultivation, harvesting and processing of crops may expose workers to a range of injury hazards that are crop-specific. *See also:*

agricultural labour and its effects on health (page 70) and mechanisation and agriculture (page 70).

Bio-accumulation of pollutants

Contamination of crops with heavy metals and the process of bio-accumulation in the food chain is cited as an important health problem (Smit *et al.*, 1996). The extent of the problem and the validity of solutions proposed are unclear and require further research. Trends in research and policy have included:

- increasing concern about effect of soil contamination on sustainable agriculture;
- inhibition of the activity of soil micro-organisms by various heavy metals;
- concentrations of heavy metals in sewage sludge and the different guidelines adopted in North America and Europe; and
- use of plants as bio-accumulators of heavy metals.

Contamination may occur through the air or from soils and irrigation waters. Air-borne deposition of heavy metals is frequently associated with road traffic and can substantially effect plant yield (Hassan *et al.*, 1995). Aerosol-deposited lead particles, however, do not penetrate plant cuticles (Alloway, 1995) and most surface deposits on leaves can be substantially reduced by washing (World Health Organization, 1995a).

There is considerable variation of rate of root uptake according to plant species, soil type and element (Alloway, 1995). Much of the literature on plant uptake is primarily concerned with deliberate extraction, in order to decontaminate soil (Kumar *et al.*, 1995; Watanabe, 1997). Varieties of *Brassica juncea* take up relatively large amounts of lead, chromium, cadmium, nickel, copper and zinc. The same plants can be grown in hydroponic beds and used to extract heavy metals from aqueous streams (Dushenkov *et al.*, 1995). A report on the human risks from contaminated

lands in the U.K. is under preparation (C. Ferguson, Environmental Agency, pers. comm.). It focuses on the assessment of risk to those working on or living on contaminated lands or consuming garden produce grown on those lands. High concentrations of metals occur near urban complexes, metalliferous mines and major road systems and we may be experiencing a silent epidemic of environmental metal poisoning (Alloway, 1995).

Several hazardous pollutants are associated with road traffic but it is unclear whether respiration or ingestion is the most important exposure pathway (Mage and Zali, 1992; World Health Organization, 1995a). Lead appears to have received most study. A Chinese study concluded that uptake of lead by ingestion of contaminated food was far more important than respiration. In the study area, a high percentage of children in rural (perhaps peri-urban) villages had clinical symptoms of lead poisoning and elevated blood levels, compared with urban children. Lead concentrations in cereals and beans were higher than in vegetables. A study of bus drivers in Bangkok observed most lead absorption from food, probably purchased from street vendors and kept uncovered. Air and water media were far less important (World Health Organization, 1995a). It has been suggested that a boundary crop should be planted beside roads (Smit *et al.*, 1996). However, Israeli and Japanese studies found little associated contamination (World Health Organization, 1995a).

Lead is a cumulative poison and has been widely monitored. Concentrations of lead and cadmium are much higher in the livers and kidneys of vertebrates and in crustacea and molluscs than in crops or milk (Anon., 1992a). The conclusion from a survey of global literature was that elevated levels of lead in children were more common in urban than non-urban communities, when industrial hot-spots were excluded, and that levels of lead in the air shared a similar pattern (Anon., 1994b). There was also a correlation with soil and dust levels. Studies in Nigeria revealed high levels of lead in the dust from unpaved roads. Other sources of contamination were edible fish, from rivers and streams contami-

nated with industrial waste, and cooking salts from springs polluted by nearby mines. Important sources of lead in Mexico include the ceramics industry, which uses lead glazing.

Agro-chemicals

More than 1000 chemical compounds, biological and physical agents are used around the world as insecticides, fungicides, herbicides, rodenticides, fertilisers and antimicrobial compounds. They have been responsible for substantially increasing food production and also in the control of some important human diseases such as malaria and typhus. However, these agro-chemicals also cause a wide range of health problems, varying from straightforward, topical-irritant reactions to complex systemic illness, which can have both acute and chronic clinical effects (O'Malley, 1997). Peri-urban horticulture uses large quantities of fertilisers and pesticides that are largely unmonitored. These penetrate waterways and food chains, posing a threat to the health of farmers and consumers, and may cause problems of pesticide resistance in disease vectors. The inactive ingredients in pesticides, such as petroleum distillates, may also have harmful effects on human health.

Key-informant concerns included pesticide residues on horticultural produce. It was suggested that cooking denatures pesticides but it is not known if this is correct.

The urban-agricultural interface provides a wide range of potential exposure pathways such as occupation, environment and consumption (O'Malley, 1997). Examples include inadequate storage in the house, re-use of pesticide containers, poor mixing techniques, contamination of water or air, unintentional exposure during work, and failure to use protective clothing (World Health Organization, 1992a). Three important forms of exposure are occupational, intentional (suicide) and non-occupational.

Poisonings occur despite control measures, because of widespread agro-chemical misuse. Estimates from WHO indicate that, world-wide, 3 million people annually suffer

ill-health from single, short-term exposure to pesticides. Of these, approximately 1 million are serious unintentional poisonings and 2 million are suicide attempts involving pesticides, resulting in 220,000 deaths (World Health Organization, 1986).

Unintentional acute and chronic pesticide poisoning is an occupational hazard of agricultural workers. It is a growing and serious problem, but poorly documented (Loevinsohn, 1987; McCracken and Conway, 1987; Pingali and Marquez, 1990; Stephens *et al.*, 1995b). The level of risk of exposure to chemicals is usually higher in intensive farming and horticulture than in traditional farming (World Health Organization, 1992a). This is of particular relevance to peri-urban agriculture.

Some 50 million people have regular contact with pesticides and 500 million have less regular contact. The latter may be particularly at risk because they will usually be less well informed of the hazards. A disturbing trend is the unrestricted use of highly toxic organo-phosphates such as methyl parathion and monocrotophos. Many older and more toxic pesticides are still available in stores and market places in developing countries. Their cheap price makes them attractive to smaller farmers, who may buy them and so circumvent donor policy. This may be of particular concern in smallholder agricultural development.

There is also an unknown number of domestic animal deaths from pesticide exposure.

COMMUNICABLE DISEASE

A major setback in the use of pesticides for public health has been the development of resistance in many disease vectors. Field-breeding mosquitoes are one of the non-target organisms affected by widespread pesticide use. Cross-resistant strains are selected which are then difficult for the public-health sector to control. The prevalence of malaria may then increase. This problem could be reduced if some categories of insecticide were reserved

for public-health use, as has happened in Sri Lanka. However, such schemes are difficult to regulate and do not overcome the problems of cross-resistance.

NON-COMMUNICABLE DISEASE

Poisoning can cause both non-communicable disease and injury. For convenience, we discuss all forms of agro-chemical poisoning in this section.

Fatality rates vary from 1%–9% in cases presenting for treatment, according to the level of health services available. Additionally, over 700,000 people a year are thought to suffer from the chronic effects of long-term exposure. The scale and nature of such effects may be under-estimated. The symptoms of pesticide poisoning may be incorrectly ascribed to other causes.

Acute pesticide poisoning has received more attention than the chronic effects of exposure. The acute clinical effects of pesticide poisoning are very varied. For example, organo-phosphates can cause a range of acute symptoms including diarrhoea, nausea, central-nervous-system excitation, irritation of the skin and upper respiratory tract, decreased pulse rate leading to dizziness and collapse, headache, memory impairment, and loss of sensation (Rosenstock *et al.*, 1990; Amr *et al.*, 1993; Stephens *et al.*, 1995b). Other pesticides can cause convulsions, cognitive impairment, liver and kidney impairment, lung fibrosis and coma (O'Malley, 1997).

Loevinsohn (1987) provided circumstantial evidence of increased mortality among adult males in intensive rice-production systems in North Luzon, Philippines. The results of detailed studies at the International Rice Research Institute (IRRI) in the Philippines tended to confirm the evidence of chronic poisoning (Pingali and Marquez, 1990). The studies questioned whether the benefit of the extra crops produced was higher than the cost of the additional ill-health. IRRI re-iterated the

need for integrated pest management and have developed more pest-resistant strains of rice to reduce pesticide use.

Chronic illness has also been associated with long-term direct exposure to pesticides and to pesticide residues in foodstuffs, including red meat, poultry, vegetables and eggs, due to concentration of agro-chemicals in the food chain (Forget *et al.*, 1993). Residues are found in human milk and the levels ingested, particularly by nursing infants, are often many times greater than the internationally acceptable daily intake (Food and Agriculture Organization, 1988).

PUBLIC AWARENESS

Many surveys of pesticide use identify lack of knowledge and improper practices as the main causes of poisonings (Forget *et al.*, 1993). Low levels of literacy and of education, with poor access to training, increase the risk of pesticide poisoning. Pesticide is often applied by itinerant, unskilled, unsupervised operators. It is still common to observe storing, mixing, application and disposal without adequate safety precautions. Protective clothing of the type used in developed countries is too expensive and unsuitable for hot countries. Poor access to water and soap for decontamination is a further risk factor. Operatives frequently eat, drink and smoke during spraying operations. Aerial spraying of insecticides often contaminates operatives, casual bystanders and local fauna, resulting in serious levels of exposure, especially to compounds of the organo-phosphate type.

Lack of knowledge of pesticide toxicity may not completely explain dangerous application practices. Although the results of studies described by Forget *et al.* (1993) indicate that many farmers are not aware of the dangers of poisoning, a recent survey in Ghana found that the majority knew pesticides were poisonous to humans (Yvon, 1997). Despite this awareness, very few farmers used protective clothing or masks when applying chemicals. Many did not worry about protecting their skin and mixed the solutions with

their bare hands, even though they all had suffered minor skin irritation and respiratory difficulties after spraying. There is a need to develop cheap protective clothing suitable for tropical climates and to improve pesticide-application technology by developing better formulations, with increased specificity, and safe, simple application equipment to complement farmer education and training. In horticulture there are believed to be many opportunities to reduce the amount and frequency of spraying, although it may be over-optimistic to suggest that use of pesticides can be eliminated entirely.

NON-OCCUPATIONAL AGRO-CHEMICAL POISONING

Unintentional mass poisoning with agro-chemicals is dramatic but rare. It occurs when people consume treated grains or contaminated stored produce. In Iraq some 6,350 people were admitted to hospital and more than 459 died after they had eaten bread prepared from cereals treated with methyl mercury fungicide (Bull, 1982). Food contaminated with the organo-chlorine endrin has also caused several clusters of illness (Rowley *et al.*, 1987).

Unintentional poisoning due to the use of pesticide containers as cooking utensils or for water storage and collection is also a major hazard. Such empty containers are often sold, to poor people, in the markets. Poor labelling may cause people to ingest insecticide by mistake. Insecticide taken as sugar in Dar es Salaam in 1974 caused 28 hospitalised deaths (R. H. Meakins, pers. comm.).

Pesticide residues in locally grown vegetables are frequently far in excess of the acceptable limits. Green leafy vegetables are especially at risk (Conway and Pretty, 1991). Many species of wild food, including fish, molluscs, crustacea, insects and vegetables, are harvested among cultivated crops. Such foods are especially important for the poor. Pesticides may either remove or contaminate such foods. Foods exported to the European Community, including fruits, fish and meats,

are rejected at the port of entry if they contain higher residues of pesticide than locally-grown produce.

Pesticides, particularly herbicides, have been found in drinking water. High levels of chlorinated hydrocarbon pesticides have been reported in water in Colombia, Malaysia, Thailand and Tanzania (World Health Organization, 1992a).

The global use of nitrogen fertilisers has increased exponentially since the Second World War. Much of the recent increase has been in developing countries and in support of high-yielding varieties of cereals. Most fertiliser is lost to surface and groundwater, finding its way into drinking supplies. There is a documented risk that nitrates may be converted to nitrites in the human gut, through the action of bacteria (Conway and Pretty, 1988). Nitrites bind to haemoglobin, impairing the transport of oxygen. The potential risk is greatest in bottle-fed infants and gives rise to the blue-baby syndrome. At present the condition is rare but there is concern for its future increase. *See also: pollution of water by agriculture (page 69) and nitrates and nitrites (page 103).*

Nitrogen and phosphate contamination of drinking-water reservoirs can stimulate the production of harmful toxins by blue-green algae (Turner *et al.*, 1990).

Increased use of urban solid waste as a fertilising material is a realistic alternative to use of chemical fertilisers in peri-urban areas, and is dealt with under the section on waste recycling and re-use (page 89). It has been suggested that there should be co-ordination between waste-management agencies, local authorities and local farmers, to set up systems for sustainable waste management which can provide a reliable supply of urban waste to near-urban farmers (Lewcock, 1995).

Integrated pest management systems

Effective pest management is essential for small-scale farmers. However, pesticides and alternative approaches suitable for developed

countries often do not work in the developing world. Alternatives to chemical pesticides have included plant breeding for resistance, biological control, microbial pesticides, botanical pesticides, and integrated pest management (IPM). Farmers' attitudes to pests and pest management are also important. Despite knowledge of the harmful effects of chemical pesticides, farmers continue to use them. Constraints to the introduction of non-chemical techniques for pest management include land availability and land ownership. The use of chemical pesticides is widespread and almost universal during production of vegetables for external markets. Farmers in Ghana felt that they would rather purchase chemicals on credit than run the risk of not spraying and having crop failure (Yvon, 1997). Considerable support may be required to develop alternative risk-reduction strategies for agriculture, and the health benefits may provide an incentive.

The prospects for IPM totally replacing pesticide use in mixed vegetable crops are regarded as poor (J. Mumford and C. Crissman, pers. comm.). Improved safety will have to depend on new formulations of existing products, improved application strategies, and better farmer education. There is general agreement that pesticides are often over-used. There is plenty of room for reduction in use, through farmer education, and this will have associated health benefits. Some recent plans for IPM research are outlined in Box 8.

Pollution of water by agriculture

Agriculture is the largest consumer of water resources, and agricultural run-off, to surface or groundwater, contains high concentrations of salts, nutrients and agro-chemicals which contribute to the deterioration of water quality. Not only does use of untreated wastewater represent a health hazard that may be disseminated by agricultural production but increased use of agricultural inputs, such as pesticides and chemical fertilisers, has led to unprecedented chemical loads in water bodies (Food and Agriculture Organization, 1993).

Box 8. Research plans for IPM

An IPM research programme for peri-urban vegetable production is planned (Anon., 1996g). More intensive production is required, but pesticide misuse is recognised as an increasing concern. The programme plans to survey pesticide poisoning, contamination and misuse in a number of West and Central African countries. None of these countries is believed to monitor health effects or keep records of poisoning. The proposal expresses concern about unwanted pesticide dumping by donor countries as part of aid donations. There is diversion of subsidised cotton pesticides to vegetables. Other familiar problems reported were pictograms not understood, insecure storage in living areas, inadequate protection, contamination, poor disposal, poor hygiene, re-use of containers, misuse as fish and bird poisons, misuse as public-health insecticides, and substantial residues in market vegetables. It was suggested that farmers understood acute poisoning but not chronic poisoning (through gradual build-up). Concern was expressed about the privatisation of extension services, as the private sector may not have the technical expertise to protect the public health. The proposal surveyed the research activities of a range of donors and institutions; few referred to human health.

The definition of a water pollutant is any living organism, mineral or chemical whose concentration limits the beneficial use of water. Agricultural activity may contribute three types of pollutants:

- suspended solids (e.g. from soil-erosion processes);
- living organisms (e.g. through irrigation with untreated wastewater and use of compost); and
- agro-chemicals (e.g. pesticides and fertilisers).

Ventura Napa (1992) showed that poor disposal of organic waste and use of wastewater for agriculture lead to biological

contamination of groundwater in Peru, with numbers of coliform bacteria exceeding the WHO's recommended limits. Infiltration of untreated wastewater used for agriculture can also cause high concentrations of nitrates in groundwater, although the significance of this, compared with that of nitrate contamination due to excess fertiliser use, is not clear. The results of a study on nitrate pollution of groundwater in Gaza in 1995, looking at fertilisation practices and public water supply, indicated that, in many areas, the nitrogen already dissolved in the groundwater from waste percolation was more than enough to cater for the needs of agriculture and that any additional nitrogen fertilisation was unnecessary (M. Gischler, pers. comm.). *See also: nitrates and nitrites (page 103).*

There is a growing need to preserve water quality in a sustainable way, without adversely affecting agricultural production, and the following procedures have been advocated (World Health Organization, 1992a; Ongley, 1996):

- establishment of systems to monitor the quality of water to be used in agriculture;
- prevention of adverse agricultural activities;
- minimisation of adverse effects from agricultural chemicals, by use of alternative pest management strategies; and
- education of communities about the pollution impacts of the use of fertilisers and chemicals on water quality and food safety.

Agricultural labour and its effects on health

INJURY

Occupational health is an important issue in tropical agriculture but it has been neglected. In their review, Rainbird and O'Neill (1993) subdivided the occupational disorders of agriculture into three categories:

- disorders associated with the use of pesticides [*see also: agro-chemicals (page 65)*];
- disorders associated with biomechanical and postural demands; and
- occupational diseases.

The poor postures and heavy physical demands associated with agricultural tasks in the tropics are a major cause of musculo-skeletal injuries, although there has been little research on the extent of such disorders in developing countries. The two most important aspects are spinal loading and the repetitive movement of the same part of the body over extended periods of time (i.e. 'repetitive strain injuries'). Rainbird and O'Neill (1993) quote several examples of musculo-skeletal problems, including back pain from using sickles and short-handled hoes, and tenosynovitis among tea pickers. Each of the different methods of water carriage (on the head, the hip or the back) is also associated with a variety of negative biomechanical effects which can cause asymmetric posture, abnormal curvature of the spine, and arthritis of the spine and hips. Rainbird and O'Neill (1993) call for a survey on the incidence of work-related over-use disorders, to identify the tasks and tools with which they are associated, and to determine their effect on productivity.

Occupational injuries are an important cause of ill-health in agricultural labourers. For example, very high rates of injury are reported among sugarcane workers as the result of their use of heavy machetes (Phool Chund, 1991). Although only 21% of the employed inhabitants of Uganda were en-

gaged in agriculture in 1987, they accounted for 33% of all occupational injuries (Sekimpi, 1992). Traditional agricultural hazards accounted for 5% of time spent off work by casual rural labourers in India (Lipton and de Kadt, 1988).

MALNUTRITION

Landless agricultural labourers are a vulnerable group because of their low and unstable wages and low levels of employment (Lipton and de Kadt, 1988). They may, for example, be unable to purchase sufficient food during the slack season. The high energy requirements of manual labour may exceed the energy levels of food intake.

Women gain mixed benefits from agricultural labour. The extra income may provide extra food but the type of work may be incompatible with child-care. As men move out of the fields and into the cash economy, women's role in subsistence production has increased. The replacement of subsistence crops by cash crops often has a direct effect on women. As a woman's workload is increased she may have less time to care for her family or to attend health clinics; her children's exposure to diseases, malnutrition and injuries may consequently rise.

Mechanisation and agriculture

COMMUNICABLE DISEASE

The reduction of livestock associated with a switch to mechanised agriculture has been associated with malaria outbreaks when the vector switches to feeding on a human host (Ault, 1989). Mechanisation may increase the number of rice crops that can be grown during the year and extend the malaria transmission season (Service, 1989b). Increased mechanisation may also reduce the transmission of vector-borne diseases. Larger, more fertile fields and improved drains reduce breeding

sites. Schistosomiasis may decrease as a result of decreased water contact (World Health Organization, 1992a).

MALNUTRITION

Agricultural mechanisation may increase the demand on women for low-productivity and physically demanding work. At the same time, it may reduce the male workload and increase male control over the processes. Even where labour-saving technologies have been introduced for traditional female work, they have sometimes been handed over to male control (Rogers, 1981). This decreases the income of women and their food security, re-inforces their position as unable to manage machines, places strains on their nutritional resources, and reduces the time and energy they have for child-care and food preparation. Introduction of a mechanical rice husker in Bangladesh, controlled by men, removed one of the few income-generating options open to poor rural women (Greeley, 1987).

Reducing labour-intensive occupations and displacing labourers can lead to reduced food security for vulnerable groups. The shift in Asia from increasing draught power to tractors usually displaces labour without increasing output. This shift is often encouraged by providing credit or by subsidising fuel and tractors. Cost of tractor hire/use is so great in smaller fields that it drastically reduces family income from land, especially in regions of high unemployment, and results in food scarcity, as in the case of most of Lesotho (R. H. Meakins, pers. comm.).

INJURY

The frequency of traumatic injury is likely to increase with mechanisation. Tractors are well known as an important cause of agricultural injuries. They are unstable because of their need for high ground clearance. Adults and children living in rural areas of developing countries often have very little appreciation of the dangers associated with these vehicles.

Most farm injuries in the U.K. are also associated with machinery (Conway and Pretty, 1991).

An extensive study in India identified the causes of agricultural injuries. Although spades and sickles were most commonly implicated, severe injuries were associated with the use of poorly designed machines including fodder cutters and threshers; 45% of fodder-cutter injuries were sustained by children (Mohan *et al.*, 1992).

The high noise levels associated with agricultural machinery may induce hearing loss as well as stress and behavioural problems (World Health Organization, 1992a)

Agricultural processing industries

In addition to the general range of occupational hazards of industry, including injury and noise, there are some specific health hazards of agricultural processing industries. These hazards are associated with non-communicable disease.

NON-COMMUNICABLE DISEASE

Commodities such as tea, coffee, sugar, jute and pyrethrum require processing in industrial plants. The processing plants expose labour to silica dust, a variety of allergens and spore contaminants that can cause or aggravate lung disease (Blanc, 1984; Yach *et al.*, 1984; Ye *et al.*, 1988). Women form a high and poorly paid proportion of such labour. There is evidence that the prevalence of chronic respiratory symptoms is higher in the female workers than the male, even though the women smoke much less (Zuskin *et al.*, 1979). Exposure to tobacco dust causes respiratory, skin, eye and gynaecological problems (Nag Anjali, 1986). Protective clothing is often not provided. Workers exposed to grain dust in South Africa had a high prevalence of irreversible loss of lung function compared with controls. There was also a high prevalence of cough, expectoration, wheeze and watery eyes in the grain workers. These

symptoms were not related to duration of employment or smoking habits (Yach *et al.*, 1984).

Rice millers in Malaysia suffer from acute and chronic irritation of the eyes, skin and upper respiratory tract, allergic responses such as nasal catarrh and asthma, and lung changes associated with dust-induced lung disease (Lim *et al.*, 1984).

A respiratory disease is associated with the handling of bagasse, the residual fibre of sugar cane after the juice has been extracted. This fibre is usually compressed and stored for drying. It is used for board and paper making. Fungi and bacteria grow in the bagasse and cause an allergic reaction. It is estimated that the disease develops in up to 50% of those exposed, although it can be prevented by modified storage of the bagasse (Phool Chund, 1991).

Textile processing produces large quantities of air-borne fibres that cause chronic lung disease, such as byssinosis in cotton workers. This can re-activate latent tuberculosis. In the cotton industry in Sudan, the prevalence of byssinosis is as high as 49% (Khogali, 1970); other respiratory symptoms are common, but no increase in tuberculosis has been reported (El Karim and El Hag, 1985). In Manchester, U.K., the prevalence of byssinosis was found to be much higher in cotton mills than in artificial-fibre mills (Fishwick *et al.*, 1990).

Kapok workers in Sri Lanka are reported to develop chronic bronchitis and mill fever. Paprika splitters and chilli millers are also known to develop allergic respiratory disease (Sekimpi, 1992).

Raw-silk processors are exposed to a dust derived from the gum which binds silk strands together. In Sri Lanka, occupational asthma was associated with the degree of exposure to this dust (Uragoda and Wijekoon, 1991). In China, pneumoconiosis has also been reported in silk workers (Liu Tie-min, 1990).

Large quantities of water are used in agricultural processing, and organic contaminants may be discharged into surface waters that are used for domestic supply. Post-harvest processing of agricultural produce can cause more severe river pollution than discharge of raw sewage (Agarwal *et al.*, 1981). The effect of discharges on downstream communities and on fish is seasonal. Much produce is processed during the dry season when temperatures are highest and river flow rates are lowest (Cairncross and Feachem, 1983).

Many of the Colombian population derive drinking water directly from rivers. These rivers were often highly polluted by discharges from the coffee, sugar and paper industries. A system of fining was introduced and this has encouraged producers to recycle some of the waste (Agarwal *et al.*, 1981).

Chapter 6

Fisheries

- The major link between aquaculture and human health is through nutrition (Table 20). Small-scale aquaculture can provide an important source of protein but large-scale, commercial enterprise can reduce access to this resource.
- Fish products can be affected by a wide range of non-communicable contaminants, including industrial chemicals and agro-chemicals, antibiotic residues, and toxic algal blooms.
- Microbial contamination of fishponds can occur by fertilisation with excreta and wastewater. Pathogens can pose a potential health risk to pond workers, fish processors and consumers.
- Fishponds can potentially create or increase breeding sites for the vectors of malaria and schistosomiasis.
- All fisheries can involve substantial post-harvest processing, which has a range of occupational health risks.
- There is a need for a food-quality standard for aquaculture produce, to ensure microbial and chemical safety of farmed fish.

Introduction

This section includes both fresh- and salt-water fisheries. Although we will briefly consider the effects of capture fisheries and coastal cities, the main aquatic resource issue at the peri-urban interface would appear to arise from increasing the productivity of small-scale systems for freshwater aquaculture.

Coastal management and human health

The coastal 8% of the world is home to 75% of the world's population and includes the poorest people on the planet (Verlaan, 1997). Most of the projected doubling of the world's population by 2050 is expected to be concentrated in coastal

cities (Food and Agriculture Organization, 1991). Coastal cities bear the cumulative burden of environmental stress, not only from overcrowding along the coast itself but also from upstream and inland development. Populations of developing countries derive between 40% and 100% of their animal protein from the sea, and seafood is an essential nutritional supplement to the mostly carbohydrate diet of the poor in Asia and Africa (Food and Agriculture Organization, 1991).

The principle anthropogenic threats to human health from capture fisheries are contamination by sewage, and pollution with chemicals and heavy metals.

Table 20. Summary of health linkages to fisheries

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Coastal capture fisheries	Domestic sewage pollution, occupational exposure to contaminated waters, post-harvest contamination	Occupational exposure to waters contaminated with chemicals, post-harvest contamination, toxic algal blooms, occupational exposure to allergens	Destruction of wild fish stocks	Sharp knives and machinery used for fish processing
Aquaculture	Vector breeding sites, water contamination with human and other excreta, consumption of infected fish, water contact, post-harvest contamination, antibiotic misuse	Poisoning by fish-culture chemicals, fish-harvesting poisons and pollutants, toxic algal blooms, occupational exposure to allergens	Destruction of wild fish stocks	Sharp knives and machinery used for fish processing
Integrated aquaculture	Mixing domestic animals and fish	-	-	-

Working in, bathing in, or consuming water contaminated by sewage leads to exposure to a variety of communicable diseases including ear, eye, skin infections, infectious hepatitis, poliomyelitis, *Salmonella* and *Shigella* infections, campylobacteriosis, cholera, typhoid, meningitis and pneumonia. Seawater pollution by chemicals and heavy metals leads to exposure to various non-communicable diseases.

The destruction of coastal and estuarine fisheries as a result of water pollution from cities has been widely documented (Rossi-Espagnet *et al.*, 1991). Examples include Lake Maryut in Egypt, the Gulf of Paria, Manila Bay, the Bay of Dakar and the Indus delta.

Aquaculture

Aquaculture refers to the practice of fish culture (notably *Tilapia* and carp) and the growing of certain aquatic plant crops such as water spinach, water chestnut, and duckweed.

World-wide fish production from aquaculture amounts to about 14 million tonnes annually, of which nearly 90% comes from inland habitats and approximately 90% is based

in Asia. There are many different forms of aquaculture from small-scale, subsistence, fish farming to intensive, commercial operations, practised in a variety of settings including brackish ponds, reservoirs, rice paddies, integrated fish-livestock farms and wastewater-fed fish-ponds. The majority of inland aquaculture in the tropics is concerned with low-value finfish species and is mostly pond-based (Beveridge and Phillips, 1993). Peri-urban aquaculture tends to be based on small-scale, semi-intensive or extensive pond systems or intensive fry nurseries (J. Turnbull and S. Adams, pers. comm.).

All fisheries can involve substantial post-harvest processing: gutting, peeling, slicing, canning, freezing and cooking. This carries a range of occupational health risks. All aquacultural schemes have interactions with other development projects and cause changes to the environment that have a range of potential health impacts on local people. The main public-health issues of developing-world aquaculture are water-borne diseases, toxic algal blooms, the microbial safety of the farmed aquatic produce, and trace environmental contaminants.

A Codex Alimentarius standard on aquacultural food is under preparation by the FAO and an expert consultation at FAO on the use of chemicals in aquaculture is to be published. Priorities for safe production systems for fish have not yet been established and there is a need for epidemiological studies.

COMMUNICABLE DISEASE

Two main areas of concern are pathogens from wastewater re-use and creation of vector-breeding sites. *See also: recycling and waste re-use (page 89) and Table 10 (page 32).*

Excreta and organic waste re-use in aquaculture

The fertilisation of aquaculture ponds with human and other animal wastes has occurred for thousands of years in Asia, and it is believed that approximately two-thirds of the total yield of farmed fish is obtained from ponds fertilised with excreta (Mara and Cairncross, 1989; Edwards, 1992). Traditional methods of fish culture in Asia employ a wide variety of organic inputs. Such re-use systems include overhanging latrines, faecally polluted, surface water, cartage of urban nightsoil to aquaculture ponds, and sewage systems.

Excreta-related diseases are very common in developing countries and so potential threats to public health from excreta re-use in aquaculture must be minimised. There is ample evidence that excreta and wastewater contain high concentrations of excreted pathogens (bacteria, viruses, protozoa and helminths) which can potentially cause at least 30 diseases of public-health importance (Feachem *et al.*, 1983). Fish, fish products and fishponds can easily become contaminated with these pathogens, which may affect workers, processors and consumers. However, aquacultural use of excreta and wastewater is only a potential risk to health, and will only result in actual health risks, if all of the following occur:

- either the infective dose of excreted pathogen reaches the pond or the pathogen multiplies in the pond to create an infective dose;

- the infective dose reaches the human host;
- the host becomes infected; and
- the infection causes disease or transmission of disease.

There are three main potential health risks associated with the aquacultural use of excreta and wastewater (Feachem *et al.*, 1983):

- passive transfer of excreted pathogens by fish and cultured aquatic macrophytes;
- transmission of trematodes whose life-cycles involve fish and aquatic macrophytes; and
- transmission of schistosomiasis.

Most aquacultural systems using raw sewage or primarily sedimented excreta do not appear to constitute a significant public-health hazard. Calcutta has the largest area of wastewater-fed fishponds in the world. There is a low potential risk of disease transmission to consumers because trematode infections are not endemic to West Bengal, the ponds are emptied and cleaned each year to remove the bottom mud and vegetation, and the fish are consumed well-cooked (Mara and Cairncross, 1989). However, there have been few good epidemiological studies on human-waste re-use in aquaculture, to see whether these practices actually cause significant increases in disease. Blum and Feachem (1985) reviewed the epidemiological evidence for disease transmission associated with aquacultural use of excreta and wastewater. They found clear evidence for transmission of certain trematode infections in excreta-fertilised aquaculture, principally clonorchiasis and fasciolopsiasis. However, they found no reports of studies dealing with occupational exposure to schistosomiasis (although this disease is still considered a major health risk for aquaculture workers) and no conclusive evidence for passive transference of excreted pathogens (particularly of bacteria).

A broader range of epidemiological studies is required before valid statements of the actual health risks of waste-fed aquaculture can be made. However, there is evidence that excreted

pathogens can survive for a sufficient length of time to pose a potential health risk to pond workers, and in some cases survival times are long enough to pose potential risks to fish processors and consumers (Mara and Cairncross, 1989). A realistic appraisal of the potential health risks could provide a basis for microbiological criteria for excreta and wastewater used for aquaculture. The transmission of the trematodes causing clonorchiasis and fasciolopsiasis occurs in very restricted areas of Asia, where the cultural preference is for eating raw fish and aquatic vegetables (Feachem *et al.*, 1983). The transmission can only be prevented by changing eating habits, ensuring that no eggs of the parasites enter the fishponds, or by controlling the intermediate snail host. The appropriate quality guideline for all excreta and wastewater to be used for aquaculture is the absence of all viable trematode eggs. The WHO's guidelines for the microbiological quality of treated excreta and wastewater for aquacultural use are zero viable trematode eggs and less than 1000 faecal coliform bacteria/100 ml (World Health Organization, 1989). These dated guidelines reflected judgments based on the best epidemiological evidence available at the time. The results of one epidemiological study in Indonesia subsequently indicated that aquacultural use of water meeting these guidelines could still be associated with childhood diarrhoea (Blumenthal *et al.*, 1992).

The most effective way to prevent human infection from excreta and wastewater use is to kill the pathogens by treatment of the wastes according to the Engelberg guidelines. *See also: recycling and waste re-use (page 89)*. However, many developing countries lack adequate wastewater-treatment procedures. One alternative is to connect fishponds in series and avoid harvesting from the first pond. A stable phytoplankton community should be established before fish stocking and then wastewater should be added slowly. Loading of wastewater into fishponds must be suspended for 2 weeks prior to harvest, in order to eliminate *Cryptosporidium*.

Aquacultural produce can also be treated to remove pathogens. Fish should be held in clean water for 2 or 3 weeks prior to harvest, to permit them to evacuate their guts and thus

decrease their contamination with faecal microorganisms. Threshold concentrations of bacteria in fish muscle must not be exceeded.

The culture of molluscs in wastewater-fed systems is not advisable because of the propensity of these animals to accumulate large quantities of contaminants, both microbial and chemical. The pollution by human excreta of waters used for harvesting shellfish can be the source of many enteric infections. An epidemic of shellfish-borne hepatitis A in China in 1988 affected 292,000 persons and was related to the consumption of contaminated clams (World Health Organization, 1991c)

A fourth component of a safe system is control of all human exposure to pathogen risk, including that of aquacultural workers, processors and consumers. Schistosomiasis control, by treatment, snail control with molluscicides, local education about the precautions necessary in wastewater-fed fishponds, and provision of sanitation facilities, is one example.

The monitoring and evaluation of all of the relevant measures, including wastewater treatment, water quality, produce quality and disease incidence, need to be improved so that the actual health risks may be determined.

Other pathogens affecting the food safety of aquacultural produce

[*See also: food safety (page 110) and Table 10 (page 32).*] Quality control is essential to ensure the safety of aquatic produce during post-harvest preparation and processing. Contamination can occur at many stages (Figure 8 on page 94). After capture, produce must be cleaned, gutted, refrigerated and stored. For example, peeling of shrimps is the process which affords the greatest risk of *Salmonella* contamination (Pullin *et al.*, 1991). The principles of hazard analysis and critical control point system (HACCP) have been applied to aquacultural production, to control food-safety hazards (Reilly and Kaferstein, 1996). This permits a systematic approach to the identification, assessment and control of hazards and risks associated with the production, distribution and use of aquatic foods. The Food and Drug Administration estimated that the introduction of HACCP by fish processors in the United States

had averted some 20%-60% of the usual number of cases of seafood-borne illness. The FAO's Codex Alimentarius Commission is in the process of preparing a standard for aquacultural foods (R. Subasinghe, pers. comm.).

The habit of eating raw or partially cooked aquatic organisms and aquatic plants is increasing among some communities and it is associated with an increasingly high prevalence of parasitic diseases, particularly trematode infections. In Indonesia, eating raw or half-cooked seafood has resulted in an increase in anisakiasis (Cross and Murrell, 1991). The effects of cross-species transmission are also an issue, with integration of aquaculture into other forms of natural-resource management. Infection with *Clonorchis sinensis*, the Chinese liver fluke, is increasing in Taiwan, and the increase in the popularity of eating raw fish, the new policy of raising pigs close to local fishponds, and farmers eating the fish uncooked are considered responsible (Cross and Murrell, 1991).

Most of the food-safety hazards associated with products from aquaculture can be controlled by good fish-farm-management practices and appropriate consumer education regarding such risks as eating raw or partially cooked products.

Integrated aquaculture and the risk of influenza pandemics

Pandemics of human influenza A commonly arise by genetic re-assortment between human and avian viruses in pigs (Scholtissek and Naylor, 1988). It has been suggested that the increase in the integration of aquaculture with the keeping of farm livestock (including waterfowl) could result in a potential human health hazard, by bringing together the two reservoirs of influenza A viruses. These risks may not have been previously considered in the assessment of the health constraints of such integrated farming. One mitigation measure would be to develop aquacultural systems where pigs are enclosed separately from waterfowl or to discourage the farming of fish in conjunction with pigs and poultry. However, the inferred link between fish farming and human influenza pandemics may be overstated (Edwards *et al.*, 1988; Edwards, 1991). Pigs and poultry have been brought

together on traditional mixed farms world-wide for centuries, and there seems to be no reason why fish farming should pose a greater threat. Also, co-location of pigs and poultry to supply manure for aquaculture is uncommon. In most small-scale aquacultural developments, only one species of livestock is used on any one farm in a feedlot.

