ENVIRONMENTAL HEALTH IMPACT ASSESSMENT OF URBAN DEVELOPMENT PROJECTS

GUIDELINES AND RECOMMENDATIONS

Prepared for

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1. INTRODUCTION

1.1 Background to the Report

Since 1950 the population of the world's urban areas has more than doubled. This level of increase has been higher in the developing than in the developed countries, reaching an annual average rate of 3.9% in the 1980's and a predicted 3.5% in the 1990's. It is estimated that by 2000 the urban population of the world will comprise over 3 billion people, and that almost 50% of the urban population will live in cities with populations of over 1 million. Table 1.1(a) shows measured and predicted urban growth in developed and developing countries from 1950 to 2000.

Table 1.1(a)

Measured and Predicted Growth of Urban Population, 1950-2000

Regions, Total: T Urban: U Rural: R	Total population (in thousands) Annual rate of growth (percentage)												
	1950	Rate	1960	Rate	1970	Rate	1975	Rate	1980	Rate	1990	Rate	2000
WORLD TOTAL T	2501243	1.8	2985937	1.9	3609600	1.9	3967005	2.0	4373210	1.9	5270041	1.7	6253135
U	714681	3.4	1006942	2.9	1350032	2.9	1557685	2.9	1799523	2.8	2385546	2.6	3103214
R	1786562	1.0	1978995	1.3	2259568	1.3	2409320	1.3	2573682	1.1	2893395	0.9	3149921
More developed Regions													
T	857305	1.3	975748	1.1	1084018	0.9	1131715	0.9	1181072	0.8	1277570	0.6	1360557
U	457339	2.5	586192	2.0	717626	1.7	782582	1.6	848670	1.5	983935	1.1	1106942
R	399966	-0.3	389556	-0.6	366393	-1.0	349133	-1.0	331402	-1.2	293635	-1.5	253615
Less developed Regions													
T	1643938	2.0	2010189	2.3	2525582	2.3	2835290	2.4	3192138	2.3	4001471	2.0	4892579
U	257342	4.9	420750	4.1	632407	4.1	775103	4.1	949859	3.9	1401711	3.5	1996272
R	1386596	1.4	1589439	1.4	1893175	1.7	2060187	1.7	2242280	1.5	2599760	1.1	2896307

Source: UNESCO; "Man and the Biosphere (MAB) Project: Approaches to the Study of the Environmental Implications of Contemporary Urbanisation". UNESCO, 1983 (MAB Technical Notes 14).

This growth of population has resulted in a growing demand for urban development.

The demand for urban development comes from two main sources:

- recent migration or displacement of populations who are unable to find housing within existing urban areas and settle on undeveloped land at the peripheries of cities, in shanty or squatter settlements;

- older city areas outstripping their current resources due to population growth or immigration, experiencing obsolescence of buildings and a general decline in the quality of life.

In recent years the problems of rapid urban development in response to this demand have become increasingly recognised. As the rate and scale of urbanisation have increased, so has recognition of the effects of cramped living conditions, lack of water supply and sanitation, and poorly drained or dangerous housing sites, on levels of disease and general ill-health. In few instances have these changes been examined before development takes place. As a consequence, their impacts on public health are not taken into account in decisions on urban development, nor are mitigating measures built in to development proposals.

During the past decade, a number of international agencies have issued guidelines on assessing the impacts of development proposals, including urban development projects. In most such guidelines, however, environmental health effects have received less attention than more readily identifiable physical effects.

In response to these problems, the World Health Organisation has organised a series of meetings, seminars and studies of the health aspects of urban development. In particular, the work of the WHO Regional Office for Europe has highlighted the importance of "environmental health factors" which determine the impact of urban development on human health. However, the World Health Organisation is now concerned to provide practical guidance on the environmental health impact assessment of urban development projects.

The aim of this report, which has been commissioned from Environmental Resources Limited (ERL) by the WHO Regional Office for Europe, is therefore to give practical guidance to planners and others on how the potential health effects of urban development projects can be identified and assessed, in order that harmful effects may be minimised. It is intended that the guidelines should be of particular use to those operating in the field on urban development projects. Although particularly aimed at the circumstances most relevant to the WHO Regional Office for Europe context, namely growth and development of urban areas particularly in the south of Europe. It is also intended that the guidelines should be of general assistance in broader circumstances.

1.2 Environmental Health Problems Associated with Urban Development

The World Health Organisation, in its Constitution, defines health as "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity". Potentially, urban development could increase the total health of inhabitants due, amongst other things, to:

- increased wealth of inhabitants and thus opportunities for improved nutrition, housing, etc.;

- o concentration of medical and public health services such as water and sewage treatment facilities;

- o concentration of social and cultural services.

Indeed, in developing countries in particular the overall level of health in urban areas may be higher than that of rural areas. In Mexico City, despite massive and uncontrolled growth over the last 35 years and a population density of 75,000 per square kilometre, life expectancy and nutritional levels are significantly higher than in rural areas of Mexico. Nevertheless, such statistics disguise wide disparities in health amongst urban dwellers, and on current trends the majority of new urban dwellers will be very poor and will reside in slums and squatter settlements "characterised by an absence of even minimal standards of housing, water supply, sewerage, streets and social facilities".(1)

Health problems arise in urban areas because they contain large numbers of people gathered together in restricted areas, together with the intermingling of residential, industrial and associated land uses. This gives rise to a number of environmental effects which can have impacts on human health (environmental health factors):

- o increased crowding both within dwellings, at the workplace and in transport;

- o increased generation of wastes, both liquid and solid;

- o introduction of new sources of pollution, both industrial and non-industrial;

- o introduction of new sources of accident and hazard, both industrial and non-industrial.

Such factors may either have a direct effect on human health (such as air pollution or traffic accidents) or may facilitate the transmission of disease (such as crowding or inadequate sewage disposal, etc.).

Table 1.2(a) indicates the main environmental health factors associated with urban developments and the health effects they may cause.

