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VALUATING THE ECONOMIC IMPACTS OF URBAN ENVIRONMENTAL PROBLEMS: ASIAN CITIES

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FOREWORD

This working paper has been prepared by the Urban Management Programme (UMP)—a 10-year global technical cooperation program designed to strengthen the contribution that cities and towns in developing countries make toward human development, including economic growth, social development, and the reduction of poverty.

The Programme is a partnership of the international community: The United Nations Centre for Human Settlements (Habitat) is the executing agency, the World Bank is the associated agency, and the United Nations Development Programme provides core funding and overall monitoring. Bilateral donors, multilateral agencies such as the World Health Organization, and nongovernmental organizations provide various types of support.

UMP's ultimate beneficiaries are the citizens who live in and use cities and towns—particularly the urban poor—who will receive better managed services and more accountable, participatory, and transparent management as a result of the Programme.

The Urban Management Programme

Through its regional offices in Africa, the Arab States, Asia and the Pacific, and Latin America and the Caribbean, UMP seeks to strengthen urban management by harnessing the skills and strategies of networks of regional experts, communities, and organizations in the public and private sectors. The Programme's goal is to strengthen this local and regional expertise.

- **City and Country Consultations.** UMP brings together national and local authorities, the private sector, community representatives, and other actors within a country to discuss specific problems within UMP's subject areas and to propose reasoned solutions. Consultations are held solely at the request of a developing country and often provide a forum for discussion of a cross-section of issues, generally resulting in a concrete action plan for policy program change.
- **Technical Cooperation.** UMP uses its regional networks of expertise to sustain follow-up to the consultations by providing technical advice and cooperation to facilitate implementation of action plans and to mobilize the resources needed for their implementation.

Through its core teams in Nairobi and Washington, D.C., UMP supports regional programs and networks by synthesizing lessons learned, conducting state-of-the-art research, identifying best practices, and disseminating program-related materials.

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ACRONYMS AND ABBREVIATIONS

μg	microgram
Bt	baht
BOD	biochemical oxygen demand
CDC	Centers for Disease Control
CO	carbon monoxide
COD	chemical oxygen demand
COI	cost of illness
CVM	contingent valuation method
dB	decibel
DO	dissolved oxygen
EPA	Environmental Protection Agency
GDP	gross domestic product
GNP	gross national product
HK	human capital
HPM	hedonic pricing method
kg	kilogram
MPN	most probable number
ml	milliliter
ng	nanogram
NO_x	nitrogen oxides
PCB	polychlorinated biphenyl
RAD	restricted activity days
SMSA	standard metropolitan statistical area
SO_2	sulfur dioxide
SO_x	sulfur oxides
TCM	travel cost method
TSP	total suspended particulates
VOSL	value of a statistical life
WHO	World Health Organization
WLD	work loss days
WTA	willingness to accept
WTP	willingness to pay

ABSTRACT

The objectives of this study are to:

- survey the current state of knowledge of urban environmental problems and their costs, focusing on low- and medium-income Asian cities;
- assess approaches to the economic valuation of environmental effects, emphasizing nonproductivity effects such as health, amenities, ecological values, and equity;
- discuss institutional/property rights approaches to valuation of urban environmental problems;
- extend the scope of economic valuation to environmental problems other than pollution, primarily congestion and the degradation of natural resource support systems;
- assess the applicability of economic valuation approaches to the environmental problems of low- and medium-income Asian cities; and
- suggest a strategy for applying valuation techniques to selected Asian cities in the near future.

Chapter 1. Due to population growth, economic development, and other factors, environmental problems are rapidly increasing in many Asian cities. The poor are affected most severely by a deteriorated environment. Urban environmental problems may be divided into three categories: pollution, congestion, and degradation of natural support systems. These problems have (at least) four types of impacts: productivity, human health and safety, amenity, and ecology.

Chapter 2. Valuation methods can be based on physical or behavioral linkages. Physical linkage methods include productivity loss, cost of illness, human capital, and replacement cost. Behavioral linkage methods can be further subdivided as revealed and stated preference approaches, and include hedonic pricing (property value, wage); travel cost; averting/mitigating behavior; and contingent valuation. Definitions, procedures, and means of and experience in application are discussed for different methods in terms of health and safety and amenity/ecological values. The role of institutional/ property rights factors is discussed in the context of problem definition and choice of technique.

Chapter 3. The current state of knowledge of environmental problems of low- and medium-income Asian cities is presented in terms of incidence, impact, and—where available—economic valuation. The focus is on air, water, and toxic wastes (pollution); traffic (congestion); and forests, land, groundwater, and aquatic ecosystems (natural support systems).

Chapter 4. Following a summary of major environmental problems, the state of the art for valuation techniques is summarized in terms of three comparative analyses. The applicability of various techniques to low- and middle-income Asian cities is evaluated for seven criteria: theoretical validity, reliance on competitive markets, physical and economic data requirements, sophistication, flexibility, and robustness. The advantages and disadvantages of specific techniques are hypothesized. Finally, a strategy is suggested for the economic valuation of environmental problems in Asian cities, taking into account such characteristic obstacles as data unavailability and low capabilities in economic analysis. The basic elements of the proposed strategy are:

- to disaggregate the analysis into poor and nonpoor populations;
- to carry out the work with interdisciplinary teams;

- depending on the technique, to do the physical analytical groundwork—such as determining dose-response relationships—prior to carrying out economic valuation;
- to start with market-based techniques, where possible;
- to use more than one technique, where possible; and
- to recognize the experimental nature of applying these techniques to the new context of developing Asian cities—adjustments to meet local conditions are inevitable and desirable.

1. URBAN ENVIRONMENTAL PROBLEMS

The urban environment is a complex, living entity. In a general sense, it is an ecosystem consisting of the structures and infrastructure built in a defined area, the naturally occurring resources and conditions that enable a city to exist, and all the human beings who reside and work in it. All these components are affected by urban growth. Consequently, when problems arise, urban administrators need to consider many factors in their search for solutions; these include physical, socioeconomic, political, and institutional factors. Economic valuation can provide them with a strong foundation for urban problem solving.

Developing countries have undergone rapid urbanization since World War II—and are now experiencing many of the attendant problems. All recent analyses suggest that urbanization is an irreversible process, but that its dimensions in the developing world are as yet poorly understood. To begin with, the actual extent of urbanization among countries is unclear because urban areas are defined differently from country to country. Moreover, in many cases, population censuses are inaccurate or nonexistent. There is little difficulty, however, in identifying the problems associated with urbanization.

1.1 Urbanization, Environmental Degradation, and Urban Poverty

Before defining the environmental problems that rapid urbanization has brought to developing countries, it is important to recognize that urban growth has also provided these countries with numerous economic, environmental, and social benefits. From an economic standpoint, urbanization has helped raise the standard of living thanks to increased household incomes; and has stimulated productivity through the centralization of capital, technology, and skilled labor. Also, the per capita cost of providing energy, transportation, communication, piped water, sewerage, waste treatment, and other services has declined as population densities have increased. From an environmental perspective, urbanization has historically been associated with declining birth rates; this reduces the pressure for unsound use of agricultural land and natural resources (USAID 1990b).

1.1.1 Environmental Degradation

The vast array of environmental problems associated with urban growth in developing countries are due in part to "excessive scale" (calculated as population times the per capita use of resources), which strains the natural resource base in and around cities (Foy and Daly 1989). To a point, the strain on the natural regenerative capacity of the land can be alleviated by importing resources from outside. But the ever-increasing amounts of waste that urban areas generate far exceed the assimilative capacity of nature—and, in many cases, the disposal capacity of urban authorities. Other urban systems and services, such as water supply, sanitation, public transportation, and roads, are increasingly stressed as well.

The inability of many local and municipal governments in developing countries to provide adequate infrastructure and services has led to the degradation of the living and natural environment in and around cities. Fewer than 60 percent of the urban population in developing countries has access to adequate sanitation, and only one-third are connected to sewer systems (World Bank 1991a). Moreover, the collection and disposal of household garbage is a persistent problem for local authorities. Uncollected wastes end up in neighborhood dumps where disease-carrying rats and insects proliferate, or in street drains where they eventually cause flooding and traffic obstruction. And solid wastes placed in open dumps often lead to groundwater pollution.

Hazardous industrial wastes pose another pressing problem, even for city governments with an adequate waste management capacity. It is difficult to monitor discharges and ensure that hazardous wastes do not flow into city sewers and natural waterways. The disposal problem is compounded by the fact that few developing countries have the technology and facilities to treat hazardous wastes (Hardoy, Cairncross, and Satterthwaite 1990).