Vector-borne disease

Small dams are built for many reasons, including fish farming and water supply. They are often built informally, to low standards and to meet local needs, and are not recorded in any inventory. In Africa they provide breeding sites for the vectors of malaria and schistosomiasis. Although the mosquito vectors of malaria could breed in the fishponds of India and Pakistan, the waters may often be too contaminated. The health hazard represented by large numbers of small reservoirs is likely to be very great because of the total area and shoreline that they represent. In Nigeria, for example, the total surface area and shoreline of small impoundments are estimated to be 3.5-fold and 10-fold greater, respectively, than those of the reservoirs behind the large dams. There are between 10,000 and 20,000 farm dams in Zimbabwe, and some 50,000 small impoundments were created in just 3 years, during the late 1950s, in Nyanza province, Kenya (Jewsbury and Imevbore, 1988).

Fishponds become mosquito-breeding sites when they are poorly managed. Good management involves removal of surface and emergent aquatic vegetation, which provides shelter for mosquito larvae. Some species of mosquitoes, such as *Anopheles sudaicus*, *An. merus* and *An. melas*, are especially adapted to brackish water habitats. Consequently, coastal ponds can also become important breeding sites for mosquito vectors. Coastal fishponds and lagoons in Indonesia become important breeding sites for malarial mosquitoes when they are covered with an algal mat or abandoned.

Antibiotic resistance

In intensive and semi-intensive aquacultural systems, artificial feeds supplemented with antibiotics are used to prevent the spread of fish pathogens and to improve feed-conversion ratios.

Antibiotics are not commonly employed in peri-urban tropical-freshwater aquaculture, although they are used to treat broodstock in Asia (M. Beveridge, A. Adams and J. Turnbull, pers. comm.).

The use of antibiotics in aquaculture has caused an increase in resistance among many groups of important fish bacteria to a range of medicines (V. Inglis, pers. comm.). A study of antibiotic resistance in bacteria from aquacultural facilities in five countries in South-east Asia in 1993 showed that resistance to oxytetracycline was generally very high and that resistance to erythromycin and streptomycin was also common. Multiple drug resistance was widespread in Bangladesh and Thailand. There is little monitoring of the use of antibacterial agents in aquaculture, although a monitoring network has been established in South-east Asia (V. Inglis, pers. comm.).

Current knowledge of the health and environmental impact of antibiotic use in aquaculture is poor. The potential human-health hazard associated with the use of antibiotics in intensive fish production is a matter of current debate (see Table 21). Residues may remain in fish for human consumption. Antibiotics released into the environment can lead to the development of antibiotic-resistant bacteria elsewhere in the food chain. Abuse of antibiotics that are important in controlling human diseases (e.g. chloramphenicol used in human enteric infections) could facilitate the development of resistance in human pathogens. Some countries retain drugs exclusively for the use of humans, although the effec-

tiveness of this depends on the control procedures. Most aquaculturalists are not informed about the practice of rotating drug use to prevent the development of resistance (Pullin *et al.*, 1991). Antibiotic use can also lead to rejection of products in export markets, as many countries now refuse to import shellfish which have been treated with antibiotics.

Occupational infections and mycobacteria

A new health hazard for those working in *Tilapia* hatcheries in the Philippines has emerged with a change in breeding technique; the workers now spend longer wading in the ponds and suffer from more foot infections (Pullin *et al.*, 1991).

A particular occupational health problem for tropical-fish farmers in peri-urban areas is *Mycobacterium marinum*. This is a rare cause of skin infections in humans, following contact with contaminated water or fish. It is only pathogenic to humans on abraded skin, and has been associated with aquatic activities including fishing, keeping tropical fish, and swimming. It has been found world-wide but is an increasing problem in South-east Asia amongst fish farmers who breed tropical fish. A recent survey in Thailand found that 20% of Japanese fighting fish were infected (S. Adams, pers. comm.). In humans, infection causes multiple granulomatous lesions and systemic arthritis. Treatment involves a combination of antibiotics for at least 6 months and complete resolution may take several years (Edelstein, 1994). Without treatment, people may require surgery to remove the granulomas, which can lead to loss of limbs. This scale of medical treatment is often unavailable to peri-urban fish

Table 21. Potential effects on human health associated with the use of antibiotics in fish (Beveridge and Phillips, 1993)

Drug	Persistence of antibiotic residues	Potential risks for human health
Chloramphenicol	48-72 hours	Bone-marrow apalasia
Oxytetracycline	15-20 days	Digestive and hepato-renal disorders
Erythromycin	48-72 hours	Rare hypersensitivity reactions
Sulphonamide	8-15 days	Hepato-renal disorders, leucopaenia, allergy
Trimethoprim	48 hours-5 weeks	Hepato-renal disorders, leucopaenia, allergy

farmers. Simple preventive measures, such as the use of gloves or at least the washing of skin after contact with fish water, could reduce the incidence of infections considerably.

NON-COMMUNICABLE DISEASE/INJURY

Contamination by industrial and agro-industrial wastes

Water for aquaculture can be affected by a wide range of hazardous contaminants, including industrial chemicals, trace metals, pesticides, disinfectants, viruses, bacteria, phycotoxins, antibiotics and hormones. Pollution by industrial and agro-industrial wastes poses a particularly serious constraint to the safe use of wastewater for aquaculture.

There are few published data on the quantities of chemicals and drugs used in western aquaculture and even less is known about the types or quantities used in the tropics. The chemicals include compounds deliberately employed to improve productivity (lime, fertilisers), or to control pests and to treat and control diseases (pesticides, insecticides, herbicides, molluscicides, piscicides, and parasiticides). The effects on the environment and human health of many of these chemicals and others polluting wastewater are unknown. This lack of adequate information makes it difficult to determine whether a source of wastewater is appropriate for safe re-use in aquaculture. Those chemicals already known to be hazardous to human health include synthetic organic compounds such as polychlorinated biphenyls (PCB), petroleum hydrocarbons, pesticides and the heavy metals cadmium, lead, arsenic, mercury, selenium, tin and copper (Verlaan, 1997). There is little information about chemical persistence and bio-accumulation.

The few toxicological studies have addressed only short-term, fatal exposure. The greatest understanding of potential health risks often comes from studies of chemical contamination and food safety but this is non-predictive. Aquaculture water and the fish products need to be monitored for toxic chemicals and trace-metal contamination.

The most common chemicals used in aquaculture today are formalin, potassium permanganate, dipterex and Malachite Green. These are added directly to the ponds and cause environmental contamination but how hazardous this is to human health is again unclear.

Fish poisons such as phosgene-producing chemicals are frequently used to harvest fish and are potentially lethal to people if wrongly handled.

Toxic algal blooms

Marine fish and shellfish are susceptible to contamination by natural toxins produced by some algae. The problem is most acute when algal blooms, often called 'red tides', occur. Algal blooms are stimulated by sewerage discharges and by agricultural run-off enriched in nutrients such as nitrogen and phosphorous. The problem is world-wide and associated with both fresh and sea waters (Dunlop, 1991). Certain algae, dinoflagellates, that appear in red tides are harmful to human health. The algae kill fish and render molluscs and crustaceans toxic. Children are especially vulnerable because their toxic thresholds are very low. Some algae produce neurotoxins that can cause paralytic shellfish poisoning (PSP). PSP causes respiratory paralysis and death by asphyxia. Other dinoflagellates produce diarrhetic toxins that cause severe gastrointestinal disorders. Another group of dinoflagellates produces ciguatoxins and these are concentrated in the food chain and cause ciguatera in the humans who eat contaminated fish (Verlaan, 1997). Ciguatera has long-term debilitating effects on neurological, cardiovascular and gastro-intestinal functions. Fear of poisoning severely restricts fish exports from several island nations. Outbreaks also disrupt the tourist industry. Ciguatoxic biotopes can be created by development activities that disrupt reef systems; these include the construction of hotels, aircraft runways and wharves (Lewis, 1986). In aquacultural developments and marine capture fisheries, monitoring of harmful algal species is crucial for public-health purposes but should not replace the concomitant testing of produce for biotoxins.

Occupational diseases

Processing of seafood, particularly crabs, has been associated with increased prevalence of chronic obstructive airway disease among the workforce (Orford and Wilson, 1985).

MALNUTRITION

Households in existing or potential fish-farming communities are often impoverished and dependent on variable resources. Aquacultural development can cause economic shifts or changes in access to resources that may disturb basic household nutrition, especially in areas where agricultural land is limited.

In Ecuador, large areas of mangrove forest along the coast have been destroyed as entrepreneurs have constructed saltwater fishponds for shrimp farming. The displaced people have been marginalised and have lost their independent

food security. For a while some worked on the fish farms but the source of fry from the sea became exhausted and the fish farms failed. Meanwhile the area is no longer capable of producing food for the indigenous population (Anon., 1992b).

In river deltas, such as those of the Ganges and Brahmaputra in Bangladesh, annual flooding traditionally provides an opportunity for intensive fishing. The landless poor, in particular, derive a substantial part of their nutritional needs from their rights to fish the flooded lands. Development projects that are designed to restrict flooding can alter fish migratory routes and spawning grounds. Some common fisheries have also been taken over by commercial enterprises and stocked with exotic species such as carp, thus turning a capture fishery into a culture fishery. Both types of project reduce the access of the poor to fish as a common nutritional resource.

Chapter 7

Livestock

- There are many diseases that can be transmitted from domestic animals to people during production, processing or consumption.
- Wastes from livestock production can contaminate drinking water with pathogens and chemicals.
- International trade in livestock can introduce exotic diseases.
- Allergens from livestock can cause occupational diseases.
- Loss of land to livestock can deprive poor people of food.
- Animals can injure people.
- Use of antibiotics in livestock rearing can be hazardous to human health—resistant strains of bacteria can develop and drug residues are metabolised into many derivatives with unknown properties.
- Contaminants in feed can be transmitted via faeces or animal products.
- Tanneries use many hazardous chemicals and discharge them in wastes. There are also many occupational health and safety problems in tanneries.
- See Table 22.

Introduction

The FAO have a programme for peri-urban livestock production. The programme recognises a spectrum of production, from intensive and industrialised, through semi-intensive to subsistence (Bagust, 1996). Many systems are characterised by:

- scarcity of land for growing feed;
- dependency on delivery of feed from outside;
- utilisation of waste from households, restaurants, and industries, and of crop residues; and

- animal scavenging.

The problem of unpenned domestic animals wandering the streets and scavenging was also mentioned in a number of community surveys conducted by the Healthy Cities Projects (Rice and Rasmusson, 1992).

Veterinary public-health hazards of major concern are zoonoses transmitted through direct contact during the production process (see Box 11) or by ingestion of contaminated products. Pathogens may spread through contaminated drinking water and transmission may be enhanced by high densities of humans and other animals.

Table 22. Summary of health linkages to livestock

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Live animals	-	Inhalation of dusts and allergens	Loss of subsistence crops, loss of income	Noise, attacks, falls, crushing
Slaughtering	Inhalation of dust	Inhalation of dusts and allergens	-	-
Products	Unpasteurised dairy products, consumption of infected meat	-	Loss of subsistence dairy products	-
Drug residues	Misuse of antibiotics	Metabolites in animal products	-	-
Animal-feed contamination	Contamination by infected faeces of animal feeds and animal products	Agro-chemicals and hazardous chemical contaminants of feed	-	-
Wastes	Discharge into water supplies, application of slurries to land, contact	Heavy metals in slurries	-	-
Tanneries	Handling infected hides	Exposure to a range of process chemicals		Chemical burns, falls, machinery

Box 11. Slaughterhouses in Ho Chi Minh city

In 1996, the FAO commissioned a case study in Ho Chi Minh city (Bagust, 1996). The conclusion of the study was that the veterinary public-health situation was precarious. Meat inspection and hygiene standards were compromised by large numbers of small 'slaughter points'. Some 20 significant zoonotic diseases were known to occur. The most important of these were bovine tuberculosis, leptospirosis, rabies, trichinosis, bovine brucellosis and taeniasis. Data on the prevalence of these diseases were lacking. Potentially hazardous adulterants were quite commonly being added to meat, to make it look fresh. There were operational problems associated with each of the several quality-control mechanisms promoted to ensure food safety. Although there was a plan to relocate formal production and slaughterhouses in the city to a central peri-urban area, the associated impacts did not seem to have been closely addressed. A policy of deregulation appeared to have been pursued in response to free market economics but without consideration of the health impacts, clearly showing the need for a prospective health impact assessment of government (or municipal) policy. Institutional problems included poor linkages between the Public Health Department of the Ministry of Health, and Veterinary Services Department of the Ministry of Agriculture. The major recommendations made by Bagust (1996) were to obtain better prevalence data for the most important zoonoses, to improve inter-sectoral linkages, and to ensure proper impact planning of the relocated industries.

Table 23. Potential positive and negative health impacts of livestock development (Anon., 1979)

Activity	Positive effects	Negative effects
Animal health: vaccination programmes, dipping tanks, disease control	Increased availability of high-quality protein in the market area, improving human nutrition, animal health and marketability	Increased pressure on range resources, potential overgrazing, loss of ground cover. Improper use of chemicals, concentration of toxic substances in water, soil and food
Livestock water supply	Increased herd size and number as water-supply constraints ease, increased livestock survivorship, improved animal health	Increased pressure on range resources (expanded potential for overgrazing and subsequent decline in soil fertility)
Establishment of markets, slaughterhouses, storage and shipping facilities	Increased availability of high-quality protein in market area, improved nutrition, increased resistance to disease. attraction of merchants, more available cash, increased availability of commercial goods and services. Decrease in livestock disease because of dipping	Increase in zoonotic diseases due to meat processing: anthrax; brucellosis; bovine tuberculosis; cattle trypanosomiasis. Possible contamination of food and water supply. Overuse of sanitation facilities due to increased immigration, leading to increases in food- and water-borne diseases (dysenteries, typhoid, cholera, intestinal worms) and vector-borne diseases (malaria, schistosomiasis, trypanosomiasis)

In contrast to the FAO programme, NRI's own project on peri-urban livestock production does not appear to focus on animal health or veterinary public-health (Silverside *et al.*, 1996), although the Renewable Natural Resources Strategy as a whole has both animal-health and livestock-production programmes

Table 23, derived from a USAID report, represents an early attempt to compare some of the positive and negative health impacts of livestock development.

Communicable disease: zoonoses

The prevalences of several communicable diseases may be increased by the importation of exotic breeds of livestock or the intensification of livestock production. Three important bacterial zoonoses are anthrax, brucellosis and bovine tuberculosis. All are carried primarily by cattle, although they can be transmitted by a variety of animal hosts, including pigs, goats, dogs and wild species. The rate of infection in humans is directly correlated with the incidence of disease in domestic animals.

World-wide there are over half a million cases of brucellosis in humans annually (Acha and Szyfres, 1987). Human infection occurs via the ingestion of contaminated, unpasteurised dairy products or following direct contact with material (blood, urine) from an infected animal. It is an occupational hazard of those who work with livestock, including slaughterhouse workers. Epidemiological evidence also indicates that brucellosis can spread by air-borne transmission and inhalation; a high rate of infection was found in people who worked in areas surrounding slaughterhouses where the killing areas were not separate (Acha and Szyfres, 1987). In humans, brucellosis can cause chronic, undulating fever and symptoms of generalised malaise which may persist for months or years, with frequent recurrences. In areas where pastoralism is common, many hospital patients who are treated for malaria or typhoid fever may actually have brucellosis. It can be cured with antibiotics in about 80% of cases but untreated it can cause death in 2% of cases (Bell *et al.*, 1988). Programmes for control and eradication of brucellosis from animal reservoirs markedly decrease the incidence of disease in humans (Acha and

Szyfres, 1987). Uncontrolled livestock movement in urban areas is of particular concern for brucellosis control. Other prevention strategies require the heat-treating of all milk and dairy products, and good personal hygiene by livestock and abattoir workers. Such measures are rarely maintained in developing countries. Of equal importance is the reduced protein supply due to livestock losses. Potential and future supplies of milk and meat are lost through abortion or calf deaths from infected animals. It has been estimated that such losses translate into a potential 1.2% decrease in the supply of milk and meat in many developing countries, with a corresponding increase in the cost of milk and meat (Metcalf *et al.*, 1994)

Human infection with bovine tuberculosis is a problem where the prevalence of infection in cattle is high. It is usually transmitted to humans by drinking untreated milk from infected cows. It causes symptoms similar to the more common human respiratory tuberculosis. This is a slow, progressive disease which can lead to recurrences and death if untreated (Bell *et al.*, 1988). A combination of antibiotics has to be taken for 6 months to ensure a cure, but the necessary drugs are often unobtainable or too expensive in many developing countries. Preventive measures mainly involve heat-treating all milk. In Peru, bovine tuberculosis accounts for over 4% of all tuberculosis in humans (Acha and Szyfres, 1987). It is thought to be an increasing public-health problem in Africa where the spread of the human immunodeficiency virus (HIV) is associated with a greatly increased risk of human tuberculosis due to *Mycobacterium bovis* infection. In rural Zambia, 8% of all cattle were found to be seropositive for *M. bovis*, and people suffering from tuberculosis were found to be six times more likely to live in households keeping infected cattle than in other households (Cook *et al.*, 1996). The difficulties in controlling the spread of bovine tuberculosis will be even greater in many urban and peri-urban areas, where animals wander the streets uncontrolled. Eradication is not feasible in the countries with endemically infected wildlife, which constantly re-infects domestic animals. Control measures must then be applied indefinitely or, alternatively, the human population could be protected

by vaccination. Both of these solutions require widespread and thorough public-health programmes to ensure adequate control is achieved, and these will prove expensive, thus increasing the costs of both milk and meat.

Anthrax is most common in people who work with livestock, eat insufficiently cooked meat from infected animals, or work in animal-product industries (such as wool or skin processing). Anthrax is found world-wide but it is endemic in Africa, South-east Asia and parts of Central and South America. There are three forms of human infection: cutaneous anthrax occurs when the infection enters through a cut on the skin; respiratory anthrax occurs when the bacterial spores are inhaled; and intestinal anthrax is the result of ingesting a contaminated animal product. Anthrax can be successfully treated with antibiotics but untreated there is a very high and rapid fatality rate (5%–75%). The disease is controlled by preventing human contact with infected animals and their products, and excluding contaminated carcasses from the food chain. A simple laboratory test for anthrax antigen can be used to investigate animal products suspected of being infected (including hides). However, this procedure is not often available, especially in many slaughterhouses. Environmental and personal-hygiene measures, such as ventilation and protective clothing, can reduce the occupational hazards of working with livestock or in animal-product industries. Vaccination may be used to protect those at high occupational risk, and animals grazing in endemic areas can also be vaccinated. Anthrax spores can remain viable in the natural environment and in animal products for long periods, although the actual time of latency is unclear. As a precaution, wool and fur should be disinfected. The long viability of the spores has led to them being considered for use in biological warfare, for example during the Gulf War in 1990–1991 (Whitford and Hugh-Jones, 1994).

Q fever is emerging as a public-health problem in areas of sheep or cattle rearing and on dairy farms (Lang, 1989). Human infection is usually through inhalation, and abattoir workers are especially at risk (Sawyer *et al.*, 1987; Somma-Moreira *et al.*, 1987). After a human

epidemic in the Cape Verde islands, some 60% of animal sera were seropositive for Q fever (Sixl and Sixl-Voigt, 1987).

Increased international trade in livestock is distributing zoonoses to new areas. For example, in 1971 domestic pigs were imported into West New Guinea from a country in which cysticercosis (due to *Taenia solium*) was endemic in pigs and people. The parasite had been previously absent from New Guinea. In 1974 there was an epidemic of severe burns among the Ekari people which was attributed to epileptic fits causing people to fall into fires. The fits were subsequently found to be caused by neurocysticercosis. The infection spread rapidly, was difficult to control because of local husbandry practices, and is believed to have caused considerable economic loss (Gunawan *et al.*, 1976; Gajdusek, 1978). The present global distribution of cystic hydatid disease (due to *Echinococcus granulosus*) is associated with the widespread importation of sheep and dogs (Thompson, 1979). Trichinosis in Africa is of rare human importance and caused by a strain of parasite which is not well adapted to domestic pigs; there is concern, however, that new strains of the nematode causing this disease may be introduced via imported pigs, from regions where the disease is of considerably greater importance (Campbell, 1991).

Leptospirosis or Weil's disease is transmitted by infected animal urine. Humans are infected by contact with the animal or affected environment, for example by handling contaminated feedstuffs and cereals, or swimming in or drinking contaminated water supplies (Rainbird and O'Neill, 1993). In Africa and India, Weil's disease is fatal in over 20% of cases.

For a more detailed discussion of zoonoses see Beran (1994) and Bell (1988).

Non-communicable diseases

Animal husbandry may entail exposure to a number of non-communicable diseases. These include asthma and allergic pneumonitis amongst those exposed to animal wastes, and occupational asthma, for example amongst those working with

poultry. Noise may also be a substantial problem, for example amongst those working in chicken batteries.

Dairy farming has been associated with increased prevalence of 'farmer's lung' disease. This is due to working long hours in enclosed spaces while exposed to organic particulate matter. In the U.S.A., deaths due to farmer's lung are more common in the dairy industry than in other kinds of farming (Mannino *et al.*, 1990).

Malnutrition

There is a general concern about the replacement of large areas of crop production by the commercial production of livestock. The use of livestock to convert biomass to human food is relatively inefficient (Pimental and Pimental, 1979) and a unit of good agricultural land can support more people through the production of crops for human consumption than through livestock production. The direct nutritional benefits of commercial livestock production are often not felt by the people in the producing areas. For example, in Mexico, the proportion of livestock being fed grain increased from 6% to 50% between 1960 and 1985 and the area of land planted with sorghum, for use as cattle feed, also increased dramatically over the same period. However, there was no concomitant increase in the area cultivated for subsistence crops, and 25 million Mexicans were too poor to eat meat in 1985 (Lappe and Collins, 1988). Soybean became an important crop in Brazil during the 1960s and the country's largest export by the late 1970s, all going to feed Japanese and European livestock. At the same time, the number of people suffering from hunger in Brazil rose from one-third of the population in 1960 to two-thirds by the early 1980s (Lappe and Collins, 1988).

Women care for dairy cattle in many parts of Africa. Their investment of time and other resources has to be increased for supplying commercial dairies, often at the expense of other food-producing tasks. Nevertheless, the dairies usually pay the men for the milk. The women have therefore increased their labour but lost an income source from occasional sales of milk and milk products (Food and Agriculture Organiza-

tion, 1984). The loss of a cash income by women may lead to a reduction in family nutrition, as male priorities may be different.

Injury

Caring for animals poses a number of potential injury hazards, including animal bites, being gored by horns (e.g. by goats and cows), lacerations, cuts and fractures from kicks, falls from animals, and crush injuries.

Drug residues

COMMUNICABLE DISEASE

In some countries large proportions of livestock receive drugs for therapy, prophylaxis or growth-promotion. For example, chickens grow 10% faster when given antibiotics. Sub-therapeutic doses of antibiotic in the animal body and residues in the environment facilitate the development of resistant strains of bacteria, including *Salmonella* (Yndestad, 1991). *Salmonella* species isolated from poultry-farm employees, shepherds, fowl and other animals in Alma Ata, Kazakhstan, had multiple antibiotic resistance, especially to the tetracycline family. This was possibly due to veterinary applications of antibiotics not only for treatment and prevention but also as food supplements (Kotova *et al.*, 1988). In the U.S.A., an outbreak of salmonellosis resistant to many antibiotics was traced to hamburgers derived from antibiotic-treated cattle (Conway and Pretty, 1991).

NON-COMMUNICABLE DISEASE

When drugs are used in livestock the possibility exists that residues will occur in the products used as human food. The parent drug is metabolised, by the animal given it, into many derivatives (Cravedi, 1991). The maximum acceptable daily intake of the parent drug and/or its derivatives has not always been established. Some of the drugs used have known teratogenic potential. In Norway about twice as many antibiotics are consumed by domestic animals and fish as by

humans (Yndestad, 1991). In India, about 80% of the animal-production industry uses antibiotics and other drugs (Singh and Vijjan, 1987).

Animal-feed contamination

COMMUNICABLE DISEASE

Animal feeds composed of meals partly of animal and partly of vegetable origin have shown to be contaminated with *Salmonella* and *Campylobacter*. Animals fed on such feeds in intensive breeding units shed large quantities of pathogens in their faeces and these contaminate the wet surfaces of slaughterhouses and meat-processing and distribution plants. The large numbers of these carrier animals have contributed to the contamination of the environment and to the creation of infection cycles of food-borne diseases (World Health Organization, 1992b). For example, in 1985 some 200,000 people were involved in an outbreak of salmonellosis in Chicago caused by consuming contaminated pasteurised milk (Ryan *et al.*, 1987). In 1989, the U.K. reported about 32,000 cases of campylobacteriosis, a leading cause of food-borne disease (Anon., 1989).

More recent concerns in the U.K. have focused on the role of contaminated animal feed in the spread of bovine spongiform encephalopathy (BSE) in cows. Brain and spinal cord from infected cows were incorporated into cattle feed in the 1980s and this has been considered responsible for the continued spread of BSE in British cattle, and the potential risk of its transmission, through the food chain, to humans. It is not known if this is a problem in other countries.

NON-COMMUNICABLE DISEASE

The presence of residues of pesticides, herbicides, fumigants and heavy metals in livestock (because of contaminated feeds) is of potential health importance (Cordle, 1988; Vreman *et al.*, 1988).

Livestock wastes

COMMUNICABLE DISEASE

Livestock waste is increasingly discharged into rivers, rendering them hazardous as water sources. It is also used as fertiliser for field crops, vegetable gardens and fish ponds. Parasites are spread from the waste to people who handle fish and prepare or consume raw food. Slurry dispersed on land in hot climates aids the rapid growth of the pathogens responsible for foot-and-mouth disease, tuberculosis and brucellosis.

Cryptosporidial infection is an emerging cause of diarrhoea among children and immunosuppressed adults (Wittenberg *et al.*, 1987, Rush, 1987); contamination of drinking water with animal faecal matter is an important source of the infection.

Contact with poultry and an environment contaminated with animal faecal matter increases the transmission of *Salmonella* and *Campylobacter* to humans (Grados *et al.*, 1988; Moelbak *et al.*, 1988). The wastewater discharges from poultry farms can carry heavy loads of these micro-organisms and may contaminate drinking-water supplies (Stelzer *et al.*, 1988). For example, abattoir workers associated with the pork industry in the Netherlands have a 1500-fold higher chance of getting meningitis associated with *Salmonella* infection than other workers (Arends and Zanen, 1988). In Alma Ata, Kazakhstan, 16% of hens and 12% of ducks on industrial poultry farms were found to be infected with *Salmonella*; humans in the area develop the *Salmonella* carrier state as a result of occupational exposure to poultry and rams (Kotova *et al.*, 1988).

NON-COMMUNICABLE DISEASE

Heavy metals in slurry may be absorbed by vegetables and consumed by humans.

Tanneries

Tanneries are an important example of industrial processing of a natural resource that takes place in peri-urban areas, uses hazardous chemicals, and produces hazardous wastes.

About 250 chemicals are used in tanneries, including tannin, chromium and alum, as well as other acids, alkalis, solvents, oils, finishes and dyes. Materials that can appear in tannery wastes include hair, hide scraps, pieces of flesh, blood, manure, dirt, salts, lime, soluble proteins, sulphides, amines, chromium salts, tannin, soda ash, sugars, starches, oils, fats, greases, surface agents, mineral acids, dyes and solvents. Some of these are hazardous to health.

Particulate matters and hydrogen sulphide are the two potential gaseous discharges of significance (World Bank, 1988a). Air pollution is mainly caused by the discharge of chemicals associated with unhairing liquid and pickling operations. Cocheo (1990) monitored air pollution in the residential area of Chiampo Valley in northern Italy, where about 150 tanneries are located, and detected the highest concentration of hydrogen sulphide within 1 km of (and downwind from) 40 tanneries.

Measures for control and treatment of wastes are available. Shavings produced when processing hides into leather can be treated to extract the chromium content for recycling. This leaves a waste by-product which can be used as glue, animal food or fertiliser for non-edible crops. However, most of the measures and regulations regarding the disposal of tannery waste are ignored, and most wastes are just dumped in the environment, especially in developing countries (Dodangoda, 1992).

COMMUNICABLE DISEASE

The main communicable health hazard of the leather industry is anthrax.

NON-COMMUNICABLE DISEASE

The main non-communicable health hazard of the leather industry is dermatitis from contact with the chemicals and hides. Chromium can cause indolent and painful chrome ulcers of the skin and nasal septum, in addition to dermatitis. Other significant hazards associated with the leather industry include exposure to excessive dust, toxic chemicals, noise, and reproductive hazards (Marinova, 1978). In Jajmau, an industrial slum of Kanpur in India, occupational morbidity among tannery workers was 28% (Shukla *et al.*, 1991). A study of 252,147 babies delivered live in Scotland between 1981 and 1984 found that women who worked in leather had rates of pre-term delivery and low birthweight which were 50% higher than in most other female manual workers (Sanjose *et al.*, 1991). In Montreal, Canada, a survey of pregnancy in leather workers found a significant excess of stillbirths (McDonald and McDonald, 1986).

Dust, produced in many leather-working processes, may be responsible for causing chronic bronchitis (World Bank, 1988b). Asthma-causing agents used in tanning include casein, chromium salts, paraphenyldiamine and formaldehyde (Olaguibel *et al.*, 1990).

Hydrogen sulphide gas is released through the mixing of sulphides and chromic acid. Though such contact is avoidable, fatal incidents have occurred (World Bank, 1988b). Several

substances used in the leather industry, such as azo dyes and chromium, are genotoxic, leading to mutagenic and carcinogenic effects (Marinova, 1978; Clonfero *et al.*, 1990a, 1990b; Dodangoda, 1992; Figure 9 on page 94). Exposure to atmospheric chromate may cause bronchogenic carcinoma, with a latent period of 10–15 years (Dodangoda, 1992). Excess levels of bladder, nasal, laryngeal and lung cancer and leukaemia have been reported in leather workers in several countries (Seniori Costantini *et al.*, 1990; Ahrens *et al.*, 1991; Yamaguchi *et al.*, 1991).

INJURY

The major injuries are caused by machinery, falls on slippery floors, and chemical burns from acid, alkalis and chromic acid. Both injury and illness rates are considerably higher in the tannery industry than the average for all other industries. In the U.S.A. in 1975, for example (World Bank, 1988b), the incidence of any injury was almost twice as high among leather-tanning and -finishing workers than among all manufacturing workers (20.9 v. 12.5 injuries/100 full-time workers; time unit not cited). The difference in the incidence of occupational illness was even more dramatic (2.4 v. 0.5 illnesses/100 full-time workers).

Chapter 8

Recycling and Waste Re-use

- Waste pickers make a substantial contribution to solid-waste management but are poorly protected from injury, infection and abuse.
- Poor quality composting may not destroy pathogens such as nematode eggs.
- Mixture of organic and inorganic materials, including sharp objects, in compost may transfer hazardous chemicals to the food chain and occupational injuries to workers.
- Poor solid-waste management creates breeding sites for the mosquito vectors of dengue and filariasis, the housefly vectors of various pathogens, and rodents and rodent fleas.
- Animal scavenging of waste tips may facilitate transmission of zoonotic diseases.
- Leachates from waste tips pollute drinking-water sources and there is a risk of explosion from methane production.
- There are many pathogens potentially transmitted by contact with, and use of domestic sewage.
- There are international wastewater-treatment standards based on faecal coliforms and nematode eggs.
- Industrial effluents can contain many hazardous chemicals and some of these are rendered more toxic by chlorination.
- Drinking-water contamination with nitrates is potentially hazardous for infants.
- Wastewater is safe to re-use if a series of barriers to infection is established. These barriers include choice of crop, choice of irrigation method, and crop certification.

Solid waste

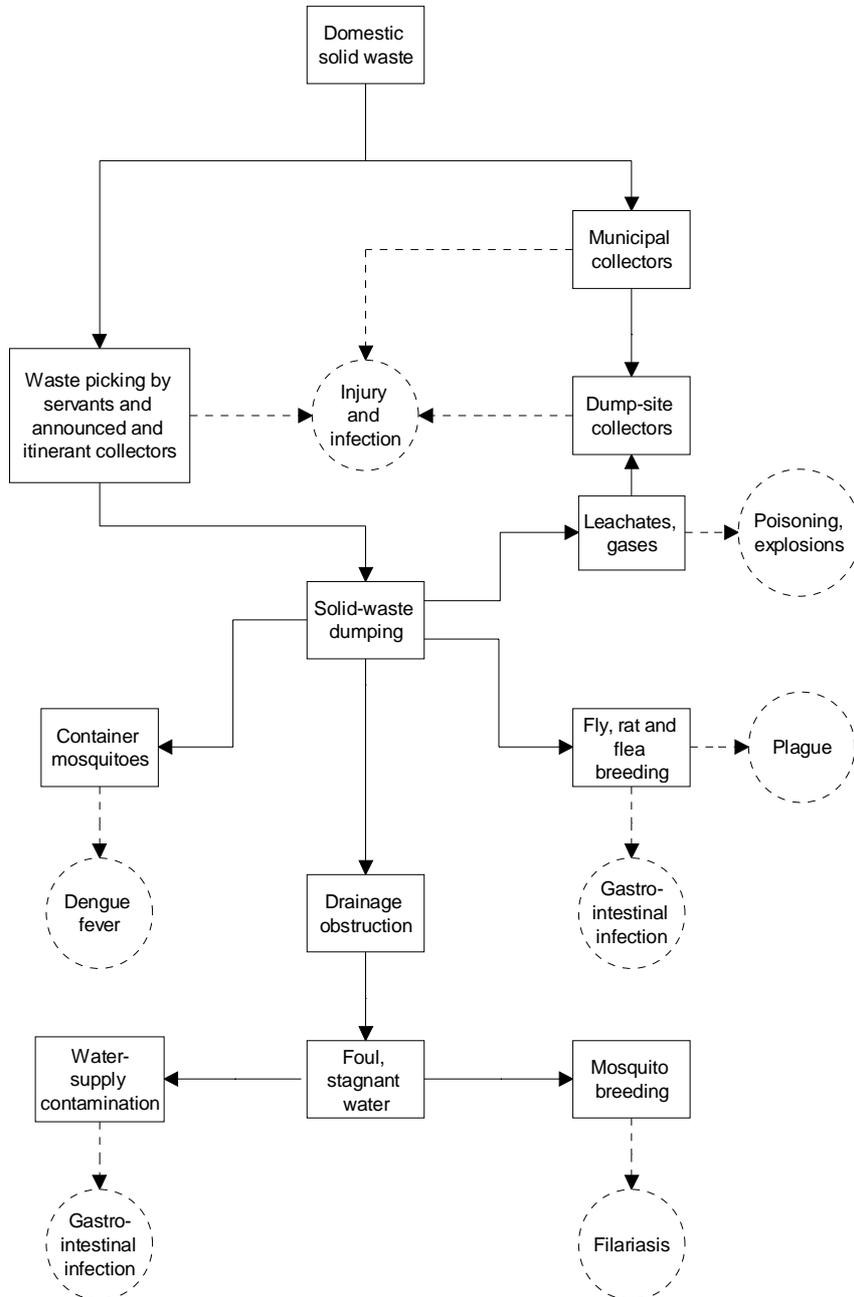
Infrequent collection and rapid decomposition of wastes provide attractive feeding and breeding sites for flies, rats and other scavengers. Human and other animal faeces and hospital wastes are often mixed with the refuse, encouraging the multiplication and spread of parasites and pathogenic micro-organisms. Domestic, and on occa-

sion industrial, solid wastes are disposed of in open spaces within residential areas (World Health Organization, 1992a).

Figure 10 is an overview of some solid-waste management and health linkages.

The provision of the hardware for waste removal is similar in rural and urban areas but there are differences in the software required for delivering and maintaining the inputs, because of

Figure 10. Some solid-waste–health linkages



differences in people's priorities, financial circumstances and organizations (Atkinson and Merkle, 1993). In Cucuta, Columbia, a low-income area tackled its solid-waste problem by establishing micro-enterprises. After training in business skills, local residents bid and were contracted to collect and transport solid waste within defined areas and to a defined landfill site. Three micro-enterprises provided twice weekly house collections for 150,000 inhabitants (Atkinson and Merkle, 1993). A similar system in Windhoek, Namibia, had 72 contractors, with costs 40% lower than a truck-based system, and facilitated sorting and recycling of waste. Close supervision was required to regulate the contractors' activities (Atkinson and Merkle, 1993).

A recent note from the World Bank advocates the use of composted urban waste in peri-urban agriculture (Schillhorn and O'Connell, 1997). Of particular interest is the identification of the policy-level changes needed to facilitate such use. These include the need for multi-sectoral frameworks and dialogues, improved

links between waste management and agriculture, and well defined priorities and strategies that recognise the need to protect human health. One successful scheme cited was a project to produce commercial compost from a Senegalese abattoir's waste.

The EHP has an active interest in urban solid-waste management, and the results of their activities are described in a recent newsletter (Anon., 1996h). The newsletter draws articles from a number of networked institutions, including WEDC in Loughborough. It reports experience in the development of micro-enterprises. The health problems associated with solid waste are reviewed but the re-use of solid waste in natural-resource development is not discussed.