The impact of environmental health factors on human health is complicated by the fact that people are not equally sensitive to either the direct effects of factors or to agents of disease. Certain groups of people may be more sensitive than others to a similar level of exposure; these are known as high-risk groups. The World Health Organisation has identified a number of particular groups within the urban environment who appear to be particularly at risk from environmental health factors:

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(1) World Bank 1972.

Table 1.2(a)

Major Environmental Health Factors Associated with Urban Development and their Associated Health Effects

Environmental Health Factor	Associated Health Effect
A. Low-level pollution sources:	
- air pollution from domestic, industrial and transport sources	Range from fatal lung cancers, through bronchitis, emphysema, asthma to general lung function impairement and eye and lung irritation
- water pollution from disposal of domestic sewage and liquid wastes, industrial effluents	Increased transmission of water related diseases, or direct pollution effects (poisoning, acute or sub-acute)
- soil pollution through uncontrolled disposal of solid or liquid wastes	Increased transmission of soil-associated disease agents; acute or sub-acute poisoning, contamination of food chains
- noise pollution from industrial, domestic or traffic sources	Partial or total hearing loss, disturbance and irritation
- occupational exposure to toxic substances	"Occupational disease", acute or sub-acute poisoning
B. Accidents and hazards:	
- transport accidents through increased traffic levels	Fatal and non-fatal injuries
- workplace accidents from poor layout, unsafe machinery etc.	Fatal and non-fatal injuries
- accidents at home from poor layout and design, including fire	Fatal and non-fatal injuries
- major hazards from natural and man-made causes	Fatal and non-fatal injuries; may be very high numbers of casualties
C. Disease transmission:	
- "overcrowding"	Increased incidence of communicable disease
- lifestyle changes	Increased evidence of communicable disease
D. Social/Psycological:	
- "overcrowding"	Increased stress, mental, health effects
- lifestyle changes	Increased stress, mental health effects

- o infants and young children;
- o pregnant and nursing women;
- o elderly people;
- o people suffering from specific chronic diseases;
- o physically handicapped people;
- o people with specific genetic deficiencies;
- o immigrants (both rural-urban and foreign);
- o people working in hazardous occupations.

In studying the health problems associated with urban development, therefore, particular attention must be paid to effects on these groups.

1.3 The Aims of Environmental Health Impact Assessment

As we have noted in Section 1.1, the aim of this report is to give guidance on the identification and assessment of the effects of urban development on human health.

Procedures and methodologies for assessing the effects of urban development projects on the environment (Environmental Impact Assessment - EIA) have been developed and used, particularly in North America and Europe, for some time. Such assessments have often paid only limited attention to human health, concentrating instead upon effects on natural resources, wildlife and conservation of the cultural heritage. Efforts have also been made to develop Health Impact Assessment (HIA) specifically aiming to predict increased levels of morbidity and mortality resulting from development projects. Two major difficulties were encountered; firstly, the lack of epidemiological data to define dose-response (cause-effect) relationships, and secondly, the sensitivity attached to direct estimates of potential mortality and morbidity of planned developments.

To overcome these problems and to strengthen the health component of EIA studies, the WHO has promoted the concept of Environmental Health Impact Assessment (EHIA). This is the assessment of the impact of development on environmental parameters recognised to have a strong health significance; these are referred to as **environmental health factors.** In this way EIA can be developed to give a general indication of both the likely health effects of, and potential mitigation measures for, urban development. Table 1.3(a) outlines the procedure for environmental health impact assessment proposed by the World Health Organisation.

Table 1.3(a)

World Health Organisation Suggested Procedure for EHIA

Step 1	Assessment of primary impacts on environmental parameters	regular EIA process
Step 2	Assessment of secondary or tertiary impacts on environmental parameters resulting from the primary ones	regular EIA process
Step 3	Screening of impacted environmental parameters of recognized health significance (EH factors)	epidemiological knowledge
Step 4	Assessment of impacts on the magnitude of exposed populations for each group of EH factors	census, land-use planning
Step 5	Assessment of impacts on the magnitude of risk-groups included in each group of exposed population	census
Step 6	Computation of health impacts in terms of morbidity and mortality	results from risk-assessment studies
Step 7	Definition of acceptable hazards (or of significant health impacts)	trade-off between human and economic requirements
Step 8	Identification of efficient mitigation measures to reduce significant health impacts	abatement of EH factors magnitude, reduction of exposure, reduction of exposed populations, protection of risk-groups

Source: GIROULT, E.; "The Health Component of Environmental Impact Assessment". Paper presented at the International Seminar on Environmental Impact Assessment, University of Aberdeen, 1984.

1.4 Organisation and Content of the Report

The aim of this report is to provide preliminary practical guidelines on environmental health impact assessment for urban development projects. The guidelines are based on the current state of knowledge of environmental health impacts and of our ability to predict such impacts. As such they draw on a wide range of published guidelines and practical experience of EHIA and EIA generally.

It is clear from the research carried out for this study that the field of EHIA is as yet not well developed. In particular urban development projects, with their wide range of environmental health factors and potential health impacts, have been poorly studied. For this reason, we have suggested in Chapter 6 of the report potential areas for further research.

One particular gap in the current state of knowledge which we have identified concerns the impacts of urban development on stress and the mental health and well being of inhabitants. Although there is considerable documentary evidence linking stress to urban development, we were unable to trace any procedures which would allow the mental health effects of urban development to be predicted and assessed in a systematic way. For this reason we have not concentrated in this report on mental health effects, but have indicated in broad terms the types of effects which have been identified and the information which would be required to predict and assess such effects.

In the remainder of this report we give guidance on the identification of environmental health factors (Chapter 2) and on prediction of their likely magnitude and impacts on human health, including high-risk groups within the population (Chapter 3). In Chapter 4 we indicate mitigation measures which can be taken to minimise the environmental health effects of urban development projects. Chapter 5 examines how information on effects and mitigation measures can be presented to decision-makers and others in a meaningful way, and in Chapter 6 we make recommendations for further work which could usefully be carried out to improve the state-of-the-art of environmental health impact assessment of urban development projects.