Air pollution is a further concern, particularly in large cities with poor natural circulation and significant emissions. Indeed the air quality in most large cities of developing countries is far below internationally accepted standards for good health (USAID 1988). Indoor air pollution is especially serious among low-income urban communities where fuelwood is used for cooking and heating in poorly ventilated housing (CSE 1985, K. Smith 1988).

Cities of all sizes in developing countries are also quickly encroaching on arable land. By the year 2000, urban areas in the developing world are expected to be twice their 1980 size, jumping from about 8 million hectares to more than 17 million hectares (USAID 1988). To accommodate the urban growth, arable land will be removed from production even as demand for food and other agricultural products increases.

1.1.2 Poverty

Different environmental problems affect rich and poor in different ways. For example, ambient air pollution is relatively "income-blind," while water-related diseases tend to affect the poor more severely. Studies of urban health conditions in developing countries reveal significant differences between rich and poor; women and children and women are, in many cases, those most vulnerable to adverse environmental conditions (Hardoy and Satterthwaite 1989).

The poor are hardest hit by environmental pollution partly because many of them live in areas where manufacturing, processing, and distilling plants are located, and where environmental protection is frequently the weakest. The urban poor also tend to settle on environmentally sensitive sites such as steep hillsides, floodplains, drylands, or the most polluted landsites near solid waste dumps and next to open drains and sewers. Such sites are often the only places where low-income groups can build or rent houses without fear of eviction. Therefore, it is virtually always the poorest groups who suffer the most from floods, landslides, or other environmentally associated disasters.

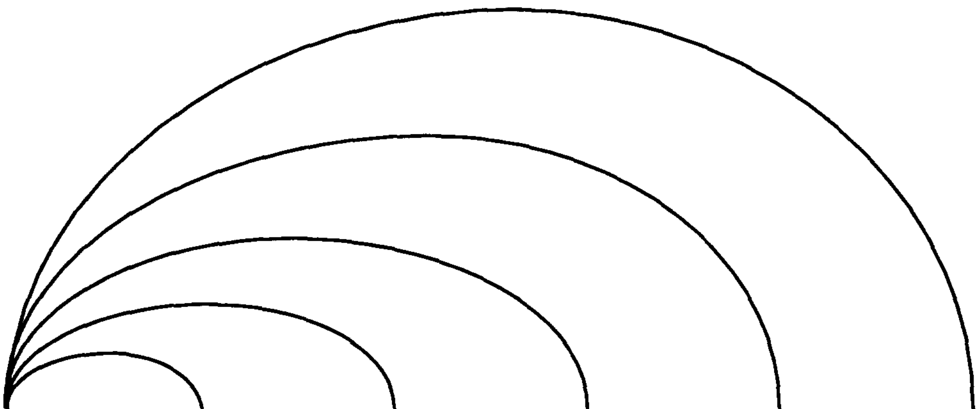
Inadequate diets exacerbate the environmental health risks of the poor by lowering their resistance to many diseases. Health and well-being are further threatened by two characteristics common to nearly all poor homes and neighborhoods: the presence of pathogenic microorganisms and crowded, cramped housing conditions (Hardoy, Cairncross, and Satterthwaite 1990). And, because the poor have unstable and inadequate incomes, they are unable to move away from dangerous and polluted residential areas. Thus, while a lack of piped water, drains, and garbage removal service may be the main cause of deteriorating environmental conditions and of the high incidence of diseases, inadequate incomes and poor quality diets increase the related health threats.

1.2 Types and Scale of Urban Environmental Problems

The conventional way of looking at urban environmental issues is to divide them up into technical areas such as air, water, sanitation, and solid waste. This approach is understandable—and perhaps unavoidable—because it reflects categorizations used by government agencies in collecting and organizing data. Unfortunately, it also slights the social, economic, and institutional factors that are critical to addressing the problems.

An alternative approach is to classify the environmental impacts of urbanization on a spatial scale (see figure 1-1).

Figure 1-1. Spatial Scale of Urban Environmental Problems



Spatial scale	**Household/ workplace**	**Community**	**Metropolitan area**	**Region**	**Continent/planet**
Key infrastructure and services	Shelter Water storage On-site sanitation Garbage storage Stove ventilation	Piped water Sewerage Garbage collection Drainage Streets/lanes	Industrial parks Roads Interceptors Treatment plants Outfalls Landfills	Highways Water sources Power plants	
Characteristic problems	Substandard housing Lack of water No sanitation Disease vectors Indoor air pollution	Excreta-laden water/soils Trash dumping Flooding Noise/stress Natural disasters	Traffic congestion Accidents Ambient air pollution Toxic dumps	Water pollution Ecological areas lost	Acid rain Global warming Ozone layer

Source: Bartone (1991).

Each part of the spatial scale defines the characteristic problems of that segment of the scale and the related infrastructure and services needed to address such problems. This approach reveals that several basic factors need to be considered when analyzing environmental issues in developing countries:

- Health impacts are greater and more immediate at the household or community level and tend to diminish in intensity as the spatial scale increases.
- Equity issues arise in relation to (1) the provision of basic services at the household or community scale and (2) intergenerational impacts at the regional and global scales due to unsustainable resource use.
- Levels of responsibility and decisionmaking should correspond to the scale of impact, but existing jurisdictional arrangements often violate this principle (Bartone 1991).

Urban environmental problems in developing countries can broadly be categorized as those arising from (1) inadequate waste disposal (pollution), (2) congestion of urban systems, and (3) degradation of natural support systems. The four types of major impacts associated with these environmental problems are those involving health and safety, productivity, amenity value, and ecological value (see table 1-1).

Table 1-1. Urban Environmental Problems and Their Impacts

	Impacts			
Problem	**Health/safety**	**Productivity**	**Amenity value**	**Ecological value**
Pollution				
Indoor air pollution	x	x		
Ambient air pollution	x	x	x	x
Freshwater pollution	x	x	x	x
Lake, coastal water pollution	x	x	x	x
Solid waste pollution	x	x	x	
Hazardous waste pollution	x	x	x	x
Fecal contamination	x	x		
Noise	x	x	x	
Congestion				
Traffic congestion	x	x	x	
Congested urban amenity			x	
Occupation of high-risk land	x	x	x	
Degradation of natural support systems				
Freshwater depletion	x	x	x	
Degradation of land and ecosystems	x	x	x	x

Source: Based on Bartone (1990a).

Some of the major impacts associated with **pollution** include health and safety effects such as health care costs, lost working days, and higher mortality rates. Another major impact is productivity loss associated with living systems (e.g., in the forestry, fishery, and agriculture sectors) as well as with nonliving systems (e.g., material corrosion or a reduction in product quality). Pollution can also lead to degradation of amenity in terms of reduced visibility, aesthetics, and recreational values.

The major impacts associated with **congestion** are loss of travel time, secondary health effects, overcrowding of public facilities, and reduced access to facilities.

The **degradation of natural support systems** can result in an increasingly scarce supply of, and consequently higher cost for, surface water; land subsidence from groundwater depletion; loss of recreational sites and cultural property; increased risk of natural hazards such as flooding and landslides; and the loss of biodiversity.

1.3 Economic Valuation of Urban Environmental Problems

To identify priorities for urban environmental management and formulate appropriate projects and programs, the costs of environmental degradation and the benefits of environmental improvements must be quantified. The theory of economic valuation has become quite sophisticated (e.g., see Johansson 1987), but very little work has been done in assessing the impacts of urban environmental problems in developing countries. Today's critical need "is not for more theory or techniques, but for application of existing methodology and approaches to concrete problems, particularly in developing countries" (Munasinghe and Lutz 1991).

The difficulty here lies in accurately appraising the relative significance of different environmental spillover effects so as to choose mitigation strategies judiciously and efficiently. Different cities have different mixes of water, air, solid, and hazardous waste pollution problems. Defensive expenditures can be enormous—such as cities relocating their water supply intakes or households substituting bottled water for untrustworthy tap sources. These outlays must be added to the more direct damage costs to yield the total costs of pollution. This aggregation helps overcome a fundamental asymmetry: Damage costs are spread over a large area and diverse population, while costs of improving the environment are more concentrated.

One of the principal purposes of this report is to review the valuation techniques that are currently available to estimate the relative costs of urban environmental problems in terms of health effects, productivity, amenity value, and ecological value. These techniques are detailed in the next chapter. A second major objective of this report is to survey urban environmental problems in Asia and determine to what extent the valuation techniques can be applied to these problems. Chapter 3 presents this analysis. Chapter 4 then summarizes the major environmental problems of Asian cities and draws some conclusions on the applicability of valuation techniques.