Collection and disposal of refuse can consume up to 50% of a municipal operating budget. In many otherwise good systems, only 50%–70% of the refuse is regularly collected. The problem is organizational rather than technical. Refuse disposal is often a non-profit-making business and thus is treated as an unwanted side-

Table 24. Summary of health linkages to recycling and waste re-use

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Solid wastes	Attraction of rodents, poor composting, poor refuse disposal, lack of hygiene when handling, smoke and dust, vector breeding sites	Accumulation of hazardous chemicals, smoke and dusts, leachates, skin contact when sorting	-	Cutting and piercing injuries during sorting, combustible gasses
Fertiliser, soil ameliorant, animal feed	Poor composting, poor refuse disposal, vector breeding sites	Accumulation of hazardous chemicals, plant uptake, leachates	-	Cutting and piercing injuries during sorting
Liquid waste	Level of treatment, retention time of domestic sewage, contamination of drinking supplies, occupational exposure	Mixing of domestic and industrial wastes, contamination of drinking supplies (including groundwater), plant uptake, chlorination	-	-
Sludge	Poor composting, vector breeding sites	Plant uptake, groundwater contamination	-	-

effect of development. Attention should be paid to storage, collection, transport, intermediate transfer to bulk transport, and final disposal.

Where markets for solid waste exist there is usually a thriving trade which supports many destitute people. The market chain has been described in some detail (Furedy, 1990a, 1990b; C. Furedy, unpubl.). It includes the scavengers, domestic servants, municipal collectors, sorters, separators, purchasers with weighing scales, middle men with trucks, and end users, in both informal and formal industrial sectors (Figure 11 on page 94). The UNCHS has produced a video that illustrates these processes. In some regions waste recovery is an important private industry employing many thousands of scavengers or waste pickers who may live or work on refuse dumps. These people are frequently ignored in urban project plans although their activities may be vital to the life of the city. Many are abandoned children and destitute families. They live and work under extensive health risks, which are largely undocumented, and suffer severe exploitation and deprivation. Suggested health hazards include raised levels of infant mortality, hand and leg injuries, intestinal and respiratory infections, eye infections, lower back pain, malnutrition, skin disorders and exposure to hazardous waste (Adan *et al.*, 1982; Bubel, 1990). Water supply, for drinking and washing, and sanitation facilities are usually very poor at dump sites. Health and welfare facilities are required.

Mexico City has 10,000 scavengers on its dump. Cairo has 16,000 traditional refuse collectors who recycle nearly half of the 5000 tonnes of daily waste (Jensen, 1990). The total number of people in Asian cities whose occupation consists of waste recovery and recycling is believed to be several million and growing (Bubel, 1990; Furedy, 1990b). Some 1%–2% of the urban population may be so employed. More than 14,000 people were said to live and work on ‘Smokey Mountain’, one of Manila’s dumpsites. Jakarta may have over 12,000 waste pickers. More than 40,000 people may gain their livelihood from waste in Calcutta (Bubel, 1990).

Waste pickers may make a substantial contribution to urban waste management. They may reduce the volume of waste by 10%–20%.

However, private collection at source may only operate in the wealthy areas where refuse contains items of value. Observers agree that the issue of waste pickers cannot be evaded. The pickers’ positive role in the management of urban solid waste should be recognised and their lot improved (Furedy, 1990b). Legislation against waste pickers is no solution.

In an unpublished article, C. Furedy notes that there is now a global philosophy of solid-waste management based on waste minimisation, recovery and recycling. This has provided a basis for inter-sectoral partnerships to solve the crisis of increasing refuse and inadequate infrastructure. Furedy surveyed research activities and noted that they focused on waste picking and the welfare of waste pickers, including street children. She noted that there were many projects to assist waste pickers and those that seemed most successful shifted the picking away from dump sites and closer to the source of the waste. Another approach is to assist waste pickers at the same time as encouraging them to find other employment; waste picking then persists, but as a temporary employment for individuals, and its detrimental effects are reduced.

Hunt (1996) examined the medical condition of waste-picking and non-waste-picking children in India and found higher rates of intestinal worm infection, scabies and upper respiratory tract infection amongst the waste pickers.

A consultative meeting on ‘recycling waste for agriculture: the rural-urban connection’ was held at the World Bank in 1996 (C. Furedy, unpubl.). Health issues were discussed, including disposal of animal wastes from slaughterhouses, composting mixed waste, removing inorganics (and the potential health hazards), composting human excreta from latrines, and the need for quality standards for municipal solid-waste streams and the composts produced from them.

There is a convergence of urban-agriculture and waste-re-use concerns through composting, to produce agricultural fertiliser or soil conditioner, and the feeding of food wastes to livestock (C. Furedy, unpubl.). Tensions occur between public-health and urban-agriculture



Figure 3. Inappropriate handling of insecticide

Figure 5. Indoor air pollution from biomass fuels is a major source of respiratory disease

Figure 6. Women's market-gardening project in Benin. Use of watering cans to irrigate the vegetable crop avoids the creation of mosquito-breeding sites

Figure 7. A river of sewage flows out of Damascus and is sometimes illegally abstracted to irrigate a variety of crops



Figure 8. Flies on fresh fish in an urban market

Figure 9. Women of child-bearing age working in a tannery in close contact with chromium salts

Figure 11. Scavengers await the garbage truck at a dumpsite in Manila

Figure 12. Drinking water is often supplied to houses before wastewater drains. Wastewater containing sewage is then allowed to pool in roadways, where it forms a breeding site for the mosquito vectors of filariasis



Figure 13. The very poor washing in sewage, in Dhaka, Bangladesh

Figure 14. Latrines at the edge of the same pond in Dhaka

Figure 15. The Al Samra wastewater-treatment lagoons outside Amman, Jordan, provide a low-cost, low-maintenance, alternative system for water treatment. However, they require a large expanse of expensive, peri-urban land

Figure 16. Dripfeed irrigation of cucumbers with part-treated, domestic sewage, on the outskirts of Cairo

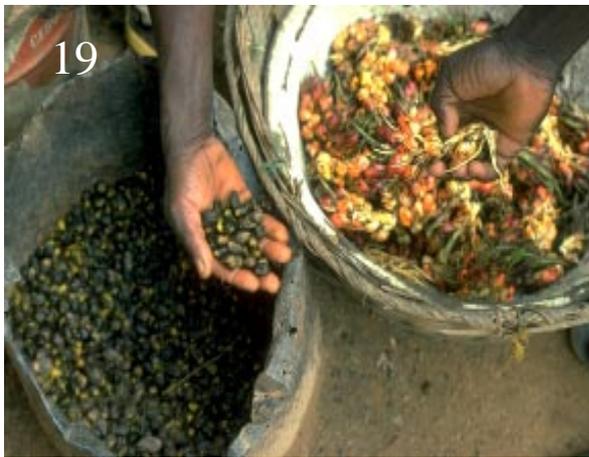


Figure 17. Harvesting salad crops irrigated with part-treated sewage

Figure 18. Queuing for water from a standpipe in a peri-urban slum

Figure 19. Boiled palm-nut kernels, for sale in an Accra market

Figure 20. Collecting water

specialists because of concerns about communicable diseases, zoonoses and injuries on the one hand and increased food production and job creation on the other. Furedy suggests that the hazards associated with excreta and wastewater have been well researched compared with the hazards associated with solid waste. She suggested the typology in Table 25.

FERTILISER, SOIL AMELIORANT AND ANIMAL FEEDS

One of the three main purposes of the Natural Resources Systems Programme Peri-urban Interface Production System is the recycling/processing of organic waste for use as a fertilisers, soil ameliorants or feeds. A review of the use of peri-urban waste in production systems at the peri-urban interface has been commissioned (Allison and Harris, 1996). One conclusion of this review was that there have been few studies

of the use of organic wastes in existing urban and peri-urban agricultural systems. The report recommended baseline studies on the current use of urban organic wastes and assessment of the value of the available waste materials and the efficacy and potential of the small-scale, on-farm methods of composting.

The main use of solid waste is as a soil improver but other uses include feed for livestock and fish. The most successful suppliers appear to be small, private traders. The range of wastes used as animal and fish feeds includes animal wastes, agro-industrial wastes such as cereals, fruit, sugar, fish, meat and poultry, and municipal wastes such as paper. The range of wastes used for soil ameliorants included sewage, nightsoil, manure, fish wastes, and agro-industrial wastes.

The use of waste for animal feed was thought to be constrained by:

Table 25. Health hazards associated with the re-use of organic waste (Furedy, 1996)

Type of re-use	Hazards
Vegetable waste from kitchens, restaurants and canteens	Fed to livestock, probably low risk of communicable disease
Regular, mixed, municipal waste, including organic and inorganic, biomedical and industrial	Risks of communicable and non-communicable disease and of injury if applied to soil without adequate composting and separation
Kitchen and yard wastes, composted in backyard	Potential for pesticide residues to accumulate
Community compost heaps	Poor control of separation of organics from inorganics and attraction of rodents (which may be disease reservoirs) and insects (which may be mechanical vectors)
Mixed, municipal wastes, delivered to centralised composting plants	Product contains glass splinters and heavy metals. Pesticide residues unknown. Most facilities have failed to operate properly.
Kitchen and yard wastes delivered to vermicomposting projects	Low-temperature composting may not destroy pathogens
Old garbage dumps used for farming	Injuries from sharp objects, respiratory problems from dust, concerns about unknown levels of industrial waste
Mining of old garbage dumps for mature compost	Injuries from sharp objects, respiratory problems from dust, concerns about unknown levels of industrial waste
Cowdung	Lack of hand-washing facilities

- the need to ensure a balanced and non-toxic diet;
- the variable and unreliable availability;
- the perishable nature of suitable waste;
- the processing requirements; and
- the risk of introducing diseases into the food chain.

Composting is the most common way of processing organic waste for use as a soil improver. In the literature, three associated health issues are discussed:

- heavy-metal contamination;
- pathogens; and
- safety from non-biodegradable fragments.

One health-related benefit of composting is that the waste may be sanitised because many of the pathogens found in nightsoil, including helminth eggs, may be killed. However, this is only successful if high-temperature composting is used or if the waste is stored for periods of about one year. Composting of waste at lower temperatures and for shorter periods is common and does not destroy helminth eggs. Introduction of heavy metals into the food chain via compost should be minimised. This does not mean that compost cannot contain heavy metals, since many are essential for proper plant nutrition and do not pose a threat to human health at low concentrations. There are several guidelines for compost world-wide but most appear to be for use in the developed world. For example, the Nova Scotia Environmental Industry Association presents classification standards recommending heavy metal and pathogen levels for different compost uses (Anon., 1997b). The compost analysis and testing scheme (CATS) developed by the Henry Doubleday Research association is a quality-assurance service for large-scale U.K. composters, designed to ensure that their compost is safe for the people using it, the environment and the plants around which it is spread. The human-health issues considered by the scheme are non-biodegradable fragments and pathogens (G. Smith, pers. comm.).

Most composting initiatives reported in the literature are large-scale, single-plant initiatives rather than decentralised, low-technology programmes. Small composting plants in Accra are said to have failed because they lacked markets, lacked the resources to subsidise production, and were located too far from the district served. In India, composting plants in major cities have closed because of high costs. There are, however, examples of successful, localised, low-technology projects in Cairo in Egypt, Kano in Nigeria, and Mali (Allison and Harris, 1996)

Nightsoil and sewage are widely used in agriculture in China and are usually processed by mixed composting, production of dry fertiliser, or covered storage. In Asia, all types of waste are used for agriculture, including city refuse, untreated sewage, composted plant residues, and manure. In Cairo, there is extensive, non-municipal waste collection and recycling. The rubbish is sorted by women and children. Organic material is fed to pigs. Pig manure and domestic waste is composted and supplied to farmers. In Thies, Senegal, untreated household rubbish from city dumps is used without any sorting of non-biodegradable items. In Kano, untreated sewage is mixed with organic household refuse. In Ghana, agricultural by-products are increasingly being used for compost.

COMMUNICABLE DISEASES

A South African study of household risk factors for diarrhoea in peri-urban areas identified not owning a refuse receptacle as a significant factor (Atkinson and Merkle, 1993).

Solid inorganic waste is a serious problem in many urban areas because of inefficient waste-collection systems. Such waste provides a receptacle for rainwater and hence a breeding site for the *Aedes* mosquitoes that act as vectors of dengue. Waste also accumulates in drains and creates pools of stagnant, organically polluted water which provides a breeding place for the *Culex* mosquitoes that transmit filariasis in some regions (Figure 12 on page 94).

Houseflies may be important in the transmission of enteric infections, particularly those responsible for infantile diarrhoea and

dysenteries. Disease transmission by houseflies is greatest where inadequate refuse storage, collection and disposal (leading to increased breeding) is accompanied by inadequate sanitation. In such conditions the flies gain greater access to human faeces. Refuse must be collected twice per week to prevent fly breeding. The role of houseflies in disease transmission has been demonstrated in Palestinian refugee camps, where the breakdown of chemical control of flies led to dramatic increases in infantile diarrhoea (West, 1953; Keiding, 1964). Experimental trials using chemical control methods in Texas and Georgia demonstrated that diarrhoea attack rates may be up to 33% higher when houseflies are uncontrolled. Prevalence of the dysentery organism, *Shigella*, was three-fold higher and death rates from diarrhoea and dysentery were measurably greater where houseflies remained uncontrolled (Watt and Lindsay, 1948; Lindsay *et al.*, 1953). A similar result has recently been demonstrated with non-*Shigella* diarrhoea in Pakistan (D. Chavasse, pers. comm.).

Domestic rats, birds and other scavenging animals act as reservoirs for many organisms transmissible to people, including those causing plague, some forms of typhus, leptospirosis, trichinosis, psittacosis or salmonellosis. Chemical control of both houseflies and rodents is not very effective because of widespread resistance. The essential basis of control remains denial of access to food and harbourage, by covered storage and efficient removal.

NON-COMMUNICABLE DISEASES

Once collected in poorly designed or poorly operated disposal sites, rubbish may contaminate groundwater with nitrates, heavy metals and other chemicals. Incineration of wastes may pollute the air with particulates and oxides of sulphur and nitrogen. The slag and ashes from incinerators may result in leachates that are rich in heavy metals and other potentially toxic substances (World Health Organization, 1985).

Urban solid wastes are a source of essential plant nutrients and are used in agriculture. A survey in India on the impact of urban solid waste on plant uptake of heavy metals revealed

that the heavy-metal content varied between plant species. The elevated levels of zinc, copper, lead and nickel found in many of the crops may prove phytotoxic and hazardous in the food chain (Jeevan Rao and Shantaram, 1995). However, Allison and Harris (1996) cite evidence, collected by Drescher (1994) in Lusaka, indicating that vegetables growing on urban landfill sites did not accumulate heavy metals. There is particular concern about common *Brassica* crops. *See also: bio-accumulation of pollutants (page 64).*

No relevant heavy-metal limits were found in FAO documentation. Further research is needed to establish the safe heavy-metal content of solid waste used for fertiliser.

INJURY

Combustible gases will be generated from waste tips for more than 20 years and these travel, under roads and through ducts, to create a hazard in buildings. In Turkey in April 1993, methane from a rubbish tip exploded, killing at least 13, injuring 100, and destroying homes (Anon., 1993).

People collecting and sorting rubbish may be injured by sharp objects, including glass, metal and wood. These may lead to puncture wounds and lacerations which may become infected and cause serious morbidity. Composted solid waste can cause similar injuries to farmers, as sharp objects are not always properly removed (Nicolaisen *et al.*, 1988). Other hazardous materials in solid waste include biomedical and toxic substances.

ASSESSMENT OF HEALTH RISKS

In an unpublished report, C. Furedy points out that official attitudes towards the health risks associated with solid waste have historically changed with necessity. She asks, in effect, whether the perceived health risks are overstated. In order to analyse the problem further, she identifies the vulnerable communities, the environmental factors and the institutional response, as follows.

The vulnerable communities

An analysis of the health risks associated with solid-waste re-use should identify the vulnerable communities. These include:

- waste workers;
- infants and children of waste workers and peripheral communities;
- farmers;
- peripheral communities to large, waste-processing plants;
- consumers of plants grown with the compost;
- consumers of animals fed on the wastes;
- consumers of water polluted with leachates;
- food handlers; and
- owners of livestock fed or grazed on the waste.

The host risk factors that determine the vulnerability of these communities include poverty, age, gender, education and behaviour.

The environmental risk factors

The environmental risk factors determine how vulnerable communities are exposed to the health hazards associated with solid waste. These include:

- the waste materials, their source, mix, and rodent and vector communities;
- the survival time of pathogens in the waste;
- the methods of application and use;
- the characteristics and exposure of livestock, including the prevalence of their infection with parasites; and
- the characteristics of the site, such as aquifers, leaching, and availability of sanitation.

Furedy suggests that principles similar to those applied in safe wastewater re-use could be applied to safe solid-waste re-use, such as establishing a series of barriers to exposure. She also suggests that, where multiple routes of exposure to infection already exist, occupational exposure to waste may not add a significant risk. However, this would depend on the latency and persistence of the infectious agent. As an example, she suggests that the barriers to exposure in community-based composting depend on (in our paraphrasing):

- the thoroughness of separation of materials at source, especially sharps;
- the quality of the composting process, which may not destroy pathogens;
- the general health of the waste generators;
- the immune status of the consumers; and
- the risk of accumulation of hazardous chemicals, including pesticides.

Institutional factors

Municipal authorities cite health risks inappropriately as a reason to restrict urban agriculture. Regulations are frequently outdated, or lack comprehensiveness. For example, hazardous chemicals may not be included, or consumers' but not workers' safety may be considered. Enforcement of regulations is also haphazard.

Furedy notes that the proponents of urban agriculture have said remarkably little about health hazards. There has been little systematic thinking. For example, she cites a 1993 IDRC request for research proposals linking urban agriculture and health, for which none were provided. She suggests that one of the reasons for the absence of systemic thinking is a lack of inter-sectoral linkages between health- and agricultural-research networks. She suggests several solutions, including health impact assessment and epidemiological studies.

Liquid waste

Liquid waste from domestic sewage is a valuable commodity that can be used for irrigation, biogas production, fertiliser for field crops and fish-ponds, and delivery of biological control agents. However, the health hazards associated with such waste include many communicable diseases, and poisoning associated with heavy metals and minerals of industrial origin. Relatively little is known about current use of wastewater in peri-urban agriculture except that it is extensive and unregulated. Little is known about local availability, supply and cost of wastewater or the differences between small- and large-scale, wastewater-re-use projects.

A series of publications during the 1980s examined the safe re-use of wastewater and sludge in agriculture and aquaculture. There was considerable progress in the development of systems for safe wastewater production and use which culminated in publication of the WHO (Engleberg) Guidelines (Mara and Cairncross, 1989; World Health Organization, 1989). These guidelines relaxed standards for faecal bacteria but introduced new standards for nematode eggs. Several issues remain unresolved. There is a series of research monographs in tropical public-health engineering from the Department of Civil Engineering, University of Leeds, U.K., which provide important additional information.

COMMUNICABLE DISEASES ASSOCIATED WITH EXCRETA

The WHO's guidelines recognised five categories of excreta-related communicable diseases and distinguished them by latency and persistence. Latency refers to the period between excretion and becoming infective to a new host. Persistence is a measure of how long a pathogen remains viable after leaving its host. Together, these help to determine the half-lives of pathogens in waste and on crops. Many worms and protozoan parasites have such a long half-life that they can contaminate the harvested crop and be transferred through the market chain to the consumer's kitchen. Produce can be decontaminated by the consumer, by peeling, cooking and, to a small

extent, by soaking in antiseptic fluids, but further contamination may occur from soil and debris in the kitchen.

Non-latent and not very persistent

This category includes viruses (such as those causing infectious hepatitis), protozoa and some helminths. Transmission is associated with personal hygiene and the domestic environment. Flies that breed in organic waste can be serious mechanical vectors of some of these pathogens and distribute them to the wider community.

The WHO guidelines concentrated on standards for bacteria and helminths and not viruses. In a recent review of the effect of viruses on human health from wastewater used in agriculture and aquaculture, Schwartzbrod (1995) suggested that current bacteriological standards do not provide good indicators of viral content or of the efficiency of disinfection procedures, and that more research is needed. The review also emphasised the need for epidemiological studies to relate clinical ill-health to different levels of viral contamination. Particular concern was expressed about decontamination procedures that use chlorination. The basic requirement for decontamination of wastewater was to reduce the suspended solids by at least 90%. Shellfish were cited as a major transmission route for enteric viruses. The risks of infection associated with sprinkler or spray irrigation were not considered to be a significant except during epidemics, when the viral concentration may be very high. It was concluded that wastewater treatment but not disinfection was required and that irrigation of market-garden produce should cease 3 weeks before harvest. Viruses also accumulate in the sludge from waste-treatment plants. As they can only be inactivated by proper drying and long-term storage of the sludge, they appear to be more persistent than previously believed.

Non-latent and moderately persistent

This category includes bacteria, such as *Shigella* and those causing typhoid and cholera, that are viable in untreated wastewater. Transmission by flies may be important. Recent epidemics of cholera associated with wastewater re-use have led to further analysis of safe production systems (see below).

Latent and persistent but with no intermediate host

This category includes *Ascaris*, hookworms and *Trichuris*. It is considered the highest risk category in wastewater treatment and re-use because of the long half-life of the pathogens. Helminths and cysts are likely to concentrate in sludge. Transmission by flies may be important.

The intestinal helminths such as *Ascaris* are extremely common in many development communities. Transmission occurs through a number of routes, in addition to that via poorly treated sewage used in agriculture. Hookworms are associated with significant disease. Poorly treated sewage waters can contain viable stages that can survive in moistened soils; these may infect agricultural workers who expose their bare skin to the soil.

Latent and persistent, with domestic animals as intermediate hosts

This category includes the beef and pork tapeworms and is important where beef cattle are grazed on pasture irrigated with wastewater or pigs scavenge on human waste; there are no equivalent parasites of sheep and goats. The pork tapeworm produces a far more serious disease in people than the beef tapeworm.

Latent and persistent, with aquatic intermediate hosts

This category includes schistosomiasis, which has a focal distribution dependent on temperature and the presence of suitable aquatic snails.

NON-COMMUNICABLE DISEASES ASSOCIATED WITH HAZARDOUS CHEMICALS IN DRINKING WATER AND WASTEWATER

Wastewater may contain a number of industrial effluents, including cyanides, acids, lyes, mordants, bleaches and heavy metals (arsenic, cadmium, chromium, copper, lead, zinc, and mercury). The risk posed by these contaminants will depend on their dilution and uptake pathways. For example, in Damascus, chromium salts from leather tanneries are of particular concern as the chromium concentration in the surface discharges at the tanneries is about 40 mg/litre

(Anon., 1996i). Chlorination of effluent containing chromium can produce two toxic products (Tarcher, 1992):

- carcinogenic and mutagenic products can result from the combination of chlorine with organic materials (this problem seems to be associated with high levels of chlorination in water destined for drinking); and
- chlorinated chromium salts may change from a less toxic to a more toxic form.

Some heavy metals may precipitate in sludge, so that their concentrations in treated wastewater may be very small. There are suggestions that other mutagenic materials are not removed and may be enhanced by activated sludge treatment (Blevins and Brennan, 1990).

The risk associated with these chemicals and others depends on the mode of exposure. Wastewater effluent is not usually destined to be drunk. However, the chemicals may percolate to groundwater, accumulate and then be extracted, in drinking water, from wells. Some chemicals may accumulate in soils and then exposure occurs during consumption of plants grown in those soils. There are soils that are already heavily polluted. For example, some 8% of wastewater-irrigated land in China is said to be heavily polluted, and pollutant accumulation is detectable in half of such land (Chang, 1995).

Guidelines for limiting human exposure to the hazardous chemicals in the wastewater used in agriculture are at an early stage of development (Chang *et al.*, 1995). There are two approaches: prevent any pollutant accumulation in waste-receiving soil; or, more realistically, take advantage of the soil's capacity to assimilate, attenuate and detoxify pollutants. In order to derive acceptable loadings, it is necessary to determine intake through consumption of plants grown in contaminated soils. The tentative conclusions are presented as acceptable concentrations of various organic and inorganic compounds in soil, such as 5 mg mercury, 150 mg

lead and 3,200 mg chromium/kg dry weight. These figures are regarded as first approximations requiring further research.

Nitrates and nitrites

Drinking water may be contaminated with nitrates and nitrites to an unacceptable level, with an associated risk of blue-baby syndrome (methaemoglobinaemia). The probable threshold for clinical illness is 100 mg NO₃/litre, and consequently the WHO standard for nitrates in drinking water is <50 mg/litre. The most vulnerable group are infants who are bottle-fed or given water to drink (Feachem *et al.*, 1983).

Six countries of the newly independent states of eastern Europe report blue-baby syndrome in infants. One third of Lithuania is covered by a drinking-water-replacement programme for pregnant women. Similar problems are expected to occur in future in other regions and may be exacerbated by wastewater re-use (Anon., 1995a).

Nitrate levels in irrigation water are self-limiting but excess nitrate has a limiting effect on plant growth and is therefore unacceptable to the farmer. Chang *et al.* (1995) refer to the FAO guidelines on irrigation-water quality, which limit the nitrogen input via irrigation to 5 mg/litre, equivalent to 60 kg/ha. In order to avoid leaching to groundwater, they suggest that no

more than 5–25 tonnes of sewage sludge should be applied per ha of cropland. They propose that no numerical limits should be set for nitrate in wastewater because the agricultural limit will suffice.

ASSESSMENT OF HEALTH RISKS

The WHO's guidelines on the safe re-use of wastewater set a series of barriers to infection. If a sufficient combination of these barriers is operational then the wastewater should be safe. The barriers consist of treatment methods, irrigation methods, working conditions, types of crop, and post-harvest processing.

VULNERABLE COMMUNITIES

The main vulnerable communities associated with wastewater-re-use projects are indicated in Table 26, together with their potential exposure to the five, excreta-related, communicable-disease categories (Mara and Cairncross, 1989).

The vulnerability of these community groups to the pathogens is determined by a number of factors, including the following.

Table 26. Vulnerable communities and excreta-related diseases (Mara and Cairncross, 1989)

Community	Disease category				
	1	2	3	4	5
Domestic	X	X			
Sewage-plant workers	X	X	X		
Farm workers		X	X		X
Crop handlers		X	X		X
Recreational users		X	X		X
Peripheral communities		X	X		X
Consumers of crops		X	X		
Consumers of beef and pork				X	

Host immunity

This is only relevant for the category-1 or -2 diseases such as hepatitis and typhoid. The immunisation status of workers who handle treated and untreated effluent could be enhanced by a vaccination policy.

Host behaviour

Community behaviour, or practice, is partly determined by knowledge, attitude and belief (Figures 13 and 14 on page 95). For example, surveys of mothers' knowledge and behaviour to childhood diarrhoea frequently demonstrate that, while many mothers know of oral rehydration therapy, few practise it. Behaviour such as using protective clothing can help protect workers from exposure to infection, especially to helminths. Agricultural workers exposed to wastewater should wear boots. Peripheral communities may stray onto effluent-treated land unless deterred by barriers, posters, warnings and health education. Children are of particular concern because they frequently transfer soil to their mouths.

When wastewater is used to grow food crops, people may be able to protect themselves by disinfecting vegetable produce in the home, using boiling water, chlorination, potassium permanganate or other additives. The effectiveness of these procedures is open to doubt, however.

Many people may use rivers, canals and irrigation channels for bathing or fishing. Urban dwellers may visit irrigated peri-urban areas during holidays. Exposure to wastewater or land treated with wastewater may then be common.

The vulnerability of consumers to excreta-related, communicable diseases depends on what crops they prefer to eat and whether the food is eaten cooked or raw. Preferences for raw salad crops, such as tomato, lettuce, parsley, cucumber and mint, are particularly important.

WASTEWATER-TREATMENT METHODS

The WHO/Engelberg thresholds defining the minimum water quality to be discharged from waste-treatment plants for unrestricted irrigation are:

- One viable nematode egg/litre; and
- 1000 faecal coliforms/100 ml.

These standards should protect agricultural workers, neighbouring communities and consumers of salad crops, as well as bathers and users of public parks. To meet these standards, 99.9999% of the bacteria and 99.9% of the helminths generally have to be removed from the waste during treatment. The standards can usually be met in a simple plant containing four to six waste-stabilisation ponds, with an overall retention time of more than 20 days at 20°C.

The WHO's guidelines were based on the best available data but have not been fully confirmed by subsequent studies (U. Blumenthal, pers. comm.). The standards used have been investigated in epidemiological studies since 1989 and found to be about right for protecting consumers (Blumenthal *et al.*, 1991/2; Cifuentes *et al.*, 1991/2). However, the nematode-egg standards may need to be made twice as strict when wastewater-treatment systems are unstable, when secondary contamination with untreated wastewater can occur, or where wild vegetables are harvested and consumed by field workers (Blumenthal *et al.*, 1996). Further epidemiological investigations are under way to establish the relative risk of different levels of water quality where the water is to be used for salad crops (S. Cairncross and U. Blumenthal, pers. comm.). Natural-resource managers are advised to measure the relative risk in their own peri-urban, vegetable-growing projects.

There is a debate about the relative merits of activated-sludge-treatment plants (ASP) versus waste-stabilisation ponds (WSP) in relation to the WHO guidelines. ASP are far more expensive to construct and operate than WSP but require less land. Land is expensive in peri-urban areas (Figure 15 on page 95). WSP retain the agricultural nutrients in irrigation water. In closed aquifers, however, this retention may pose a danger of nitrate and potassium contamination of groundwater. The World Bank noted that an ASP costs >5.8 times more to construct and >15 times more to operate than a WSP (Shuval, 1990). It concluded that WSP were cheaper than AST even when land prices

were very high. Waste could be pumped far from a city to areas where land was cheaper. There are concerns about the high evaporative losses from WTP in areas of water scarcity, but these should be offset against the high operational requirements of ATP.

According to the WHO guidelines, activated sludge plus secondary sedimentation can remove 0%–99% of bacteria and helminths whereas chlorination may remove between 99% and 99.9999% of the bacteria but few if any helminths (to a maximum of 90%). The higher removal rates in ASP depend on long retention times (i.e. more than 24 hours) and efficient operation. In practice, these optima may not be achieved. In Egypt, for example, an ASP with chlorination removed 99.99% of faecal coliforms and other bacteria and all helminths except hookworms (Wahaab, 1995). Protozoa were not removed and viral density was only reduced by 33% but *Salmonella* and cholera vibrios were removed completely. In Jordan, a WSP outside Amman does not operate as designed because the current level of wastewater production far exceeds its capacity.

An ATP produces large quantities of dried sludge which is in high demand as a soil conditioner. The treatment process concentrates some helminths and other pathogens in the sludge. According to WHO standards, sludge-derived fertiliser for surface application must contain fewer than one viable nematode egg/litre or kg wet weight and fewer than 1000 faecal coliforms/100 ml or 100 g wet weight. In order to meet the WHO's standards, sludge needs to be treated at temperatures above 50°C for 13 days, composted, applied sub-surface or stored for periods of about one year. Sludge treated at lower temperatures and stored for shorter periods is still a significant health risk.

A practical guide to the laboratory measurement of faecal coliforms and nematode eggs in wastewater has been published very recently (Ayres and Mara, 1996). It lists the advantages and disadvantages of various methods and indicates where further research is needed. Measurements should be made one to four times per month, depending on the treatment process used.

There is a need for more methods of treating liquid waste, including on-farm stabilisation ponds, reed beds, duck-weed farming and artificial wetlands, and the research in these areas needs following up. Research in progress includes experiments with covered waste-stabilisation ponds for farm use (T. Brabbin, pers. comm.); the intention is to raise the water temperature sufficiently to kill nematode eggs.

A website containing a thought-provoking article on natural systems for the treatment of wastewater has been created (Montgomery, 1997). The systems covered include ponds, constructed wetlands (CWL), hyacinth ponds, and reed beds. The merits and demerits of each are listed. Good removal rates for pathogens, heavy metals, nitrates and other pollutants are reported in many of these systems. The need for mosquito control is briefly discussed but the solutions presented are open to doubt.

TYPE OF CROP

When effluent is used for irrigation, choice of crop can provide an important barrier to the transmission of pathogens (Mara and Cairncross, 1989). However, over-stringent crop restriction reduces the economic benefit of the irrigation. The WHO's guidelines divide crops into three categories and recommend safety requirements for each.

Category A: protection only for field workers

This category includes dry fodder, fibre, wood and seed crops. As the crops are processed before consumption there is negligible risk to the consumer. However, field workers are exposed to the effluent and require protection by rubber boots, potable water supplies, and hygienic behaviour.

Category B: further control measures may be needed to prevent transmission

This category is affected by the type of irrigation, and the category assumes no spraying. It consists of orchard and vineyard products and vegetables to be cooked or processed. Irrigation should be

stopped a week or two before harvest and the crop should not contact the ground. Spray irrigation would contaminate the fruit.

Category C: treatment to Engelberg standards essential

This category consists of crops that are normally eaten raw. It also includes public parks where people can sit and play on irrigated land. Wastewater treated to the Engelberg standards promoted by the WHO is regarded as reasonably safe for unrestricted irrigation.

IRRIGATION METHOD

The WHO's guidelines list five application categories: field flooding, ridge and furrow, sprinklers, dripfeed, and sub-surface. Each requires different levels of protection for field workers, crop handlers and peripheral communities.

In many countries there is a strong interest in making irrigation more efficient by moving from field flooding to dripfeed and spray. Dripfeed or localised irrigation methods increase human safety and are highly recommended (Figure 16 on page 95). Spray irrigation with treated effluent is only practical on large farms where sanitary barriers can be constructed at the periphery.

POST-HARVEST PROCESSING

For many practical reasons it is likely that salad crops will continue to be grown in contaminated waters. Attention must then turn to methods of ensuring their safety at the post-harvest stage. There are two main options:

- decontamination; or
- crop restriction and certification.

Decontamination

The common practice of domestic disinfection of salads is of dubious value and there may be an opportunity for mass disinfection of market

produce, as is the practice for water cress in the U.K. (E. Potts, pers. comm.). *See also: food safety (page 110).*

Crop restriction and certification

The WHO's guidelines on wastewater re-use develop standards for water treatment and have a different perspective to that of the user in the agricultural community. The perspective of the user is presented in two FAO papers (Pescod, 1992; D. Westcot, unpubl.). Westcot's unpublished report builds on the previous work done by WHO but starts with the premise that appropriate treatment plants will not be widely installed for a long time to come. The main action required is crop restriction or safe production areas for high-risk crops. However, this action must be based on well-defined water-quality standards. The report grew out of a project in Chile that sought methods to restrict and certify the safety of vegetables in the wake of a cholera epidemic. In metropolitan Santiago, some 60% of the irrigated area used water with more than 10,000 faecal coliforms/100 ml. A vigorous programme of crop restriction reduced the number of cases of cholera, hepatitis and typhoid. Opponents of this programme note that it substantially increased crop prices and denied the benefits of fresh vegetables to low-income communities (Smit *et al.*, 1996).

The alternative to controlling quality at the point of treatment is to control the place where the water can be used. This requires a broader institutional structure and jurisdiction over cropping in the re-use area. Since such jurisdiction is usually poor and illegal extraction of water frequently occurs, an alternative is to identify safe production areas and use market pressures to promote safe crop production. Westcot's report describes an approach in which water-quality certificates are issued to producers. The article also provides a review of wastewater-borne pathogens, including survival times in sewage and soil.

Westcot emphasises that the WHO's guidelines for water quality were for the design of treatment plants and not for water quality at the point of use. As techniques for monitoring helminth eggs were not considered to be well established, Westcot proposed a system of water-

quality monitoring based solely on the numbers of faecal coliforms. The emphasis of the report is extraction from contaminated rivers. Some 45% of 110 rivers tested throughout the world carried faecal coliform loads higher than that recommended by the WHO for unrestricted irrigation (i.e. 1000/100 ml); 15% carried levels that were 10 times in excess of this standard. The effect of rivers on the longevity of helminth eggs is unknown and requires further research. The association between coliform and helminth levels in rivers is also unknown. Reliable routine methods of counting low densities of helminth eggs in wastewater are urgently needed and research of this nature should be promoted (but see Ayres, 1996). The report reviews several available methods of monitoring faecal coliforms and the need for portable sampling systems. It recommends further research on the practical field use of membrane-filter techniques. It provides a decision tree for the analysis of faecal coliform counts that could provide a legal basis for a crop-control programme. The need to separate coliforms of human origin from those from other animals is explained.

The report notes that crop restriction and certification programmes can offer protection to the consumer but not to the producer, labourer or peripheral community. These groups will still have contact with contaminated and potentially infectious water. The difficulties associated with crop restriction are discussed. Priority is given to establishing national programmes to identify large irrigated areas that can safely meet (national and export) vegetable-production goals without the cost of implementing large surveillance and enforcement programmes for crop

restriction. Such programmes should be a joint activity between the Ministries of Health and Agriculture and should:

- assess the extent of contamination of existing irrigation waters;
- define an approach for certifying safe production areas; and
- maintain a database that will support the development of national strategies.