This report has drawn on a wide range of published sources. Where direct quotations or extracts are used, these are referenced in the text. A bibliography of the main sources used is presented at the end of the report: this is necessarily limited to major, more readily available sources by limitations of space. The guidance given in the report is also based on examination of numerous guidelines on EIA and on experience of application of the procedures and recommendations they contain. A review of some of the main EIA guidelines relevant to EHIA is presented in Annex 1 to the report.

8.

2. IDENTIFICATION OF ENVIRONMENTAL HEALTH FACTORS

2.1 Introduction: Sources of Environmental Health Factors in Urban Development

2.1.1 Steps in Identifying Environmental Health Factors

Urban development projects give rise to health impacts because they alter the environment giving rise to environmental impacts. The first step in both environmental health impact assessment and in EIA is thus to identify the aspects of a development which may give rise to these environmental impacts. This requires a systematic consideration of the way in which the development interacts with the environment to cause environmental change. Environmental changes which may give rise to health impacts, known as environmental health factors, may then be screened out.

It is necessary first to identify all the different components involved in the proposed urban development project which may interact with the surrounding environment. Urban development is a complex process which may involve a large and varied number of components, including some or all of the activities identified in Table 2.1(a).

Once the different components of the development have been identified, each can be screened for impacts it may have on the environment which would give rise to environmental health factors. This process is described in the remainder of Section 2 and a checklist of potential environmental health factors in urban development is given at the end of the section.

2.1.2 Problems in Identifying Environmental Health Factors

Environmental factors may affect health in any of the following ways (1):

- Contact with agents of diseases:
  - exposure to agents of communicable disease;
  - intensive exposure to toxic materials or agents causing immediate acute disease;
  - low-level exposure to toxic materials or agents which may cause acute or chronic diseases after long exposure;
- Exposure to agents which may cause genetic changes;
- Lowering of resistance to infection;
- Producing subclinical irritation, nuisance and discomfort;
- Contributing to aggravation of existing disease;

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1) GIROULT, E. "The health component of environmental impact assessment", International Seminar on Environmental Impact Assessment, Aberdeen 1984.

Table 2.1(a)

Checklist of Possible Components of Urban Development Projects

1. Site Clearance

- clearance of vegetation
- removal of existing population
- drainage or infilling of land
- levelling and compaction
- diversion of water courses
- demolition of existing structures

2. Construction

- transportation of construction materials
- building and construction activities
- use of hazardous construction materials
- use of heavy (noisy) machinery
- introduction of temporary workforce
- construction and use of temporary accomodation and access routes
- disposal of construction waste, and wastes from temporary workforce

3. Operation/Use

- relocation of communities
- increased population density
- disposal of domestic and industrial waste
- water supply and sewage disposal
- generation of industrial air, water and noise pollution
- increased traffic generating noise and risks of accidents
- risk of accidents from industrial operations
- supply of urban services (fuel supply, food and consumer goods, entertainment, social and medical services, housing, education, comunications, power supply).

o Creating conditions incompatible with, or derogatory to, the achievement of physical, mental and social well-being.

In the past, the identification of environmental factors afecting human health has occurred mainly by chance, and through epidemiological study of past associations of disease with environmental factors.(1) Environmental health impacts tend to be very complex, due to the complexity and inter-related nature of the environmental systems in which they arise. For example, increased exposure to communicable disease may arise because environmental health factors:

- favour an increase of the pathogen population;

- favour an increase in the population of the pathogen's immediate host;

- facilitate direct contacts between human beings and the pathogen;

- facilitate pathogen infection of food, liquid or air directly ingested by humans.

The effects of environmental changes on health are complicated further by the variety of exposure pathways and human sensitivities.

The problem of identifying potential environmental health factors is particularly acute where new types of development are involved, and there is no past experience to draw upon. Many countries now have procedures for health screening of new chemicals prior to use (for example the EEC EINECS and USA TSCA systems), but alterations in methods of use and in environmental conditions may affect their toxicity to man. Changes in building design may also introduce environmental health factors. The movement to development of high-rise urban dwellings in many developing countries during the 1960's, for example, gave rise to many unforeseen physical and mental health effects.

A further complication arises where new sources of environmental health factors may combine with existing factors (eg. from current pollution sources) to cause increased effects on human health.

The aim of environmental health impact assessment in these conditions of uncertainty must be to take a systematic approach to identification of environmental health factors and to use as many sources of information as possible. These may include not only published guidelines, but also discussion with environmental and health experts, and with representatives of the local population. Below we discuss identification of environmental health factors within each of the main groups identified in Table 1.2(a).

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(1) See: PARKE, D.V.; "Limits and Constraints of Scientifically Based Environmental Health Risk Assessment." WHO Working Group on Health and the Environment, Vienna, 12-16 December, 1983.

2.2 Pollution as a Source of Environmental Health Factors

2.2.1 Introduction

Environmental pollution may arise from many components of urban development. The first step of environmental health impact assessment is to identify possible sources of pollution arising from an urban development project, and to screen out those which may affect health. Exposure to pollutants may affect health in a number of different ways. These are listed in Table 2.2(a).

Table 2.2(a)

Environmental Health Effects of Pollutants

Environmental pollution may affect health in any of the following ways:

- intensive exposure to toxic materials or agents causing immediate acute health effects (see Section 2.3);
- low-level exposure to toxic materials or agents which may cause acute or chronic disease long after exposure;
- exposure to agents which may cause genetic changes;
- lowering of resistance to infection;
- producing sub-clinical irritation, nuisance or discomfort;
- contributing to aggravation of existing disease;
- creating conditions incompatible with, or derogatory to, the achievement of physical, mental and social well being.

Source: Adapted from GIROULT, E.; "The Health Component of Environmental Impact Assessment: Background Information." International Seminar on Environmental Health Impact Assessment, Aberdeen University, July 1984.

Many different pollutants may have health effects. An indication of the range of substances involved is given by the list of those for which the World Health Organisation has developed Environmental Health Criteria. This is given in Table 2.2(b).