2. ECONOMIC VALUATION OF URBAN ENVIRONMENTAL PROBLEMS

2.1 Economic Valuation Methods: Overview

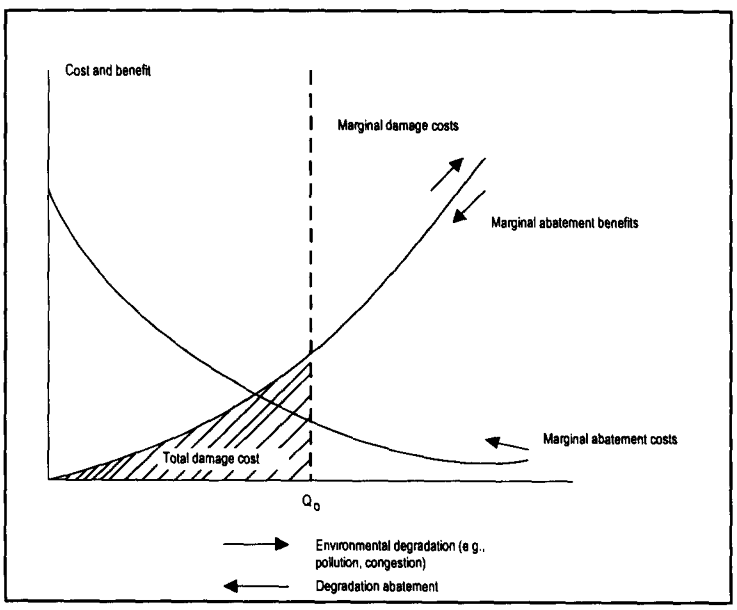
To address urban environmental problems in a rational way, it is necessary to know the magnitude of various kinds of degradation and their impacts on humans, the economy, and the ecosystem. This study aims to estimate in monetary terms the value of environmental damages. Monetary valuation is a useful tool for providing a single, standardized measure of welfare change. People indicate their willingness to pay (WTP) for particular goods and services by exchanging money for them, thus revealing their preferences through market transactions (Pearce and Turner 1990).

Unfortunately, most environmental goods have no well-defined property rights or markets from which the value of environmental degradation can be derived. Thus, their value usually must be determined indirectly. The valuation of environmental degradation is further confounded by a lack of accurate data and an incomplete scientific understanding of the interactions between human activity, environmental degradation, and the resulting damages.

The valuation techniques that do exist have, for the most part, been developed and applied in the United States and Europe. Few efforts have been made thus far to evaluate the economic impacts of environmental degradation in the developing world. Here, we assess the potential applicability of each technique to Asian cities, recognizing that many are not automatically transferable.

Valuation techniques have been used to estimate the environmental benefits expected from pollution control—that is, the value of environmental improvements over the original condition. However, what is of interest is to estimate the total costs of existing urban environmental degradation. To do so, the monetary cost of all environmental degradation from some natural clean state must be evaluated (see figure 2-1).

Figure 2-1. Costs of Environmental Degradation and Benefits of Abatement



At any point, the marginal damage cost of one additional unit of pollution is the same as the marginal abatement benefit of preventing one unit of pollution. Marginal damage cost is thus the mirror image of marginal abatement benefit. However, the total damage incurred at the existing level of pollutants, say at Q_0, becomes identical to the total benefits of pollution control only when all existing pollutants are eliminated. Understanding this distinction is critical in applying the various techniques of valuating total environmental damage. To obtain the total cost of environmental problems, abatement costs, plus the costs of defensive measures undertaken, must be added to the remaining damages.

2.2 Types of Economic Valuation Methods

Economic valuation methods may be classified based on the role of individual preference in valuing environmental damage—thus implicitly assuming that individuals' preferences should be the basis of environmental damage valuation. In this classification, all existing valuation techniques can be broadly categorized as involving either **physical linkages** or **behavioral linkages** (Smith 1986). Physical linkage—or damage function—methods examine the technical relationship between environmental degradation and physical damage without taking into account the subjective preferences of affected people. For example, increased respiratory disease or crop damage can be attributed to deteriorated air quality; the nature of this relationship is objectively determined, based on statistical analysis or crop production data.

On the other hand, behavioral linkage methods assume that the value of environmental goods should be based on people's willingness to pay to secure better environmental quality or to escape environmental deterioration. Behavioral linkage methods can be subdivided further depending on whether preferences are revealed **indirectly** through market behavior or stated **directly**, as in a survey. The **revealed preference approach**—also referred to as a surrogate market approach—is based on Mäler's (1974) concept of "weak complementarity," which occurs wherever an individual must consume some amount of a market good in order to get utility from a nonmarket good such as environmental quality.

The **stated preference approach** assumes that people would respond to hypothetical market situations as if they were actual markets. While revealed preference methods value people's willingness to pay for certain environmental goods indirectly, stated preference methods derive values directly from responses by affected parties, e.g., in surveys. This latter approach allows consumer surplus to be estimated (which is important in many environmental contexts); it can also be used to determine willingness to accept (WTA) compensation for damages. The stated preference method is also called the survey or contingent valuation method (CVM).

Different environmental impacts necessitate different valuation methods, as shown in table 2-1. This matrix is based on the assumption that the major urban environmental problems are—as stated earlier—pollution, congestion, and the degradation of natural support systems. These problems have adverse effects on health and safety, productivity, amenity value, and/or ecological value. Environmental impacts on health and safety can be valuated with either physical or behavioral linkage methods. Productivity loss and materials damage seem to require valuation by physical linkage methods, although the averting/mitigating behavior approach can be applied as a supplementary technique. Amenity value is estimated either by revealed or stated preference methods. Ecological value refers mainly to the nonuse values attached to the extinction of species or the destruction of ecosystems; it is primarily derived from stated preference methods.

Table 2-1. Economic Valuation Methods for Urban Environmental Problems

	Pollution				**Congestion**			**Degradation of natural support systems**			
Valuation method	**H/S**	**P**	**A**	**EV**	**H/S**	**P**	**A**	**H/S**	**P**	**A**	**EV**
Physical linkage											
Cost of productivity loss	—	x	—	—	—	x	—	—	x	—	—
Cost of illness	x	—	—	—	x	—	—	x	—	—	—
Human capital	x	—	—	—	x	—	—	x	—	—	—
Replacement cost	—	x	—	—	—	x	—	—	x	—	—
Behavioral linkage											
Revealed preference											
Hedonic pricing: property value differential	x	—	x	—	x	—	x	x	—	x	—
Hedonic pricing: wage differential	x	—	x	—	x	—	x	x	—	x	—
Travel cost	—	—	x	—	—	—	x	—	—	x	—
Averting/mitigating behavior	x	x	—	—	x	x	—	x	x	—	—
Stated preference											
Contingent valuation	x	—	x	x	x	—	x	x	—	x	x
Contingent ranking	x	—	x	x	x	—	x	x	—	x	x

Key: HS = health and safety; P = productivity; A = amenity value; EV = ecological value; x = useful method; — = method unusable or of very limited use.

Since each valuation method has its own advantages and disadvantages for specific applications, it is difficult to rank them in terms of overall performance. Following are brief introductions to each technique, including procedures and methods of application. Detailed discussions of specific applications are provided in later sections; chapter 4 presents an overall evaluation.

2.2.1 Physical Linkage Methods

Of the four valuation techniques listed under physical linkage in table 2-1, two—the cost of illness (COI) and human capital (HK) approaches—are used to value the health and safety effects of environmental degradation, and two—the costs of productivity loss and replacement cost methods—are used to measure the economic cost of productivity losses and materials damage. All four methods require the estimation of a damage function or a dose-response function which relates exposure to environmental pollution to effects on health or productivity. Thus, physical linkage analysis is usually an interdisciplinary task.

The procedure for estimating health and productivity effects consists of three steps.

1. Relate the exposure associated with different levels of environmental quality to human mortality/morbidity rates, the productivity of living systems, and/or material damages. This step requires risk assessment studies for health effects or damage function studies for productivity loss. The relationship between environmental quality and physical damage to health or productivity cannot be assessed without scientific knowledge and relevant data. Thus, a frequent drawback in physical linkage analysis is a lack of scientific knowledge about cause-effect relationships. As Freeman (1979a) points out, "getting better information on the relationship between air quality and human health is itself a major and difficult research task."

2. Calculate the magnitude of physical damage using the dose-response coefficient estimated in step 1.
3. Evaluate the monetary cost of measured damages. For nonhuman capital or costs such as medical expenses, resource or opportunity costs usually can be calculated easily using market prices. Since there is no explicit market for human morbidity or mortality, their value is usually determined based on lost income.

2.2.2 Revealed Preference Methods

Hedonic Pricing

The hedonic pricing method (HPM) is an indirect way of deriving the implicit price of nonmarket attributes such as environmental quality or amenity value. Named from the Greek word for "pleasure," the hedonic approach assesses the implicit value of attributes of market goods.