Westcot discusses what is needed to assess the extent of irrigation-water contamination. This includes a GIS that identifies rivers, discharge points, monitoring points, major vegetable-growing areas and the percentage of each vegetable species grown in each area. He emphasises that monitoring points should be at field level.

The basis of the proposed certification programme is to create positive market pressures for certified crops and negative market pressures for unsafe crops. These economic pressures must operate in peri-urban areas where high-risk, high-economic-return crops are grown. In Chile, there was a heightened awareness of product quality by consumers in the wake of the cholera epidemic. This led farmers to adopt an informal system of labelling their produce, declaring that it was grown in safe water. This, in turn, focused consumer interest. The report discusses various requirements of a certification programme. One issue is that producers who submit the crops for laboratory testing place themselves at considerable economic risk. Westcot proposes that, instead of certifying the quality of each product, there should be a more general certificate to show that the product was produced in a safe

Chapter 9

Cross-cutting Issues

- Food crops may be contaminated by chemical uptake, from air, water or soil media, that affects consumers.
- Foods are often freshly contaminated during post-harvest processing, marketing, and cooking as both domestic and street food.
- Foods are often contaminated during storage, for example by moulds and bacteria.
- Migrant labour is especially vulnerable to sexually transmitted diseases, including HIV infection.
- Returning labourers carry communicable and non-communicable diseases back to their family homes.
- Loss of rural labour to migration may interfere with subsistence-crop production.
- Change in land use in the peri-urban environment may increase or decrease transmission of vector-borne-disease. It may also increase malnutrition, by removing sources of wild food or by loss of subsistence crops.
- Increased road traffic and conflicts between motorised and non-motorised transport leads to increased traffic injuries.
- Construction workers are vulnerable to sexually transmitted diseases as well as a range of occupational diseases.
- The conflict between supplies of drinking and irrigation water may lead to rapid falls in groundwater levels and pollution of drinking water with pathogens and minerals. It may also deprive peri-urban communities of their water sources.
- The attitudes and practices of rural and peri-urban people towards water and health issues may be dissimilar.
- Liquid-waste discharges from cities pollute bathing waters in peri-urban areas. Recreational users may be ill-informed about the associated risks.

Introduction

There are several issues that occur as a component of so many different development activities that they require separate attention. Of particular concern are projects which cause or contribute to

population growth and population movement. Development projects may change fertility and hence the size of the vulnerable population of pregnant women and infants; the relationship is complex and outside the scope of this review.

Table 27. Summary of health linkages to cross-cutting issues

Development sub-category	Diseases		Malnutrition	Injury
	Communicable	Non-communicable		
Food safety	Food storage, contamination	Food adulteration, contamination, plant poisons, antibiotic residues	Consequences of aflatoxins	-
Labour mobility	Promiscuity, crowding, poor sanitation	Dust	Rural deprivation	-
Changes in land use	Vector-breeding sites, water pollution, dust	Dust	Loss of natural resources, land and subsistence	Traffic and occupational
Construction	Promiscuity, poor sanitation, exposure to vectors	-	-	Occupational exposure
Water supplies and pollution	Water quality	-	-	-
Tourism and recreation	Water quality, exposure to sewage	-	-	-

Disruption of the social environment provides a high-risk situation for transmission of pathogens such as HIV. Individuals may experience feelings of powerlessness and lack of control over their lives, separation from partners, reduced social concern about casual sexual relationships, worry about immediate provision of food, abuse of alcohol and other addictive drugs, and lack of information and resources. These problems may be exacerbated by homelessness, landlessness, unemployment, rapid peri-urban settlement, migration, population relocation, and poverty (Zwi, 1991).

Food safety

Much natural-resource development is concerned with food production and delivery and there are many associated health hazards (Figure 17 on page 96). Some 1500 million children under the age of 5 years suffer from diarrhoea and 4–5 million consequently die each year. Many diarrhoeal episodes may be due to food-borne rather than water-borne pathogens (World Health

Organization, 1992b). Some of the food-borne pathogens, such as *Listeria* and *Toxoplasma*, are particularly dangerous during pregnancy, as they may cause the death or serious malformation of the foetus.

Many urban dwellers cannot find formal employment and have adopted a wide range of livelihood strategies that affect household activities and health. They often become vendors of street foods. This provides a cheap source of food for the poor urban population as well as a source of income for the vendors, who are often disadvantaged women. The results of studies in Africa indicate that street food is no less nutritious than modern commercial food and no less safe than other foods available in the household, providing it is eaten soon after purchase; the purchasers may also make savings in preparation time, fuel costs and costs of the foodstuffs (Atkinson and Merkle, 1993).

HAZARD ANALYSIS CRITICAL POINT CONTROL (HACCP)

HACCP is a widely used procedure in food-safety studies (see Box 10). It consists of determination of the microbiological hazards, assessment of the associated risks, risk management through critical-point control, and the monitoring

Box 10. Example of the use of hazard analysis critical point control

Several studies have involved the use of HACCP to analyse the hazards associated with food preparation and storage in poor domestic environments, and some of these are specifically peri-urban. Bryan *et al.* (1988) studied domestic food preparation by peri-urban migrants in Lima, Peru. The micro-organisms of interest were *Salmonella*, *Shigella*, *Staphylococcus*, *Clostridium*, *Bacillus cereus*, *Escherichia coli* and general aerobic mesophilic bacteria. The households studied were of diverse rural origin but their food-preparation behaviours were similar. Food was prepared in the morning, eaten at lunch and held without heat until supper, when it was reheated. Critical control points were identified as food preparation, cooking, storing and reheating. Particular concern was expressed about the holding period, which would enable micro-organisms to become active and multiply. Infants in the study households had diarrhoea, and contamination of food by faecal matter was observed. Vacuum flasks and containers for baby milk were not properly sterilised and baby foods were kept too long after opening or preparation. Domestic animals, including chickens, pigs, cats and dogs, had access to food-preparation areas. Reheating procedures were relatively ineffective. Refrigerators were either present but poorly used or unavailable. In addition to the domestic food preparation, there was a mother's club where nutritious food was prepared and sold. Local inhabitants purchased this food at about noon, took it home and stored it until the evening meal.

The report of the study lists the opportunities available for changing risk behaviour at the critical control points.

of critical points (Bryan, 1992, 1993; Anon., undated). It is similar to the more general procedure of health impact assessment advocated in this review. Some key informants have suggested that adoption of HACCP enables governments to reduce the number of food inspectors that they employ.

NRI has an active programme of research on food quality which includes food safety and human health. The programme uses HACCP methods to define indicators of food quality. These indicators may be useful for illuminating a 'food-quality transition' associated with the rural-urban transition. Further research may be needed to determine the epidemiological consequences of food-quality risk factors in new environments. For example, key informants have suggested that traces of aflatoxin in weaning foods may be more significant when weaning occurs early as a consequence of urbanisation.

CODEX ALIMENTARIUS COMMISSION

The Codex Alimentarius Commission was established in 1961 under the Joint FAO/WHO Food Standards Programme (Food and Agriculture Organization, 1995b). It provides a uniform global system for protecting the health of consumers and ensuring fair practices in food trade, by establishing standards. Committees of particular interest include those concerned with:

- residues of veterinary drugs in food;
- food additives and contaminants; and
- pesticide residues.

All countries in the United-Nations system are members but it has been noted that representatives of very few African countries actively attend meetings (various informants). One reason for this may be the low volume of food exports from the region. The main focus of the joint programme seems to be international food trade and it is normative rather than research-oriented. The problems associated with rapid urbanisation have been reviewed by the commission (Lupien, 1985).

STORED PRODUCE

The international trade in food products depends on an increasingly complex technology. Many countries lack the necessary regulations and enforcement to ensure product integrity. Refrigerated products are especially important in terms of food safety (World Health Organization, 1992a).

Communicable disease

The bacterium *Listeria monocytogenes*, cause of listeriosis, is one of many food-borne pathogens which is of great concern to the commercial food industry. This bacterium can be found in a variety of dairy products, leafy vegetables, fish and meat products. It can grow in refrigerated foods and is heat-resistant. Those predisposed to listeriosis include the immunocompromised and pregnant women and their foetuses. Meningitis, spontaneous abortion and septicaemia are the primary manifestations of the disease (Farber and Losos, 1988). The introduction of a refrigerated food industry could result in an increase in the incidence of listeriosis. An outbreak of listeriosis in California was linked to the consumption of Mexican-style soft cheese and involved more than 300 cases, 30% of which were fatal (Farber and Losos, 1988).

A study in Liberia revealed higher rates of *Campylobacter* infection in urban children than in rural. Although water quality was better in the urban areas, much of the food consumed in the urban homes had been prepared in bulk and stored for several days. The two main reasons for the long food-storage times were the employment of women outside the home, which reduced the time they had for cooking, and the high price of charcoal in the urban areas (Atkinson and Merkle, 1993; Anon., 1996a).

Non-communicable disease

Stored food products are susceptible to contamination by mycotoxins, such as aflatoxin. These are produced by fungi under specific conditions of temperature and humidity (World Health Organization, 1979a). Storage of produce in plastic bags is especially dangerous. The many adverse effects of mycotoxin poisoning can

include reduced effectiveness of immunisation programmes and increased susceptibility to communicable diseases such as measles and HIV. Animal experiments have provided evidence of interactions between malaria and aflatoxins (Hendrickse *et al.*, 1986; Young *et al.*, 1988). The adverse effects of contamination by mycotoxins can include acute fatal poisoning, immunosuppression and long-term risks of liver cancer (Hendrickse, 1991). These toxins are extremely stable molecules that are unaffected by cooking, fermenting or pickling, and there is no reliable method of decontamination. The fungi producing them can infect growing crops as a consequence of pest damage and produce the toxins before, during or after harvest. Outbreaks of aflatoxicosis are common in farm animals and the toxins can carry over to meat and milk. Aflatoxins cross the placenta and are excreted in mother's milk (Maxwell *et al.*, 1989). Powdered milks may also contain aflatoxins. Occupational exposure occurs in those who work with stored products. An outbreak of acute and fatal liver disease in India was associated with ingestion of maize that was heavily contaminated with aflatoxin. Geographical variation in the prevalence of liver cancer has been associated with daily aflatoxin intake (Hendrickse, 1991).

The export of stored food products by developing countries to industrialised countries is jeopardised by mycotoxins. Products are tested on arrival and may be condemned; exports of Turkish figs to the EC were affected in 1989. There are reports of condemned foodstuffs being resold to poorer countries. Supplies of food for emergency relief can also become contaminated while awaiting trans-shipment. See also Jemmali (1995).

Aflatoxins from mouldy feed are expressed, but not concentrated, in cows' milk. The milk is often fed to infants that are weaned earlier than usual due to the pressures of the urban economy. There is still uncertainty about the maximum acceptable level of aflatoxin contamination in various foods but there is agreement that there is a substantial long-term risk of liver cancer associated with consumption of this mycotoxin.

Street sellers may obtain their raw materials from a range of uncontrolled sources and these may often be low-grade or contaminated. An anecdote (FAO, pers. comm.) illustrates this point. The aflatoxin level of samples of street-purchased peanut butter was found to be remarkably high. This was traced back to the producer, who was obtaining her raw materials from a dump used by the official peanut-marketing sector for the disposal of poor-quality produce. (There was an interesting link here with the lack of proper waste-disposal facilities.)

Malnutrition

Aflatoxin exposure is suspected to be a common cause of kwashiorkor, in association with protein-energy malnutrition (Hendrickse and Maxwell, 1989).

OTHER FOOD-SAFETY ISSUES

There are many food-safety issues associated with livestock and fish production. *See also: water- and food-borne parasitic diseases (page 30), aquaculture (page 74) and livestock (page 81).*

Recent examples of emergent food-borne diseases include those caused by *Escherichia coli* O157:H7 (EHEC) and multiple-drug resistant *Salmonella typhimurium* DT 104 (MDRST) (World Health Organization, 1996a, 1997b). Both of these bacterial strains appear to be transmitted to people by consumption of undercooked meat and milk products. They are new, more toxic strains of old and well-known organisms. They usually cause diarrhoea. However, in patients who are immunocompromised, very young or very old, a serious systemic infection can develop and this is life-threatening. MDRST is believed to have emerged from antibiotic-treated domestic animals. Prevention measures include improved hygiene when handling animals and animal products, and adequate cooking and storage of meat products.

The spread of multi-antibiotic resistant strains of pathogenic organisms from antibiotic-treated animals remains a potentially important human-health issue. Use of contaminated animal faeces may spread drug-resistant pathogens

through the food chain. Poultry are of particular concern because they are commonly reared intensively in the peri-urban environment and their faeces are then used in other parts of the farming system. Widespread use of antibiotics in aquaculture may also lead to antibiotic resistance in human pathogens, although there are no studies confirming this. *See also: antibiotic resistance (page 77).*

There is widespread agreement that insufficient is known about post-harvest decontamination of vegetable crops grown with solid or liquid waste. The WHO has commissioned a report on the subject, to be titled *Development of WHO Guidelines for the Decontamination of Fresh Fruits and Vegetables Eaten Raw*. The report will review the scope of the problem, the epidemiological aspects and the known actions that can be taken and their efficacy, and will recommend future research. The practice of decontaminating salads in the home with potassium permanganate or chlorine is considered of low efficacy. However, one key informant suggested that if strong solutions are used they taint the salad and the substantial washing that then takes place to remove the taint would wash off many nematode eggs and micro-organisms.

At the commercial level, there is special concern about the international trade in fruit and salad crops. Where these are kept moist and refrigerated there is concern that pathogenic micro-organisms can survive as long as the product itself. There is anecdotal evidence, for example, of cases of shigellosis from imported lettuce and hepatitis from imported strawberries.

Processes that work in rural areas may not work in the peri-urban environment. An example cited by a key informant concerned cassava processing to remove cyanide. When this is scaled up by cottage industries, a large amount of cyanide is discharged into the peri-urban environment. There is said to be a widespread preference for fermented starches, both for the taste and for the improved food safety. An informant at FAO suggested that the resources spent to develop low-cyanide cassava had been wasted because most consumers wished to ferment it anyway and this process removed the cyanide. However, it was also suggested that commer-

cialisation led to reduced boiling of crops before fermentation and that this could increase exposure to aflatoxin.

Key informants at FAO suggested that chemical contamination of foods was reasonably controlled in developed countries but rife in some developing countries (see Anon, 1992a, undated).

Labour mobility and resettlement

Mobile populations are vulnerable to new health hazards (Prothero and Gould, 1984). Many different kinds of population movement may occur in response to a development project.

Economic development of plantations, mines and other industries has usually been accompanied by labour mobility. Temporary workers, drawn from a largely underdeveloped hinterland, are then exposed to severe health hazards. These hazards are generally occupational, such as the exposure to dusts and toxic chemicals, or associated with poor living conditions. Tuberculosis, pneumoconiosis and pneumonia are common (Giel and Van Luijk, 1967). Migrant workers are also vulnerable to mental disorders (Anon., 1974, 1986; Levi, 1984).

Increasingly, women are forming part of the migrating work-force as rural demand for their labour decreases. They migrate to new industrial developments in the cities or to concentrations of male labour. Female-headed households are more likely than male-led households to live in poverty, in substandard housing with unsafe drinking water and inadequate sewers, and with insufficient income to eat a balanced diet (Browner, 1989).

Migrant labourers may choose to remain when a construction project is completed. They may create new settlements without infrastructure, live in unsanitary conditions, and contribute to disputes over land and common property resources (Odingo, 1979).

Two important forms of resettlement are settlement of new lands to achieve a public good and displacement to resettlement as part of the attainment of a public good. In the former case the settled community represents a productive

resource and will receive support. In the latter case the community are viewed as an obstacle to development and may receive either negligible or inappropriate support (Colson, 1971; Roundy, 1989). Health hazards are rarely seen as a major constraint to resettlement success compared with problems of administration or agricultural planning. In Tonga, 56,000 people were displaced to resettlement by the Kariba Dam. A subsequent study noted that: disruption of social routines lasted more than 5 years; the community became hostile to government; local leaders lost their legitimacy; and the community were less willing to accept innovations in health care (Colson, 1971). Resettled rural people frequently take their compensation money and migrate to urban slums where they are disoriented, unsupported, poor and susceptible to alcoholism and prostitution (Bhatia, 1991).

COMMUNICABLE DISEASE

Migrant-labour systems world-wide present high-risk situations for the transmission of the causative agents of communicable diseases, such as HIV infection (Zwi, 1991). Many labourers are single males who are separated from their families and communities. Workers' accommodation is often intolerable, insecure and depressing (Hunt, 1989). High prices, legislation and poor quality of urban dwellings force migrant workers to live apart from their families. The men seek companionship with women living near their place of work, posing a high risk for multi-partner sexual activity and the spread of sexually transmitted diseases including HIV infection. One major cause of the heterosexual spread of HIV in Africa has been ascribed to the special prominence of labour mobility in that region (Hunt, 1989). The prevalence of STDs often increases during the harvesting season, emphasising the link with labour mobility (Bennett, 1964). Other reports include those of studies from Nairobi, where 94% of those infected with STDs were working more than 400 km from their native area (Verhagen and Gemert, 1972), and from Kampala, where 50% of the STD patients came from the surrounding rural area and the rest were migrants (Bennett, 1962).

Waged employment for women is often harder to obtain or poorer paid than for men (Browner, 1989). Women in such a position are at risk from sexual harassment and rape and some, perhaps many, become sex workers. Others may be required to exchange sexual favours for food and accommodation. Boys and young men may do the same. There is evidence that heterosexual STD transmission was restricted in South African mine workers by homosexual practices (Moodie, 1989). Impoverishment, rapid urbanisation, anonymity of city life, migrant labour, poor wages and dependency of women were identified as the main factors leading to women seeking sex in exchange for money in Bulawayo, Zimbabwe (Wilson *et al.*, 1990).

Returning labourers may carry new communicable diseases to their place of origin, where health-care facilities are frequently poor (Packard, 1989). These diseases may include STDs that lead to female infertility (Raikes, 1989). Migrant workers and militia may have been the means by which a cholera epidemic moved from Tanzania to most of southern Africa between 1978 and 1983 (Meakins, 1988). Packard (1989) showed that 60% of miners diagnosed as having tuberculosis while working in South Africa died within 2 years of returning home.

NON-COMMUNICABLE DISEASE

Returning labourers may have occupational diseases for which industry has failed to accept responsibility. The burden for their care falls on their families. Some conditions, such as asbestosis, or malignant mesothelioma (a cancer of the lining of the lung due to asbestos exposure), may be especially disabling.

MALNUTRITION

The hinterland itself may be a dependent labour reserve with declining agriculture, labour shortage, poor health-care facilities and malnutrition. The burden of both agricultural production and care of dependants falls more heavily on the

women who are left behind. Crop production may then shift to more easily grown but less nutritious staples; child-care may also decline. Malnutrition and susceptibility to disease may increase in consequence. The family may not be able to leave the impoverished land without losing their claim to it (Raikes, 1989). On the other hand, remittances from migrants may raise household incomes and provide access to a wider range of food. Richards (1939) investigated a rural labour reserve in Zambia during the 1930s and concluded that labour shortage prevented bush clearing, leading to overuse of cultivated areas and a shift to less nutritious crops such as cassava (Richards, 1939).

Changes in land use

Changes in land use can effect both the environment and human contact with the environment. Land use in peri-urban areas may change from agricultural production to infrastructure development or industrial processes, as well as from one agricultural system to another. Previously unexploited land may have provided natural regulation systems, such as flood protection or habitats for predators of agricultural pests, and valuable resources for the local population.

COMMUNICABLE DISEASE

The abundance of vector-breeding sites and the degree of contact between people and vectors may be altered. The abundance of the animal hosts which act as reservoirs of human pathogens may also change.

Land-distribution schemes may promote colonisation of new lands. Settlers are likely to encounter natural foci of communicable diseases for which they may be ill-prepared. Examples include encounters with leishmaniasis in the steppes of the former U.S.S.R. and in the forests of South America (World Health Organization, 1992a). In forest areas, the opening of new roads has encouraged an influx of farmers, miners, loggers and others. In Brazil there has been a serious resurgence of malaria, concentrated on settlements, mines and peri-urban areas (Coimbra, 1988).

Deforestation tends to degrade watersheds, leading to increased surface run-off. Erratic stream-flows lead to alternate water shortage and flooding. Floods contaminate potable water supplies and water shortages lead to reliance on contaminated supplies; both promote the transmission of water-borne diseases.

Changes in land use, due to change in agricultural practices or development for mining, construction, reservoirs or road building, can remove surface cover and degrade soils. Exposed, dry soils turn into dust bowls. High levels of air-borne dust promote eye and respiratory disease and increase transmission of meningitis (Greenwood *et al.*, 1984).

MALNUTRITION

Many development projects reduce the land available for the gathering of common property resources such as food, water or fuel. Common property resources and forests play a critical role in cushioning the effect of seasonality and food shortage. This role is especially important for the more vulnerable members of communities and households whose entitlements are few. Policies which protect common land strengthen the coping mechanisms of the poor (Agarwal, 1990). The very poor, and among them pregnant and lactating women and pre-school children, are especially vulnerable to infectious diseases as a result of bodyweight changes associated with seasonal malnutrition and immunodepression (Carswell *et al.*, 1981).

Loss of natural resources or changes in farming systems may increase the workload of women who are already overworked. The excess work may lead to a negative energy balance and a reduction in the nutritional status of the women. Another consequence is that the women may have less time available to care for children or to attend health clinics. The increase in workload can occur in several ways. It is often the duty of women to gather wild food and fuelwood or to collect water. After land they have exploited for these resources is used for a development project, they must seek alternative sources and these are often further away from their homes.

Switching land use from subsistence to cash crops can also increase women's workloads. Cash crops may require more work in areas for which women are traditionally responsible, such as weeding. A change of cropping system may alter the flow of cash into the household. The cash earned may be controlled by men and not used to buy additional food for the family, as women would prefer. This may replace a subsistence system in which food is grown and used directly for household consumption. The consequence may be a reduction in family nutrition.

Land tenure, legal access and control over land can have important effects on household income and hence on health. Other determinants of household income include improved access to credit, working capital and physical security. Development schemes have sometimes ignored or suppressed women's land rights, negotiations about land re-allocation being conducted only with men. In Africa, particularly, loss of land customarily used for subsistence crops has been associated with food scarcity (Rogers, 1981). Many types of development project increase the value of farming land, promoting land sales and cash cropping and reducing food security.

INJURY

Changes in land use may bring an increase in traffic, an increase in contact between people and roads, and an associated increase in road-traffic injuries. Dwellings or business operations may be established by individuals without any consultation with the authorities. Even planned developments by government departments or development agencies may not go through a consultation process with other departments. Often the relevant technical and planning expertise may be in short supply. Responsibilities in some areas may overlap or be duplicated or there may be no responsible organisation at all. Access ways, buildings and advertising hoardings may then be built too close to the roadway. This creates conflict between pedestrians and traffic. It also creates conflict between stationary, slow-moving and fast-moving traffic (see Anon., 1991b).

Construction

Many development projects include a construction phase. Large-scale construction requires migrant labour. Small-scale construction may only use a local labour force, sub-contracted through the informal sector. Special health services are often provided by construction companies for large projects. Such facilities may or may not be made available to other vulnerable communities, such as resettlers and temporary, informal-sector residents. The facilities may or may not be integrated into the national health system when the construction phase is completed.

COMMUNICABLE DISEASE

Construction workers are subject to a range of communicable diseases as a result of migration from different environments. Construction camps are notoriously insanitary. The large concentrations of single men and the populations of camp followers provide situations of high risk of STD transmission. Malaria transmission has frequently been affected by construction (Rao *et al.*, 1946; Brown and Deom, 1973; Tauil, 1986).

NON-COMMUNICABLE DISEASE AND INJURY

Occupational health and safety are key issues in construction projects. Workloads are heavy and there is often exposure to unsafe noise levels, dust, toxic chemicals, gases, vibration, flammable materials and high temperatures. Much morbidity is work-related rather than occupational, and associated with stress, long hours, low pay, poor food, smoking and drinking. Among those who work in the construction industry in the U.K., there are 10 fatalities/100,000 employees each year, the ratio of major injuries to fatal injuries is 27, and cancers, respiratory and circulatory diseases are more common than in other workers (Snashall, 1990). Elsewhere, many women are involved in construction work and the work conditions may increase their vulnerability to spontaneous miscarriage. High mortality rates

from injuries and infection have also been noted in children living on construction sites (Bhatt *et al.*, 1988).

The use of major items of equipment such as turbines, bulldozers and the lorries required to move large amounts of soil and concrete provides major hazards for road users (Webster, 1960). In the construction of the Kainji dam in Nigeria, road crashes and collisions were the most important cause of death and of major morbidity; road-traffic injuries caused more deaths than all the many communicable diseases in the region (Wyatt, 1991).

MALNUTRITION

The poor nutritional status of impoverished labourers and the anaemia associated with their parasitic burden, significantly reduce productivity (Brooks *et al.*, 1979; Wolgemuth *et al.*, 1982). The energy expenditure of heavy labour may exceed energy intake. When Wolgemuth *et al.* (1982) investigated road workers in Kenya, they found that helminth infection and anaemia were common and that 67% of the workers were malnourished. Although energy-food and iron supplementation improved productivity, many workers used the energy food as a partial substitute for their normal diet rather than a supplement. Surprisingly, the nutritional status of the female workers was better than that of the males.

Water supplies and pollution

[See also: *pollution of water by agriculture* (page 69) and *Box 11.*] In areas of water shortage there is frequently a conflict between abstraction of water for drinking and that of water for agricultural and industrial uses, especially in peri-urban areas (Listorti, 1996b). In the absence of effective planning, the most economically powerful abstractors are likely to dominate the process. This may be manifest in rapid and unsustainable falls in groundwater levels, as is occurring in Sana'a, Yemen, for example. Where effective planning prevails, drinking-water supplies are likely to receive priority—providing decreased resources for agricultural development.

At the same time, there may be little control of pollution of the groundwater resource. The peri-urban poor may be faced with the need to increase the depth of boreholes in order to abstract water of decreasing quality. Potential pollutants include pathogens, heavy metals, nitrates and salts. Contamination with pathogens is likely to occur mainly from poorly sealed boreholes, as pathogens do not usually move far through the soil. The other contaminants do move through soils, although heavy metals may

become bound to soil particles. Saline intrusion is a consequence of excessive freshwater abstraction, particularly in coastal areas.

WaterAid, an NGO, has published a stimulating review of water shortage and waste-disposal problems (Black, 1994). The report is principally concerned with the 18 developing-country cities that are predicted to have over 10 million inhabitants each by 2000. Many of these cities face an absolute shortage of drinking water due to aquifer depletion or pollution of surface supplies. The report cites a World Bank review that concludes that every time a new engineering scheme replenishes an urban water supply from further away, the unit cost of raw water doubles. The report argues that there has been a consistent research bias towards the rural poor and the urban rich and that the urban (and implicitly peri-urban) poor have been neglected (Figure 18 on page 96). It reveals that, despite widespread agreement to follow low-cost, people-centred approaches, some 80% of investment was still on high-cost technologies. Less than 5% of donor aid was spent on low-cost solutions. Attitudes and practices observed in the rural poor towards health issues have been attributed inappropriately to the urban poor. In the report, it is argued that public supply of infrastructure and the removal of responsible action from individuals cannot solve the current crisis. The solution involves a re-appraisal of the slum dwellers as upwardly mobile entrepreneurs. The residents of overcrowded, flood-prone warrens appear to place a high priority on sanitation compared with the rural poor; consequently, they are prepared to pay for services. Several NGO projects are cited in support of this suggestion. The report concludes by advocating a new sanitary revolution—different in concept to the one employed in 19th-century Europe.

Box 11. Strategic sanitation plan, Kumasi

Kumasi is the second largest city in Ghana, with a population of about 1 million (Gear *et al.*, 1996). Three major sanitation plans have been prepared over the past 40 years, all based on expensive, conventional, mains sewerage. In 1996 there was still no mains sewerage city-wide and conditions had deteriorated. About a quarter of the population relied on 'pan latrines' (buckets). The municipality was short of money and had laid off 400 nightsoil collectors. Nightsoil was being emptied into streams and drains, and septic tanks were overflowing. Less than 10% of the solid waste was properly collected, although over U.S.\$1 million of revenue was being collected for this purpose. Public latrines were not being maintained. A strategic sanitation plan was prepared with World Bank support. The new plan recognised the need to provide sanitation to all and not just the privileged few, to consider various sanitation technologies, and to take account of the users' preferences and their willingness to pay. In areas of low-density, indigenous housing, where 60% of the community lived, ventilated, improved, pit latrines were promoted. The design was altered to accommodate the number of people using each latrine and a cost-sharing system was worked out. The demand for public latrines was carefully calculated. Many components of the plan were implemented by the private sector, including construction, operation and maintenance. The major lessons learned were that people were willing to pay, that private-sector participation was effective, and that technical solutions do exist.

GROUNDWATER

An overview of groundwater-contamination issues in relation to impact assessment is provided by Canter (1996). Although focused on the conditions in the U.S.A., this book contains many insights into the nature of groundwater, soil and

Box 12. Picnicking outside Damascus

The Ghouta is a peri-urban area of Damascus that is famous for the blossom of its trees in spring and the shade provided by the trees in spring and summer. Damascenes frequently go there to picnic during the spring and summer months. The entire area is irrigated with untreated sewage that flows in all the rivers and streams (pers. obs.). The sewage water is mostly used to irrigate tree crops, rather than vegetables. A field-flooding or ridge-and-furrow technique is used. The extent of exposure of Damascenes to the hazardous water and soil is hard to judge. It is known that some geohelminths are highly prevalent in the community, and seasonal outbreaks of cholera are recorded. On the other hand, the Damascenes are very aware of the unpleasant nature of the 'black water' and try to avoid it. There is presently a project to treat the sewage before discharge. This will render it less offensive but not necessarily more safe. The treated waters may then appeal to bathers and picnickers.

pollutant interactions. It also provides a comprehensive typography of sources of contamination and an extensive bibliography.

Tourism and recreation

Much domestic and industrial liquid waste is discharged untreated or partly treated into rivers and coastal seas (Box 12). These receiving waters are often used by urban residents and tourists as bathing sites and there is a potential for communicable-disease transmission. Bathers spend considerable periods of time exposed to contaminated water or beaches.

There are many communicable diseases which may be transmitted by bathing, including gastro-intestinal, skin, eye, ear, nose, throat and respiratory infections. The most relevant patho-

gens have a low infective dose. The methodology used in previous, prospective, epidemiological studies of bathers may be flawed (Saliba and Helmer, 1990). The evidence for clinical ill-health from bathing in contaminated marine waters remains mixed. However, there are EEC standards for the microbiological quality of bathing water, with a maximum threshold of 100 faecal coliforms/100 ml. A proposed dose-response relationship indicates that, at this concentration, there should be 25–40 cases of symptomatic gastro-intestinal infection per 1000 people exposed.

Chapter 10

Urban-health Research in Developing Countries

- The Healthy Cities programme is described, together with current research priorities such as the healthy-marketplace concept.
- The determinants of urban health are discussed.
- The perspective of a number of international agencies, including the World Bank, the World Health Organization and USAID, is outlined.
- Work on the development of environmental-health indicators is summarised.

Healthy cities

The dramatic effect of urbanisation on human health was very clear in the industrial towns of 19th-century Britain. The great reformers of that time derived solutions in what they called ‘the sanitary idea’ (Ashton, 1992). Later, the emphasis shifted from preventive to curative medicine, until a new public-health movement emerged. In 1986, the Healthy Cities Project (HCP) was launched through the WHO. An ‘ecological idea’ began to replace ‘the sanitary idea’. For example, the Victorians solved the problem of waste by moving it far from where it was created. However, as biological systems become overloaded this solution ceases to work, and waste must then be recycled *in situ*. The HCP challenges urban communities to create cities that work with natural systems rather than attempting to subdue them. Thus good natural-resource management is seminal to good public health.

The results of many studies have demonstrated that poverty and deprivation are strongly associated with ill-health. Indicators of health and deprivation have been investigated over small areas of cities and found to be closely

associated. A typical health indicator is the standardised mortality ratio of those under 65 years of age. A typical deprivation measure combines unemployment, ownership of common goods, occupants per household and tenancy.

The HCP emphasised the need for all the agencies involved to consider the health-promotion potential of their activities. The project has set a number of objectives (Goldstein *et al.*, 1995; World Health Organization, 1995b). These include:

- reducing inequalities in access to health services;
- creating physical and social environments that support health; and
- strengthening the community’s capacity, capability and opportunity to take action to support health.

Some of these objectives are directly addressed by research on natural-resource management. The objectives might be met by providing a framework that:

- increases awareness among all municipal authorities;
- exchanges information and technology between cities; and
- links technical, political and community action, by developing new partnerships between government agencies, NGOs, universities and communities.

In general, there is little mention of the peri-urban interface in the healthy-cities literature. Inter-sectoral collaboration is widely stressed but there is little mention of natural-resource management other than sanitation. In the America Region, the healthy-cities initiative explicitly includes the peri-urban areas, because the municipality is the principal administrative unit. There is a Healthy Municipalities Movement. A network of healthy cities has been established in Francophone Africa. It is co-ordinated from Dakar and supported by the Canadian government. Other projects included Accra, Johannesburg and Dar es Salaam. In Accra, Ghana, a review of health problems has considered sanitation, food hygiene, community involvement, and land-use planning. Kumasi has been involved and a focus on sub-district, health-management teams has been identified. In the European Region, cities that achieve appropriate criteria are designated 'healthy cities' and it appears that the designation is valued as political capital.

Some of the conclusions and recommendations of the HCP, to date, include recognition that:

- each Ministry of Health needs a 'foreign/external ministry' section to liaise with other sectors more effectively;
- EIA and HIA are needed for urban-development projects;
- comparison of intra-urban differentials is an effective tool; and
- better co-ordination of urban-development activities can be assisted by a municipal health plan.

Some of the research priorities identified include the need for:

- environmental-health monitoring (normal health indicators do not adequately reflect rapid urbanisation);
- community participation in the work of municipal agencies, such as solid-waste management; and
- development and use of HIA procedures for use in urban-development projects.

HEALTHY MARKETPLACES

One concern of the HCP, with strong linkages to natural-resource management, is the healthy-marketplace initiative. The health linkages of many peri-urban markets can be summarised as:

- poor infrastructure (water, toilets, and physical layout);
- the health conditions of stall-holders and food handlers (and the availability of health services);
- the practices for storage and handling of raw and semi-processed foods;
- the safety of street-vended food (Figure 19 on page 96);
- the environmental impacts;
- the management of solid and liquid waste;
- the role of government authorities, such as food inspectors; and
- consumer education.

In many cities, and peri-urban communities, the marketplace can be considered as a commercial and social centre (World Health Organization, 1996c). Often it has evolved without planning, infrastructure or consideration of food safety. In consequence, the food sold there is commonly contaminated. However, the

social role of the market offers an opportunity to educate the consumer about a range of health issues.

An HACCP analysis of food safety in the marketplace identified four main hazards:

- food which becomes unsafe during primary production and/or transport and is brought to the market and sold without inspection or control;
- food which becomes unsafe while in the market due to improper handling and storage;
- food which becomes unsafe in the market due to poor environmental conditions; and
- food which is misrepresented or adulterated, leading to health, nutritional or economic problems for the consumer.

It was concluded that infrastructural improvement is not enough. To address the problems identified above, the marketplace must have an organisation structure that involves the municipal health authorities. This requires basic laws, inspectors and analytical laboratories as well as hygiene education. Selective and discriminating consumers can create a demand for food safety. This idea is clearly consistent with crop certification. Pilot projects on healthy marketplaces are being undertaken by the WHO in various cities. The contact point is the healthy-city co-ordinator in each regional office of the WHO. *See also: food safety (page 110).*

Determinants of urban health

Some 29%–45% of urban populations live below absolute poverty levels (Cairncross *et al.*, 1990). Until recently, little has been known about the differential health impacts of this poverty within cities. Two aspects of the scale of differentials stand out: the large, relative differences in health status between the privileged and the deprived in the urban environments of developing countries; and the scale of the population at risk of inflated death rates (about 50%). The results of a series of studies have revealed that differences between

neighbourhoods in environmental conditions were associated with larger differentials in child health than in household facilities.

There have been several attempts to identify the principal determinants of urban health (see Table 28; Harpham and Tanner, 1995).

Bradley *et al.* (1992) reviewed over 100 epidemiological and demographic studies on the intra-urban differentials in health and mortality in urban communities. Their review excluded studies from rural areas, such as those on environmental microbiology and vector biology, which may be important in a more peri-urban focus. The most vulnerable community groups were women, children and the elderly. Urban children who were under 5 years of age had a similar pattern of mortality to their rural counterparts, from the same infectious diseases, including diarrhoea, malaria and ARI. Injuries associated with traffic were the leading cause of death in those aged between five and 14 years. In older citizens, however, injuries associated with violence were the leading cause of death (homicide). In elderly groups, the prevalence of chronic disease was significantly higher among the poor.

The review noted that links could be drawn between poverty, or socio-economic status, and mortality, without reference to intermediate variables. Table 29 summarises the review's conclusions from the results of studies on the causes of morbidity.