Accidental exposures of the population to high levels of pollution have occurred in several countries during the last 20 years. These are discussed further in Section 2.3. In this section we discuss the potential effects of lower-level exposure to pollutants. The following forms of pollution are considered:

- o air pollution;
- o water pollution;
- o soil pollution/waste disposal;
- o noise pollution;
- o exposure to toxic substances at work.

2.2.2 Air Pollution

Potential sources of air pollution in urban development projects may include:

- o industrial processing;
- o power generation;
- o vehicle engines;
- o domestic combustion;
- o dust-raising activities (e.g. construction and transportation);
- o evaporation/emission from stored substances (chemicals, building materials such as asbestos, polyurethane foam, etc., natural materials in soils or plants).

Air pollutants may be generated both within and outside the home, and their production and distribution may be governed by a wide range of factors such as types of fuel used, rates of combustion, meteorological factors and arrangement of buildings.

The average male adult inhales about 15 kg air per day, compared with 1.5 kg food and 2.5 kg water. Thus air pollutants have a considerable potential to cause health effects ranging from lethal lung-cancers, causation or aggravation of bronchitis, asthma or emphysema to general impairment of lung function and sensory irritation of eyes and lungs. Air pollution may also affect general well being through smells, interference with visibility, and damage to plants and materials.

Table 2.2(b)

Titles in the Series of WHO Environmental Health Criteria

1. Mercury
2. Polychlorinated Biphenyls and Terphenyls
3. Lead
4. Oxides of Nitrogen
5. Nitrates, Nitrites and *N*-Nitroso Compounds
6. Principles and Methods for Evaluating the Toxicity of Chemicals, Part I
7. Photochemical Oxidants
8. Sulfur Oxides and Suspended Particulate Matter
9. DDT and its Derivatives
10. Carbon Disulfide
11. Mycotoxins
12. Noise
13. Carbon Monoxide
14. Ultraviolet Radiation
15. Tin and Organotin Compounds
16. Radiofrequency and Microwaves
17. Manganese
18. Arsenic
19. Hydrogen Sulfide
20. Selected Petroleum Products
21. Chlorine and Hydrogen Chloride
22. Ultrasound
23. Lasers and Optical Radiation
24. Titanium
25. Selected Radionuclides
26. Styrene (*in press*)
27. Guidelines on Studies in Environmental Epidemiology (*in press*)
28. Acrylonitrile (*in press*)
29. 2,4-Dichlorophenoxyacetic acid (2,4-D) (*in press*)
30. Principles for Evaluating Health Risks to Progeny Associated with Exposure to Chemicals During Pregnancy (*in press*)
31. Tetrachloroethylene (*in press*)

Source: WHO (various dates)

Table 2.2(c) summarises principal sources and health effects of major air pollutants. In addition, health may also be affected by inhalation of the following pollutants.

- other toxic metals released by industrial processes (e.g. mercury, cadmium, beryllium, manganese, arsenic);
- fluorides, chlorine and hydrogen chloride;
- asbestos;
- organochlorine pesticides;
- mercaptans and hydrogen sulphide (odours);
- biological pollutants (aeroallergens such as pollen or airborne micro-organisms).

2.2.3 Water Pollution

The main sources of water pollution in urban development are:

- uncontrolled disposal of domestic sewage and liquid wastes;
- uncontrolled disposal of industrial effluents;
- surface run-off;
- deliberate addition of chemicals to water (e.g. herbicides in water courses, pesticides);
- solution of substances from pipes and storage vessels.

Water pollution can affect human health:

- either through increased transmission of disease agents (pathogenic micro-organisms, parasites);
- or through direct contact with toxic or hazardous substances.

Effects may occur through human ingestion of polluted water (in drink or food), other direct contact (e.g. bathing) or through accumulation in aquatic food sources.

Table 2.2(d) describes disease transmission associated with water pollution. A wide variety of water pollutants have been associated with human health effects. Toxic or hazardous water pollutants associated with human health effects include the following:

- nitrates (effects on infant health);
- fluorides (fluorosis);

Table 2.2(c)