The HPM method is most commonly used in estimating property value, particularly housing prices. HPM derives implicit prices of environmental variables by estimating the hedonic price function such as

$$P_h = f\,(S, N, A, Q)$$

where P_h is the housing price

S is a set of property attributes such as house size and number of rooms

N is a set of neighborhood attributes such as crime rates and quality of local schools

A is a set of accessibility attributes such as proximity to market and main roads, and

Q is a representative environmental quality attribute such as air quality, noise, or scenic views

The partial derivative of the hedonic price equation with respect to Q is the marginal implicit price of environmental quality. In equilibrium, the marginal implicit price of an environmental quality is equal to the marginal willingness of an individual to pay for it.

The aggregate value of environmental quality is calculated by finding the sum of individual marginal implicit prices. The marginal implicit price function derived from the estimation of the hedonic housing price equation shows a locus of points on the demand curves of many different households. Properly, we need to derive price functions where marginal willingness to pay varies with household income and household characteristics as the second step of the hedonic pricing approach. However, most empirical studies skip this step and assume that all households' marginal implicit price function is the same. The third step is to add all of the consumer surpluses lost to environmental degradation.

Eighteen empirical studies on air pollution and property value linkages in the United States were carried out during 1967-78 (Freeman 1979b). All of these adopted multiple regression equations using a range of independent variables from 5 to 57, indicating a very heavy data requirements burden for HPM. In fact, data on environmental quality, real estate sales, detailed characteristics of houses sold, various neighborhood characteristics, and socioeconomic information on buyers are all needed.

HPM can also be applied to job markets to infer the marginal implicit price of job safety or amenity value, such as the degree of accidental injury or exposure to toxic substances, as well as urban environmental amenities. If the job market has no transfer barriers, workers will freely move from one urban area to another in search of better environmental and job-related characteristics.

HPM can only be applied if well-functioning markets are present. If housing or job markets are heavily regulated or otherwise distorted, the available market data will convey incorrect information on people's willingness to pay for better environmental quality, safety, or amenity value.

In summary, HPM has a theoretically sound background and is consistent with the principle of valuing nonmarket public goods based on individual willingness to pay. However, the very strength of the method leads to various complications. For example, HPM requires an extensive understanding of economic theory and econometrics, and there are several stages at which professional judgment is essential to producing meaningful outcomes. In addition, HPM has very demanding data requirements: In many cases, adequate data may not exist or may be prohibitively expensive to collect, especially under developing country conditions.

Travel Cost Method

The travel cost method (TCM) is widely used to estimate amenity values of outdoor recreation sites such as parks or lakes. The underlying assumption of this method is that travel cost can be a surrogate for the price of using the recreation site. Travel costs include transportation costs and the travel time spent on the journey. People living far from a site have to pay higher travel costs than those living closer; accordingly, the visitation rate for the former will be smaller than for the latter. Steps in applying TCM are as follows.

1. Collect data through a visitor questionnaire at the site. Required data include transportation expenditures, amount of time spent traveling, and various socioeconomic characteristics of visitors.
2. Derive an equation that relates the visitation rate to the independent variables affecting it, such as a visitor's total travel cost and other socioeconomic variables.
3. Construct a system of demand equations to obtain an aggregate demand curve for the site.
4. Measure the area under the aggregate demand curve to determine the benefits from the recreation site.

Since Clawson's (1959) initial work, TCM has been applied in various studies to evaluate the demand for recreation sites. The method has certain drawbacks, however. First, it requires a substantial amount of both primary and secondary data. Second, the valuation procedure involves many steps and various statistical complications. Third, as TCM is based on travel cost, it is less applicable to urban amenities that require only short trips. Where it can be applied, however, experience has proven TCM to be a useful tool to value recreational benefits (V. Smith 1988).

2.2.3 Stated Preference Methods

Stated preference methods attempt to measure individual willingness to pay by directly questioning representative individuals. Major advantages of this method are its universal applicability in valuing nonmarket environmental goods, including nonuse benefits such as option value or existence value, and its minimal requirement for secondary data.

Various techniques are available, such as direct question, bidding game, payment card, and ranked choice (see table 2-2). Most of these explicitly ask individuals the amount they are willing to pay—a **cardinal preference approach**. The ranked choice technique asks people to rank a number of alternatives consisting of a hypothetical payment and a corresponding level of environmental quality from most preferred to least preferred; this is an **ordinal preference approach**. Often, it is easier for respondents to order their preferences than to give them specific values.

Table 2-2. Characteristics of Alternative Question Formats for Contingent Valuation: An Assessment

Question format	Ease of use	Ease of understanding	Effect on valuation responses
Direct question	One of the easiest to use because it simply asks respondent for maximum amount; can be used equally well in all types of surveys—mail, telephone, or in-person.	Easy for respondent to know what is being asked, but probably the most difficult to answer because it asks for a cardinal (i.e., monetary value) response.	No chance of influencing response because no anchors of any type are given or implied.
Bidding game	Relatively easy to use with in-person interviews. Can be awkward if starting value differs substantially from final bid. Also could be awkward for telephone with sufficient framing—not suitable for mail surveys.	Auction-type format can surprise respondents, but they usually understand and learn basis for responses quickly.	Starting value likely to provide an anchor for respondents in determining their values.
Bidding game with budget constraint	More difficult to use than straight bidding game because respondents must be asked for income information early in interview.	Auction-type format can surprise respondents, but they usually understand and learn basis for responses quickly.	Starting value likely to provide an anchor for respondents in determining their values.
Payment card	Unanchored is easy to use both in mail and personal interviews because no extra information is needed to use it. Anchored requires respondent to give income ranges early in interview. Requires several cards for different income groups. Could be awkward in a mail survey. Neither unanchored nor anchored cards would work well on the telephone.	Unanchored provides limited help to respondent in giving cardinal responses. Anchored gives perspective of amounts paid for other public goods.	Arrangement of values in unanchored version could imply a "reasonable bid"; anchored version may cause respondents to "anchor" on a bid different from their true bid.
Close-ended or "take it or leave it"	One of the easiest to use because of its yes or no format; can be used equally well in all types of surveys—mail, telephone, and in-person.	Easy to know what is being asked and asks respondent only for a yes/no response.	Value used in question could provide an anchor, but seems less prone with yes/no response. Requires specification of budget-constrained random utility model for benefit measurements.
Ranked choice	One of the easiest to use because it asks for a ranking of choices; could be used equally well in mail or in person, but not likely to work in telephone surveys.	Easy to know what is being asked and asks respondent only to rank order choices. May be less reliable with more than five choices.	Requires specification of budget-constrained random utility model for benefit measurement. Dollar amounts used in choices may benchmark valuations derived from analysis of estimated indirect utility functions used in benefit estimation.

Source: Smith and Desvousges (1986a).

Stated preference methods follow these basic steps (Cummings, Cox, and Freeman 1986).

1. Design the survey instrument: explain the survey and its purpose; describe the public good to be valued; include an optional request for respondent's income and expenditure patterns;

ask about willingness to pay or willingness to accept payment, describing payment vehicles; include an optional request for demographic (e.g., age, sex) and attitudinal data.

2. Conduct a pilot study with a small sample of respondents or a focus group. The results may show that changes are needed in the survey instrument.
3. Choose a final sampling design and survey area.
4. Train the interviewers.
5. Implement the survey.

Stated preference methods have been extensively applied in the United States, especially in the last 15 years. Various biases can, however, affect the credibility of the research outcome—including general biases stemming from strategic responses, incomplete information, or inaccurate hypotheses; procedural biases related to sampling and interview techniques; and instrument-related biases such as the starting point and payment vehicle chosen. Nonetheless, although many studies appear to have a starting point bias (Smith and Desvousges 1986b), "most respondents take the valuation questions seriously and they do not appear to act strategically" (Smith, Desvousges, and Freeman 1985).

Assessments of the contingent valuation method have been mixed. Some find that it can accurately measure values of environmental amenities for which a comparable market exists, but that it performs poorly for other amenities such as water or air quality (Cummings, Brookshire, and Schulze 1986). Others note the limits of expressed values in predicting people's actual behavior (Bishop and Heberlein 1986). The most optimistic view concludes that "many of the conventional biases, if they exist at all, can be viewed as problems in either the framing of the contingent commodity or in the survey procedures" (Mitchell and Carson 1989); economists therefore should pay more attention to improving questionnaire design and survey-related issues.

2.2.4 Survey of Valuation Techniques

The remainder of this chapter examines the various valuation methods as they are applied in valuing the impacts of environmental degradation on health and safety (section 2.3) and on amenity and ecological values (section 2.4). Productivity changes and material losses from environmental degradation are not discussed in detail, because such costs are generally manifested in the market. It is sufficient to investigate noticeable changes in productivity or materials damage and use resource or opportunity costs to assess environmental damage cost; specific nonmarket valuation techniques are not needed (OECD 1989). The chapter concludes with a discussion of the role of institutional analysis in evaluating the economic costs of environmental degradation. The purpose of this section is not to develop new valuation techniques, but rather to determine the institutional elements that should be considered in assessing environmental damage costs.