Comparable differentials were revealed in several studies between squatter settlements and the areas of organised housing. The clearest associations between housing and health were for ARI and indoor air pollution, diarrhoea and water (supply, storage and hygiene factors), and accidents. However, the correlation between poverty and deficient home environment was so close that separating them as causal factors was difficult.

A seminal study mapped health and indices of socio-environmental deprivation in metropolitan Accra and São Paulo. The health data were sub-divided between communicable, chronic and psychosocial disease. Causes of

Table 28. Urban health hazards, determinants and actions (Harpham and Tanner, 1995)

Hazard	Determinant	Vulnerable group	Action by sector (other than health sector)
Communicable diseases			
Diarrhoea	Water, sanitation, hygiene-related behaviour	Children	Provision of water, sanitation, education
Acute respiratory infection	Indoor and outdoor air pollution, crowding	Children	Housing, legislation, education, infrastructure
Pneumonia/tuberculosis	Indoor and outdoor air pollution, crowding	Adults	(Health sector)
STDs, including AIDS	Changing social context	Adults	Education
Measles	Overcrowding, poor immune status	Children	(Health sector)
Helminths	Housing, sanitation, behaviour	Children	Provision of water, sanitation, education
Malaria	Housing, drainage, climate	All	Housing, infrastructure
Skin diseases	Water, sanitation, behaviour, housing	Children and adolescents	(Health sector)
Non-communicable diseases			
Chronic respiratory disease	Overcrowding, poor immune status, air pollution, housing	All	Legislation
Obstetric deaths	Antenatal care, abortion legislation, education	Women	Legislation
Perinatal deaths	Antenatal care, education	Women	(Health sector)
Cancer	Life-style, smoking, diet (occupation, exposure to pollution)	Adults	Pollution control, education
Cardiovascular disease	Life-style, smoking, diet, occupation	Adults	Education
Malnutrition	Poverty, education, food availability and access	Children	Food supply (and security)
Injury			
Traffic	Transport and infrastructure	All	Legislation (road design and siting, pedestrian separation, vehicle maintenance)
Occupational	Workplace practices, maintenance of machinery, lighting, education	Workers	Legislation, monitoring
Violence	Alcohol, drugs, social factors	All	Housing, lighting, police, open spaces
Household	Housing and living conditions	Children (and elderly)	-
Mental disorders			
Alcoholism and other drug addiction	Stress and life events, lack of social support	Adolescents and adults	Social support

Table 29. Conclusions of a review by Bradley *et al.* (1992) on intra-urban health differentials

Category	Summary
Gastro-intestinal disease	A range of studies from Asia, Africa and South America indicates a greater prevalence of diarrhoea and helminth infection in environments with poor housing, poor sanitation and poor water facilities than elsewhere. The studies do not indicate whether higher socio-economic status confers protection. An analysis of infant morbidity and mortality and their relation to water accessibility, water quality and sanitation showed some of the strongest associations of environmental variables and disease outcomes. Children from households using public standpipes and cesspools are several times more likely to die of diarrhoea than those with in-house, piped water and sewerage.
Nutrition	There is a large amount of evidence of intra-urban differentials in nutritional status related to socio-economic status.
Air-borne infection	There is a shortage of studies on respiratory diseases. The results of a study in São Paulo indicated that there were no differences, between socio-economic groups, in acute respiratory infection. There was evidence that reductions in respiratory impairment of young children were associated with improvements in particulate and sulphur-dioxide levels over the same period, in Cuatao, Brazil.
Skin- and arthropod-borne infections	Relevant studies on skin- and arthropod-borne diseases are rare.
Vector-borne diseases	There are few studies which indicate differentials in urban malaria and plague.
Psychosocial disease and trauma	There is a growing literature on differentials in mental health within cities, indicating that the highest prevalence of psychosocial disease occurs in the low-income, physically deteriorated areas.

death were grouped as: infectious and parasitic disease (including cholera, TB, malaria, hepatitis); diseases of the respiratory system (including acute, pneumonias and chronic); diseases of the circulatory system (including heart failure, hypertension and cardiovascular); or external injuries. In Accra, circulatory diseases cause 25% of deaths and have replaced infectious and parasitic diseases (18%) as the principal cause. Respiratory diseases have maintained their rank of third place but still form 12%. Infectious diseases dominate in those under 14 years of age whereas chronic diseases dominate in the elderly. Malaria remained a principal cause of morbidity.

Stephens *et al.* (1994) identified seven socio-economic zones by using three indicators: income per household; population density; and age/ethnicity (related to old and new migrant groups). Their study was focused on the metro-

politan area and the only clearly peri-urban community investigated was one of low density and middle class. There was a severe disparity in the cost, availability and quality of water between rich and poor zones. Formal facilities for solid-waste disposal and collection were barely existent for many communities and there was an extreme shortage of toilets. Overcrowding was intense, with five or six households (30-34 people) living in each house in deprived areas, compared with one or two households (seven to nine people) per house in the better areas. In the high-density, low-class areas, some 23% of household heads had no formal education.

Cause-specific mortality generally varied intuitively between socio-environmental zones, although there were some surprises. For example, circulatory disease was more important in poorer areas than might be expected. The death rate

from circulatory, infectious/parasitic and respiratory diseases was much higher in poorer zones than richer zones. A particular conclusion was that a large burden of disease from infectious and parasitic diseases was avoidable. It was noted that death rates from malaria were much higher in the poor areas which were close to low-lying swamps containing relatively clean water than in poor areas further from the swamps or without the relatively clean water. The low-lying areas were also flood-prone and liable to epidemics of cholera and typhoid. It was less easy to explain the differentials seen in the mortality from respiratory disease, although overcrowding seemed an important factor. Similarly, the higher-than-expected death rates from circulatory disease among the poorer residents may be explained by their stress and lack of access to emergency services, and the poor roads in the areas in which they live.

Overall, it can be concluded that improvements to the environmental conditions in the poorer neighbourhoods could have a major impact on human health.

In a related study, Songsore and McGranahan (1993) included a specifically peri-urban community in the Greater Accra Metropolitan Area, which they referred to as a 'rural fringe' community. Most (68%) of the subjects surveyed used charcoal as their main cooking fuel and 8% used wood. In the poorest group about 20% used wood. An attempt was made to relate respiratory problems to indoor environments but the results were unclear. In all economic groups, the majority took some precautions against mosquitoes, with 58% of the poorest using mosquito coils and 6% using mosquito nets. There was some evidence of an association between the use of mosquito coils and respiratory problems. Similar evidence from Jakarta led to the suggestion that use of these coils should be discouraged (Surjadi, 1993).

World Bank

A recent review of trends in urban-health research indicated that the World Bank has moved away from project support, such as the upgrading of slums, to building urban-management capacity (Harpham and Tanner, 1995). This is, in part, a

recognition of a failure to achieve city-wide impacts from neighbourhood-based projects. It is a move from project to policy analysis that seeks to enhance the productivity of the poor by improving access to social services, including health services. The review also indicates that policies of structural adjustment have had a disproportionate and negative impact on the urban poor. The members of this population are considered particularly vulnerable because they depend on their own labour, rather than other assets, and a cash economy. Structural adjustment reduces employment opportunities and raises the price of goods and services. It was once thought that free-market conditions would enhance the economy of the informal urban (and peri-urban) sector, but it is now suggested that the opposite may have occurred. On the supply side, the urban poor have lost access to the raw materials that are now recycled by the formal sector. On the demand side, there has been a contraction in demand from the low-income wage-earners who, in the past, bought from informal producers.

There are several World-Bank reports that illuminate the problems of urban health. The Bank's lending for urban development has focused on projects with mainly health objectives (Hecht, 1995). The 1992 World Development Report emphasised risk factors in the household environment: contaminated drinking water; inadequate sanitation; and indoor air pollution from cooking fires. In the 1993 report it was suggested that these risk factors accounted for 30% of the global burden of disease, and that feasible improvements in the household environment, in cities and rural areas, could avert about 25% of this burden of disease (equivalent to 2.5 million infant deaths/year). The results of studies supported by the World Bank indicate that, even in urban areas, the poor have less access and longer waiting times for poorer health services than the non-poor. Inconsistencies between the 1992 and 1993 reports are the subject of a continuing debate (pers. comm.).

Issues to be considered by the Bank in the future include:

- identification of the interventions which have the greatest impact on the urban poor; and
- defining the respective responsibilities of urban local government and central agencies such as the Ministry of Health, in developing policies and managing health services. In many cases, the allocation of responsibility may depend on the capacity of municipal governments and their legal framework for delegating authority.

Listorti (1996a) recently emphasised the need:

- to examine problems within a triple context of public health, environment and pollution;
- to subordinate pollution to human health (not, as is so common, the reverse);
- to place the pollution of poverty on a par with industrial pollution;
- to identify multiple sources for the same health problems, to ensure that remedial measures do not deal with only part of the problem; and
- to seek targeted collaboration among those agencies which have similar objectives but typically do not work together.

Listorti (1996b, 1996c) provided an annotated literature review which overlaps with the current review. It focuses on Africa and cites a survey, by Levy (1992), of research topics in environmental health in developing countries. This identified 500 projects of which 77% concerned chemical hazards, 26% physical hazards, 10% biological hazards and 10% psychosocial hazards. It noted that:

- the health risks of communities living in airsheds and watersheds near industrial concentrations have received relatively little attention compared with in-plant hazards;

- the tendency to consider occupational health and safety as a separate discipline to environmental health is not valid in peri-urban environments, where industries are small or not covered by occupational health-and-safety regulations;

- most causes of disease, injury and death in developing countries lie outside the jurisdiction of the health sector (yet the policies of sectors that exert these direct health impacts are not set by health criteria); and

- there was very little literature combining ecology and public health. There was a need for shared monitoring criteria on contamination of the food chain through agriculture and water pollution. For example, engineering indicators of water quality such as BOD do not correlate well with pathogenicity.

Listorti's main recommendations were as follows:

- research is needed on the 'urbanisation' of traditional rural diseases and the remedial measures that are practical through infrastructure provision;
- targeted collaboration is required between the health sector and the sector responsible for creating or resolving a problem (the agriculture and energy sectors were considered particularly important);
- there is a need for rapid procedures to assess environmental-health impacts; and
- research is needed on the linkages between nutrition, agriculture and sanitation.

UNICEF

UNICEF has a programme entitled Primary Environmental Care which is part of its Urban Basic Services programme. It focuses on the

fulfilment of basic needs through community empowerment (Padmini, 1995). It includes the supply of safe water and liquid- and solid-waste disposal. It emphasises environmentally sustainable practices such as the community-based, hygienic recycling of inorganic wastes and composting of organic waste, the use of hand carts, the use of compost in urban agriculture, the reduction of air pollution by use of alternative fuels, the use of better stoves, and small-scale tree planting.

WHO

A background WHO document on strategies for urban health strongly advocates inter-sectoral action to improve the environments that determine health (World Health Organization, 1991b). Key issues were the increased risks of communicable disease because of overcrowding and immigration, and the increasing vector populations associated with changing settlement patterns. The non-communicable diseases were considered to be strongly influenced by pollution. The types of pollution included indoor air pollution from biomass fuels, outdoor air pollution from vehicular emissions and industrial emissions (acid rain), exposure to toxic substances in industry, homes and agriculture, and chemical contamination of food, water and air.

The risk factors requiring intervention were listed as:

- rising population growth;
- poor housing/squatter settlements;
- increasing density, overcrowding, traffic congestion, and loss of open space;
- increasing urban poverty;
- pollution of air, water and land from industrialisation, transportation, energy production and use and waste; and
- institutional inability to provide the infrastructure needed for clean water and sanitation, to manage wastes, and to ensure adequate employment, housing, food supply, safety and environmental controls.

The 44th World Health Assembly discussed the urban-health crisis and the strategies required (World Health Organization, 1993b). Resolution WHA 44.27 advocates the assessment of the impact on health of the policies of agencies concerned with energy, food, agriculture and other sectors.

USAID

USAID has attempted to incorporate health activities into other economic development activities since 1961 (Fluty and Lissfelt, 1995). Until the late 1980s the focus remained largely rural. Since then there have been several urban-health projects but these may have not been integrated with more environmental concerns. The most relevant programme, entitled Water and Sanitation for Health (WASH), was associated with the Office of Health and Nutrition and initiated in 1980. This project was initially concerned with technical assistance with safe water, sanitation and hygiene education. Later it became concerned with urban-waste issues. Later still, a comparative health-risk-assessment programme emerged (Brantly *et al.*, 1997) and this is described below.

USAID has a specific focus on peri-urban-health issues. This programme acknowledges that conventional approaches to delivering services to poor communities have been ineffective (Varley *et al.*, 1996). Building infrastructure does not change the behaviours which lead to illness and pollution. Subsidised services generate little sense of community and do not engage or strengthen community organisations. In recognition of this experience, many agencies have developed participatory approaches that focus on partnerships, community input, local demands, and behavioural changes, and explore new ways to cover cost. The solutions require cross-sectoral collaboration. They move responsibility for services closer to the users.

In pursuit of this philosophy, the Environmental Health Program of USAID (EHP) has developed a method based on local demand. This method is partly concerned with willingness-to-pay at the individual level. For example, it is well known that many poor people pay high charges to water vendors in order to obtain drinking

water. The charges are often several times higher than those paid by households for directly piped water, but represent what that poor community are actually willing to pay. The willingness-to-pay analysis is linked to a community-participation approach which ensures community ownership of the infrastructural improvement.

The EHP has reviewed the health-risk factors for children in urban slums (Anon., 1996b). In comparisons of urban and rural health it is now widely accepted that poverty is a significant predictor of urban morbidity and mortality. The comparisons indicate that urban health is better than rural health but the relevant data are misleading as they hide the large differences between rich and poor and the common omission of the poor from the statistics (Anon., 1996b). Malaria, a typically rural disease, is increasingly important in urban settings. Dengue is at epidemic levels and spreading in urban centres; a state of emergency was declared in Guatemala and El Salvador in 1995 because of dengue epidemics. Respiratory diseases are more prevalent in urban than rural areas because overcrowding promotes the transmission of infectious organisms.

Table 30 provides an overview of the environmental risk factors for children in urban (and peri-urban) slums. The factors that most clearly may be influenced by natural-resource development are indicated by shading. Important environmental determinants include domestic water supply, sanitation, hygienic facilities, food storage and handling, markets, slaughterhouses, cooking facilities, fuel, and industrial pollutants (Anon., 1996b). It is widely recognised that many of these factors cannot be addressed by the health services on their own but require a multi-sectoral approach that enables several programmes to attack the various environmental causes of ill-health simultaneously. These programmes often compete for resources but require methods for sharing resources. This has been referred to as the integration of primary health and environmental care.

The EHP produced a strategic framework for 1995–1999 (Anon., 1995). It covers similar ground to the present review, with regard to urban/rural differences and transitional economies, and then provides an analysis of environmental-health burdens, trends and approaches for each developing region, including Africa, Asia and the Near East. It draws on the World Bank's

Table 30. Child-health risk factors in urban slums (Anon., 1996)

Risk factor	Disease			
	Acute respiratory infection	Diarrhoea	Malaria	Death
Poor water quality		X		
Poor sanitation		X		
Insufficient garbage collection/disposal		X		
Poor drainage/free-standing water			X	
Crowding	X			
Air pollution (in- and out-door)	X			
Poor nutrition	X	X		X
Poverty	X	X	X	X
Low maternal education				X
Lack of primary-health-care facilities nearby				X

concept of disability-adjusted life-years (DALYs) to distinguish trends and establish priorities.

India is characterised as having severe environmental-health problems associated with both traditional diseases, such as malaria, filariasis, dengue, Japanese encephalitis and diarrhoeal diseases, and modern diseases associated with poor industrial-waste disposal and rising air pollution. The main trends are rapid population growth and urbanisation. Seasonal urban migration of farm workers is common and brings rural communicable diseases into the cities. Urban systems of water supply and sanitation are inadequate and becoming more so. There has been an increase in economic deregulation, free enterprise and foreign investment. This has produced a capable middle class, industrial growth, and rising consumption, and increased waste-disposal problems. The options for improving environmental health are summarised as:

- supporting local capacity to set priorities, by introducing tools such as the assessment of environmental health risks;
- focusing on vector-borne diseases, using community-based approaches; and
- focusing on urban areas, while fostering community involvement and institutional development.

Africa is regarded as still maintaining the characteristics, in general, of a pre-transition society. It is one of the least urbanised regions and will remain so for the next generation. By 2020 some 40% of the population will live in urban centres. Political disturbances have caused whole groups to move to peri-urban areas and establish 'urban villages', in which culture and community are preserved in a radically different environment. EHP proposes to focus on rural problems but also notes that there is more opportunity to address the problems of urbanisation because it is happening at a slower speed. The effect of urbanisation on malaria in Africa requires attention.

The EHP's strategic framework refers specifically to the peri-urban sector in relation to the Near/Middle East and Latin America, where rapid population growth and urbanisation create a great need to improve environmental health in urban areas. In the Near/Middle East, water conservation and wastewater re-use are priorities. In Latin America and the Caribbean it is estimated that the peri-urban population will grow from 10%-20% of the total population in the early 1990s to 40% by the year 2000. Little of the urbanisation is planned and infrastructure lags far behind. Some 60%–80% of urban populations breathe air of marginal or unacceptable quality.

The overall EHP strategy is to promote sustained wellness by reducing risks. The key to this is seen as bridging or promoting collaboration between public health and institutions concerned with environmental improvement. This includes promoting health impact assessment as part of environmental-impact assessment.

Yacoob and Kelly (1997) addressed the specific needs for environmental health of peri-urban populations, in relation to municipal roles and responsibilities. They note that the peri-urban poor are often ignored, misunderstood and denied access to public moneys. Efforts by government to improve the living conditions are often ineffective, partly because of administrative complexity. The solution is multi-sectoral and requires new partnerships. The new participatory approach is referred to as community involvement in management of environmental pollution (CIMEP). The objective is to extend and maintain a basic pollution-preventing infrastructure. The project works on changing municipal and community perceptions and behaviour. For example, municipal authorities may mistakenly believe that 'participation' means communities supplying free labour for centrally planned projects. Conversely, communities may believe 'participation' means municipalities supplying them with free infrastructure. CIMEP tries to provide a framework in which both sides can work out new partnerships. The project provides training in multi-sectoral collaboration and in rapid appraisal using social-survey techniques, including community mapping. Yacoob and

Kelly (1997) describe the specific interventions that a community identified as priorities, through the process, and the subsequent outcomes.

COMPARATIVE RISK ASSESSMENT

Comparative health-risk assessment is a method used by USAID to assist public-health and environmental officials to set priorities and make sound funding decisions (Brantly *et al.*, 1997). The output of such an assessment is a ranking of environmental-health problems into high-, medium- and low-risk categories, with a comparison between richer and poorer, urban areas. Risk levels are classified by considering the two dimensions of probability of effect and severity of effect; events with low probability and low severity are considered to have low risk.

The method builds on health-risk assessment. Health-risk assessment uses exposure assessment and dose–response assessment to characterise risks as the number of new cases of a disease in a year for a population exposed to a given dose. It is oriented towards diseases in which a dose–response model can be postulated—the post-transition diseases. Comparative health-risk assessment, a modification of comparative risk assessment, can be used for the pre-transitional or communicable diseases, for which no dose–response relationships exist. It can also cope with the less reliable data that are generally all that is available.

This technique has now been used in several studies. In each study, the potential health impacts of a range of problems were identified and then ranked according to their predicted magnitude. Most of the data used were secondary. Primary data were generated only from ethnographic or social surveys. Such surveys were considered particularly important in peri-urban neighbourhoods, where official, environmental data rarely exist. The surveyors used focus-group discussions, key-informant interviews and semi-structured observations.

Comparative health-risk assessment is oriented towards environmental impact rather than social impact, and does not currently include malnutrition, injuries or mental disorder. Recent

attempts to address these issues have focused on increasing community participation in setting priorities and implementing solutions.

GTZ

Merkle (1995) suggests that health in the city was neglected during the 1960s–1970s, in favour of a concentration on rural programmes that were expected to reduce urban migration, although this did not happen. Urban statistics disguised differentials between the rich and poor. The health impact of industrialisation, modernisation and uncontrolled growth was not recognised. Since 1980, GTZ has implemented a number of urban health and health-related projects, including some on water and waste.

Merkle proposed that four types of area should be distinguished in cities:

- old centres with high population density, decaying buildings, outdated services and informal production sectors;
- planned, middle-class areas, with moderate population density and adequate services;
- prosperous elite areas, with low population densities and all services; and
- peri-urban areas, which are undefined, densely populated, mixed with industries and fast-growing.

The communities in the peri-urban areas fall into three categories: legally accepted settlements; illegal squatters; and floating populations.

Important characteristics of urban growth included environmental hazards, toxic waste, and unplanned growth. Environmental hazards and toxic waste are present at the workplace, in homes and everywhere in the city, often spilling into rural areas. Merkle surmises that such hazards cause more morbidity than communicable diseases. The leading problems are poor solid-waste disposal, unsafe water supply and sanitation, inadequate housing and hygiene, exposure to toxic substances and pollution, poor food safety, and social and mental stress. City administrations have been unable to cope with

unplanned growth and have lost control over large parts of their cities. Existing laws and regulations are bypassed and city planning is manipulated by powerful groups.

GTZ has carried out a number of baseline surveys of health among the urban poor. These surveys have included nutrition, morbidity, a KAP study about water, sanitation and intestinal parasitism, a KAP study about dengue, and a survey of hospital waste. The surveys have revealed that accidental injury, homicide and suicide may be leading causes of death. Morbidity was dominated by accidental and violent injury, STDs, substance abuse and psychosocial problems.

The nutritional surveys indicated:

- a greater diversity of foods but reliance on purchases of cheap foods, with insecurity associated with price and income fluctuation;
- hazards from street food;
- inappropriate supplementary feeding of infants;
- that 80% of young children receive three or fewer meals per day; and
- a high prevalence of diarrhoea (approximately 20% in children aged less than 5 years).

GTZ's experience has led it to rethink conventional approaches to health improvement. Health services should be community-oriented, meeting their clients' needs in their own time and place. Activities should not be restricted to health services but should include factors such as income generation and housing. Laws and regulations are now considered less effective than support and incentives to develop a healthier environment. Health programmes have to become inter-sectoral. Various actions are proposed including an analysis of health hazards arising from environments and occupations, and health advocacy among inter-sectoral groups. Primary environmental care was considered to have an important role and was described as a process by which individuals and communities learn to

understand the effect of constructed environments and develop responsibility for environmental protection.

IDRC

The Canadian IDRC has a health and environment programme that shares a similar philosophy to that of USAID (Forget, 1997). The centre seeks to promote community participation and empowerment to set research priorities and choose solutions. It identifies the important health issues for the city as the interfaces between three determinants of health: production activities; socio-behavioural determinants; and environmental determinants. The primary health issues were considered to be:

- pollution by toxic chemicals at the environment-production interface;
- faecal contamination and vector-breeding sites at the behaviour-environment interface; and
- occupational disease and injury at the behaviour-production interface.

In 1997 the IDRC prepared a proposal to stimulate research into urban agriculture (Mougeot, 1997). There are several references to the need for health-risk research, including the following:

- locally adequate risk-assessment, regulation and enforcement to prevent food contamination;
- the promotion of space-confined self-production of micronutrients;
- the nutritional benefits of self-production for household members;
- the toxicological health risks from the uptake of heavy metals by plants;
- safe methods of using wastewater; and
- low-cost wastewater technology.

IIED

The IIED has had a long programme of research and publication on urban health. Much of this programme has been led by Dr D. Satterthwaite, who recently described the impact on health of environmental problems in urban areas of the Third World (Satterthwaite, 1993). He identifies the natural resources essential for health as food, uncontaminated drinking water, fuel, and safe sites for dwellings. He also identifies the interaction of environmental, social, economic and political factors in influencing health in urban areas. City populations provide an opportunity for cost-effective provision of infrastructure and services. In the absence of effective planning, however, rapidly growing populations can exacerbate the problems in environmental health.

Satterthwaite stresses the quality of housing as an influence on respiratory disease, through over-crowding, poor ventilation, dampness and indoor air pollution from coal or biomass fuels. Acute respiratory infections, including measles or pneumonia, remain one of the main causes of child mortality. The incidence of tuberculosis is also linked to overcrowded conditions in poor urban areas. Within the home, there are interconnections between water, sanitation, animals, personal hygiene and food that create risks of diarrhoea.

Atkinson (1993) summarised the contributions of many authors to a workshop on urban health, without citing individual contributors. The workshop concluded that opportunities for improving health existed in the wider planning context, through:

- the support of economic activities among low-income groups;
- the creation of micro-enterprises to provide environmental services such as solid-waste collection and water distribution; and
- the resolution of legal residence status.

Mazingera Institute, Kenya

The Mazingera Institute conducted a survey of urban food production and cooking fuels in Kenyan towns during 1985 (Lee-Smith *et al.*, 1987). There was no specific classification according to 'peri-urbaness'. More than half of the urban farmers were women. The report includes some health data. The perceived causes of ill-health in children were primarily ARI, fever (presumed malaria), and diarrhoea. Families rarely used traditional healers but relied on health centres or modern medicines. The respondents typically grew some of their own food, kept livestock, and used charcoal for cooking. Fuel shortages had caused about 10% to change their cooking habits from maize and beans to maize porridge or to pre-cooked foods such as potato chips and bread. These changes seemed to be to a less balanced diet. There was an inverse relationship between income and the proportion of income spent on fuel. The availability of flush toilets seemed to be a good indicator of income and municipal services. About 30% of the respondents in Nairobi had pit latrines although these were illegal. Indigenous wild vegetables were collected or purchased and eaten by a large proportion of the respondents. About half the respondents kept livestock (mostly poultry and goats). Use of commercial agro-chemicals was rare. Only a minority used fertiliser and this did not appear to include wastewater or human waste. Irrigation appeared to be mainly with river or piped water, using buckets. Most production was for subsistence rather than market.

Environmental health indicators

There is considerable interest among the health community in the development of environmental-health indicators (EHIs) that parallels interest in the development of indicators by the natural-environment community. Both may have been triggered by statements in Agenda 21 (Kjellstrom and Corvalan, 1995) regarding indicators of sustainable development .

A health and environmental analysis for decision-making project (HEADLAMP) was established by the WHO in 1993, in collaboration with USAID and UNEP (Anon., 1995b; Corvalan and Kjellstrom, 1995). The project is concerned

with the quantifiable linkage between environmental pollution and health outcomes. It seeks to determine whether routinely collected, environmental data, such as those from the global environment monitoring system (GEMS), can be associated with routinely collected, public-health data. It also uses rapid survey methods. Pollution of air, water, food or soil is included, as is the general, occupational and domestic environment. Both traditional and modern sources of pollution are included. For example, the project is concerned with indoor air pollution from biomass fuels as well as that from fossil fuels. The type of health problem considered tends to be amenable to the dose–response method of analysis, where functional relationships have already been established. The method is being used in conjunction with intra-urban differential studies. For example, the results of a study of São Paulo (Stephens *et al.*, 1995a) indicated that air pollution is monitored for the city as a whole but has relatively little effect on health. However, the large, intra-urban, environmental differentials, which are associated with large health differentials, are not routinely monitored.

HEADLAMP seeks to promote the development of EHIs. These may be derived from routine health or environmental data or by survey techniques. One pilot scheme, referred to as a community-based environmental management information system (CEMIS), has been tested in Accra (Songsore and Goldstein, 1995).

Kolsky and Blumenthal (1995) discuss the impracticality of using routine health and environment data to quantify the health burden of poor water and sanitation. The problems are the multiple routes of infection, many of which depend on individual behaviour, and the methodological difficulties of measuring exposure. They propose, instead, the development of EHIs for sanitation-related disease. The main use of such indicators is to set priorities for action rather than to establish functional relationships between exposure and disease. The priorities should be objective rather than biased by the specialist knowledge of the investigator. Kolsky and Blumenthal (1995) argue that indicators are available for modern health risks more readily than for traditional health risks. They stress the

need to develop indicators based on the communities' own priorities. Indicators should be constructed that are based on a mixture of heuristics and rigorous epidemiological research. Examples of the kinds of data that could be collected include:

- access to water;
- hours/day that a piped-water supply is available;
- excreta-disposal type and share;
- price and demand for soap;
- proportion of streets that are paved;
- number of persons/room;
- proportion of houses affected by floodwaters;
- number of faecal coliforms/100 ml consumed water; and
- disposal practices for children's faeces.

Such indicators must be scientifically and causally associated with health outcomes if they are to be of value (Kjellstrom and Corvalan, 1995). Static and dynamic indicators, and descriptive and analytical indicators, can be distinguished. Dynamic indicators would signify trends. Analytical indicators would reflect an exposure–effect relationship. Analytical indicators can be fitted into a plausible causal-chain relationship between the generation of pollutant, the exposure of the community, and the health outcome. Various definitions of EHIs have been proposed, and all share the concept of providing information that guides decision-makers' actions towards reductions in environmental-health risks. Appropriate indicators have not yet been widely agreed.

Wills and Briggs (1995) reviewed the environmental and health indicators that have been developed, and refer to natural-resource indicators. They identified 233 indicators from 26 indicator projects world-wide. Most of these indicators were environmental rather than health-oriented. One, for example, was 'wild salmon runs through local streams'. Health-related environmental indicators (the environmental

conditions indicating potential health effects) were distinguished from the environment-related health indicators (health outcomes indicative of environmental causes). Wills and Briggs concluded that most of the environmental indicators in their survey were unsuitable for health analysis.

Stephens and Harpham (1992) discuss the methodological problems, including confounding factors, inherent in household surveys designed to link environment and health indicators.

It may be concluded that a potentially important researchable theme for natural-resource managers is the development of environment and health indicators to measure the health state of the peri-urban environment.

Chapter 11

The Hubli–Dharwad and Kumasi Case Studies

- The peri-urban-interface programme of the NRSP has focused on two case-study cities: Hubli–Dharwad in India and Kumasi in Ghana.
- The following descriptions are drawn from the baseline studies and indicate some of the health hazards that are of concern.

Hubli–Dharwad

The unpublished Hubli–Dharwad inception report defines the peri-urban interface, tentatively, as that socio-economic, ecological and spatial region where interactions between the city and its hinterland are dense, multiple and complex, and where the city's human and ecological impact is substantial. This led to the definition of several geographical areas, delimited by:

- the municipal corporation's boundary;
- the urban-development authority's boundary;
- the limit of city-bus travel; and
- the outer, undefined ring.

The initial list of issues identified within these rings included:

- pollution of surface water by domestic and industrial waste;
- use of unprocessed sewage for vegetables and other crops;
- landfill sites for nightsoil and garbage, accessed by pigs and scavengers;

- demand for high-value products, including milk products, meat, vegetables and fruit;
- reducing firewood demand;
- intensification of agro-chemical use; and
- increase in tractor usage.

Three production systems were described: one in the metropolitan area; one in a 20–25-km-wide belt around the metropolitan area; and one in an outer belt. The metropolitan system consisted of villages engulfed by urban expansion; relevant activities/characteristics included urban dairies, urban scavenging pigs, poultry units, migratory sheep, goatherding, intensive vegetable production, brick production, stone quarrying, factories, crafts, aquaculture, garbage tips, and nightsoil tips.

The 20–25-km belt consisted of orchards, dryland agriculture, irrigation, and villages that were both off and on main roads. The outer belt consisted of forest fringe, forest communities and other production.

The report noted that pigs consume a large but unknown proportion of street garbage. The associated hazards of encephalitis and

cystercercosis were noted. A need for improved pig-production systems was suggested. There were some municipal-waste-management proposals and their relative health effects need discussion.

Fuelwood was being replaced by LPG but was still extensively used. Cotton stalks were an important domestic fuel and also used for bricks and pots. There were plans and projects involving biogas. In other parts of India, forest encroachment has been associated with outbreaks of tick-borne disease. Industrial pollution was mainly associated with emissions from a paper mill and road traffic. Many streams were polluted by domestic effluent (Figure 20 on page 96). There was concern that tanks used for drinking water for humans or cattle were polluted. Concern was also expressed about the falling level of groundwater but no reference was made to groundwater pollution.

Various organisations with natural-resource-management interests were identified and their information requirements and jurisdictions were to be determined. There was an institutional transition from rural to urban.

Other issues identified included encroachment on sensitive areas, such as river boundaries, deforestation and commodity flows. It was suggested that watershed management should be included in the study, as an approach to understanding water inflows to, and sewage outflows from the city.

Kumasi

The Kumasi, peri-urban, baseline study defines the peri-urban interface by the characteristics of strong urban influences, easy access to markets, services and other inputs, ready supplies of labour, relative shortages of land, and risks from pollution and urban growth (Holland *et al.*, 1996).

Two geographical zones were identified: a zone of direct impact and a wider, market-related zone.

The zone of direct impact consisted of nearly urban villages which experienced direct urban influences, such as land demands and

pollution. The 'peri-urbaness' of a village was judged by the presence of agricultural land but with competition from non-agricultural uses. The decision on how far to track the market relationships in the wider, market-related zone of influence was left open.

The main, local, natural-resource issues identified by the main stakeholders were:

- solid- and liquid-waste disposal;
- the importance of livestock;
- the increasing importance of horticulture and increased agro-chemical use;
- land-use competition;
- labour markets; and
- mains electricity supply.

ENERGY

Charcoal was the most common fuel (93% of households), with fuelwood, sawdust, electricity, gas, and kerosene used in lesser amounts (the last three fuels being limited by supply). Fuelwood was preferred at the periphery, where it was cheaper and accessible. Respiratory-disease hazards associated with charcoal use were noted. The use of cleaner fuels, such as LPG, was encouraged by subsidies but was still very low. There were large quantities of biomass available and these included sawmill wastes and domestic and market refuse. Some experimental work had been done on biogas converters. The rapid increase in powered-vehicle transport and the low-density growth of the city were considered to have implications for future energy sustainability.

TOWN AND COUNTRY PLANNING

Maps and plans provided the main component of the legal framework for physical development of land, and an opportunity to reserve a space for particular land use and to co-ordinate development activities. The enforcement of the provisions of the latest (1963) town map for Kumasi had been ineffective. There were no town maps for surrounding districts. The proposed urban

transport and urban environmental sanitation projects supported by the World Bank were expected to review the whole development-control system.

The preparation of planning layouts for particular sectors of the city was a legal requirement under the Planning Act and should control planning approval. However, production of these layouts had tended to be slow and to follow rather than precede development. Their producers had taken little account of the livelihood requirements of local residents, such as the need for agricultural land. There had been little or no co-ordination of plot layouts with the provision of necessary services, such as water supply, by statutory agencies. The development initiative in Kumasi had been taken by householders, chiefs, and statutory bodies for water and electricity supply pursuing business plans. This had resulted in large-scale encroachment on land reserved for agriculture, community and recreational uses.

There was a high-density city centre, with rapid construction of low-density new housing (with 7% of housing using 50% of the developed land). The low density of new housing had implications for the high cost of providing water and sanitation services. There was a large amount of temporary cropping on construction plots. Land was administered at village level by 'stool chiefs' and this included holding land for the benefit of village development. On the other hand, increasing land sales by chiefs to wealthy individuals, for residential development, were leading to a loss of agricultural land.

FOREST AND FISHERIES

Forest products other than timber included charcoal and firewood. Some small fish farms with vegetable production had been established and there was a potential for contamination by agro-chemicals. Little information on the current levels of pesticides in water or fish was available.

AGRICULTURE

A series of different agricultural systems was identified. In bush-fallow, intercropped food systems there was little use of chemical fertilisers, pesticides and organic manure. The fallow periods had shortened, however, and become ineffective. In mixed, valley-bottom systems, soil-fertility and pest-management practices were rare. Heavy organic pollution of some peri-urban streams favours lush growth of taro-yam. Public-health implications were raised. Specialised, intensive, valley-bottom, vegetable farms frequently used fertilisers and pesticides, leading to watercourse contamination. In backyard farms there was frequent use of manure, 'black soil' (composted town waste from old tips) and inorganic fertilisers. There were increasing pressures towards intensification in many of the agricultural systems. There were concerns about the accumulation of various heavy metals. These included lead, mercury, cadmium and copper in water, soil and the vegetables grown around Lake Bosomtwe. Some sampling and analysis had taken place but no results were available.

PROCESSING AND STORAGE OF CROPS AND MEAT

Processing of crops was usually at the household level and often by hand. Small-scale, improved technology was used. This included electrically powered maize mills. Graters and screw presses were used for cassava-meal processing and the associated occupational hazards were noted. The only large-scale plants for food processing were breweries. Small-scale production of cooked food for sale was an important economic activity for women. There was extensive and large-scale meat processing of cattle from all over northern Ghana. The associated food-safety hazards were noted.

LIVESTOCK

Urban livestock included sheep, goats, milk and beef cattle. These were usually penned and fed on household food scraps or grazed on crop residues, pasture or refuse. In the peri-urban areas there were medium-sized livestock farms

on which the animals were fed on scraps and brewers' grains. There were also commercial production systems for poultry fed on imported feed.