Principal Sources and Principal Health Effects of Major Air Pollutants

Pollutant	Main characteristics	Principal sources	Principal health effects
Carbon monoxide (CO)	Colorless, odorless gas with strong affinity for hemoglobin in blood; victim is usually aware of presence of CO only after early poisoning symptoms appear (such as nausea, headache, dizziness, difficulty in breathing).	Incomplete combustion of fuels and other carbonaceous materials, industrial processes, cigarette smoking, forest fires, decomposition of organic matter; natural processes produce ten times as much CO as automobile and industrial processes combined, but problem is high concentrations in urban environments.	Absorbed by lungs; reduces oxygen-carrying capacity of blood; reduces tolerance for exercise, impairs mental function, affects fetal development, aggravates cardiovascular disease; several studies show that prolonged low-level exposure diminishes visual perception, manual dexterity, ability to learn and perform intellectual tasks; other studies have produced no such adverse effects at low levels of exposure.
Hydrocarbons (HC)	Organic compounds in gaseous or particulate form (e.g., methane, ethylene, acetylene); component in formation of photochemical smog.	Incomplete combustion of fuels and other carbon-containing substances, such as those in motor-vehicle exhausts; processing distribution, and use of petroleum compounds such as gasoline and organic solvents; natural events such as forest fires and plant metabolism; atmospheric reactions.	Acute exposure causes eye, nose, and throat irritation; chronic exposure suspected of causing cancer; some groups of combustion hydrocarbons especially implicated in induction of cancer in laboratory animals.
Lead	Heavy, soft, malleable, gray metallic chemical element; often occurs (as environmental contaminant) as lead oxide aerosol or dust.	Ingestion by young children with pica (abnormal craving for nonfoods) who eat leaded paint and dirt; occupational exposure in industries such as smelting and battery making; airborne lead from nonferrous metal smelters; auto exhausts along highways; agricultural use of leaded arsenates; lead salts in some pottery glazes released when in contact with slightly acidic liquid or when heated; in moonshine whiskey, which is often made in apparatus with lead-welded copper tubing or in old automobile radiators.	Enters primarily through respiratory tract and wall of digestive system; more than 40 percent of lead inhaled is absorbed into bloodstream; accumulates in body organs; early signs of lead poisoning are impairment of mental function, behavior problems, and anemia; higher levels cause vomiting, cramps, serious impairment of kidney, nervous system, possible brain damage; study of rats and mice fed lead for life in concentrations comparable to levels in human tissues in the United States showed early mortality, shortened lifespan, increased susceptibility to infection, visible aging and loss of weight, hardening of the arteries and heart attacks; studies of the fetal development of mice show currently accepted safe blood levels of lead cause developmental deficiencies in certain individuals.
Nitrous oxides (NO_x)	Brownish red gas with pungent odor.	Primarily from internal combustion engines; also high-temperature stationary combustion (power plants) and atmospheric reactions; may occur around explosives plants.	Major role as component in creation of photochemical smog; also has distinct effects apart from those associated with smog; has been shown to be toxic to experimental animals; some studies indicate NO_2 produces animal diseases that have human counterparts (emphysema, other lung diseases); in study of school children in high NO_2 area (near TNT plant), found that children contracted significantly more respiratory disease than children in control area; has been shown to aggravate respiratory and cardiovascular illness and chronic nephritis.
Particulate matter	Any solid or liquid particles dispersed in atmosphere, such as dust, pollen, ash, soot, metals, and various chemicals; particles often classified according to size, as settleable particles (larger than 50 microns), aerosols (smaller than 50 microns), and fine particulates (smaller than 3 microns).	Natural events such as forest fires, wind erosion, volcanic eruptions; stationary combustion, especially of solid fuels (e.g., power plants that burn coal), construction activities, industrial processes, atmospheric chemical reactions.	Direct toxic effects or aggravation of the effects of gaseous pollutants; aggravation of asthma or other respiratory or cardiorespiratory symptoms; increased cough and chest discomfort; increased mortality.
Photochemical oxidants (smog)	Oxidizing type of pollutant found in many urban areas; results from chemical combination of reactive hydrocarbon vapors with nitrogen oxides in presence of sunlight; the resulting production of photochemical oxidants consists of a number of toxic compounds: ozone, peroxyacetyl nitrates (PAN), aldehydes, other chemical compounds.	Most hydrocarbons from motor-vehicle exhausts, and nitrogen oxides from motor-vehicle exhausts and stationary combustion sources; photochemical smog a problem not only in southern California but also in desert cities of the Southwest and eastern cities that now may be receiving more sunlight because of reduction in smoke layer; meteorological conditions necessary for formation of oxidants stationary high accompanied by adequate sunshine with low wind speeds in early morning.	Aggravation of respiratory and cardiovascular diseases, irritation to eyes, respiratory tract, impairment of cardiopulmonary function; some concern about possible mutagenic effects of ozone; one study of Los Angeles showed no association between "alert days" when oxidant levels were high and mortality increase; poorer athletic performance has been related to high oxidant levels; possibility of developing tolerance to oxidant pollution, as has been shown in experimental animals, may account for the relatively few changes associated with chronic exposure.
Sulfates	Aerosol formed by sulfur oxides in moist environment appears as sulfuric acid (H_2SO_4) mist or rain.	Atmospheric reactions of SO_2; secondary chemical reactions in atmosphere from other sulfur compounds. Recent indications that automobiles with catalytic converters designed to decrease hydrocarbon and carbon monoxide emissions may emit more sulfates than automobiles without converters.	Aggravation of respiratory diseases, including asthma, chronic bronchitis; reduced lung function; irritation of eyes and respiratory tract; increased mortality.
Sulfur dioxide (SO_2)	Colorless gas with pungent odor; oxidizes to form sulfur trioxide (SO_3), which forms sulfuric acid with water.	Combustion of sulfur-containing fossil fuels, smelting of sulfur-bearing metal ores, industrial processes, natural events such as volcanic eruptions.	Classed as mild respiratory irritant; most SO_2 inhaled is absorbed in upper respiratory tract and never reaches lungs; penetrates when clings to particulate matter; aggravates respiratory diseases including asthma, chronic bronchitis, emphysema; can result in reduced lung function, irritation of eyes, possible increased mortality.

Source: W. J. Baumol and W. E. Oates, Economics, Environmental Policy, and Quality of Life (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1979).

Table 2.2(d)

Disease Transmission Associated with Water Pollution

Water borne diseases are caused by highly infective organisms, only a small number of which are needed to cause disease. The diseases are transmitted by contamination of water supplies by faeces from a human carrier of the infective organism. The two classic examples of waterborne disease are typhoid and cholera. In addition, diarrhoea and dysentry may be caused by waterborne organisms, including protozoa (for example giardiasis), amoebae (such as Entamoeba hisolytica) and enterobacteria, (especially the Shigella genus).

Water based diseases are infections by worms, including flukes and trematodes. Most depend on aquatic crutacean hosts (called intermediate or secondary hosts) for their transmission. Faeces from infected humans contain worm eggs, which enter the secondary crustacean hosts through contamination of water. Parasite larvae emerging from the snails are able to bore through human skin contact with water. The most important water based disease, schistosomiasis, is dependent on Bulinid snails as the main secondary hosts. Another water based disease, guinea-worm infection, is transmitted by ingestion of water containing the microscopic crustacean secondary host of the disease (Cyclops spp.). The disease organism leaves the secondary host once it is inside the primary host, the human body.

Water related diseases are transmitted by insect vectors that breed in or around water. Mosquitoes, tsetse flies (Glossina species) and Simulium species are the most important vectors of water-related diseases; they carry a wide range of infections including malaria, sleeping sickness, onchocerciasis and viral diseases. The diseases are transmitted when the insect bites an infected human host followed by an uninfected human.

In contrast to the other types of water related disease, the transmission of **water washed** disease is reduced, not aided, by water. This group includes diseases where the level of infection may be reduced by provision of more abundant or more accessible water supplies. The diseases are transmitted from one person to another when personal hygiene is poor due to lack of adequate water supplies. The most important water washed diseases are diarrhoeas transmitted by a faecal-oral route; others include skin ulcers, scabies, skin fungus infections and trachoma.