An important issue in economic valuation is the appropriate discount rate to be used in economic analysis of specific projects or programs. Because it is a generic issue of benefit-cost analysis rather than specific to the valuation techniques themselves, this issue is not addressed in this report. For further information on this topic, see Dixon and Hufschmidt (1986), Markandya and Pearce (1991), and Norgaard (1991).

2.3 Valuation Techniques for Health and Safety

Environmental degradation affects human health in varying degrees, from minor irritations to fatal diseases or sudden death. It is common practice to divide health effects into **morbidity** and **mortality**. Morbidity can be defined in various ways, such as duration of illness (chronic or acute), degree of impairment of activity, type of symptom and number of symptom-days, or number of cases of specific diseases (Cropper and Freeman 1990). Mortality is formally defined as the conditional probability at age t of dying before the t+1st birthday, given that the person is alive on his/her tth birthday. A change in the mortality rate is measured by a change in the probability of dying.

Five categories of costs are associated with adverse effects on human health and safety (Cropper and Freeman 1990):

- the medical expenses associated with treating pollution-induced disease,
- productivity losses resulting from the inability to work at normal levels,
- the defensive or averting expenditures associated with attempts to prevent pollution-induced diseases,
- the disutility associated with the symptoms and lost opportunities for leisure activities caused by the illness, and
- changes in the risk of death.

The first three effects constitute the cost of illness and can easily be quantified in monetary terms. The fourth effect—which includes pain and suffering—is often ignored in economic valuation because it is difficult to measure. Valuing the last effect "is filled with moral as well as methodological difficulties" (Leitmann 1991a). However, various techniques have been devised to value mortality.

Physical linkage methods for health and safety valuation include the human capital approach for valuation of mortality changes, and the cost of illness approach for morbidity effects. Among the behavioral linkage methods for dealing with health and safety, revealed preference methods include property value differentials, wage differentials, and defensive expenditures. Stated preference methods such as surveys have also been applied to estimate willingness to pay, or to accept compensation, for changes in risk of death or symptoms of illness.

2.3.1 Physical Linkage Methods

Physical linkage estimates of human health costs from environmental degradation entail three steps (Freeman 1979a).

1. Determine the relationship between changes in exposure to environmental pollution and human health as measured by morbidity and mortality rates.
2. Use this relationship to predict the changes in morbidity and mortality associated with specific changes in environmental pollution and exposure to pollutants.
3. Derive monetary measures of changes in health status.

The first step involves establishing a **damage function** or **dose-response function**. Dose-response coefficients are obtained either through statistical analysis or from the biomedical literature. A damage function relates physical damage to the level of pollution; a "monetary cost function" is the physical damage function multiplied by a unit economic value of physical damage (OECD 1989).

Damage functions take various forms. Some focus mainly on mortality (Lave and Seskin 1977, Crocker et al. 1979, Chappie and Lave 1982, Lipfert 1984); others concentrate on morbidity effects (Ostro 1983, 1987; Portney and Mullahy 1986, 1990).

Lave and Seskin (1977) used multivariate regression techniques on U.S. standard metropolitan statistical area (SMSA) data to investigate the relationship between various air quality indicators and mortality rates. They found no evidence of thresholds for sulfates, particulates, or sulfur dioxide, and concluded that a linear model best fits the data. The estimated elasticities between mortality and degrees of sulfate and particulate pollution at the means of the data were fairly similar (within a range of 0.09 to 0.12) across different data sets, model specifications, and degrees of disaggregation. Thus, a 1 percent increase in pollutants concentration will increase the mortality rate by about 0.1 percent. Lave and Seskin used the coefficients to estimate the health benefits of controlling air pollution in urban areas.

Lipfert (1984) used the same SMSA data in an improved model on demographic, environmental, and lifestyle variables. He also obtained statistically significant correlations between mortality and drinking water quality, ozone concentration, percentage of net migration, and percentage of nonwhite population. However, particulates and sulfates were not significant variables for changing mortality, as they were in Lave and Seskin's study. Lipfert's work suggests that many other variables besides those related to pollution greatly affect morbidity and mortality. Unless these are accounted for, the effects of pollution on health may be overstated.

Ostro (1983, 1987) used damage functions to estimate the effect of air pollutants on morbidity. Restricted activity days (RAD) and work loss days (WLD) were regressed to particulates, sulfates, and several socioeconomic variables. The regression results showed that particulates affect both RAD and WLD significantly. The elasticity was 0.45 for WLD and 0.39 for RAD. Ostro's equation was used in a detailed study of environmental health risks in Bangkok (USAID 1990a); that work forms the basis for a valuation exercise in section 3.2.

Human Capital Approach

The human capital approach to valuing mortality implicitly assumes that the value of an individual is what he or she produces. The value of a life is thus measured by the discounted present value of a person's expected future earnings (Landfeld and Seskin 1982).

According to Mishan (1982), the present value of a person's expected future earnings may be calculated as follows:

$$L_1 = \sum_{t=j}^{\infty} Y_t P_j^t / (1 + r)^{t-j}$$

where Y_t is the expected gross earnings by the person during the t^{th} year

P_j^t is the probability in year j of the person being alive during year t, and

r is the social rate of discount expected to rule during the year t

Alternatively, net income can be specified by subtracting C_t, the individual's expected expenditure during year *t*, from Y_t.

There are several problems in applying this human capital approach. First, nonmarket productivity is usually excluded from the valuation. Thus, retired people have zero economic value (or negative value in the case of the net output approach), and work within the household—especially by women and children—is not taken into account. Second, the HK approach fails to consider other dimensions of illness and death such as pain, suffering, aversion to risk, loss of leisure, and adverse effects on others (Dalvi 1988). Many economists argue that lost wages constitute only a part of the total economic effects of pollution exposure, which include many other subjective issues. Third, it is difficult to identify an appropriate social discount rate. The human capital value of children and young adults is very sensitive to the choice of a discount rate. Application of a high rate reduces the present value of future earnings of all age groups, especially young age groups (Landfeld and Seskin 1982). Finally, the greatest drawback of the HK approach is that it ignores individual preferences. People care about their health and safety for many reasons other than to maintain future output. Thus, this approach yields only an absolute minimum value of a statistical life.

An adjusted WTP/HK approach addresses some of these problems. It calculates the value of human capital as follows:

$$L_2 = \left[\sum_{t}^{T} Y_t / (1+r)^t\right] \propto$$

where *T* is remaining lifetime

Y_t is after-tax labor and nonlabor income

r is the individual's opportunity cost of investing in risk-reducing activities, and

$\propto$ is a risk-aversion factor

The adjusted WTP/HK estimates still have a downward bias because they exclude intangible factors such as pain and suffering; however, they are theoretically an improvement over the original HK approach. Although the adjusted WTP/HK may be a more appropriate method for evaluating environmental policies that involve risks to human health, only Landfeld and Seskin (1982) have used this approach in estimating the value of statistical life. In the situation they considered, an individual's opportunity cost of investing in risk-reducing activities was substituted for the social discount rate, and an insurance risk premium was explicitly considered as the risk-aversion factor. Table 2-3 summarizes three applications of physical linkage methods.

Table 2-3. Physical Linkage Studies

Author/method	Effects analyzed	Data required (year)	Data source	Findings
Cooper & Rice (1976) Human capital, cost of illness	Estimates of (1) direct, (2) mortality, and (3) morbidity costs of illness	Medical expense, mean annual earnings (1972)	Social Security Administration, National Health Survey, Bureau of the Census, National Center for Health Statistics	Direct costs exceeded mortality costs. The largest mortality loss is from circulatory disorders, accidents. Total cost of illness is US$188.8 billion (1972 price) at 4% discount rate.
Lave & Seskin (1977) Human capital, cost of illness	Air pollution on mortality and morbidity	Air quality indicators for SMSA, disaggregated mortality rates (age, sex, disease) (1972)	SMSA data, resource-opportunity cost from Cooper & Rice (1976)	Total benefits of pollution reduction = US$16.1 billion (1972 price).
Landfield & Seskin (1982) Adjusted WTP/HK	Comparison of human capital and adjusted WTP/HK estimates of a statistical value of life	After-tax income, average after-tax rate of return on household's economic assets, insurance risk premium	Bureau of the Census	VOSL = US$2,039 - US$976,304 (1977 price). Better VOSL estimates for elderly and children obtained.

Notes: HK = human capital; SMSA = standard metropolitan statistical area; VOSL = value of a statistical life; WTP = willingness to pay.