POLLUTION SOURCES

There was limited access to clean drinking water beyond the reticulated piped-water supply. A series of studies by the local university revealed that the quality of several watercourses in Kumasi was poor, with pollutant levels higher than the WHO's standards. The main water-supply reservoirs for the city were polluted by wastewater from peri-urban drains and from municipal dumping of sewage. For example, the city's waste department collected nightsoil and then simply tipped it into the Nsibun River. Waste petroleum products from vehicle disassembly were contaminating groundwater draining into Owabi reservoir. Pesticide contamination was a probable but unmeasured effect of intensive crop production and there are studies in progress. Other sources of water pollution included residues from the soap works and sawmill wastes. All major streams had been found to harbour the snail vector of schistosomiasis. Air pollution was caused by charcoal burning, using sawmill off-cuts. Soil-pollution concerns included arsenic contamination from gold-mining activities at Obuasi.

WASTE MANAGEMENT

There were problems with municipal collection and disposal of organic wastes, leading to a large number of peri-urban environmental and health impacts. At least one dump site for household wastes was situated above the headwaters of a stream supplying a city district. Proposals for an environmental sanitation programme with the World Bank would provide controlled landfill, composting of nightsoil, solid wastes and market wastes, and a wastewater-treatment plant. There was some village-level waste management but limited re-use. There was a private-sector, waste-recycling network. This included dumpsite

scavenging and collection or purchase of glass, plastic bottles, and food waste (for animal feed). These products were sold in the central market.

Concern was expressed about the health hazards of waste-utilisation strategies. These included:

- use of industrial/agro-industrial wastes as soil improvers;
- use of poultry manure from commercial waste by intensive horticulturists;
- use of sawmill waste;
- use of market and city-centre, organic wastes contaminated with non-combustibles; and
- the planting of bananas on old dump sites and of vegetables on latrine sites.

Generally, there was a lack of detailed information about pollution sources and the value of waste, water and land for agricultural use. Studies on environmental and natural-resource indicators were planned. A GIS project was under way and this would include many layers of information. A meta-database was being prepared; there was a challenge to determine how this database can be used for health research and intervention.

CONCERNS OF KEY INFORMANTS

The health-related concerns of key informants included:

- the contamination of starch foods with water of poor quality;
- the safety of human and other animal faeces in compost;
- the loss of medicinal plants and wild foods;
- the reduction in child-care when women have to switch to increased tillage of cash crops;
- the child labour used for hoeing;

- land tenure and support for on-farm infrastructure, such as toilets; and
- the specific health hazards associated with urban livestock, such as cows.

ODA (DFID) natural resources research strategy

The ODA's strategy for research on renewable natural resources contained several references of relevance to human health. The socio-economic research programme, now part of NRSP, has identified how NGOs can support poor urban women in Africa. It found that support was required in providing credit, training in skills and awareness (literacy, hygiene, family planning), work, and legal rights. It has observed how poor women traded natural resources imported from their rural home areas and also depended on urban farming, although this was constrained by space and water.

The post-harvest programme was concerned with the distribution chain of marketed crops. Poor management often meant high losses of valuable crops through poor storage. There was a proposal to research the needs of rural and

urban poor communities, so as to improve the opportunities they have to recoup their investments in time and energy. There were special concerns about women and children and the consequences of using new technologies. In Ghana, there was a special interest in the garden-scale growing of vegetables, tomatoes and eggplants, for national and international markets. Mycotoxin control in oilseed and cereals remains an active research interest; a low-cost sampling technique and a chemical detoxification process had been developed.

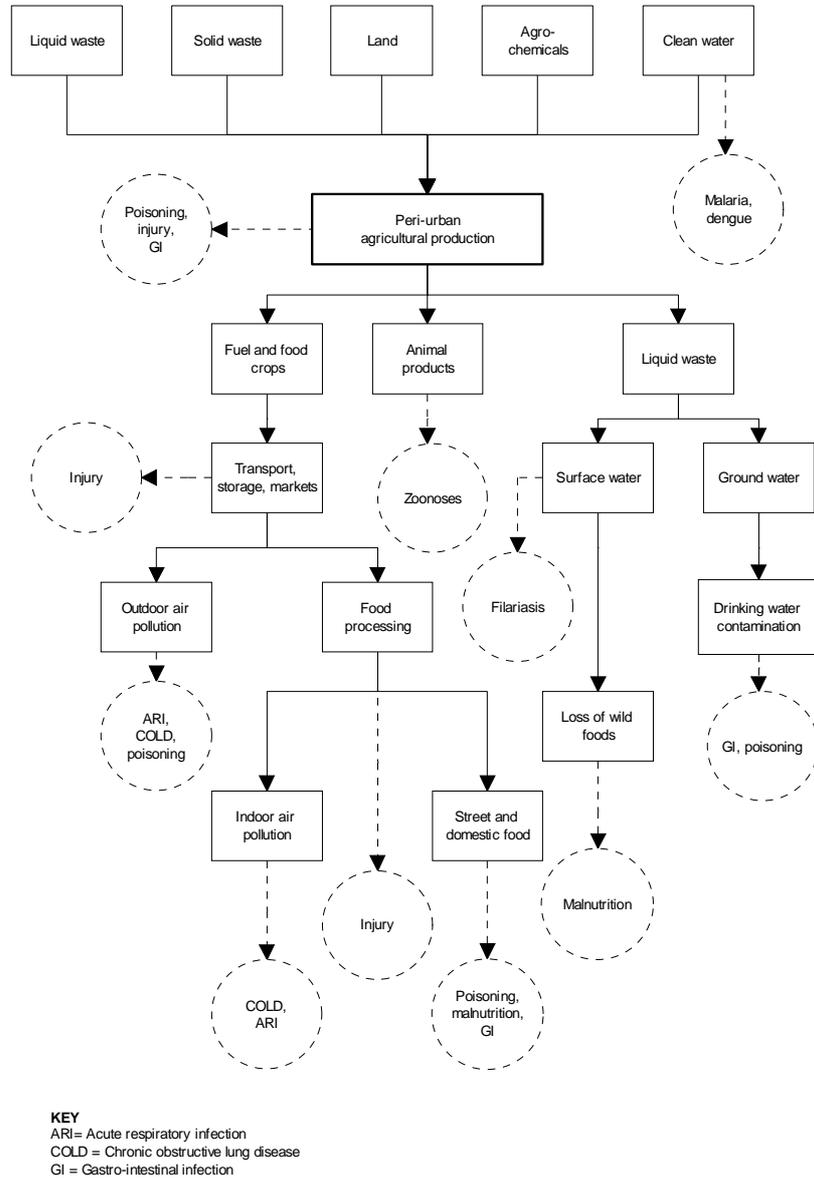
The forestry-research programme was concerned with the protection of catchments and had indirect benefits for water supplies for urban areas. The livestock-production programme had new projects planned to describe livestock production in peri-urban systems and to determine how the research needs in such systems differed from those in rural systems. Safe meat and milk production may be relevant. The fisheries programme did not mention the peri-urban interface. It did include a post-harvest programme which was concerned about unsafe application of pesticides to protect stored, dried fish.

Chapter 12

Conclusions

- Many of the causes of ill-health in the urban and peri-urban environment are multi-factorial. Consequently, single interventions are unlikely to produce measurable improvements, although this does not invalidate the interventions. Many urban-health researchers emphasise the need for community-based approaches that are, by nature, multi-sectoral and integrated, and address community priorities (Satterthwaite, 1993). The challenge for the peri-urban-interface projects within the NRSP, or those supported by DFID, is then to develop effective mechanisms for multi-sectoral research and to include health impact assessment within other project-appraisal systems.
- Health hazards emerge in this review as a factor in all natural-resource management and development. Figure 21 (overleaf) provides one view, out of many, on the linkages between natural-resource flows and health hazards. In the figure, the natural-resource components are indicated by rectangles and the health-hazard linkages by circles. The central pivot in the figure is agricultural production. A series of inputs of natural resources drives this production and five of the inputs are indicated in the figure. Clean water is highlighted because of its linkage with vector habitats. The outputs of the production include foods, animal products, and wastes. These are further sub-divided in the figure, and some of the related health linkages are indicated.
- Several other institutions have activities that are relevant to the theme of this review. Important bilateral agencies include USAID and the IDRC. The multilateral CGIAR system, which specialises in agricultural production, is taking an increasing interest in the health impacts of its activities. Examples include IIMI, IRRI, WARDA and ISNAR. It is not clear whether the CGIARs have a specific interest in the peri-urban interface. The FAO has a specific peri-urban interest in relation to animal production; within this programme there is general interest in zoonoses.

Figure 21. Some natural-resource–health linkages in the peri-urban environment



Chapter 13

Recommendations

- This review of the literature associated with the health impacts of the peri-urban development of natural resources has highlighted a number of researchable themes. These are collected in the remaining sections. They include:
 - the effect of urban agriculture on psychosocial disorders;
 - the uptake of pollutants by plants used as food;
 - the integration of health issues in GIS overlays;
 - the occupational health and safety of using biomass fuels;
 - the post-harvest decontamination of food crops;
 - the development of safe systems for aquaculture;
 - the rural–urban transition, in relation to various health risks, including malaria, respiratory illness and diarrhoea;
 - wastewater re-use; and
 - fuelwood from waste.

Aquaculture

Aquaculture is one of the fastest growing areas for increasing production. There are many health concerns that require further research. The priorities for safe fish-production systems have not yet been established and there may be a need for epidemiological studies.

Biomass fuels

The FAO has suggested that relatively little work has been done on the occupational health and safety of workers in the cottage-scale, industrial and institutional use of biomass fuels. Industrial examples include brickmakers and ceramic factories, and the relevant institutions include schools and hospitals.

There is a continuing interest in improving cooking stoves and kitchens so as to reduce indoor air pollution, and detailed proposals have been put to funding agencies, for measuring the health benefits of such interventions.

Listorti (1996) suggested that under-researched areas include the cost implication on nutrition of fuel prices, and the contribution of tobacco smoking to indoor air pollution mainly caused by biomass fuels.

Decontamination of food crops

There is widespread agreement that further work is required on the post-harvest decontamination of food crops. This may include individual actions in the kitchen or mass decontamination in the market. Mass decontamination might be

sustainable if it created a perceived market advantage for the produce. Crop certification is a related issue.

Food fuels, cooking stoves and wastewater

Fuelwood crops provide a safe method of using untreated wastewater. Promotion of fuelwood plantations grown with wastewater could usefully be linked with promotion of cooking stoves which reduce indoor air pollution.

Food safety

There have been many studies of food safety in the urban environment, often using the HACCP method. However, there appear to be no reports of studies in which the safety of similar foods was compared along the rural–urban continuum; this could be referred to as a food-quality transition.

GIS

A GIS project for Kumasi is under way and this will include many layers of information. A meta-database is being prepared. There is a challenge to determine how this database can be used for health research and intervention.

Groundwater

Groundwater resources need to be protected from contamination and over-use. Procedures and policies are required that assist municipal authorities to regulate activities that may affect groundwater. These include the use of fertiliser and wastewater in agriculture, well development, systems for liquid-waste disposal, and use of latrines. The trade-offs between consumption of nitrate- and pathogen-contaminated water may need to be clarified in order to establish practical, rather than ideal, nitrate-consumption thresholds for small children.

Healthy cities–natural resource linkages

The linkages between the healthy-cities and the natural-resources research-and-implementation communities appear to be poorly developed. The

healthy-cities documentation, in particular, recommends the need for inter-sectoral action. It is hoped that this review will help to provide a linkage, but further action is clearly needed. This should take the form of a multi-disciplinary conference or workshop, with representatives from both communities.

Intra-urban variability and indicator variables

Intra-urban differentials provides an effective comparative tool for studying urban problems, including health. A comparison of indicator variables between wholly urban, peri-urban and wholly rural areas may provide a practical method of combining health with other aspects of the NRSP's research on the peri-urban interface. These variables may also be used to provide an objective, statistical definition of 'rural', 'peri-urban' and 'urban', which will facilitate comparisons of health and environmental changes along the continuum. The livestock programme at the NRI has defined 19 indicators for this purpose and field-tested them in Bangladesh.

IPM

IPM is presented in NRI plans as a solution to a public-health problem, as well as to agricultural problems. Care should be taken to avoid a trap associated with earlier NRI work on pheromones (Mumford *et al.*, 1997). If health concerns are cited as a justification for research then a later evaluation may seek evidence that a health improvement was an outcome of the project. This will require research and monitoring of the prevalence of pesticide poisoning, or proxy indicators, among communities that adopt IPM versus those which do not. There are parallels with the IRRI's adoption of IPM in rice, which was followed by substantial funding to determine the economic cost of pesticide poisoning. IRRI were able to conclude that the extra profit from intensive pesticide use was entirely offset by the economic cost of poisoning (Pingali and Marquez, 1990).

Malaria and other vector-borne diseases

There has been no systematic epidemiological survey of malaria in Ghana since the 1960s (G. Barnish, pers. comm.). It is generally believed that, in Africa, malaria is more common in rural areas than urban, and the results of several studies have supported this hypothesis. However, little is known about the changing epidemiology of malaria along the rural–peri-urban–urban transition. Research is needed to determine:

- the changes in the ratio of vector species, such as *An. gambiae*/*An. arabiensis*;
- the relative importance of different types of breeding sites, including vegetable gardens;
- the effect of different land-use types;
- the protective behaviour adopted by different communities; and
- the capacity, capability and jurisdiction of various health-protection services.

Similar sets of information are required for filariasis, dengue and schistosomiasis.

Pollutants in food crops

Guidelines for waste re-use in agriculture and aquaculture were issued by the WHO in 1989. Many issues remain unresolved and are the subject of further work. The members of the WELL group at the London School of Hygiene and Tropical Medicine are engaged in epidemiological studies of communities exposed to various levels of pathogens. The number of field sites is small, however, and the study requires extension to new sites.

The WHO guidelines did not cover chemical contaminants such as metals. The pertinent issues involve the decontamination of wastewater by soil particles and uptake by the crop. Preliminary acceptable levels have been suggested but require further testing on various soils. Further research is required to clarify the severity and

extent of pollutant uptake by food plants. Field experiments will be needed in contrasting, peri-urban areas.

Natural-resource managers should take note of the FAO's proposed crop-certification programme for reducing the health impacts of wastewater re-use in agriculture. Further research on implementation should be included in the systems programme and will require collaboration between agricultural, irrigation and health specialists. The certification should include water used for production, processing and packing of vegetable crops and some fruits. Improved laboratory techniques will have to be implemented for monitoring the numbers of human coliforms and nematode eggs in water samples.

Prioritisation of health risks

The general hazards associated with peri-urban agriculture, such as pesticide and wastewater use, are known. The practical risks associated with these hazards require more assessment, however, by examining actual food sources, agricultural practices and consumption patterns (Listorti, 1996c). Research is needed to compare and contrast the community-based perception of health risks with that of managers and researchers.

Prospective health impact assessment

Prospective health impact assessment should always be included in project plans and planning procedures. In most cases, a simple, rapid assessment, based on the principles in this review, will suffice. Research is needed to determine the precise requirements of the managers of natural-resource projects and the kind of assessments that they would accept.

Psychosocial disorders

Does urban agriculture provide a sense of empowerment, or control of defensible space, and hence contribute to stress reduction and reduce the risk of psychosocial disorders?

Transition theories

The health and other transitions referred to in this review are still hypotheses in the context of the rural–peri-urban–urban transition. They require testing and, if proved reasonably correct, they may have a useful predictive and planning value. There may also be important linkages between these transitions. For example, the hypotheses imply that the community at the more urban end of the transition relies on mechanical transport and is more exposed to the modern health hazards of traffic injury and the effects of outdoor air pollution from vehicle emissions, and less exposed to the effects of indoor air pollution, than other communities. The high cost of the modern fuels used in the urban community leads to a lower quality of nutrition and food safety. The community at the more rural end of the transition expends time and energy on the collection of biomass, may suffer muscular–skeletal damage from carrying heavy weights, and is exposed to indoor air pollution from the biomass fuels used in the traditional kitchens.

Urban agriculture

More data are needed on a set of issues related to urban agriculture, including the following:

- the communicable-disease hazards associated with irrigation of food crops using wastewater in the peri-urban environment;

- the range of water qualities typically used in a number of cities in the developing world where small farmers exploit available sources of wastewater;
- the residual levels of pathogens, such as helminths, on produce destined for human consumption;
- the effect on vector breeding;
- the appropriate technical/water-management solutions to reduce the health risks to farmers and the urban public;
- the need for public-awareness programmes to improve hygiene; and
- the capability, capacity and vigilance of existing health-protection agencies towards the health risks posed by these agricultural activities.

Waste treatment

There is a need for more methods of treating liquid waste, including on-farm stabilisation ponds, reed beds and artificial wetlands, and the research in these areas needs following up.

Chapter 14

Bibliography

A

- Acha, P. N. and Szyfres, B. (1987). *Zoonoses and Communicable Diseases Common to Man and Animals*. Second Edn. Pan American Health Organization, Washington, DC.
- Adan, B. L., Cruz, V. P., Palaypay, M. and Trezek, G. J. (1982). *Scavenging in Metro Manila*. Ad hoc Committee of the Metro Manila Solid Waste Management Study, Manila.
- Adiamah, J., Koram, K., Thomson, M., Lindsay, S., Todd, J. and Greenwood, B. (1993). Entomological risk factors for severe malaria in a peri-urban area of The Gambia. *Annals of Tropical Medicine and Parasitology*, **87**, 491–500.
- Agarwal, A., Kimondo, J., Moreno, G. and Tinker, J. (1981). *Water, Sanitation, Health—for All? Prospects for the International Drinking Water Supply and Sanitation Decade, 1981–1990*. Earthscan Publications, London.
- Agarwal, B. (1990). Social security and the family: coping with seasonality and calamity in rural India. *Journal of Peasant Studies*, **17**, 341–412.
- Ahrens, W., Jockel, K. H., Patxak, W. and Elsner, G. (1991). Alcohol, smoking and occupational factors in cancer of the larynx: a case control study. *American Journal of Industrial Medicine*, **20**, 477–493.
- Akin Aina, T. (1990). *Health, Habitat and Underdevelopment in Nigeria*. International Institute for Environment and Development, London.
- Allison, M. and Harris, P. (1996). *A Review of the Use of Urban Waste in Peri-urban Interface Production Systems*. Henry Doubleday Research Association, Coventry, U.K.
- Alloway, B. J. (Ed.) (1995). *Heavy Metals in Soils*. Blackie Academic and Professional, London.
- Amr, M. M., El Batanouni, M., Emara, A., Mansour, N., Zayat, H. H., Atta, G. A. and Sanad, A. (1993). In *Impact of Pesticide Use on Health in Developing Countries*, eds Forget, G., Goodman, T. and de Villiers, A. pp. 118–130. International Development Research Centre, Ottawa.
- Anderson, J., Maclean, M. and Davies, C. (1996). *Malaria Research: an Audit of International Activity*. Wellcome Trust Unit for Policy Research in Science and Medicine, London.
- Anon. (undated). *Food Safety, a Statement of the Capability of the Natural Resources Institute to Assist Development*. Natural Resources Institute, Chatham Maritime, U.K.
- Anon. (1974). In *International Labour Conference, 59th Session, Volume VII(1)*. International Labour Office, Geneva.

- Anon. (1979). *Health Impact Guidelines for the Design of Development Projects in the Sahel: Volume 1: Sector-specific Reviews and Methodology*. United States Agency for International Development, Washington, DC.
- Anon. (1986). *Psychosocial Factors at Work: Recognition and Control*. International Labour Office, Geneva.
- Anon. (1989). *Communicable Disease Report*. Public Health Laboratory Services, Colindale, U.K.
- Anon. (1990). *The Philippine Environment of the Eighties*. Department of Environment and Natural Resources, Manila.
- Anon. (1991a). *Summary of Activities*. World Health Organization Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS), Kuala Lumpur.
- Anon. (1991b). *Towards Safer Roads in Developing Countries. A Guide for Planners and Engineers*. Her Majesty's Stationery Office, London.
- Anon. (1992a). *The Contamination of Food*. United Nations Environment Programme, Nairobi.
- Anon. (1992b). *Shrimp Fever*. Television Trust for the Environment, Channel 4 Television, London.
- Anon. (1993). Refuse kills 13. *The Times*, **29 April**, 15.
- Anon. (1994a). *ODA Renewable Natural Resources Research Strategy 1995–2005*. Overseas Development Administration, London.
- Anon. (1994b). *The Global Dimensions of Lead Poisoning: an Initial Analysis*. Environmental Defense Fund, Alliance to End Childhood Lead Poisoning, Washington, DC.
- Anon. (1995b). Foreword. *World Health Statistics Quarterly*, **48**, 70.
- Anon. (1995b). *Strategic Framework 1995–1999*. Environmental Health Project (USAID), Washington, DC.
- Anon. (1996a). *World Resources 1996–97: the Urban Environment*. Oxford University Press, New York.
- Anon. (1996b). *Health and the Environment in Urban Poor Areas: Avoiding a Crisis through Prevention*. Environmental Health Project (USAID), Washington, DC.
- Anon. (1996c). *Urban Challenges to Nutrition Security: a Review of Food Security, Health and Care in the Cities*. International Food Policy Research Institute, Washington, DC.
- Anon. (1996d). *Ngleshie–Amanfro: a Participatory Rapid Appraisal of Food Security in a Peri-urban Community*. Noguchi Memorial Institute for Medical Research, Legon, Ghana.
- Anon. (1996e). *A Review of Energy Utilisation in Peri-urban Production Systems*. ETSU, Harwell, U.K.
- Anon. (1996f). *Solid Waste Management and Urban Agriculture in the City of Santiago de Los Caballeros*. Pontificia Universidad Catolica Madre y Maestra, Santiago de los Caballeros, Dominican Republic.
- Anon. (1996g). *Appropriate Technology for Environmentally Sustainable Vegetable Production for Urban Markets: Resource Paper for Pilot Vegetable IPM Initiative for West Africa*. Natural Resources Institute, Chatham Maritime, U.K.
- Anon. (1996h). Coping with the growing threats of mounting urban wastes. *Voices from the City, Newsletter on Urban Environmental Health Issues*, **6**, 1–14.
- Anon. (1996i). *Study on the Development of a Water Supply System for Damascus City. Phase 1*. Nippon Koei and Damascus Water Supply Authority, Damascus.
- Anon. (1997a). In *Workshop on Arsenic Disaster in Bangladesh Environment*. Dhaka Community Hospital Trust and Disaster Forum, Dhaka.
- Anon. (1997b). *Discussion Paper by the Compost Task Force of the Nova Scotia Environmental Industry*. Nova Scotia Environmental Industry Association, Halifax.

- Anon. (undated). *Removing Smoke from Households dependent upon Biomass Burnt in Un-vented Fireplaces can Seriously Improve People's Health*. Intermediate Technology Development Group, Rugby, U.K.
- Arata, A. A., Balderrama, F., Bermudez, H., Casanovas, C., Navin, T., Ormsby, G., Torrico, F. and Velarde, R. (1994). *The Work of the MRSSP/CCH Chagas Control Pilot Program*. Ministerio de Desarrollo Humano, Secretario Nacional de Salud, La Paz, Bolivia.
- Arends, J. P. and Zanen, H. C. (1988). Meningitis caused by *Streptococcus suis* in humans. *Review of Infectious Diseases*, **10**, 131–137.
- Ashton, J. (Ed.) (1992). *Healthy Cities*. Open University Press, Milton Keynes, U.K.
- Atkinson, S. and Merkle, A. (Eds) (1993). *Urban Health in Africa*. International Institute for Environment and Development, London.
- Ault, S. K. (1989). In *Demography and Vector-borne Diseases*, ed. Service, M. W. pp. 283–301. CRC Press, Boca Raton, FL.
- Ayres, R. M. and Mara, D. D. (1996). *Analysis of Wastewater for Use in Agriculture. A Laboratory Manual of Parasitological and Bacteriological Techniques*. World Health Organization, Geneva.

B

- Bagust, T. (1996). *Animal Health, Veterinary Public Health and Delivery of Veterinary Services in Peri-urban Production Systems, Mission to Viet Nam: Ho Chi Minh and Hanoi*. Food and Agriculture Organization, Rome.
- Bell, J. C., Palmer, S. R. and Payne, J. M. (1988). *The Zoonoses—Infections Transmitted from Animals to Man*. Edward Arnold, London.
- Bennett, F. J. (1962). The social determinants of gonorrhoea in an East African town. *East African Medical Journal*, **39**, 332–336.
- Bennett, F. J. (1964). Gonorrhoea: a rural pattern of transmission. *East African Medical Journal*, **41**, 163–167.
- Beran, G. W. (1994). *Handbook of Zoonoses*. Second Edn. CRC Press, Boca Raton, FL.
- Beveridge, M. C. M. and Phillips, M. J. (1993). In *Environment and Aquaculture in Developing Countries. ICLARM Conference Proceedings 31*, eds Pullin, R. S. V., Rosenthal, H. and Maclean, J. L. pp. 213–236. International Center for Living Aquatic Resources Management, Makati City, Philippines.
- Bhatia, J. C. (1991). In *Health Implications of Public Policy*, ed. Ghosh, B. pp. 18–55. Indian Institute of Management, Bangalore.
- Bhatt, E. R., Desai, A. S., Thamarajakshi, R., Pande, M., Arunachalam, J. and Kohli, V. (1988). *Shramshakti. Report of the National Commission of Self-employed Women and Women in the Informal Sector*. Government of India, Ahmedabad.
- Birley, M. H. (1991). *Guidelines for Forecasting the Vector-borne Disease Implications of Water Resources Development*. World Health Organization, Geneva.
- Birley, M. H. (1995). *The Health Impact Assessment of Development Projects*. Her Majesty's Stationery Office, London.
- Black, M. (1994). *Mega-slums, the Coming Sanitary Crisis*. Water Aid, London.
- Black, M. (1996). *Thirsty Cities, Water Sanitation and the Urban Poor*. WaterAid, London.
- Blanc, P. (1984). Environmental health and development in a developing country: Rwanda, a case study. *Journal of Public Health Policy*, **6**, 271–288.

- Blevins, R. D. and Brennan, L. A. (1990). Fate of mutagenic activity during conventional treatment of municipal wastewater sludge. *Archives of Environmental Contamination and Toxicology*, **19**, 657–664.
- Blue, I. and Harpham, T. (1996). Mental health matters. *World Health*, **49**, 34–35.
- Blum, D. and Feachem, R. (1985). *Health Aspects of Nightsoil and Sludge Use in Agriculture and Aquaculture. Part III: an Epidemiological Perspective*. International Reference Centre for Waste Disposal, Dubendorf, Switzerland.
- Blumenthal, U., Abisudjak, B., Cifuentes, E., Bennett, S. and Ruiz-Palacios, G. (1991/2). Recent epidemiological studies to test microbiological quality guidelines for wastewater use in agriculture and aquaculture. *Public Health Reviews*, **19**, 237–242.
- Blumenthal, U., Mara, D., Ayres, R., Cifuentes, E., Peasey, A., Stott, R., Lee, D. and Ruiz-Palacios, G. (1996). Evaluation of the WHO nematode egg guidelines for restricted and unrestricted irrigation. *Water Science Technology*, **33**, 277–283.
- Bobadilla, J., Frenk, J., Lazano, R., Frelka, T. and Stern, C. (1993). In *Disease Control Priorities in Developing Countries*, eds Jamison, D., Mosley, W., Measham, A. and Bobadilla, J. pp. 51–63. Oxford University Press, Oxford.
- Bourbeau, R. (1992). Analyse comparative de la mortalité violente dans les pays développés et dans quelques pays en développement durant la période 1985–1989. *World Health Statistics Quarterly*, **46**, 4–33.
- Bowyer-Bower, T. and Drakakis-Smith, D. (1996). *The Needs of the Urban Poor versus Environmental Conservation: Conflict in Urban Agriculture*. Department of Geography, School of Oriental and African Studies, London.
- Bradley, D., Stephens, C., Harpham, T. and Cairncross, S. (1992). *A Review of Environmental Health Impacts in Developing Country Cities*. International Bank for Reconstruction and Development/World Bank, Washington, DC.
- Brantly, E., Hetes, R., Levy, B., Clydette, P., Whiteford, L. and Yacoob, M. (1997). In *International Perspectives on Environment, Development and Health, towards a Sustainable World*, eds Shahi, G., Levy, B., Binger, A., Kjellstrom, T. and Lawrence, R. pp. 388–409. Springer, New York.
- Brooks, R. M., Latham, M. C. and Crompton, D. W. T. (1979). The relationship of nutrition and health to worker productivity in Kenya. *East African Medical Journal*, **56**, 413–421.
- Brott, K. (1981). Tobacco smoking in Papua New Guinea. *Papua New Guinea Medical Journal*, **24**, 229–236.
- Brown, A. W. A. and Deom, J. O. (1973). In *Man-made Lakes, their Problems and Environmental Effects*, eds Ackerman, W. C., White, G. F. and Worthington, E. B. pp. 755–764. American Geophysical Union, Washington, DC.
- Browner, C. H. (1989). Women, household and health in Latin America. *Social Science and Medicine*, **28**, 461–473.
- Bryan, F. (1992). *Hazard Analysis Critical Control Point Evaluations, a Guide to Identifying Hazards and Assessing Risks associated with Food Preparation and Storage*. World Health Organisation, Geneva.
- Bryan, F. (1993). HACCP—street vending in developing countries. *Food Australia*, **45**, 80–84.
- Bryan, F., Michanie, S., Fernandez, N., Vizcarra, M., Taboada, D., Navarro S., O., Alonso, A. and Requejo, E. (1988). Hazard analyses of foods prepared by migrants living in a new settlement at the outskirts of Lima, Peru. *Journal of Food Protection*, **51**, 323.
- Bubel, A. Z. (1990). Waste picking and solid waste management. *Environmental Sanitation Reviews*, **30**, 53–66.

Bull, D. (1982). *A Growing Problem: Pesticides and the Third World Poor*. Oxfam, Oxford.

C

- Cairncross, S. and Feachem, R. G. (1983). *Environmental Health Engineering in the Tropics: an Introductory Text*. John Wiley & Sons, Chichester, U.K.
- Cairncross, S., Hardoy, J. E. and Satterthwaite, D. (Eds) (1990). *The Poor Die Young*. Earthscan Publications, London.
- Cairncross, S., Rajavel, A., Vanamail, P., Subramaniam, S., Pailly, K., Ramaiah, K., Amalraj, D., Mariappan, T. and Srinivasan, R. (1988). Engineering, mosquitoes and filariasis: a case report. *Journal of Tropical Medicine and Hygiene*, **91**, 101–106.
- Campbell, W. C. (1991). In *Parasitic Helminths and Zoonoses in Africa*, eds Macpherson, C. N. L. and Craig, P. S. pp. 83–100. Unwin Hyman, London.
- Canter, L. (1996). *Environmental Impact Assessment*, McGraw Hill, New York.
- Carswell, F., Hughes, A. O., Palmer, R., Higginson, J., Harland, P. S. E. G. and Meakins, R. H. (1981). Nutritional status, globulin titers and parasitic infestations of two populations of Tanzanian school children. *American Journal of Clinical Nutrition*, **43**, 1292–1299.
- Chang, A., Page, A. and Asano, T. (1995). *Developing Human Health-related Chemical Guidelines for Reclaimed Wastewater and Sewage Sludge Applications in Agriculture*. Document WHO/EOS/95:20. World Health Organization, Geneva.
- Chavasse, D., Ahmad, N. and Akhtar, T. (1996). Scope for fly control as a diarrhoea intervention in Pakistan: a community perspective. *Social Science and Medicine*, **43**, 1289–1294.
- Chinery, W. (1984). Effects of ecological change on the malaria vectors *Anopheles funestus* and the *Anopheles gambiae* complex of mosquitoes in Accra, Ghana. *Journal of Tropical Medicine and Hygiene*, **87**, 75–81.
- Cifuentes, E., Blumenthal, U., Ruiz-Palacios, G. and Bennett, S. (1991/2). Health impact evaluation of wastewater use in Mexico. *Public Health Review*, **19**, 243–250.
- Clonfero, E., Venier, P., Granella, M. and Levis, A. G. (1990a). Leather azo dyes: mutagenic and carcinogenic risks. *Medicina del Lavoro*, **81**, 222–229.
- Clonfero, E., Venier, P., Granella, M. and Levis, A. G. (1990b). Identification of genotoxic compounds used in leather processing industry. *Medicina del Lavoro*, **81**, 12–221.
- Cocheo, V. (1990). Environmental impact of tanning industry. *Medicina del Lavoro*, **81**, 230–241.
- Coimbra, C. E. A. (1988). Human factors in the epidemiology of malaria in the Brazilian Amazon. *Human Organization*, **47**, 254–260.
- Colson, E. (1971). *The Social Consequences of Resettlement*. Manchester University Press, Manchester.
- Conway, G. R. and Pretty, J. N. (1988). Fertilizer risks in the developing countries. *Nature*, **334**, 207–208.
- Conway, G. R. and Pretty, J. N. (1991). *Unwelcome Harvest: Agriculture and Pollution*. Earthscan Publications, London.
- Cook, A. J., Tachili, L. M. and Foster, S. D. (1996). Human and bovine tuberculosis in the Monze district of Zambia—a cross-sectional study. *British Veterinary Journal*, **152**, 3–5.
- Cooper Weil, D. E. C., Alicbusan, A. P., Wilson, J. F., Reich, M. R. and Bradley, D. J. (1990). *The Impact of Development Policies on Health: a Review of the Literature*. World Health Organization, Geneva.
- Cordle, M. K. (1988). USDA regulation of residues in meat and poultry products. *Journal of Animal Science*, **66**, 413–433.

- Corvalan, C. and Kjellstrom, T. (1995). Health and environment analysis for decision making. *World Health Statistics Quarterly*, **48**, 71–77.
- Covello, V. T. and Frey, R. S. (1990). Technology-based environmental health risks in developing nations. *Technological Forecasting and Social Change*, **37**, 159–179.
- Cravedi, J. P. (1991). In *The Problems of Chemotherapy in Aquaculture*, pp. 243–250. Office International des Épizooties, Paris.
- Cross, J. H. and Murrell, K. D. (1991). The 33rd SEAMEO–TROPMED regional seminar on emerging problems in food-borne parasitic zoonoses: impact on agriculture and public health. *Southeast Asian Journal of Tropical Medical Public Health*, **22**, 4–15.

D

- Dearden, P. J. and Cassidy, E. M. (1990). Food security: an ODA view. *IDS Bulletin*, **21**, 81–83.
- Dennerly, P. (1996). Urban agriculture in informal settlements: how can it contribute to poverty alleviation? *Entwicklung and Landlicher Raum*, **6/96**, 5–7.
- Diekstra, R. and Gulbinat, W. (1992). The epidemiology of suicidal behaviour: a review of three continents. *World Health Statistics Quarterly*, **46**, 52–68.
- Dodangoda, K. D. G. P. (1992). Protein from toxic wastes. *ASEP Newsletter*, **8**, 6–7.
- Dunlop, J. M. (1991). Blooming algae. *British Medical Journal*, **302**, 671–672.
- Dushenkov, V., Kumar, P., Motto, H. and Raskin, I. (1995). Rhizofiltration: the use of plants to remove heavy metals from aqueous streams. *Environmental Science and Technology*, **29**, 1239–1245.
- Dutt, D., Srinivasa, D. K., Rotti, S. B., Sahai, A. and Konar, D. (1996). Effect of indoor air pollution on the respiratory system of women using different fuels. *National Medical Journal of India*, **9**, 113–117.

E

- Edelstein, H. (1994). *Mycobacterium marinum* skin infections. *Archives of Internal Medicine*, **154**, 1359–1364.
- Edwards, P. (1991). Integrated farming and influenza pandemics. *World Aquaculture*, **22**, 2–6.
- Edwards, P. (1992). *Reuse of Human Wastes in Aquaculture: a Technical Review*. World Bank, Washington, DC.
- Edwards, P., Kwei Lin, C., Macintosh, D. J., Leong Wee, K., Little, D. and Innes-Taylor, N. L. (1988). Fish farming and aquaculture. *Nature*, **333**, 505–506.
- Egboka, B. C. E., Nwankwor, G. I., Orajaka, I. P. and Ejiofor, A. O. (1989). Principles and problems of environmental pollution of groundwater resources with case examples from developing countries. *Environmental Health Perspectives*, **83**, 39–68.
- El Karim, M. A. A. and El Hag, A. A. (1985). Byssinosis and tuberculosis in the cotton industry in Sudan. *East African Medical Journal*, **62**, 491–500.
- Esrey, S. (1991). *Interventions for the Control of Diarrhoeal Diseases among Young Children: Fly Control*. Document WHO/CDD/91.37. World Health Organization, Geneva.

F

- Farber, J. M. and Losos, J. Z. (1988). *Listeria monocytogenes*: a foodborne pathogen. *Canadian Medical Association Journal*, **138**, 413–418.