Source: WHO Regional Office for Europe; "Environmental Health Impact Assessment of Irrigated Agricultural Developments". Report prepared by Environmental Resources Ltd. 1982.

- o mercury, arsenic, selenium and other toxic metals;
- o organochlorines;
- o polynuclear aromatic hydrocarbons;
- o radionuclides.

Other water pollutants may have indirect effects on human health, for example:

- o changes in the pH of water may affect uptake of heavy metal pollutants.
- o pollution of wastewater by anionic detergents may inhibit sewage treatment and self-cleansing;

2.2.4 Soil Pollution

Soil pollution associated with urban developments largely arises from uncontrolled or poorly planned disposal of wastes:

- o disposal of human and/or animal faeces;
- o disposal of domestic waste including organic components;
- o disposal of toxic or hazardous waste from industry;
- o disposal of radioactive wastes.

Where such disposal is carried out in close proximity to residential areas, and with insufficient isolation of the wastes from the surrounding air, soil and groundwater, human contact can result through a number of pathways:

- o direct contact of humans (particularly children) with the soil, through ingestion or penetration through the skin;
- o transmission of soil parasites by insects, rodents, domestic animals;
- o contamination of human or animal foodstuffs by toxic substances;
- o contamination of water supplies by leaching of toxic substances.

Disease agents associated with soil pollution and their transmission pathways are listed in Table 2.2(e).

Toxic chemicals associated with soil pollution are generally similar to those associated with water pollution.

Uncontrolled or poorly planned waste disposal may also give rise to potential for hazards and accidents (see 2.3).

Table 2.2(e)

Disease Agents Associated with Soil Pollution

1. Organisms excreted by man and transmitted to man by direct contact with contaminated soil or consumption of crops grown in contaminated soil (man-soil-man):

   - **Enteric bacteria and protozoa,** including the agents of cholera, salmonellosis, bacillary dysentry, typhoid and paratyphoid, amoebiasis;

   - **Parasitic worms** (helminths), including Ascaric lumbricoides (roundworm), Trichuris trichiura (whipworm), Necator americanus, Ancylostoma duodenale, Strongyloides steracoralis.

2. Pathogenic organisms of animals, transmitted to man by direct contact with soil contaminated by animal wastes (animal-soil-man):

   - heptospirosis,
   - Anthrax,
   - Q fever (Coxiella burnetii),
   - Cutaneous larva migrans (Ancylostoma biaziliense)
   - Visceral larva migrans (Toxacaracanis).

2.2.5 Noise

Sound is generated by a great many activities associated with urban development, including each stage of site clearance, construction and operation of installations. Sound is perceived as noise when it impinges on human activities, through close proximity of people to sound sources, inadequate shielding, (eg. too thin walls of dwellings) etc.

People's perception of noise may vary due to a number of factors, including their natural sensitivity and hearing ability, past experience of sound, cultural factors and the time of day at which sound is experienced. Continuous sound may be perceived very differently from intermittant sound at the same level.

High or continuous sound levels may cause permanent loss of hearing, ranging from reduced perception of certain frequencies (making conversation, for example, seem unclear) to total deafness. Such sound levels have also been observed to give rise to non-specific physiological effects, whose significance is unclear. These include changes to heartbeat and respiration rate, and eye and skin responses.

At lower levels sound may have psychological effects including disturbance of sleep, effects on performance of psychomotor tasks, annoyance and irritation. Table 2.2(f) indicates human perception of sources of noise in different environments.

2.2.6 Occupational Disease

Although occupational disease is not necesarily linked to urban development, increased industrial development often forms a major component of urban development projects, and provides a source of increased exposure to environmental health factors. Within the workplace environment, people may be directly exposed to contact with high levels of toxic or dangerous substances which may include both substances which also pollute the external environment, and intermediary chemicals which are rarely found outside the workplace.

Many industrialised countries have formally recognised the existence of "occupational diseases" caused by workplace exposure. Such recognition may include the payment of compensation to workers incurring the disease. Annex 2 lists recognised occupational diseases of some European countries.

Whilst the concentrations of dangerous substances are likely to be higher in the workplace than in the external environment, and might be expected to cause greater effects, it should be remembered that workplace exposure is generally limited to working hours (although these may be long) and may involve mainly the less sensitive sections of society (healthy adult males).

Table 2.2(f)

Sound Levels and Perception of Noise Sources

Overall level in dB *		Industrial and military	Community (outdoor)	Home (indoor)
140 –		Carrier deck jet operation (140 dB)		
	Painfully loud	Oxygen torch (126 dB)		
130 –		Pneumatic chipper (122 dB)		
120 –		Pavement breaker (115 dB)		Discotheque (120 dB)
	Uncomfortably loud	Textile loom (112 dB)		
		Cut-off saw (106 dB)		
110 –		Farm tractor (103 dB)	Jet aircraft flyover at 300 m (110 dB)	
		Newspaper press (101 dB)		
			Power mower (103 dB)	
100 –			Excavation rock drill at 15 m (100 dB)	
		Bench lathe (95 dB)		
	Very loud	Milling machine (90 dB)	Motorcycle at 8 m (96 dB)	Food blender (90 dB)
90 –		Bed press (86 dB)	Heavy truck at 15 m (93 dB)	Alarm clock (85 dB)
		Key-punch machine (82 dB)	Train whistle at 150 m (90 dB)	Garbage disposal (83 dB)
				Clothes washer (82 dB)
80 –			Passenger car, 100 km/h at 15 m (76 dB)	Living room music (78 dB)
				Dishwasher (76 dB)
	Moderately loud		Church bells at 50 m (70 dB)	TV-audio (73 dB)
70 –			Light traffic at 30 m (66 dB)	Vacuum cleaner (72 dB)
				Toilet flush (65 dB)
60 –				Conversation (60 dB)
50 –	Quiet			
40 –				
30 –				
	Very quiet			
20 –				
10 –	Just audible			
0 –	Threshold of hearing			

Source: World Health Organisation; "Health Hazards of the Human Environment". Geneva: WHO. 1972.