Cost of Illness Approach

The cost of illness approach measures the cost of environmental damage in terms of direct outlays for the treatment of illness (hospital care, cost of service for physicians and other medical personnel, and cost of drugs) plus indirect losses in output due to illness, as measured by the social cost of lost earnings. Two major cost categories are omitted: the social value of averting expenditures and the value of personal pain, suffering, and inconveniences associated with illness. As in the HK approach to mortality, the COI approach considers only the observable costs of morbidity, and therefore presents only a lower bound to WTP.

This problem can be adjusted for by including the value of time (both work and leisure) lost due to illness and the averting expenditures in cost of illness. Cropper and Freeman (1990) suggest that society's willingness to pay to reduce health risk should also be added to obtain the full social cost of illness.

2.3.2 Behavioral Linkage Methods

Behavioral linkage methods have the advantage of not being so dependent on complicated damage functions or dose-response coefficients for the valuation of environmental health and safety costs. Instead, they focus on actual willingness to pay or willingness to accept compensation, which—as noted above—are considered the best measures of preferences and changes in welfare.

Logically, willingness to accept compensation for one's life should be infinite, because money is of no use without life. Willingness to pay to save one's life is probably close to whatever assets the person has to offer at the time. However, the impact of environmental degradation on mortality is usually not evaluated in terms of a specific person's life but rather in terms of a statistical life. This distinction explains why more tends to be spent on an actual, rather than a statistical, life (Dalvi 1988). Society has shown itself willing to pay up to US$200 million to save a single known life (Wilson et al. 1980), but the value of a statistical life is considerably lower.

In the physical linkage approaches described above, a statistical life was valued according to future earnings. In behavioral linkage methods, on the other hand, the value of a statistical life is approximated by the product of a change in the probability of death and the relevant individual marginal rate of substitution of wealth for risk of death. Usually the appropriate value to place upon the avoidance of death or injury is given by the "population mean" of the relevant marginal rate of substitution (Jones-Lee, Hammerton, and Philips 1985).

Hedonic Pricing: Property Value Approach

Hedonic pricing methods examine willingness to pay for marketed goods that are "complementary" to nonmarketed attributes reflecting environmental quality. The property value approach to health and safety risks assumes that part of the difference between what people are willing to pay for housing in polluted and nonpolluted neighborhoods is the value they place on avoiding health risks. Individuals are assumed to be aware of pollution and associated risks, and optimize according to the implicit prices.

Portney (1981) and Smith and Desvousges (1986a) use property value differentials to value mortality; Harrison and Rubinfeld (1978a) apply this method to morbidity. Harrison and Stock (1984) apply a hedonic housing price function to estimate the benefits of cleaning up a hazardous waste site near Boston. Their techniques and results are summarized in table 2-4.

Since the property value approach is used more frequently in measuring lost amenities rather than human health, its advantages and disadvantages are discussed more fully in section 2.4.

Hedonic Pricing: Wage Differential Approach

Compensating wage differentials for risky jobs can be used to estimate individuals' willingness to pay or willingness to accept payment for a change in the risk of death. This approach assumes that workers will accept risk up to the point where the marginal benefit of compensation is equal to the marginal cost of taking the risky jobs. A risk premium is obtained by the partial derivative of the wage function with respect to the risk of death, where the wage function is specified in terms of job characteristics and the variables affecting worker productivity.

This method rests on three assumptions:

1. The labor market is free and in equilibrium.
2. Workers correctly perceive safety risks in the workplace (Dalvi 1988).
3. Workers have a range of job choices from which to choose.

Table 2-4. Revealed Preference Studies

Author/method	Effects analyzed	Data required (year)	Data source	Findings
Mortality				
Portney (1981) Property value differential	Housing price, air pollution, risk of death	SO_x, TSP level, age-sex specific mortality rate	Environmental Protection Agency, etc.	VOSL = US$142,000 for typical household, US$378,000 for single male, US$576,000 for single female. US$34/year is necessary to improve air quality at 10% interest rate.
Smith & Desvousges (1986a) Property value differential	Hazardous waste disposal site and mortality	Household demand for distance from hazardous site	609 households in suburban Boston (1984)	Households realize a consumer surplus of US$330 - $US495/year/mile from the disposal site.
Thaler & Rosen (1976) Wage differential	Occupational death risk	(1) wage, (2) occupational mortality, (3) job-related characteristics	1967 Survey of Economic Opportunity (1) (3); 1967 Occupation Study of the Society of Actuaries (2)	VOSL = US$200,000 ± US$60,000 (1967 price). Young, married, unionized workers have higher risk premium.
Olson (1981) Wage differential	Occupational death risk of fatal or nonfatal injury	Wage, probability of fatal or nonfatal accident, workdays lost	1973 Current Population Survey	VOSL = US$3.2 million. The estimated value of a life decreased as risk increased. Workers with risky jobs are less risk averse than workers with safe jobs.
Marin & Psacharopoulus (1982) Wage differential	Occupational death risk	Specific death rate, other worker characteristics	Office of Population Census and Surveys	VOSL = £2.2 million (nonmanual workers), £0.65 million (manual workers) (1975 price).
Moore & Viscusi (1986) Wage differential	Occupational death risk	Job-specific death rate	National Institute of Occupational Safety and Health	VOSL = US$0.2 - US$6.6 million (1986 price). Improved risk data doubled the VOSL estimate.
Blomquist (1979) Averting/defensive expenditure	Tradeoff between risk and time/ inconvenience costs of seatbelt use	Seatbelt use data (1972)	Survey Research Center	VOSL = US$0.37 million (1978 price) shows the lower bound of VOSL.
Morbidity				
Harrison & Rubinfeld (1978a) Property value differential	Value of health by NO_x and particulate reduction	WTP for clean air from housing market data	Census from the Boston metropolitan statistical area	Benefits of US$47 - US$118/ household/year. The marginal value was sensitive to the hedonic housing value equation.
Harrison & Stock (1984) Property value differential	Housing price and benefits of cleaning up hazardous waste sites in Boston area	2,182 individual housing transactions in the Boston urban area from November 1977-March 1981, 14 structural attribute variables, 4 employment accessibility variables, 4 neighborhood variables	Housing census (1980)	WTP for clean up of three sites = US$3.6 million - US$17.4 million (1980 price).
Gerking & Stanley (1986) Averting/defensive expenditure	Benefits of improved ozone exposure	Cross-sectional survey data of medical care consumption	2,594 households in St. Louis (1977-80)	WTP = US$18.45 - US$28.48/ household/year for 30% reduction in ambient ozone exposures.
Dickie & Gerking (1991) Averting/defensive expenditure	Benefits of ozone control from demand for medical care	Long-term health status, contacts with medical care delivery system, socio-economic/demographic, and work environment characteristics.	226 residents in Los Angeles	WTP = US$170 annually.

These assumptions, however, do not hold true in most real-life situations. Further difficulties in using a hedonic wage differential approach to infer the value of life in a pollution-risk context include the following (OECD 1989):

- Pollution exposure is usually related to low probabilities of death, although these probabilities may affect a large number of people.
- The wage-risk studies relate to compensation received for increases in risk over some average level.
- The risk premium is compensation received for a voluntarily accepted risk. However, some risks are imposed, which would require far greater compensation than voluntary risk.

Also, application of the wage differential approach requires separable data on job-related risk of death and injury as well as on other job characteristics.

Despite these weaknesses, the method has been amply applied, as shown in table 2-4. In the various wage differential studies conducted, the calculated value of a life ranged from US$200,000 to US$6.6 million (in year-of-study prices). In their review of wage-risk, contingent valuation, and consumer market studies, Fisher, Chestnut, and Violette (1989) conclude that "the most defensible empirical results indicate a range for the value-per-statistical-life estimates of US$1.6 million to US$8.5 million (in 1986 dollars)."

Averting Behavior Approach

The averting behavior (or defensive expenditure) approach infers the value of risk reduction by observing people's voluntary purchase of certain risk-reducing goods or efforts to avert consumption. According to this approach, people use life-saving consumer goods such as seatbelts or smoke detectors until the marginal cost is equal to the benefit of reducing the probability of death. This averting expenditure is an approximation of individual willingness to pay to avoid risks. A statistical value of life can be calculated by dividing the annual cost of averting behavior by the reduced risk of death.

The average value of willingness to pay is estimated from data on the cost of averting activity and on its effect in reducing the risk of death for a cross section of individuals. Using a probit model, Blomquist (1979) estimates the value of a statistical life at US$370,000 to US$1.4 million (in 1978 prices). He assumes that in the absence of legal enforcement, an individual's decision to wear a seatbelt can be considered a tradeoff between reduced risk and time and inconvenience costs.