- Feachem, R. G., Bradley, D. J., Garelick, H. and Mara, D. D. (1983). *Sanitation and Disease: Health Aspects of Excreta and Wastewater Management*. John Wiley & Sons, Chichester, U.K.
- Fillmore, C. M. and Hussain, M. A. (1984). Agriculture and anthropometry: assessing the nutritional impact. *Food and Nutrition*, **10**, 2–14.
- Fishwick, D., Fletcher, F., Pickering, C. A., Riven, R. and Raza, N. (1990). A cross-sectional study of respiratory symptoms in textile spinning mills. *American Review of Respiratory Disease, Part 2*, **141**, A248.
- Fleuret, P. and Fleuret, A. (1980). Nutrition, consumption, and agricultural change. *Human Organization*, **39**, 250–260.
- Fluty, H. and Lissfelt, J. (1995). In *Urban Health in Developing Countries, Progress and Priorities*, eds Harpham, T. and Tanner, M. pp. 153–171. Earthscan Publications, London.
- Food and Agriculture Organization (1984). Economic change and the outlook for nutrition. *Food and Nutrition*, **10**, 71–79.
- Food and Agriculture Organization (1988). Guidelines for predicting the dietary intake of pesticide residues. *Bulletin of the World Health Organization*, **66**, 429–434.
- Food and Agriculture Organization (1991). *Development of Coastal Areas and Enclosed Seas*. FAO, Rome.
- Food and Agriculture Organization (1993). *Technical Consultation on Integrated Rural Water Management*. FAO, Rome.
- Food and Agriculture Organization (1995a). *Street Foods*. FAO, Calcutta.
- Food and Agriculture Organization (1995b). *Codex Alimentarius Commission Procedural Manual*. FAO, Rome.
- Forget, G. (1997). In *International Perspectives on Environment, Development and Health, Towards a Sustainable World*, eds Shahi, G., Levy, B., Binger, A., Kjellstrom, T. and Lawrence, R. pp. 644–659. Springer, New York.
- Forget, G., Goodman, T. and de Villiers, A. (Eds) (1993). *Impact of Pesticide Use on Health in Developing Countries*. International Development Research Centre, Ottawa.
- Frankish, C., Green, L., Ratner, P., Chomik, T. and Larsen, C. (1996). *Health Impact Assessment as a Tool for Population Health Promotion and Public Policy*. Health Promotion Development Division of Health Canada, Vancouver.
- Furedy, C. (1990a). In *International Seminar on Wastewater Reclamation and Reuse for Aquaculture*, ed. Edwards, P. A. R. P. pp. 251–265. Environmental Sanitation Centre, Asian Institute of Technology, Bangkok.
- Furedy, C. (1990b). Social aspects of solid waste recovery in Asian cities. *Environmental Sanitation Reviews*, **30**, 1–52.

G

- Gajdusek, D. C. (1978). Introduction of *Taenia solium* into West New Guinea with a note on an epidemic of burns from cysticercus epilepsy in the Ekari people of the Wissel Lakes area. *Papua New Guinea Medical Journal*, **21**, 329–342.
- Garenne, M., Ronsmans, C. and Campbell, H. (1992). The magnitude of mortality from acute respiratory infections in children under 5 years in developing countries. *World Health Statistics Quarterly*, **45**, 180–191.
- Gear, S., A. B. and Mathys, A. (1996). *Strategic Sanitation Plan—the Kumasi Experience*. World Bank, Washington, DC.

- Ghosh, S. K., Parikh, J. R., Gokani, V. N., Kashyap, S. K. and Chatterjee, S. K. (1979). Studies on occupational health problems during agricultural operation of Indian tobacco workers. A preliminary survey report. *Journal of Occupational Medicine*, **21**, 45–47.
- Giel, R. and Van Luijk, J. N. (1967). The plight of daily labourers in a coffee growing province of Ethiopia. *Tropical and Geographical Medicine*, **19**, 304–308.
- Goldstein, G., Rossi-Espagnet, A. and Tabibzadeh, I. (1995). In *Urban Health in Developing Countries, Progress and Priorities*, eds Harpham, T. and Tanner, M. pp. 110–122. Earthscan Publications, London.
- Grados, O., Bravo, N., Black, R. E. and Butzler, J. P. (1988). Paediatric *Campylobacter* diarrhoea from household exposure to live chickens in Lima, Peru. *Bulletin of the World Health Organization*, **66**, 369–374.
- Greeley, M. (1987). *Postharvest Losses, Technology and Employment: the Case of Rice in Bangladesh*, Westview Press, Boulder, CO.
- Greenwood, B. M., Bradley, A. K., Blakebrough, I. S. and Wali, S. (1984). Meningococcal disease and season in sub-Saharan Africa. *Lancet*, **326**, 1339–1342.
- Guerrero, R. (1996). Cali: the right priorities. *World Health*, **49**, 10.
- Gunawan, S., Subianto, D. B. and Tumada, L. R. (1976). Taeniasis and cysticercosis in the Pania Lakes area of Irian Jaya. *Bulletin Penelitian Kesehatan. Health Studies in Indonesia*, **4**, 9–17.

H

- Haimanot, R. T., Kidane, Y., Wuhib, E., Kalissa, A., Alemu, T., Zein, Z. A. and Spencer, P. S. (1990). Lathyrism in rural northwest Ethiopia: a highly prevalent neurotoxic disorder. *International Journal of Epidemiology*, **19**, 664–672.
- Hamilton, A. C. (1984). *Deforestation in Uganda*. Oxford University Press, Oxford.
- Hardoy, J. and Satterthwaite, D. (1997). In *International Perspectives on Environment, Development and Health, Towards a Sustainable World*, eds Shahi, G., Levy, B., Binger, A., Kjellstrom, T. and Lawrence, R. pp. 123–162. Springer, New York.
- Harpham, T. and Blue, I. (Eds) (1995). *Urbanisation and Mental Health in Developing Countries*. Avebury, Aldershot, U.K.
- Harpham, T. and Tanner, M. (Eds) (1995). *Urban Health in Developing Countries, Progress and Priorities*. Earthscan Publications, London.
- Harrison, P. (1987). *The Greening of Africa: Breaking through in the Battle for Land and Food*. Paladin, London.
- Hassan, I., Ashmore, M. and Bell, J. (1995). Effect of ozone on radish and turnip under Egyptian field conditions. *Environmental Pollution*, **89**, 107–114.
- Hecht, R. (1995). In *Urban Health in Developing Countries, Progress and Priorities*, eds Harpham, T. and Tanner, M. pp. 123–141. Earthscan Publications, London.
- Heise, L. (1992). Violence against women: the hidden health burden. *World Health Statistics Quarterly*, **46**, 78–85.
- Hendrickse, R. G. (1991). Clinical implications of food contaminated by aflatoxins. *Annals of the Academy of Medicine (Singapore)*, **20**, 84–90.
- Hendrickse, R. G. and Maxwell, S. M. (1989). Aflatoxins and child health in the tropics. *Journal of Toxicology—Toxin Reviews*, **8**, 31–41.
- Hendrickse, R. G., Lamplugh, S. M. and Maegraith, B. G. (1986). Influence of aflatoxin on nutrition and malaria in mice. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **80**, 846–847.

- Holland, M. D., Kasanga, R. K., Lewcock, C. P. and Warburton, H. J. (1996). *Peri-urban Baseline Studies, Kumasi, Ashanti Region, Ghana, Volume 1*. Natural Resources Institute, Chatham Maritime, U.K.
- Holmboe-Ottesen, G., Wandel, M. and Oshaug, A. (1989). Nutritional evaluation of an agricultural development project in southern Sri Lanka. *Food and Nutrition*, **11**, 47–56.
- Hunt, C. (1996). Child waste pickers in India: the occupation and its health risks. *Environment and Urbanisation*, **8**, 111–118.
- Hunt, C. W. (1989). Migrant labour and sexually transmitted disease: AIDS in Africa. *Journal of Health and Social Behaviour*, **30 December**, 353–373.
- Hunter, J. M., Rey, L. and Scott, D. (1982). Man-made lakes and man-made diseases; towards a policy resolution. *Social Science and Medicine*, **16**, 1127–1145.
- Hutabarat, L. (1994). *Street Foods in Bangkok, the Nutritional Contribution and the Contaminants Content of Street Foods*. Food and Agriculture Organization, Rome.

J

- Jamison, D., Mosley, W., Measham, A. and Bobadilla, J. (Eds) (1993). *Disease Control Priorities in Developing Countries*. Oxford University Press, Oxford.
- Jeevan Rao, K. and Shantaram, M. V. (1995). Contents of heavy metals in crops treated with urban solid wastes. *Journal of Environmental Biology*, **16**, 225–232.
- Jemmali, P. (Ed.) (1995). *Ochratoxine A*. L'Association Africaine de Microbiologie et d'Hygiene Alimentaire, Sousse, Tunisia.
- Jensen, L. (1990). Sorting out solutions to waste. *Source*, **2**, 13.
- Jeronimo, S., Oliveira, R., Mackay, S., Costa, R., Sweet, J., Nascimento, E., Luz, K., Fernandes, M., Jernigan, J. and Pearson, R. (1994). An urban outbreak of visceral leishmaniasis in Natal, Brazil. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **88**, 386–388.
- Jewsbury, J. M. and Imevbore, A. M. A. (1988). Small dam health studies. *Parasitology Today*, **4**, 57–59.

K

- Keiding, J. (1964). *Report on a Consultancy on Control of House Flies and other Insects of Public Health Importance in the Eastern Mediterranean Region*. World Health Organization, Geneva.
- Khogali, M. (1970). Industrial health problems in developing countries: types of risks and their prevention. *Journal of Tropical Medicine and Hygiene*, **73**, 272.
- Kjellstrom, T. and Corvalan, C. (1995). Framework for the development of environmental health indicators. *World Health Statistics Quarterly*, **48**, 144–154.
- Kjellstrom, T. and Rosenstock, L. (1990). The role of environmental and occupational hazards in the adult health transition. *World Health Statistics Quarterly*, **43**, 188–196.
- Kolsky, P. and Blumenthal, U. (1995). Environmental health indicators and sanitation-related disease in developing countries: limitations to the use of routine data sources. *World Health Statistics Quarterly*, **48**, 132–139.
- Kotova, A. L., Kondratskaya, S. A. and Yasutis, I. M. (1988). Salmonella carrier state and biological characteristics of the infectious agent. *Journal of Hygiene, Epidemiology, Microbiology and Immunology*, **32**, 71–78.
- Kumar, P., Dushenkov, V., Motto, H. and Raskin, I. (1995). Phytoextraction: the use of plants to remove heavy metals from soils. *Environmental Science and Technology*, **29**, 1232–1238.

L

- LaDou, J. (1992). In *Occupational Health in Developing Countries*, ed. Jeyaratnam, J. pp. 341–367. Oxford University Press, Oxford.
- Lang, G. H. (1989). Q fever: an emerging public health concern in Canada. *Canadian Journal of Veterinary Research*, **53**, 1–6.
- Lappe, F. M. and Collins, J. (1988). *World Hunger: 12 myths*. Earthscan Publications, London.
- Lee, J. A. (1985). *The Environment, Public Health and Human Ecology: Considerations for Economic Development*. John Hopkins University Press, Baltimore.
- Lee-Smith, D., Manundu, M., Lamba, D. and Gathuru, P. (1987). *Urban Food Production and the Cooking Fuel Situation in Urban Kenya, Results of a National Survey in 1985*. Mazungira Institute, Nairobi.
- Leitmann, J. (1991). *Energy–environment Linkages in the Urban Sector*. United Nations Development Programme, New York.
- Levi, L. (1984). *Stress in Industry: Causes, Effects and Prevention*. International Labour Office, Geneva.
- Lewcock, C. (1995). Farmer use of urban waste in Kano. *Habitat International*, **19**, 225–234.
- Lewis, N. D. (1986). Disease and development: ciguatera fish poisoning. *Social Science and Medicine*, **23**, 983–993.
- Lim, H. H., Domala, Z., Joginder, S., Lee, S. H., Lim, C. S. and Abu Bakar, C. M. (1984). Rice millers' syndrome: a preliminary report. *British Journal of Industrial Medicine*, **41**, 445–449.
- Lindsay, D. R., Stewart, W. H. and Watt, J. (1953). Effect of fly control on diarrhoeal disease in an area of moderate morbidity. *Public Health Reports*, **68**, 361–367.
- Lindsay, S., Campbell, H., Adiamah, J., Greenwood, A., Bangali, J. and Greenwood, B. (1990). Malaria in a peri-urban area of The Gambia. *Annals of Tropical Medicine and Parasitology*, **84**, 553–562.
- Lines, J., Harpham, T., Leake, C. and Schofield, C. (1994). Trends, priorities and policy directions in the control of vector-borne diseases in urban environments. *Health Policy and Planning*, **9**, 113–129.
- Lipton, M. and de Kadt, E. (1988). *Agriculture–health Linkages*. World Health Organization, Geneva.
- Listorti, J. (1996a). *Bridging Environmental Health Gaps*. World Bank, Washington, DC.
- Listorti, J. (1996b). *Bridging Environmental Health Gaps. Volume 2: Cross-sectoral Literature Review and Analysis*. World Bank, Washington, DC.
- Listorti, J. (1996c). *Bridging Environmental Health Gaps. Volume 3: Recommendations for sub-Saharan Africa and the Rest of the Bank*. World Bank, Washington, DC.
- Liu Tie-min (1990). Tussah silk pneumoconiosis: investigation and experiment study. *American Review of Respiratory Disease*, **141**, A248.
- Loevinsohn, M. E. (1987). Insecticide use and increased mortality in rural Central Luzon, Philippines. *Lancet*, **332**, 1359–1362.
- Longhurst, R. (1988). Cash crops, household food security and nutrition. *IDS Bulletin*, **19**, 28–36.
- Lumbreras, H. (1972). El problema de la enfermedad de Chagas en los diferentes departamentos del Peru. *Revista Viernes Medico*, **23**, 43–77.
- Lupien, J. (1985). *Codex Coordinating Committee for Latin America and Caribbean, Vol. CX/LA 85/5*. Food and Agriculture Organization, Havana.

M

- Mage, D. and Zali, O. (Eds) (1992). *Motor Vehicle Air Pollution, Public Health Impact and Control Measures*. World Health Organization, Geneva.

- Mannino, D. M., Parker, J. E. and Townsend, M. C. (1990). Dairy farming production in the US and death with farmer's lung from 1976–1986: an ecological study. *American Review of Respiratory Disease*, **141**, A588.
- Mara, D. and Cairncross, S. (1989). *Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture*. World Health Organization, Geneva.
- Marinova, G. (1978). Problems of interrupted pregnancy among working women. *Akusherstvo i Ginekologiya (Sofia)*, **17**, 412–417.
- Maxwell, S. M., Apeageyi, F., de Vries, H. R., Mwanmut, D. D. and Hendrickse, R. G. (1989). Aflatoxins in breast milk, neonatal cord blood and sera of pregnant women. *Journal of Toxicology–Toxin Reviews*, **8**, 19–29.
- McCracken, J. A. and Conway, G. R. (1987). *Pesticide Hazards in the Third World: New Evidence from the Philippines*. International Institute for Environment and Development, London.
- McDonald, A. D. and McDonald, J. C. (1986). Outcome of pregnancy in leatherworkers. *British Medical Journal*, **292**, 979–982.
- McGranahan, G. (1992). In *Planning for Sustainable Urban Development. Cities and Natural Resource Systems in Developing Countries*, pp. 1–22. University of Wales, Cardiff.
- McGranahan, G., Songsore, J. and Kjellen, M. (1996). In *Sustainability, the Environment and Urbanization*, ed. Pugh, C. pp. 103–133. Earthscan Publications, London.
- Meakins, R. H. (1988). In *Southern Africa Research for Development*, ed. Sefali, M. M. ISAS NUL, Rome.
- Merkle, F. and Knobloch, U. (1995). In *Urban Health in Developing Countries, Progress and Priorities*, eds Harpham, T. and Tanner, M. pp. 172–181. Earthscan Publications, London.
- Meslin, F. (1992). Surveillance and control of emerging zoonoses. *World Health Statistics Quarterly*, **45**, 200–207.
- Metcalf, H. E., Luchsinger, D. W. and Winthrop, C. R. (1994). In *Handbook of Zoonoses, Volume 1*, Second Edn, ed. Beran, G. W. pp. 9–39. CRC Press, Boca Raton, FL.
- Moazami, N. (1994). In *UNESCO/WHO Meeting of Experts*, pp. 97–112. United Nations Educational, Scientific and Cultural Organization, Paris.
- Moelbak, K., Hoejlyng, N. and Gaarslev, K. (1988). High prevalence of *Campylobacter* excreters among Liberian children related to environmental conditions. *Epidemiology and Infection*, **100**, 227–237.
- Mohan, D., Qadeer, I., Patel, R., Varghese, M., Shah, S. J., Kumar, H., Chahar, L. S., Guar, M. and Kumar, A. (1992). *Grains of Blood: Prevention and Control of Farm Injuries in India*. Centre for Biomedical Engineering, Indian Institute of Technology, Delhi.
- Montgomery, T. (1997). In *World Wide Web*—<http://www.tortuga.com/earth/agua/tsystems.html>.
- Moodie, T. D. (1989). Migrancy and male sexuality on South African gold mines. *Journal of South African Studies*, **14**, 228–256.
- Motarjemi, Y., Kaferstein, F., Moy, G., Miyagishima, K., Miyagawa, S. and Reilly, A. (1995). *Food Technologies and Public Health*. Document WHO/FNU/FOS/95.12. World Health Organization, Geneva.
- Mougeot, L. (1997). *Development Research in Urban Agriculture, an International Awards Programme*. International Development Research Centre, Ottawa.
- Mumford, J., Henderson, S., Harrap, K. and Birley, M. (1997). *Pheromones*. Overseas Development Administration, London.
- Murrell, K. (1995). Foodborne parasites. *International Journal of Environmental Research*, **5**, 63–85.
- Mutere, A. (1991). Domestic air pollution in rural Kenya. *Boiling Point—Intermediate Technology Group*, **April**, 23–27.

Mutere, A. B. (1990). *Third Report on Tests of the Estimation of Polycyclic Aromatic Hydrocarbons (PAHs), Total Suspended Particulate (TSP) Emissions and Carbon Monoxide (CO) from Traditional and Improved Woodburning Stoves in Kiambu, Kenya, East Africa*. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn.

N

Nag Anjali (1986). *Occupational Health Hazards for Women in India*. National Institute of Occupational Health, Ahmedabad, India.

Nicolaisen, D., Plog, U., Spreen, E. and Thapa, S. B. (1988). *Solid Waste Management with People's Participation. An Example in Nepal*. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn.

O

Odingo, R. S. (Ed.) (1979). *An African Dam. Ecological Survey of the Kamburu/Gtaru Hydro-electric Dam Area, Kenya*. Swedish Natural Science Research Council, Stockholm.

Olaguibel, J. M., Hernandez, D., Morales, P., Peris, A. and Basomba, A. (1990). Occupational asthma caused by inhalation of casein. *Allergy*, **45**, 306–308.

O'Malley, M. (1997). Clinical evaluation of pesticide exposure and poisonings. *Lancet*, **349**, 1161–1166.

Ongley, E. D. (1996). *Control of Water Pollution from Agriculture*. Food and Agriculture Organization, Rome.

O'Reilly, C. and Gordon, A. (1995). *Survival Strategies of Poor Women in Urban Africa: the Case of Zambia*. Natural Resources Institute, Chatham Maritime, U.K.

Orford, R. R. and Wilson, J. T. (1985). Epidemiologic and immunologic studies in processors of the king crab. *American Journal of Industrial Medicine*, **7**, 155–169.

P

Packard, R. M. (1989). Industrial production, health and disease in sub-Saharan Africa. *Social Science and Medicine*, **28**, 475–496.

Padmini, R. (1995). In *Urban Health in Developing Countries, Progress and Priorities*, eds Harpham, T. and Tanner, M. pp. 142–152. Earthscan Publications, London.

Payne, P. R. (1990). Measuring malnutrition. *IDS Bulletin*, **21**, 14–30.

Pescod, M. (1992). *Wastewater Treatment and Use in Agriculture*. Food and Agriculture Organization, Rome.

Phool Chund, H. (1991). Health and safety in agriculture: the sugarcane industry. *African Newsletter on Occupational Health and Safety*, **1**, 83–85.

Pimental, D. and Pimental, M. (1979). *Food, Energy and Society*. Edward Arnold, London.

Pingali, P. L. and Marquez, C. (1990). In *Annual General Meeting of the American Agricultural Economics Association, Volume 90-04*, pp. 1–9. Social Science Division, International Rice Research Institute, Manila.

Popkin, B. (1996). Understanding the nutrition transition. *Urbanisation and Health Newsletter*, **30 September**, 3–19.

Prothero, R. M. and Gould, W. T. S. (1984). In *Geography and Population, Approaches and Applications*, ed. Clarke, J. I. pp. 111–118. Pergamon Press, London.

Pullin, R. S. V., Rosenthal, H. and L, M. J. (Eds) (1991). *Aquaculture and Environment in Developing Countries*. International Center for Living Aquatic Resources Management, Manila.

R

- Raikes, A. (1989). Women's health in East Africa. *Social Science and Medicine*, **28**, 447–459.
- Rainbird, G. and O'Neill, D. (1993). *Work-related Diseases in Tropical Agriculture*. Silsoe Research Institute, Silsoe, U.K.
- Rao, R. B., Rao, H. R. and Sundaresan, B. (1946). Epidemiology of malaria in the Tungabhadra project area of the ceded districts of Madras. *Journal of the Malaria Institute of India*, **6**, 323–357.
- Reichenheim, M. and Harpham, T. (1991). Maternal mental health in a squatter settlement of Rio de Janeiro. *British Journal of Psychiatry*, **155**, 44–47.
- Reilly, A. and Kaferstein, F. (1996). In *IFS/EU Workshop on Aquaculture Research and Sustainable Development in Inland and Coastal Regions in Southeast Asia*. University of Can-Tho, Can-Tho, Viet Nam.
- Rice, M. and Rasmusson, E. (1992). In *Healthy Cities*, ed. Ashton, J. pp. 70–84. Open University Press, Milton Keynes, U.K.
- Richards, A. I. (1939). *Land, Labour and Diet in northern Rhodesia*. Oxford University Press, Oxford.
- Ripert, C. L. and Raccurt, C. P. (1987). The impact of small dams on parasitic diseases in Cameroon. *Parasitology Today*, **3**, 287–298.
- Rogers, B. (1981). *The Domestication of Women*. Tavistock Publications, London.
- Romieu, I., Weitzenfeld, H. and Finkelman, J. (1990). Urban air pollution in Latin America and the Caribbean: health perspectives. *World Health Statistics Quarterly*, **43**, 153–167.
- Rosenstock, L., Keifer, M., Daniel, W. E., McConnell, R. and Claypoole, K. (1990). Chronic central nervous system effects of acute organophosphate pesticide poisoning. *Lancet*, **338**, 223–227.
- Rossi-Espagnet, A., Goldstein, G. and Tabibzadeh, I. (1991). Urbanisation and health in developing countries: a challenge of health for all. *World Health Statistics Quarterly*, **44**, 187–244.
- Roundy, R. W. (1989). In *Demography and Vector-borne Diseases*, ed. Service, M. W. pp. 193–205. CRC Press, Boca Raton, FL.
- Rowley, D., Rab, M. and Hardjotjanjo, W. (1987). Convulsions caused by endrin poisoning in Pakistan. *Paediatrics*, **79**, 928–934.
- Rush, B. A. (1987). *Cryptosporidium* and drinking water. *Lancet*, **333**, 632.
- Ruttan, V. (Ed.) (1994). *Agriculture, Environment and Health: Sustainable Development in the 21st Century*. University of Minnesota Press, Minneapolis, MN.
- Ryan, C. A., Nickels, M. K., Hargrett-Bean, N. T., Potter, M. E., Endo, T., Mayer, L., Langkop, C. W., Gibson, C., McDonald, R. C. and Kenney, R. T. (1987). Massive outbreak of antimicrobial-resistant salmonellosis traced to pasteurized milk. *Journal of the American Medical Association*, **258**, 3269–3274.

S

- Saliba, L. and Helmer, R. (1990). Health risks associated with pollution of coastal bathing waters. *World Health Statistical Quarterly*, **43**, 177–187.
- Sanjose, S., Roma, E. and Beral, V. (1991). Low birthweight and preterm delivery, Scotland, 1981–84: effects of parents' occupation. *Lancet*, **338**, 428–431.

- Satterthwaite, D. (1993). The impact on health of urban environments. *Environment and Urbanization*, **5**, 87–111.
- Satterthwaite, D., Hart, R., Levy, C., Mitlin, D., Ross, D., Smit, J. and Stephens, C. (Eds) (1996). *The Environment for Children*. Earthscan Publications, London.
- Sawyer, L. A., Fishbein, D. B. and McDade, J. E. (1987). Q fever, current concepts. *Review of Infectious Diseases*, **9**, 935–946.
- Schillhorn, T. and O'Connell, P. (1997). In *Agriculture Technology Notes, Volume 17*. Agricultural and Forestry Systems Division, World Bank, Washington, DC.
- Schmunis, G., Zicker, F. and Moncayo, A. (1996). Interruption of Chagas disease transmission through vector elimination. *Lancet*, **348**, 1171.
- Schofield, C. (1994). *Triatominae—Biology and Control*. Eurocommunica Publications, Bognor Regis, U.K.
- Scholtissek, C. and Naylor, E. (1988). Fish farming and influenza pandemics. *Nature*, **331**, 215.
- Schwartzbrod, L. (1995). *Effect of Human Viruses on Public Health associated with the Use of Wastewater and Sewage Sludge in Agriculture and Aquaculture*. Document WHO/EOS/95.19. World Health Organization, Geneva.
- Sekimpi, D. K. (1992). In *Occupational Health in Developing Countries*, ed. Jeyaratnam, J. pp. 31–88. Oxford University Press, Oxford.
- Seniori Costantini, A., Merler, E. and Saracci, R. (1990). Epidemiologic studies on carcinogenic risk and occupational activities in tanning, leather and shoe industries. *Medicina del Lavoro*, **81**, 184–211.
- Service, M. (1989a). In *Demography and Vector Borne Diseases*, ed. Service, M. pp. 59–83. CRC Press, Boca Raton, FL.
- Service, M. W. (1989b). The importance of ecological studies on malaria vectors. *Bulletin of the Society of Vector Ecology*, **14**, 26–38.
- Service, M. (1990). Control of urban mosquitoes. *Pesticide Outlook*, **1**, 17–20.
- Shukla, A., Kumar, S. and Ory, F. G. (1991). Occupational health and the environment in an urban slum in India. *Social Science and Medicine*, **33**, 597–603.
- Shuval, H. I. (1990). *Wastewater Irrigation in Developing Countries: Health Effects and Technical Solutions*. International Bank for Reconstruction and Development, Washington, DC.
- Silimperi, D. R. (1995). In *Urban Health in Developing Countries, Progress and Perspectives*, eds Harpham, T. and Tanner, M. Earthscan Publications, London.
- Silverside, D., Sherington, J. and Marsland, N. (1996). *Report on a Visit to Bangladesh to Initiate a Research Project entitled Improvements in the Production of Livestock Products in Peri-urban Areas of Cities in Asia*. Natural Resources Institute, Chatham Maritime, U.K.
- Sims, J. (Ed.) (1994). *Women, Health and Development, an Anthology*. World Health Organization, Geneva.
- Singh, Y. P. and Vijjan, V. K. (1987). Ill effects associated with the use of feed additives in livestock production. *Livestock Adviser*, **12**, 33–36.
- Sixl, W. and Sixl-Voigt, B. (1987). Research on a possible Q-fever infection in humans and animals on the Cape Verde Islands (Santa Cruz/Santiago, West Africa). *Journal of Hygiene, Epidemiology, Microbiology and Immunology*, **31** (Supplement), 472–474.
- Smit, J., Ratta, A. and Nasr, J. (1996). *Urban Agriculture, Food, Jobs and Sustainable Cities*. United Nations Development Programme, New York.
- Smith, K. (1993). Fuel combustion, air pollution exposure, and health: the situation in developing countries. *Annual Review of Energy and the Environment*, **18**, 529–566.

- Smith, K. (1997). In *International Perspectives on Environment, Development and Health, Towards a Sustainable World*, eds Shahi, G., Levy, B., Binger, A., Kjellstrom, T. and Lawrence, R. pp. 51–62. Springer, New York.
- Smith, K. R. (1987). *Biofuels, Air Pollution and Health: a Global Review*. Plenum Press, New York.
- Smith, K. R. (1991a). *The Health Effects of Biomass Smoke: a Brief Survey of Current Knowledge*. Environment and Policy Institute, Honolulu, HI.
- Smith, K. R. (1991b). Managing the risk transition. *Toxicology and Industrial Health*, **7**, 319–327.
- Snashall, D. (1990). Safety and health in the construction industry. *British Medical Journal*, **301**, 563–564.
- Somma-Moreira, R. E., Caffarena, R. M., Somma, S., Perez, G. and Monteiro, M. (1987). Analysis of Q fever in Uruguay. *Review of Infectious Diseases*, **9**, 386–387.
- Songsore, J. and Goldstein, J. (1995). Health and environment analysis for decision-making (HEADLAMP): field study in Accra, Ghana. *World Health Statistics Quarterly*, **48**, 108–117.
- Songsore, J. and McGranahan, G. (1993). Environment, wealth and health: towards an analysis of intra-urban differentials within the Greater Accra Metropolitan Area, Ghana. *Environment and Urbanization*, **5**, 10–34.
- Stelzer, W., Mochmann, H., Richter, U. and Dobberkau, H. J. (1988). A study of *Campylobacter jejuni* and *Campylobacter coli* in a river system. *Zentralblatt für Hygiene und Umweltmedizin*, **189**, 20–28.
- Stephens, C. and Harpham, T. (1992). Health and environment in urban areas of developing countries. *Third World Planning Review*, **14**, 3.
- Stephens, C., Timaeus, I., Akerman, M., Avle, S., Borlina Maia, P., Campanario, P., Doe, B., Lush, L., Tetteh, D. and Harpham, T. (1994). *Environment and Health in Developing Countries: an Analysis of Intra-urban Differentials using Existing Data*. London School of Hygiene and Tropical Medicine, London.
- Stephens, C., Akerman, M. and Maia, P. (1995a). Health and environment in Sao Paulo, Brazil: methods of data linkage and questions of policy. *World Health Statistics Quarterly*, **48**, 95–107.
- Stephens, R., Spurgeon, A. and Calvert, I. A. (1995b). Neuropsychological effects of long-term exposure to organophosphates in sheep dip. *Lancet*, **345**, 1135–1139.
- Surjadi, C. (1993). Respiratory diseases of mothers and children and environmental factors among households in Jakarta. *Environment and Urbanization*, **5**, 78–86.

T

- Tarcher, A. B. (Ed.) (1992). *Principles and Practice of Environmental Medicine*. Plenum, New York.
- Tauil, P. L. (1986). Comments on the epidemiology and control of malaria in Brazil. *Memórias do Instituto Oswaldo Cruz*, **81** (Supplement 2), 39–41.
- Thompson, R. C. A. (1979). Biology and speciation of *Echinococcus granulosus*. *Australian Veterinary Journal*, **55**, 93–98.
- Trape, J. and Zoulani, A. (1987). Malaria and urbanization in Central Africa: the example of Brazzaville. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **81** (Supplement 2), 1–33.
- Trape, J.-F., Lefebvre-Zante, E., Legros, F., Ndiaye, G., Bouganali, H., Druilhe, P. and Salem, G. (1992). Vector density gradients and the epidemiology of urban malaria in Dakar, Senegal. *American Journal of Tropical Medicine and Hygiene*, **47**, 181–189.
- Turner, P. C., Gammie, A. J., Hollinrake, K. and Codd, G. A. (1990). Pneumonia associated with cyanobacteria. *British Medical Journal*, **300**, 1440–1441.

U

Uragoda, C. G. and Wijekoon, P. N. B. (1991). Asthma in silk workers. *Journal of the Society of Occupational Medicine*, **41**, 140–142.

V

Varley, C., Yacoob, M. and Smith, S. (1996). *Beyond Participation: Locally Based Demand for Environmental Health in Peri-urban Areas*. Office of Health and Nutrition, United States Agency for International Development, Washington, DC.

Ventura Napa, M. (1992). In *Prevention of Water Pollution by Agriculture and Related Activities*, Volume 1, pp. 159–167. Food and Agriculture Organization, Santiago, Chile.

Verhagen, A. R. and Gemert, W. (1972). Social and epidemiological determinants of gonorrhoea in an East African country. *British Journal of Venereal Diseases*, **48**, 277–286.

Verlaan, P. A. (1997). In *International Perspectives on Environment, Development and Health, Toward a Sustainable World*, eds Shahi, G., Levy, B., Binger, A., Kjellstrom, T. and Lawrence, R. pp. 259–272. Springer, New York.

Vreman, K., van der Veen, N. G., van der Molen, E. J. and de Ruig, W. G. (1988). Transfer of cadmium, lead, mercury and arsenic from feed into tissues of fattening bulls: chemical and pathological data. *Netherlands Journal of Agricultural Science*, **36**, 327–338.

W

Watanabe, M. (1997). Phytoremediation on the brink of commercialization. *Environmental Science and Technology*, **31**, 182A–186A.

Watt, J. and Lindsay, D. R. (1948). Diarrheal disease control studies 1. Effect of fly control in a high morbidity area. *Public Health Reports*, **63**, 1319–1334.

Webster, M. H. (1960). The medical aspects of the Kariba hydro–electric scheme. *Central African Medical Journal*, **6** (Supplement), 1–36.

West, L. S. (1953). *Fly Control in the Eastern Mediterranean and Elsewhere; Report of a Survey and Study*. World Health Organization, Geneva.

Westcot, D. (undated). *Quality Control of Wastewater for Irrigated Crop Production*. Food and Agriculture Organization, Rome.

Whitford, H. W. and Hugh-Jones, M. E. (1994). In *Handbook of Zoonoses, Volume 1*, Second Edn, ed. Beran, G. W. pp. 61–82. CRC Press, Boca Raton, FL.

Will, S., Ardern, K., Spencely, M. and Watkins, S. (1994). *A Prospective Health Impact Assessment of the Proposed Development of a Second Runway at Manchester International Airport*. Manchester and Stockport Health Commissions, Stockport, U.K.

Wills, J. and Briggs, D. (1995). Developing indicators for environment and health. *World Health Statistics Quarterly*, **48**, 155–163.

Wilson, D., Sibanda, B., Mboyi, L. and Msimanga, S. (1990). A pilot study for an HIV prevention programme among commercial sex workers in Bulawayo, Zimbabwe. *Social Science and Medicine*, **31**, 609–618.

Wittenberg, D. F., Smith, E. G., van den Ende, J. and Becker, P. J. (1987). *Cryptosporidium*-associated diarrhoea in children. *Annals of Tropical Paediatrics*, **7**, 113–117.

- Wolgemuth, J. C., Latham, M. C., Hall, A., Chesher, A. and Crompton, D. W. T. (1982). Worker productivity and the nutritional status of Kenyan road construction labourers. *American Journal of Clinical Nutrition*, **36**, 68–78.
- World Bank (1988a). *Environmental Guidelines*. Environment Department, World Bank, Washington, DC.
- World Bank (1988b). *Occupational Health and Safety Guidelines*. Environment Department, World Bank, Washington, DC.
- World Bank (1993). *World Development Report 1993*. Oxford University Press, New York.
- World Health Organization (1977). *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death*. WHO, Geneva.
- World Health Organization (1979a). *Mycotoxins*. Environmental Health Criteria No.11. WHO, Geneva.
- World Health Organization (1979b). *Sulphur Oxides and Suspended Particulate Matter*. Environmental Health Criteria No. 8. WHO, Geneva.
- World Health Organization (1981). *Hydrogen Sulphide*. Environmental Health Criteria No.19. WHO, Geneva.
- World Health Organization (1983). *Health Impact of Different Energy Sources. A Challenge for the End of the Century*. Working Group on Health and Energy in Europe, WHO, Geneva.
- World Health Organization (1985). *Environmental Pollution Control in Relation to Development*. Technical Report Series No. 718. WHO, Geneva.
- World Health Organization (1986). *Informal Consultation on Planning for the Prevention of Pesticide Poisoning*. Document VBC/86.926. WHO, Geneva.
- World Health Organization (1989). *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture*. Technical Report Series No. 778. WHO, Geneva.
- World Health Organization (1991a). *Control of Chagas Disease*. Technical Report Series No. 811. WHO, Geneva.
- World Health Organization (1991b). *Health and the Cities: a Global Overview*. WHO, Geneva.
- World Health Organization (1991c). *Report of the Food and Agriculture Panel*. Commission on Health and the Environment, WHO, Geneva.
- World Health Organization (1992a). *Our Planet, Our Health*. Commission on Health and Environment, WHO, Geneva.
- World Health Organization (1992b). *Report of the Panel on Food and Agriculture*. Commission on Health and Environment, WHO, Geneva.
- World Health Organization (1992c). *Epidemiological, Social and Technical Aspects of Indoor Air Pollution from Biomass Fuel*. Document WHO/PEP/92.3A. WHO, Geneva.
- World Health Organization (Ed.) (1993a). *Application of the Hazard Analysis Critical Control Point System for the Improvement of Food Safety*. Food Safety Unit, WHO, Geneva.
- World Health Organization (1993b). *The Urban Health Crisis, Strategies for Health for All in the Face of Rapid Urbanization, Report of the Technical Discussions of the Forty-fourth World Health Assembly*. WHO, Geneva.
- World Health Organization (1995a). *Human Exposure to Lead*. Document WHO/EHG/95.15. WHO, Bangkok.
- World Health Organization (1995b). *WHO Healthy Cities: a Programme Framework, a Review of the Operation and Future Development of the WHO Healthy Cities Programme*. Document WHO/EOS/95.11. WHO, Geneva.