2.3 Health Effects of Accidents and Hazards

2.3.1 Introduction

In Section 2.2 we have discussed health effects of pollution from normal, everyday activities, usually involving low-level, long-term exposure. However, the health effects of such exposure may be greatly exceeded by the effects of catastrophic pollution due to major accidental releases, or physical accidents. We discuss below the health effects of:

- transport accidents,
- accidents at work,
- accidents at home,
- major hazards.

2.3.2 Transport Accidents

A major potential consequence of urban development projects is an increase in the level of motorised transportation, in terms of both the number of vehicles in use and the time which people spend in travelling.

In badly planned urban developments roads may be crowded and pedestrians may come into close and frequent contact with traffic, which can lead to rapid increases in accidental injury and death.

In general, the level of accidents increases with the level of private transport use. Accidents involving private motor vehicles occur eight times as frequently (and accidents involving motor cycles or mopeds 150 times as frequently) as those involving public transport.

There are also significant differences between accident frequencies for different age groups, with the rate of accidents being highest for the younger age groups (children, teenagers and young adults).

2.3.3 Accidents at Work

As with occupational disease, workplace accidents are not necessarily linked with urban development projects, but increased industrial development is often a major component of such projects.

Accidents in the workplace are generally recognised as arising from two sets of factors: environmental and human.

Environmental factors leading to increased frequency of accidents include:

- o poor layout of the workplace;
- o unsatisfactory or absent guards on machines;
- o inadequate maintenance of equipment;

- defective or poor lighting;
- excessive noise and vibration;
- unsuitable floors, walls, roofs, etc.;
- unsatisfactory or absent lifting equipment;
- unsatisfactory or absent barriers to prevent falling.

Accident levels within the construction industry are often particularly high, with falls being a major cause of injury or death. This may be of particular significance during the construction phase of urban development projects.

The human factors which have been implicated in work accidents include:

- casual attitude towards dangers;
- incorrect work practices;
- failure to observe safe practices and to use safety equipment.

However, such factors can often be related to poor or absent training in safety matters and a failure to adapt work practices and safety equipment to man (for example the use of safety harnesses which restrict movement to an intolerable degree).

2.3.4 Accidents at Home

A variety of factors in the home environment can lead to increased levels of accidents. Accidents in the home are a particularly significant source of mortality and morbidity for children, old people, and people who are physically, socially or mentally handicapped.

Environmental factors which can affect the level of home accidents include:

- poor design, particularly of stairs, leading to increased numbers of falls (the most common cause of accidental deaths at home);
- poor fire resistance of construction materials, especially use of materials giving off toxic fumes when burnt (fires are also a frequent cause of accidental deaths);
- faulty electrical wiring, giving rise to both electrocution and fires;
- faulty installation of domestic gas supplies, leading to both poisoning and explosions (effects of the latter can be exacerbated by poor structural design).

In areas where a significant amount of work is carried out in the home, accidents of the type described in section 2.3.3 may also arise.

2.3.5 Major Hazards

The term "major hazards" is a broad one, covering accidental occurrences which can lead to death or injury to a large number of people.

Major hazards may arise from **natural causes**, such as earthquakes, volcanoes, typhoons and floods. Natural causes such as these may also combine with man-made factors. Examples include destruction of industrial installations leading to major release of hazardous substances, flooding of poorly-sited shanty towns and incidents where climatic factors exacerbate air pollution effects, such as the London smog of 1952 which is estimated to have caused 3-4 thousand deaths.

Major man-made causes of major hazards include the following:

- **Explosions** of industrial plant, stored fuel, etc. leading to injury and death, directly or through subsequent fire. For example a gas explosion in Mexico City in November 1984 caused up to 1000 deaths. Table 2.3(a) lists some incidents involving liquified petroleum gas.

- **Releases of toxic substances** from industrial plant or storage, leading to short-term high-level pollution of air or water. These releases may also be caused by explosion. Examples include the release of a cloud of toxic gas from a fertilizer plant at Bhopal, India in December 1984 which caused 4-5,000 deaths and 10 times as many injuries and release of dioxin from a plant in Seveso, Italy in 1976 which caused widespread lung and skin damage.

- **Release of radionuclides** from nuclear power generation or reprocessing plant malfunction. Although the potential health effects of such a release are high, no major accident involving radionuclide release has yet taken place. However, an incident at Three Mile Island Plant, USA, potentially posed such a hazard and lower-level releases have occurred.

The initial cause of major hazards is often disputed, the extent of damage making the exact chain of events difficult to decipher.

Most major hazards which have occurred have caused effects which, though serious, are limited in time and space. A major reason for the large number of deaths which have resulted in some cases (particularly in Bhopal and Mexico City) has been the proximity of potentially hazardous plant to densely populated residential areas.

Table 2.3(a)

Some Major Incidents Involving Liquified Petroleum Gas

1944: Cleveland Ohio. Tanks containing 4200 cubic metres of LNG split and spill into streets and sewers. A cloud forms and ignites, engulfing houses. Then, in the heat, a second tank ruptures. Buildings 250 metres away catch fire. 130 people die.

1959: Meldrum, Georgia. An LPG tank on board a train ruptures and a cloud of gas spreads over a picnic ground before igniting. 25 people die.

1966: Feyzin, France. Valve on an LPG tank jams open. Leaking gas surrounds tank and explodes 1½ hours later, taking other tanks with it. 45 people die.

1972: Brazil. Liquefied butane explosion kills 37 people.

1973: Staten Island, New York. LNG left in a tank being repaired explodes, killing 40 workers inside the tank.

1974: Tokyo Bay, Japan. Ship carrying LPG collides with cargo vessel. Liquid naptha ignites. 33 people die.

1978: Los Alfraques, Spain. A road tanker carrying 43 cubic metres of LPG springs a leak as it passes a camp site. Vapour cloud spreads over camp and bursts into flame. More than 150 people killed. Temperature at centre of fire was 1500° C.

1978: Highway near Mexico City. Road tanker spills LPG onto road after an accident. Some 20 people die.