Several recent studies have used this approach to value the morbidity effects of air pollution (see table 2-4). Gerking and Stanley (1986), for example, measure mitigating behavior in terms of visits to the doctor and thereby estimate willingness to pay for ozone reduction. Dickie et al. (1986) estimate a function that relates each of nine respiratory symptoms with three pollution variables—ozone, sulfur dioxide, and nitrogen oxide—doctor visits, and various forms of averting behavior. Long-term averting behavior includes the use of electricity in cooking, living in an air-conditioned home and driving an air-conditioned car although only a part of the costs of these actions can be assigned to averting the ill effects of air pollution.

Harrington, Krupnick, and Spofford (1989) note that information about the cause of waterborne disease affects willingness to pay to avoid it as measured by the value of averting and mitigating expenditures and extra time spent. When people are aware of the cause of disease, averting behavior—

such as purchasing water purification devices or bottled water—is the main component of WTP. When people do not know that contaminated water is the cause, mitigating expenditures such as medical treatment constitute the main components of WTP.

Contingent Valuation Method

The contingent valuation method includes various survey techniques asking individuals to state their willingness to pay to reduce health/safety damage or willingness to accept payment to tolerate the damage. CVMs are called contingent market approaches, because the respondent is asked to state his or her willingness to pay for nonmarket goods in a hypothetical market, contingent upon the existence of such a market (Dalvi 1988).

CVM has several advantages. For one thing, it is technically applicable in all circumstances. Also, it can be applied to a broad segment of the population and to the causes of death specific to environmental hazards (Cropper and Freeman 1990). Third, CVM is not subject to the data constraints characteristic of the methods cited above.

Contingent valuation involves directly asking people about their willingness to pay to reduce pollution or to alleviate certain symptoms. In the latter case, estimation of the dose-response function is a prerequisite to value the economic cost of environmental degradation. In applying CVM to measure willingness to pay for morbidity reduction, it is preferable to separate the population into several groups—based on health status, age, and income—and derive separate WTP measures for each group (Cropper and Freeman 1990). Some studies applying CVM to morbidity and mortality are listed in table 2-5.

Note that accidental deaths must be treated with some caution in estimating the mortality cost of environmental pollution. The problem is that job-related or road accidents are often the result of the victim's own choice or negligence, while many environmental risks are involuntarily imposed. Thus, WTP estimates in the two cases may not be transferable. Furthermore, accidental death is usually instantaneous; in comparison, most environmental hazards cause death through diseases like cancer, which has a long latency period followed by an extensive period of pain and suffering. The value of mortality should be different in the two cases.

Three contingent valuation surveys of acute respiratory symptoms in the general population revealed sharp differences between the mean and median values of willingness to pay for a reduction of one symptom-day (see table 2-6). The fact that mean values were often many times higher than median values reflects the distorting influence of very large bids in survey responses. Clearly, the outcome is sensitive to the way the survey is structured, especially in considering averting behavior and the budgetary implication of responses (Cropper and Freeman 1990). The results may imply either large disparities in income, since a few are willing to pay much more than the rest; or a strategic bias that leads some people to overstate their WTP. Another bias, reported by Tolley et al. (1986), is that WTP increases with the number of symptom-days experienced and with the actual condition of poor health.

Table 2-5. Stated Preference Studies

Author/method	Effects analyzed	Data required (year)	Data source	Findings
Mortality				
Jones-Lee, Hammerton & Philips (1985) CVM	Mortality in transportation	WTP for reduced mortality	1,150 individuals (1982)	VOSL = £0.5-2.2 million (1982 price). People's WTP varies according to income and age. People do not distinguish a small change in mortality. Individuals place higher WTP to unfavorable ways of dying.
Smith & Desvousges (1986a, 1987) CVM	How an individual's valuation of a risk varies with the level of baseline risk of hazardous disposal site	WTP for reduction in risk by regulation	609 households in suburban Boston (1984)	Marginal valuation of risk change decreased with increases in the level of baseline risk.
Gerking et al. (1988) CVM	Marginal value of job safety perceived by workers	WTP & WTA for changes in job-related fatal accident risks	Mail survey from 6,000 households (1984)	WTP = US\$665, WTA = US\$1,705. The marginal value of job safety of US\$2.66 million - US\$6.82 million. The marginal value increased with the increase in initial level of risk.
Morbidity				
Loehman et al. (1976) CVM	Value of health effects for reducing air pollution by using low sulfur fuel for power plant	WTP for days of illness	404 individuals (1970)	Benefit of reducing SO_2 emission was US\$10 - US\$15 per household. Dose-response function required.
Viscusi et al. (1991) CVM	Tradeoff between ozone exposure risk and (1) automobile accident or (2) dollar	WTP for reducing probability of contracting chronic bronchitis	389 individuals using an interactive computer program	People are willing to pay (1) US\$2.29 million, (2) US\$0.46 million for 1/100,000 reduction of chronic bronchitis. People can state risk-risk tradeoffs more accurately than risk-dollar tradeoffs.

Table 2-6. Willingness to Pay for Acute Symptom Reduction

	WTP for a change in one symptom-day (1984 US\$)					
	Dickie et al. (1987)		Tolley et al. (1986)		Loehman et al. (1979)[a]	
Symptom	Mean WTP	Median WTP	Mean WTP	Median WTP	Mean WTP	Median WTP
Cannot breath deeply	1,140.00	1.00				
Pain on deep inspiration	954.13	3.50				
Shortness of breath	7.88	0.00			78.00 (127.00)	8.00 (18.00)
Wheezing	58.00	2.00				
Chest tightness	813.72	5.00				
Cough	355.10	1.00	25.20	11.00	42.00 (73.00)	4.40 (11.00)
Throat irritation	15.00	3.00	28.97	13.00		
Sinus congestion	239.50	3.50	35.05	14.00	52.00 (85.00)	6.00 (13.00)
Headache	178.39	1.00	40.10	20.00		
Eye irritation			27.73	12.50		
Drowsiness			31.41	15.00		
Nausea			50.28	17.50		

[a]Numbers in parentheses refer to severe symptoms. Numbers above them refer to mild symptoms.

Source: Krupnick (1988).

CVM's credibility depends on whether it can avoid various kinds of biases. It should therefore describe the hypothetical market as closely to real market terms as possible and vividly portray the institutional context in which the nonmarket good is provided and the way in which it would be financed. Because there is no actual market within which to assess the accuracy of CVM results, these are usually compared with values obtained from other valuation techniques. Schechter (1991) carried out such a comparison; in his study of valuation of changes in air quality in Haifa, Israel, he used three CVM techniques and three indirect valuation methods: cost of illness, averting/mitigating expenditure, and a preference model. The results obtained from the various methods were roughly comparable, thus lending credibility to the CVM results. CVM is most useful, however, in cases where other valuation techniques cannot be applied—thus, the accuracy of CVM output cannot be assessed, which is one of the drawbacks of the approach.

Another problem in using CVM relates to the difference in valuation between willingness to pay and willingness to accept compensation. Technically, WTP measures changes in consumer surplus by equivalent variation; WTA measures these by compensating variation (Mäler 1974). While theoretical studies show little difference between WTP and WTA, in actual CVM studies, WTA is many times higher than WTP (see table 2-7 and Bishop 1982). Part of this difference depends on what an individual considers to be the "normal" state. For example, if people believe they have the "initial right" to enjoy clean air or water, their valuation of environmental degradation will be much higher using the WTA—versus the WTP—approach. As Turner (n.d.) explains:

> CV [compensating variation] measures the welfare impact of changes as if the individual had a right to his/her initial level of welfare (e.g., existing environmental commodities set). He/she thus has the choice of keeping what they already have or voluntarily trading for changes. EV [equivalent variation] treats the individual as if he/she only has a right to the subsequent level of welfare, which has to be accepted or can only be reversed back to the initial welfare situation via trading. WTP^{EV} (i.e., payment to prevent a loss of environmental quality or physical asset) may well be considered offensive by individuals because of the inferior reference level of welfare.

Table 2-7. Disparities between WTP and WTA in Contingent Valuation Studies

Study	Willingness to pay	Willingness to accept
Hammack and Brown (1974)	247.00	1,044.00
Banford, Knetsch & Mauser (1977)	43.00	120.00
	22.00	93.00
Sinclair (1976)	35.00	100.00
Bishop and Heberlein (1979)[a]	21.00	101.00
Brookshire, Randall & Stoll (1980)	43.64	68.52
	54.07	142.60
	32.00	207.07
Rowe, d'Arge & Brookshire (1980)	4.75	24.47
	6.54	71.44
	3.53	46.63
	6.85	113.68
Coursey, Shulze & Hovis (1983)	2.50	9.50
	2.75	4.50
Knetsch & Sinden (1983)	1.28	5.18

Note: All figures are in year-of-study dollars.