- World Health Organization (1996a). *Escherichia coli* O157:H7. *World Health Organization Factsheet*, **125**, 3.
- World Health Organization (1996b). *Essential Requirements for Street-vended Foods*. Document WHO/FNU/FOS/96.7. WHO, Geneva.
- World Health Organization (1996c). *Healthy Marketplaces*. Food Safety Unit, WHO, Geneva.
- World Health Organization (1997a). *Health and Environment in Sustainable Development: Five Years after the Earth Summit*. WHO, Geneva.
- World Health Organization (1997b). Multi-drug resistant *Salmonella typhimurium*. *World Health Organization Factsheet*, **139**, 4.
- Wyesundera, M. S. (1988). Malaria outbreaks in new foci in Sri Lanka. *Parasitology Today*, **4**, 147–150.

Y

- Yach, D., Myers, J., Bradshaw, D. and Benatar, S. R. (1984). A respiratory epidemiologic survey of grain mill workers in Cape Town, South Africa. *American Review of Respiratory Disease*, **131**, 505–510.
- Yacoub, M. and Kelly, M. (1997). Creating sustainable environmental health conditions by redefining municipal roles and responsibilities: experiences from Tunisia and Ecuador. *Natural Resources Forum*, **21**, 39–50.
- Yamaguchi, N., Watanabe, S., Okubo, T. and Takahashi, K. (1991). Work-related bladder cancer risks in male Japanese workers: estimation of attributable fraction and geographical correlation analysis. *Japanese Journal of Cancer Research*, **82**, 624–631.
- Ye, T. T., Lewis, D. M., Sorenson, W. G. and Olenchock, S. A. (1988). Inflammatory potential of grain dust. *Biomedical and Environmental Sciences*, **1**, 115–124.
- Yndestad, M. (1991). In *The Problems of Chemotherapy in Aquaculture*. Office International des Épizooties, Paris.
- Young, R. H., Hendrickse, R. G., Maxwell, S. M. and Maegraith, B. G. (1988). Influence of aflatoxin on malarial infection in mice. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **82**, 559–560.
- Yvon, J. (1997). *Farmers' Perceptions: Pests and their Management for Tomato and Garden Egg Production*. Integrated Food Crops Systems Project, Natural Resources Institute, Chatham Maritime, U.K.

Z

- Zuskin, E., Valic, F. and Skuric, Z. (1979). Respiratory function in coffee workers. *British Journal of Industrial Medicine*, **36**, 117–122.
- Zwi, A. B. (1991). Identifying “high risk situations” for preventing AIDS. *British Medical Journal*, **303**, 1527–1529.

Annex 1

Methodology and Dissemination

Methodology adopted to undertake this review

The majority of this report consists of a review of health linkages arranged according to natural resource categories. Information was gathered by key-informant interview and by literature search. At the outset, we created two databases. The first provided a reference-management system and used ENDNOTE PLUS software. The second provided a contact-management system and was based on ACCESS software. The literature search and analysis were strictly time-limited—more documentation was obtained on a wider set of topics than could be processed in the time available. Priority was given to existing reviews. This review was undertaken in 1997.

Meetings were arranged with as many potential key informants as possible, at institutions such as the London School of Hygiene and Tropical Medicine, Imperial College, the NRI, the WHO, the FAO, the World Bank, USAID, the Urban Agriculture Network, the World Resources Institute, and the Environment and Groundwater Institute. The key purposes of the programme were discussed with each key informant and notes were taken of potentially interesting references, other contact names, and lines of current research.

Strategies for identifying relevant literature and key informants

This is not a systematic review. In our opinion, the systematic-review method is only appropriate for single issues and not for the open-ended identification phase of a project. It would be

possible to conduct a systematic review, one at a time, of the many issues that we identify. This would be a later project. The purpose of a systematic review might include prioritising the health issues that we have identified.

As part of our information-gathering phase, a simple questionnaire was circulated that explained the purpose of the project and asked four questions. The questions sought an opinion of the recipient about relevant health issues, lists of relevant publications, and possible additional contacts. We encouraged the recipient to forward the questionnaire to their own contacts. When the recipient had no e-mail address the questionnaire was transmitted as a hard copy.

The questionnaire was sent directly to 212 people from a wide range of organizations, including NRI, ODA, the World Bank, FAO, WHO, IDRC, USAID, GTZ, SANDEC, and CGIAR research centres and universities. The response rate was 31%.

It was hypothesised that many NGOs may be active at the peri-urban interface because of problems of jurisdiction for municipal authorities. A special survey of NGOs was conducted using members of BOND, an association of British Overseas NGOs for Development.

The Web was browsed but a systematic search was not regarded as a priority within the available time constraint.

We visited the following relevant WWW sites:

-  City Farmer: <http://www.cityfarmer.org/>
-  CIRAD: <http://www.cirad.fr/>

- CGIAR: <http://www.worldbank.org/html/cgiar/centers.html>
- Environmental Health Project (EHP): <http://www.access.digex.net/~ehp/>
- Food and Agriculture Organization of The United Nations (FAO): <http://www.fao.org/>
- International Development Research Centre (IDRC): <http://www.idrc.ca/>
- One World online (links to many organizations, including NGOs): <http://www.oneworld.org/>
- Coalition for Healthier Cities and Communities: <http://www.healthycities.org/cgi-bin/>
- World Bank: <http://www.worldbank.org/>
- US Agency for International Development (USAID): <http://www.info.usaid.gov/>
- USAID environmental links page: <http://www.info.usaid.gov/environment/enric/elinks.htm>
- United Nations Centre for Human Settlements: <http://www.undp.org/un/habitat>
- United Nations Environment Programme (UNEP): <http://www.unep.no/>
- World Health Organization: <http://www.who.ch/>
- WHO Healthy Cities Project: <http://www.who.dk/tech/hcp/index.htm>

We also posted a request for information on the following e-mail discussion lists:

- INFOTERRA, the e-mail discussion list of the United Nations Environment Program: infoterra@cedar.univie.ac.at
- Mailbase Public Health list: public-health@mailbase.ac.uk
- City Farmer (urban agriculture): <http://www.cityfarmer.org/>

The University of Liverpool and the NRI CD-ROM collection were searched using the logical construct:

- health AND {peri-urban OR periurban OR urban OR outskirts} AND {natural resource OR agriculture OR fuel OR food OR forestry OR livestock OR fish OR waste OR pollution OR recreation}.

The databases searched were as follows:

- MEDLINE (1991–date);
- CAB (1984–date)—the Commonwealth Agricultural Bureau International disc;
- TROPAG and RURAL (1975–date)—the Royal Tropical Institute of the Netherlands disc;
- AGRIS (1981–date)—the Food and Agriculture Organization disc;
- FSTA (1969–date)—the Food Science and Technology Abstracts disc from the International Food Information Service;
- AGRICOLA (1970–date);
- SESAME (1991–date)—the CIRAD database;
- USAID (1996–date)—the USAID database; and
- CAIRS—the NRI database.

We also sent our search request to the ODA natural-resources database to elicit details of relevant ODA projects and to the AHRTAG bibliographic database for information on air pollution.

Dissemination

The report was subjected to independent and anonymous peer review by the commissioners. The reviewers approved the report and recommended its publication. A commercial publisher declined to participate on the grounds that the market was small. The commissioners then funded in-house publication. We intend to deliver a copy to each of the individuals who responded to the information-gathering phase. A draft copy of the report has been posted on the net at www.liv.ac.uk/~mhb. This may be replaced with the current version if time permits.

Annex 2

Glossary

A

- abscess A cavity containing pus and surrounded by inflamed tissue.
- acoustic trauma Hearing loss, from exposure to continuous loud noise over a period of time or a sudden explosion or blow to the head or other injuries. May be temporary or permanent.
- Ae.* Abbreviation of *Aedes*.
- Aedes* A genus of mosquitoes capable of transmitting dengue, yellow fever and encephalitis.
- aflatoxicosis A disease condition caused by the presence of aflatoxins in the body.
- aflatoxin A class of mycotoxins produced by a mould that grows on damp food.
- agro-chemicals Chemicals used in the agricultural industry, such as fertilizer, pesticides and weed killers.
- AIDS Auto Immune Deficiency Syndrome, caused by infection with the human immunodeficiency virus.
- airshed A concept used to denote the boundaries of a mass of air; often used in relation to pollution concentrations.
- allergen Any substance that induces an allergic reaction.
- An.* Abbreviation of *Anopheles*.
- anaemia A condition characterised by a low haemoglobin level in the blood.
- analysis An examination in order to understand. See assessment.
- anisakiasis An infection of the gastro-intestinal tract by larval nematodes of the subfamily Anisakidae; people become infected by eating raw or inadequately treated fish.
- Anopheline One of two groups into which mosquitoes are divided.
- Anopheles* A genus of mosquitoes that transmit malaria.
- antenatal A time period between conception and birth; it is important for women to have adequate treatment and advice during this time.
- anthrax A bacterial disease caused by the organism *Bacillus anthracis*.

- antimony A toxic chemical element.
- appraisal A critical examination of an identification report, which selects and ranks the various solutions, from the points of relevance, technical, financial and institutional feasibility and socio-economic profitability, and precedes the approval by the authorities of the proposed action.
- aquatic Living, growing or taking place in or on water.
- arbovirus An arthropod-borne virus.
- arsenic A toxic chemical element.
- arthritis A condition characterised by painful, stiff joints that ultimately damages the joints involved, producing considerable morbidity and disability.
- arthropod An animal group including insects, ticks and mites.
- asbestos A fine fibrous mineral that can damage the lungs.
- asbestosis A disease in which the lung tissue thickens in response to irritation by inhaled asbestos fibres and which consequently obstructs respiration.
- Ascaris* A genus of large parasitic worms that infest the small and large intestines of humans and other animals, producing occasional symptoms. Also called roundworm. Found in temperate and tropical regions.
- Asian tiger mosquito Common name for *Aedes albopictus*.
- assessment An examination in order to decide. See analysis.
- axil The angle between the leaf and the stem. In some plants, such as bromeliads, water collection in the axil can provide breeding places for mosquitoes.

B

- bacteria A class of microscopic organisms of simple structure that cause many diseases.
- bancroftian filariasis Filariasis caused by the nematode *Wuchereria bancrofti*. See filariasis.
- beedi An indigenous Indian cigarette.
- benefit–cost A term that represents the relationship between the benefits accrued for the cost incurred.
- benthic Adjective of benthos.
- benthos Flora and fauna on the bottom of a water body.
- benzene A carcinogenic liquid, the fumes of which are irritating to the eyes, mucous membranes and upper respiratory tract and may cause dermatitis.
- berm An earthen bank raised above the ground.

- bilharzia See schistosomiasis.
- biofuel A biological, renewable source of energy.
- biomass Material derived from living matter.
- biotopes The smallest geographical unit of the biosphere or of a habitat that can be delimited by convenient boundaries, characterised by its flora and fauna.
- bivalves A class of marine or freshwater molluscs.
- blue-baby syndrome A condition, suffered by babies, of insufficient oxygen in the blood. It can be caused by nitrite ingestion.
- bromeliads The family of plants to which the pineapple belongs. They are associated with breeding sites for mosquitoes.
- bronchitis A disease in which the lining of the bronchial tubes of the lungs is inflamed. It may be caused by bacteria, viruses, chemicals and other substances such as asbestos and dusts.
- bronchogenic carcinoma A malignant lung tumour that originates in the bronchi.
- browse The shoots and leaves of plants. Fodder.
- brucellosis A bacterial infection of animals causing abortion. It can be transmitted to man via direct contact or ingestion of dairy products, resulting in recurrent or chronic fever. Also called undulant fever.
- byssinosis A lung disease of cotton workers, caused by an allergic reaction to dust or fungi in inhaled cotton, flax and hemp fibres.

C

- cadmium A toxic element.
- Campylobacter* A genus of bacterium that causes human infections and abortion and infertility in cattle.
- carcinogenic A substance that induces the development of cancer.
- carcinoma A malignant, abnormal growth of new tissue.
- carcinogenicity Of or pertaining to the ability to cause the development of a cancer.
- cardiovascular Of or pertaining to the heart and blood vessels.
- cassava tapioca; an edible root. It contains toxic cyanide compounds in its skin and outer layers that need to be leached out during the cooking process.
- Chagas A disease in South America affecting the heart, liver, spleen and colon, due to infection with the parasite *Trypanosoma cruzi*.
- checklist A list for verification purposes; a comprehensive list; an inventory.
- chemoprophylaxis The use of antibiotics and chemicals (chemotherapeutants) to prevent the occurrence or spread of a disease in man.
- chlorination A treatment process in which chlorine is used. For example, to sterilise water or to extract gold from ore.

- chloroquine A drug used in the prophylaxis and treatment of malaria. There is increasing resistance in malarial parasites to chloroquine.
- cholera A highly infectious disease caused by *Vibrio cholerae* and characterised by vomiting and 'rice-water' stools, leading to rapid dehydration and death. It is spread by the faeco-oral route and contamination of water and food. It is subdivided into two biotypes: cholerae (classical) and El Tor.
- chromium A toxic element that can cause indolent and painful ulcers of the skin as well as dermatitis.
- chromate A salt of chromic acid that may be toxic.
- chronic Of a disease or disorder; developing slowly and persisting for a long time or constantly recurring.
- ciguatera A non-bacterial food-poisoning caused by eating fish contaminated with ciguatera toxin.
- clonorchiasis A disease caused by the Chinese liver fluke, a human parasite transmitted via intermediate stages in aquatic snails and fish.
- Clostridium* A genus of spore-forming anaerobic bacteria. *Clostridium botulinum* causes botulism food poisoning, *C. perfringens* causes food poisoning and wound infections, and *C. tetani* causes tetanus.
- coir The strong fibre of coconut husks.
- coliforms A group of bacteria. Some of them, faecal coliforms, are normally found in human and other animal faeces.
- communicable disease Any disease that is transmitted from one animal to another via a host of agents, such as insects, foods and contaminated materials.
- congenital Dating from birth.
- conjunctivitis An inflammation of the thin transparent lining of the eye (the conjunctiva), caused by viruses, bacteria, chemical substances or degenerative changes.
- cor pulmonale An abnormal condition of the heart, characterised by an enlarged right ventricle.
- cortical cataract An eye condition resulting in blurred and distorted vision.
- cretinism A disorder with physical and mental symptoms. Associated with iodine deficiency.
- cross-resistance The development of resistance, to different antibiotics, drugs or pesticides of the same or related class, by micro-organisms or vectors.
- Cryptosporidium* A microscopic organism normally found in the gut of animals. It is capable of producing diarrhoea in humans, particularly in those who are immuno-suppressed.
- Cu.* Abbreviation of *Culex*.
- Culex* A genus of mosquitoes that transmit filariasis and viral encephalitis.
- culvert An arched channel beneath a road or railway to carry water.

cysticercosis An infection with the larval stages of the pork tapeworm *Taenia solium*. It is acquired by eating inadequately cooked, infected pork.

D

- DDT An organo-chlorine-based insecticide
- demographic Relating to or pertaining to the study of populations; information about the composition and characteristics of a population.
- dengue An acute tropical fever caused by a virus, occasionally fatal; also known as break-bone fever. The vectors are mosquitoes of the *Aedes* genus.
- dermatitis An inflammation of the skin, usually because of infection or irritation by chemical substances that come in contact with the skin.
- diarrhoea Persistent purging or looseness of bowels, commonly due to infection by micro-organisms such as *Salmonella*.
- diabetes mellitus A complex disorder of carbohydrate, fat and protein metabolism, primarily due to a lack of insulin secreted by the pancreas.
- dracunculiasis A parasitic infection caused by infestation by the nematode *Dracunculus medinensis*. People are infected by drinking contaminated water. Also called guinea-worm infection.
- draught power The use of animals to draw heavy loads.
- drawdown The magnitude of the change in water-surface level in a well, reservoir or natural body of water, resulting from the withdrawal of water.
- dysentery An inflammation of the large intestine that may be caused by bacteria, protozoa, other parasites or chemical irritants. It is characterised by the frequent, bloody stools. Amoebic dysentery is caused by *Entamoeba histolytica* and bacillary dysentery by *Shigella* species.
- dyspnoea A shortness of breath. Difficulty in breathing.

E

- ecology The study of the relationship between communities of organisms and their environment.
- effluent Liquid industrial and agricultural waste; outflowing sewage during purification.
- encephalitis Inflammation of the brain tissue.
- endemic Of a disease or micro-organism: indigenous to a geographical area or population.
- enteric Pertaining to the intestines; enteric fever or typhoid fever is an infectious disease caused by *Salmonella typhi* and is characterised by fever, rash, enlarged spleen and ulcers in the intestines.

- environmental monitoring Observation of the effects of development projects on environmental resources and values, including sampling and analysis, during construction and operation.
- epidemic The occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health-related events clearly in excess of normal expectancy within a specific area and time period.
- epidemiology The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.
- epiphyte A plant or animal growing or living on another plant or animal without being parasitic (giving the adjective: epiphytic).
- Escherichia coli* A species of coliform bacteria normally present in the intestinal tract of humans and other animals, and common in water, soil and food. It can be pathogenic, causing urinary-tract infections, food poisoning and septicaemia.
- evaluation An examination, as systematic and objective as possible, of the design, implementation and results of an on-going or completed project or programme, to evaluate efficiency, effectiveness, impact, sustainability and relevance of the objectives, and to guide decision-makers.
- ex-post Referring to an evaluation of an intervention after it has been completed, to see how well the aid has served its purposes and to draw conclusions for similar interventions in the future.
- excreta Faeces and urine.

F

- farmer's (or farmers') lung A respiratory disorder caused by inhalation of organic dusts from mouldy hay.
- faeco-oral Related to a route of transmission of pathogens that involves food, water or objects contaminated by faecal material entering the mouth.
- falciparum malaria The most severe form of malaria, caused by *Plasmodium falciparum*.
- fallout A deposit of dust from an explosion or industrial plant.
- fasciolopsiasis A disease caused by the giant intestinal fluke, a human parasite transmitted via intermediate stages in aquatic snails and plants.
- feasibility A measure to prove that the technical options are sustainable and are also the best in that situation.
- fertility The ability to bear or reproduce.
- filariasis A disease caused by the presence of filarial worms in the blood and lymph nodes. The vector is a mosquito.
- fluorosis The condition resulting from excessive, prolonged ingestion of fluorine.

- focus Point or region of greatest activity of a disease and/or its vector. Plural is 'foci'.
- food security Access to food for all people at all times, both physically and economically.
- foraging The act of searching for fodder for horses and cattle.
- formaldehyde A disinfectant, preservative and germicide. It is used to make synthetic resins. It is toxic.
- fry A swarm of young fish just spawned.
- fuelwood Wood collected for use as fuel.
- fungi Plants without chlorophyll, such as mushrooms and moulds.
- fungicide A chemical substance that kills fungi.

G

- gastro-enteritis Inflammation of the lining of the stomach and intestines producing vomiting and diarrhoea, caused by infection with micro-organisms or toxins.
- genotoxic A substance which is toxic to genes.
- geohelminth A parasitic worm with part of its life-cycle occurring in or on the soil.
- genu valgum A deformity in which the legs are curved inward so that the knees are close together, knocking as the person walks. Also called knock-knee.
- giardiasis An infection caused by the protozoan *Giardia lamblia* which is spread by contaminated food and water and by person-person contact.
- goitre A condition, associated with iodine deficiency, in which the thyroid gland is abnormally enlarged.
- gonorrhoea An infection of the genito-urinary tract with the bacterium *Neisseria gonorrhoeae*. It is sexually transmitted.
- granuloma Term applied to a tumour or new growth made of granulation tissue and caused by chronic inflammation.
- grass-pea A type of a legume, *Lathyrus sativus*, also called the chickling pea. Consumption can cause lathyrism. See also lathyrism.
- groundwater Water that occurs naturally beneath the ground surface and may include the fraction of the precipitation which infiltrates the land surface.
- guinea-worm infection Common name for dracunculiasis.

H

- habitat The normal abode or locality of an animal or plant; the physical environment of a community; the place where a person or thing can usually be found.
- haematuria The presence of blood in the urine.

- haemoglobin The red oxygen-carrying pigment present in the red blood cell.
- harbourage A place of shelter and refuge; it may be natural or artificial.
- hardware Refers to mechanical equipment or infrastructure.
- health hazard A potential for causing harm to people.
- health impact (of a project) A change in the frequency of some health indicators among the vulnerable community which is reasonably attributable to the project.
- health risk The possibility that a health hazard will cause harm to a human community. Measure of probability that a hazard will cause harm. As there are great uncertainties, only a simple ranking procedure can be used.
- health-risk management Action intended to reduce health risk.
- helminth A parasitic worm.
- hepatitis An inflammatory condition of the liver which may be caused by bacterial, viral or parasitic infection, alcohol, drugs, toxins or transfusion of incompatible blood.
- hepatitis A A form of infectious viral hepatitis caused by the hepatitis A virus. It is spread by direct contact or through contaminated food and water.
- hexachlorohexane An insecticide of the organo-chlorine group (of organic chemicals containing chlorine).
- hinterland A region lying inland from a port or an urban centre, or a centre of affluence; terrain on the back of a folded mountain chain.
- HIV Human immunodeficiency virus that causes the auto-immune deficiency syndrome (AIDS).
- hookworm A parasitic worm that causes anaemia.
- host An organism, on or in which a parasite lives and feeds.
- hydatid disease Infection with the larval stages of the dog tapeworm *Echinococcus granulosus*. Infection is acquired through faeco-oral contact and the larvae may migrate to any organ of the body.
- hydraulic Conveying water.
- hydrogen sulphide A gas that can cause asphyxiation.
- hyperkeratosis Thickening of the superficial layer of the skin.
- hypoxia Oxygen deficiency, caused by reduced oxygen-carrying capacity, insufficient oxygen in inspired air, impaired tissue utilisation of oxygen, or inadequate blood flow.
- HYV High-yielding variety, of agricultural crops.
- immunisation A process that induces or increases the capacity of a person or other animal to resist infection.
- immuno-suppression A decrease in the capacity of a person or animal to resist infection.

impact (of a project) A term indicating whether the project has had an effect on its surroundings in terms of: technical, economic, socio-cultural, health, institutional and environmental factors.

I

incidence The number of cases of a specified disease diagnosed or reported during a defined period of time, divided by the number of persons in the population in which they occurred.

infection The invasion of the body by pathogenic micro-organisms which multiply, causing disease.

infectious A disease organism capable of causing an infection.

infertility The inability to bear or produce offspring.

influenza An acute viral disease of the respiratory tract, characterised by the presence of fever and the severity of the symptoms.

informal sector Economic activities that are not subject to regulation.

immigration Migration inwards to a focal point.

J

Japanese encephalitis A mosquito-borne arbovirus which can cause severe or fatal disease.

'jeepney' A small bus characteristic of the Philippines.

jute A plant fibre used for making sacks and mats.

K

keratitis An inflammation of the cornea of the eye.

kwashiorkor A nutritional disease of weaning children in the tropics, due to a relative deficiency of protein, probably as a result of altered protein metabolism.

L

laryngeal Of or pertaining to the larynx.

larynx The upper part of the windpipe.

lathyrism A disease caused by eating the grass-pea, *Lathyrus sativus*, which contains a toxic, chemical substance. If the toxin is consumed in large quantities the nerves in the spinal cord are damaged, causing stiffness or paralysis of the lower limbs.

leachate The products of leaching. See leaching.

leaching The removal of readily soluble components, such as chlorides, sulphates and carbonates, from soil by percolating water.

- Legionnaire's disease An acute bacterial pneumonia caused by infection with *Legionella pneumophila*. Moist soil and contaminated cooling towers for air-conditioning may be sources of the bacteria.
- leishmaniasis A disease caused by a protozoan parasite of the genus *Leishmania* that is transmitted from person to person by sandflies; also known as kala-azar and Oriental sore.
- leptospirosis A disease caused by bacteria of the genus *Leptospira*. It is transmitted to people by contact with animals or moist soil or by recreational, accidental or occupational immersion in water or vegetation contaminated with the urine of infected animals such as pets and rodents.
- leukaemia Cancer of the blood.
- listeriosis An infectious disease caused by the bacterium *Listeria monocytogenes*.
- loiasis A form of filariasis caused by the worm *Loa loa*. It is transmitted by African deerfly or horsefly. It occurs in African moist forest.
- lymphoma Cancer of the lymphoid tissue.

M

- maloprim A drug used in malaria prophylaxis.
- malaria A mosquito-borne disease caused by *Plasmodium* parasites. See also falciparum malaria and vivax malaria.
- malnutrition Under- or over-nourishment. Under-nourishment is a deficiency condition in which one or more necessary nutrients are unavailable in sufficient amounts for normal growth maintenance and health.
- marginalization The process by which a vulnerable population group is moved to the periphery of the socio-economic mainstream.
- measles An infectious viral disease common in children, causing fever and a rash.
- mefloquine A drug used in the treatment of malaria, particularly chloroquine-resistant malaria.
- meningitis An infection or inflammation of the membranes covering the brain and spinal cord.
- meningococcal meningitis Meningitis caused by the bacterium *Neisseria meningitidis*.
- metastatic Of or pertaining to the process by which tumour cells are spread to distant parts of the body.
- methyl isocyanate A highly reactive chemical which contains phosgene, a nerve gas.
- methyl parathion A relatively toxic pesticide.
- micronutrient A nutrient necessary for the normal growth and maintenance of the body but required in very small amounts, such as vitamins and minerals like iron and zinc.

- migration The permanent movement of a population from one habitat or location to another.
- milch Giving milk. Usually applied to cows which are kept for milking.
- monitoring A management function which uses a methodical collection of data to determine: whether the material and financial resources are sufficient; whether the people in charge have the necessary technical and personal qualifications; whether the activities conform to work plans; and whether the work plan has been achieved and has produced the original objectives. See surveillance.
- monocrotophos A relatively toxic pesticide.
- monoculture The cultivation or culture of a single crop or species to the exclusion of others; as in replanting deforested areas with only one species.
- morbidity The condition of illness or abnormality; the rate at which an illness occurs in a particular area or population.
- mortality The condition of being subject to death. The mortality (death) rate is the frequency or number of deaths in any specific region, age-group, disease or other classification.
- muco-cutaneous Of or pertaining to the mucus membrane and skin.
- mutagenic Inducing genetic mutation(s) or increasing the mutation rate.
- mutagenicity Of or pertaining to the ability to cause genetic mutation.
- mycobacteria A group of rod-shaped, acid-fast bacteria containing several significant pathogenic species: *Mycobacterium tuberculosis* and *M. bovis* both cause tuberculosis and *M. leprae* causes leprosy.
- mycotoxins Toxins produced by fungi that are harmful (e.g. aflatoxin).

N

- nasal septum The partition dividing the nostrils.
- neonatal Refers, formally, to the period from birth to 28 days of age.
- neoplasm An abnormal growth of new cells that is unrestrained. It can be benign or malignant. It is malignant if it invades other tissues of the host or spreads to distant parts.
- nephropathy Any disorder of the kidney, including inflammatory and degenerative conditions.
- neuropathy Nerve damage.
- neurotoxin A toxin that has an affinity for the nervous system.
- niacin A member of the vitamin-B group of micronutrients.
- nightsoil A euphemism for human excreta stored in containers which are not connected to sewers. The containers are usually emptied at night and the partially decomposed matter may be used as a fertilizer.
- nomadism A sustainable lifestyle that requires frequent travelling from place to place, usually within a well-defined geographical territory.

non-communicable Cannot be spread from one person to another.

non-immune Susceptible to a disease.

O

occupational disease A disease common among workers engaged in a particular occupation brought about by the conditions of that occupation.

onchocerciasis A disease caused by the parasitic worm *Onchocerca volvulus* that is transmitted by blackflies; also called river blindness.

opencast Relating to a mining process by which the material is excavated from an extensive area of the earth's surface.

Opisthorchis viverrini A liver fluke acquired by eating inadequately cooked, infected fish. Causes chronic liver disease and can be fatal.

organo-phosphates A group of chemicals used as pesticides.

outbreak A sudden occurrence of, or increase in, cases of a disease in a population in an area or locality.

P

paludrine A drug used in malaria prophylaxis.

pandemic An epidemic of disease of a regional, national or global significance.

paralytic shellfish poisoning A toxic, neurological condition that results from eating clams or mussels that have ingested protozoa containing the toxin saxitoxin.

parasite An organism that lives on or in another organism termed the host, and draws nourishment from it (giving the adjective: parasitic).

parathion An insecticide from the organo-phosphate group of insecticides.

particulate Having the form of particles.

pastoralism The keeping of herds of cattle, goats, sheep or similar animals.

pathogen An organism that causes disease. Most pathogens are microscopic in size.

peri-urban Relating to localities bordering a city or other urban area.

phosgene A suffocating and highly poisonous gas.

phosphine 1. Hydrogen phosphide, a toxic gas.
2. A coal-tar dye, extremely destructive to some life forms.

pinworm A common parasitic intestinal nematode (*Enterobius vermicularis*).

plague A disease caused by infection with the bacillus *Yersinia pestis*, that is usually transmitted from rodents to people by fleas.

plume A narrow column of smoke or noxious gases.

pneumoconiosis A disease of the lung caused by long-term inhalation of dust, usually mineral dusts of occupational or environmental origin.

pneumonia	An inflammation of the lung caused by pathogenic organisms such as bacteria, viruses and chemicals.
poliomyelitis	A communicable disease caused by one of the three polio viruses, that may result in paralysis.
polychlorinated biphenyls	Toxic fluids that are widely used in industry, including additives in paints, adhesives and plastics. They are considered a carcinogenic risk to humans. Often abbreviated to PCBs.
potable water	Water that is palatable and safe for human consumption, in which any toxic substances, pathogenic organisms and factors are at, or have been reduced to, safe or acceptable levels.
prevalence	The number of people ill because of a particular disease at a particular time in a given population. Often expressed as a proportion of a population affected.
prophylaxis	The methods used to prevent the occurrence of, or progression to disease.
protection agency	A government agency responsible for protecting the health and safety of the community and the environment.
protein-energy	Energy derived from the metabolism of proteins in the human body.
protozoan	A simple, single-celled animal (e.g. <i>Entamoeba histolytica</i>).
psittacosis	A type of pneumonia that is transmitted from birds to humans.
pulmonary	Of or pertaining to the lungs or the respiratory system.
pyrethroid	A group of powerful, synthetic insecticides.
pyrethrum	A natural insecticide extracted from chrysanthemum flowers.

Q

Q fever	An acute febrile illness, usually respiratory, caused by <i>Coxiella burnetii</i> . Humans acquire the disease through contact with infected animals by inhalation (from hides), consuming infected milk, or by tick bite.
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R

recrudescence	The recurrence of a disease because of re-infection rather than a re-activation of existing micro-organisms.
resistance	The capacity of an organism to remain unaffected by toxins or pathogenic micro-organisms.
respiratory	Pertaining to the lungs and the breathing apparatus of the body.
rodenticide	A chemical used to kill rodents.
roundworm	A group of parasitic nematode worms, including <i>Ascaris</i> and <i>Strongyloides</i> .

run-off Precipitation which flows over the surface of the land, as opposed to that which penetrates beneath the surface.

S

Salmonella A genus of bacterium, including species that cause typhoid, diarrhoea and other diseases. It is usually associated with poultry and animal husbandry and transmitted from other animals to humans and from humans to humans, by the faeco–oral route and contamination of food and drinking water.

sandfly A common name for flies of the phlebotomine group, including the genus *Phlebotomus*. Sometimes vectors of leishmaniasis.

scabies A contagious disease caused by the mite *Sarcoptes scabiei*, which burrows in the outer layers of skin. It is transmitted by skin contact.

Schistosoma haematobium A species of *Schistosoma* found chiefly in Africa and the Middle East. Affects the bladder and pelvic organs, causing painful, frequent and bloody urination.

Schistosoma japonicum A species of *Schistosoma* found in Japan, the Philippines and eastern Asia. Causes gastro-intestinal ulcerations and fibrosis of the liver.

Schistosoma mansoni A species of *Schistosoma* which is found in Africa, the Middle East, the Caribbean and South America. Causes symptoms similar to those of infection with *Schistosoma japonicum*.

schistosomiasis A disease caused by infestation of the human body by trematode worms of the genus *Schistosoma*, characterised by the passing of blood in the urine or stool. Also called bilharzia.

scoping A process of defining which communities, hazards, geographical areas and project phases to include in an impact assessment.

screening A process of sorting project proposals as part of an initial environmental examination, to ascertain the need for health impact assessment.

scrub typhus Mite-borne typhus fever.

seasonality Showing periodicity related to seasons.

sedentarization The settlement of nomads in permanent locations.

septicaemia Systemic infection in which pathogenic micro-organisms are present in the bloodstream.

septic fringe The unsanitary environment of slums and squatters.

seropositive A positive reaction in a blood test.

sewage Human excreta and wastewater flushed along a sewer pipe.

Shigella A genus of pathogenic bacterium that causes gastro-enteritis and bacterial dysentery. See dysentery.

silicosis A chronic lung disease caused by long-term inhalation of silica dust.

- Simulium damnosum* A species of biting fly ('blackfly') that is an important vector of onchocerciasis (river blindness). Found near fast-flowing water.
- smallholder A farmer who owns or rents a small area of farmland.
- soakpit A pit to promote seepage of effluent into the ground.
- software The rules by which hardware is effectively managed.
- spillway A structure for the discharge of overflow water.
- standpipe A tap on the end of a free-standing water-pipe.
- steppe A dry, grassy, generally treeless and uncultivated plain.
- Strongyloides* A genus of parasitic intestinal nematode or roundworm.
- subsistence Providing the bare necessities of living.
- sullage Domestic dirty water not containing excreta; also called grey water.
- surveillance A continuing scrutiny of all aspects of the occurrence and spread of a disease that are pertinent to effective control. Alternatively, a special reporting system for a particular health problem for a limited time-period.
- susceptibility The incapacity to resist contracting a disease when exposed to the agent causing that disease.
- sustainability The extent to which the objectives of an aid activity will continue after the project assistance is over; the extent to which the groups affected by the aid want to take charge themselves to continue accomplishing its objectives.
- syndrome A characteristic pattern of symptoms and signs that describes a disease entity.
- synergistic Pertaining to a combined or co-ordinated action in which the effect of a substance or an organ is augmented by its use with another.

T

- taeniasis An infection with a tapeworm of the genus *Taenia*.
- tailings Soil and other debris washed out of a mine works.
- tannin A chemical used in tanning and dying.
- tapeworm A parasitic, intestinal worm that infects humans and other animals.
- tenosynovitis A painful disorder of a muscle tendon, often related to long-term exposure to repetitive motion, vibration, or inappropriate posture.
- teratogenicity Refers to the ability to cause interference with normal, prenatal development in the foetus.
- Tilapia* A genus of edible freshwater fish.
- 'top-down' Refers to a theory in development in which improvements and incentives are envisaged to percolate through the society and economy from the top level to the broad-based, lower levels.

- toxoplasmosis A common infection with the protozoan *Toxoplasma gondii*, an intracellular parasite of cats and other hosts which is transmitted to humans by ingestion or transplacentally from mother to foetus.
- transmission Any route by which a human being is exposed to an infectious agent.
- trematodes Flat worms, including the parasitic worms called flukes.
- trichinosis A disease caused by the migration through the skin of larvae of a worm called *Trichinella spiralis*.
- Trichuris* A parasitic worm that infests the intestines of humans.
- trypanosomiasis A disease of animals, including humans, caused by a *Trypanosoma* parasite; called sleeping sickness in Africa and Chagas disease in South America.
- tsetse A blood-sucking fly that is the vector of trypanosomiasis in Africa.
- tuberculosis A chronic and disabling disease of the lungs, and less frequently other parts of the body, which is fatal if not treated.
- tungsten Wolfram. A rare metal.
- typhoid An infectious disease in humans caused by *Salmonella typhi* bacteria. It is transmitted by the faeco-oral route, usually via contamination of drinking water and food.
- typhus An infectious disease spread from person to person by body lice, fleas, mites or ticks. Caused by micro-organisms of the genus *Rickettsia*.

V

- vector An animal—often an insect—transmitting an infectious agent from an infected animal to another animal.
- virus A very small parasitic organism which can only reproduce inside the animal or plant cells of a host, but can survive elsewhere.
- vivax malaria A form of malaria caused by *Plasmodium vivax*. It is the most common form of malaria and rarely fatal. See also: malaria.
- vulnerability The liability to be injured or damaged or hurt.

W

- watershed A ground area (usually elevated) either side of which rainfall flows into different river systems. In the U.S.A., the term is used to denote a rainfall-catchment area for a river system.
- whipworm Common name for the parasitic roundworm *Trichuris trichiura*. Infects the intestinal tract. Indirectly transmitted from human to human through soil.
- wild food Food which is gathered, fished, or hunted, but not cultivated.

Y

yellow fever An acute arbovirus infection transmitted by mosquitoes, for which there is no treatment.

Z

zoonosis An infectious disease transmissible, under natural conditions, to humans from other animals.

zooprophyllaxis The use of other animals to divert vectors from humans.