1984: Cubataoan, Sao Paulo. LPG pipeline explodes in industrial suburb. At least 80 people die.

1984: Mexico City. Explosion at distribution centre for LPG in midst of shanty town kills more than 500 people.

Source: New Scientist, 29 November, 1984.

2.4 Disease transmission

In addition to the specific environmental health factors identified in the preceding sections, urban development may affect health by the changes it causes to the population density and lifestyle of its inhabitants. These effects include increased disease transmission due to both overcrowding and lifestyle changes.

Urban development may introduce conditions where large numbers of people are confined together in restricted areas. This may occur both in the home, due to inadequate housing size and elsewhere, for example on public transport. In Mexico City, the metro system consists of nine-car trains with a theoretical capacity of 1,630, including 170 standing. On occasions, however, loads of up to 2,800 have been recorded. Where such overcrowding is combined with poor ventilation, ideal conditions are created for the transmission fo droplet-borne infections such as colds and influenza.

Similarly upward indoor air currents in high-rise buildings may facilitate transmission of droplet-carried infections, leading to increased risk of disease amongst upper-storey residents.

Where air conditioning is installed to improve ventilation, health effects may arise from viral infections breeding in air washing chambers (eg. "Legionnaires Disease").

Increased potential for disease transmission may also arise from other effects of urban development on lifestyle. It has been argued that the increased consumption of hot food purchased from street traders or other outlets may assist the spread of gastro-intestinal disease.

2.5 Social/Psychological

The effects of urban development upon mental health are the subject of considerable controversy. Whilst a considerable amount of research has been carried out, the facts remain unclear. The World Health Organisation concluded that it was "... not so much the environment itself as the personal, social, socio-economic, educational and other situations which created stressful conditions affecting man's behaviour towards his fellow human beings and his state of mental health and well-being".(1) Urban development projects may bring major changes to these situations; for example through disruption of lifestyles, increased division between home and work, disruption of family life, increased opportunities for crime, and in general the "de-personalisation" of urban life. Such personal and socio-economic factors are beyond the scope of this report, and will not be discussed further here.

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(1) MARTIN, A.E.; "Environmental Health Aspects of Human Settlements: Report on a Study." Copenhagen: WHO Regional Office for Europe, 1978.

Nevertheless, a number of environmental factors appear to be implicated in the incidence of mental ill-health, particularly through increasing stress. These include factors relating to physical planning of development projects such as:

- o stress due to inadequate housing (overcrowding and lack of privacy);
- o stress due to increased need for frequent travelling often in crowded conditions (in Mexico City inhabitants spend on average $2\frac{1}{2}$ hours each day travelling to and from work) as living and working locations are separated;
- o stress due to isolation from the community through poor building design, for example amongst residents of high-rise blocks;
- o stress due to lack of opportunities for recreation particularly amongst children.

2.6 Key Points in the Identification of Environmental Health Effects

Table 2.6(a) gives a checklist of environmental health factors for urban development projects. In addition, the following key points should also be noted:

- o effects may be beneficial as well as harmful (e.g. better provision of public health services in urban areas);
- o effects are not restricted to the immediate interaction between an activity and the environment; these primary effects may themselves cause secondary effects;
- o effects may be reversible or irreversible, reparable or irreparable;
- o effects can occur over the short or long term, they may be continuous or temporary, and they may increase or decrease in time;
- o effects can be local, regional, national or global in scale;
- o accidental effects from both man-made and natural causes should be considered;
- o urban development may stimulate further developments which may affect health, e.g. industrial or transport developments. These indirect effects should also be considered as consequences of the proposed activity;

- one development may act as a precedent for further development which may give rise ultimately to far greater health impacts;

- effects may arise related to sources already present within an area, for example where residential developments are located in close proximity to existing pollution sources;

- there will be changes to the environment and thus health even if development does not proceed; this "moving baseline" should be taken into account in the assessment of a proposed development.

Table 2.6(a)

Checklist for Potential Health Impacts of Urban Development Projects

A. Effects of Pollution

- o Will the development contain potential sources of air pollution? e.g. from:
  - industrial developments,
  - power generation,
  - transportation in motor vehicles,
  - domestic fuel combustion,
  - dust-raising activities,
  - evaporation/emission from stored substances.
- o Will the development give rise to sources of water pollution? e.g. from:
  - disposal of domestic sewage and liquid wastes,
  - disposal of industrial effluents,
  - surface run-off,
  - addition of pesticides etc. to water courses,
  - solution of substances from unsuitable pipes and storage vessels.
- o Will the development give rise to major requirements for solid waste disposal?
  - disposal of human and/or animal faeces,
  - disposal of domestic waste,
  - disposal of toxic or hazardous industrial waste,
  - disposal of radioactive waste.
- o Will the development give rise to increased sound levels? Will sound levels be high in proximity to residential areas?
- o Will the development result in the introduction of new industries using toxic and/or hazardous substances?
- o Will the development result in location of people in proximity to existing pollution sources?

B. Effects of Accidents and Hazards

- o Will the development give rise to increased levels of private transport? Will traffic be in close proximity to residential areas?
- o Will new industries be introduced which may give rise to increased risk of occupational accidents? (including construction industry).

Table 2.5(a) (Continued)

Checklist for Potential Health Impacts of Urban Development Projects

- Will new residential and similar areas be located in close proximity to hazardous industry, traffic areas, etc.
- Can residence designs give rise to risk of accidents? (including installation of gas and electricity services).
- Will the development lead to introduction of potentially hazardous installations? (e.g. factories using dangerous substances, oil and gas storage depots). Will residential area be in close proximity to such installations?
- Is development located in an area susceptible to natural hazards (earthquakes, volcanoes, typhoons)? Are potential hazardous installations susceptible to such natural hazards?

C. Disease transmission

- Will development give rise to conditions facilitating disease transmission? (crowding of dwellings and transport, with poor ventilation, etc).

D. Social/Psychological

- Will development give rise to physical factors leading to increased stress? (eg. overcrowding, isolation).
- Will social/recreational opportunities be provided?