[a]Mitchell and Carson (1984) reestimated Bishop and Heberlein's results with contrary conclusions.

Source: Cummings, Brookshire, and Schulze (1986).

Also, WTP is constrained by income (which is a major obstacle in most Asian cities). WTP is generally appropriate for valuing potential environmental benefits, while WTA is more appropriate for eliciting the amount of compensation necessary for damages already incurred. In all too many cases, damage occurs without compensation and the victims are asked how much they would be willing to pay to have the damage reversed. This implies that de facto property rights are vested in the polluter rather than the victim and represents a violation of the "polluter pays principle" (Bishop 1982, Bromley 1988).

2.4 Valuation Techniques for Amenity and Ecological Values

Common examples of urban amenities are clean air, clean water, quiet surroundings, attractive views, open spaces, parks and recreation areas, public libraries, and museums. In economic terms, an amenity is a location-specific good with public good characteristics (Diamond and Tolley 1982). Some amenities, such as clean air, constitute "pure" public goods, in that their consumption is noncongestible and nonexcludable. Others, such as urban parks and museums, are quasi-private goods, in that they can become congested and access to them for some consumption purposes is technically excludable, although nonuse (existence) values are nonexcludable.

Because of their public good characteristics, amenities are not directly bought and sold in private markets. They are priced indirectly through the costs of other things—e.g., land and housing—to which they are related (Diamond and Tolley 1982).

Ecological values are also public goods. Apart from productivity values associated with maintaining the ecosystem, ecological values include nonuse (existence) values and options values for future benefits, which cannot be assessed with standard neoclassical methods. Examples of physical systems with high ecological value are wetlands, mangrove forests, and other habitats for endangered species.

Because amenities and ecological systems are largely public goods without markets, their value is assessed via behavioral linkages, as shown in table 2-1. Consumer willingness to pay is estimated based on either revealed preferences or stated preferences.

2.4.1 Revealed Preference Methods

Hedonic Pricing: Property Value Approach

Given that the market price of property is in part a function of urban amenities, price differentials can be used to derive implicit values for these amenities. This approach was closely studied in the 1970s, using residential property values to estimate the benefits of improved environmental quality (Hufschmidt et al. 1983). Table 2-8 summarizes the results of some of these early studies. In a survey of studies on air pollution and property values, Pearce and Markandya (OECD 1989) report that a 1 percent increase in particulates lowers property values by 0.05 percent to 0.14 percent.

The hedonic pricing of property value technique appears to have been applied almost entirely to urban areas in the United States, with air quality and proximity to waste disposal sites as the most important environmental quality variables. A few property value studies of aircraft and traffic noise have been reported in Australia, Canada, the Netherlands, Switzerland, and the United Kingdom (OECD 1989), but—apparently—this technique has yet to be applied to valuation of environmental variables in developing countries.

Table 2-8. Air Pollution and Property Value Differential Studies

Study	Effects analyzed	Data required (year)	Data source	Findings
Anderson & Crocker (1971)	Air pollution and residential property values in St. Louis, Kansas City, Washington, D.C.	Property value for owner and rental; SO_x; suspended particulates; property characteristics (percentage classified as dilapidated, distance from central business district, median number of rooms in housing units); neighborhood characteristics (percentage of occupied housing inhabited by nonwhites, percentage of units more than 20 years old in 1959); median family income	1960 Census of Housing (1962)	SO_x and suspended particulates affect residential housing values; 10 $\mu g/m^3$ increase in particulate and 0.1 $\mu g/100cm^2$ day increase in SO_x reduce mean property value by US$300 - US$700.
Wieand (1973)	Level of air pollution and property values in St. Louis	Per unit price of land; property characteristics (percentage of standard unit, percentage of units in 1950 built before 1920, average age of housing); neighborhood characteristics (percentage white population, average income in dwellers, distance in miles from central business district, four dummy variables)	1960 Census of Population and Housing, Interstate Air Pollution Study (1966)	
Schnare (1976)	Racial and ethnic preferences in an urban Boston housing market (includes air pollution variable)	Property value (gross rent), particulates, seven property characteristic variables, 11 neighborhood characteristic variables	1960, 1970 Census of Population and Housing	Particulates had significant effects in reducing property values.
Goodwin (1977)	Value of housing quality in downtown St. Louis area	Median census tract dollar monthly rent, pollution index, four housing characteristic variables, 21 socioeconomic variables, 21 location and transportation variables	1970 Census of Housing and Population (St. Louis area)	Pollution index has significant effect on monthly rent.
Harrison & Rubinfeld (1978)	Effects of air pollution on housing and property values in Boston standard metropolitan statistical area	Median property value of owner-occupied housing; NO_x concentration; property characteristics (average number of rooms, proportion of owner units built prior to 1940); location characteristics (distance to employment centers, index of accessibility to radial highways); neighborhood characteristics (property tax rate, pupil-teacher ratio, black proportion of population, proportion of population of low socioeconomic status, crime rate, proportion of land in large lots, proportion of nonretail business land, riverside location)	1970 census tracts in Boston standard metropolitan statistical area	At mean values of NO_x and other variables, median change in housing values for 1 pphm change in NO_x is US$1,613.
Smith (1978)	Estimation of price gradients for several urban amenities in Chicago	Site value premium; particulates; accessibility to work (distance to the Chicago center, distance to airport, accessibility to employment, distance from major commuter transportation); property tax; school expenditures per pupil; crime rate (1971); percentage nonwhite population	Mortgage applications and appraisal reports of Chicago savings and loan associations, Department of Housing and Urban Development	10 $\mu g/m^3$ increase in particulates reduces individual site premium by US$430 - US$510.

Source: Adapted from Freeman (1979b).

Although hedonic pricing has the advantage of producing equilibrium implicit prices for public goods, theoretical and econometric problems have limited the technique's use (Freeman 1985, Cummings, Cox, and Freeman 1986). For example:

- The hedonic price function is difficult to specify due to multicollinearity.

- Individuals may not be aware of the attributes in question.
- Environmental quality affects not only property prices but also wages.
- The data requirement is generally quite large.

Graves et al. (1988) studied hedonic pricing as applied to urban air quality, focusing on the empirical importance of four econometric issues: variable selection, measurement error, functional form, and alternative distributional assumptions. They found that the impacts on property values of changes in air quality were highly sensitive to these econometric factors. Therefore, complete, accurate, and correct judgments must be made based on these factors, or the results will be "misleading at worst and unconvincing at best."

The main problem with hedonic pricing methods is their large data requirement. Detailed market price data are needed on all relevant housing characteristics—structural, neighborhood, and environmental; such data are hard to obtain. Harrison and Stock (1984), for instance, had to comb through data on 2,182 housing transactions in 80 towns in the Boston suburbs over a 3½ year period; they obtained housing price and characteristic data from the Society of Real Estate Appraisers. Their most difficult and time-consuming data collection task was to determine the location (latitude and longitude) of each house. They used U.S. Census Bureau computer-readable maps for about two-thirds of the houses, and manually coded locations from street guides and detailed census tract maps for the other one-third. Data on waste sites were obtained from information compiled by the Massachusetts Department of Environmental Quality Engineering.

Hedonic Pricing: Wage Differential Approach

The wage differential approach is most useful for health and safety effects, as noted in the previous section, but has also been applied in some studies of urban amenities. Hoehn et al. (1987) estimate marginal values for a large set of location-specific amenities. With 16 amenity variables related to climate, urban conditions, and the environment, amenity prices were estimated by regressing interregional wages on local amenities. Not surprisingly, the researchers found that all of the environmental variables—which included air quality (total suspended particulates and visibility), water pollution, Superfund sites, landfills, and hazardous waste disposal sites—had negative impacts on amenity value.

Izraeli (1987) examined the relationship between air quality, as measured by total suspended particulates, and wage rates and housing values for 237 SMSAs in the United States. He found that the full implicit price of air quality would include both a wage differential and a housing price differential. Clark and Kahn (1989) extend the hedonic wage approach to a two-stage model to estimate willingness to pay for improvements in freshwater fishing quality through both general and specific water quality improvements. They studied white male wage earners in 15.83 million households in 175 SMSAs in the United States. The first-stage model yielded marginal implicit prices for catches of warmwater and coldwater fish. These prices were then used as inputs to a second-stage model which yielded the willingness-to-pay values.

Like the property value approach, this method is rather data intensive. Also, to estimate hedonic wage functions correctly, the labor market must be in equilibrium and not be segmented into submarkets or regions with incomplete mobility among segments (Cummings, Cox, and Freeman 1986).

Travel Cost Method

The travel cost method uses information on the amount of money and time that people spend in getting to a recreational site to estimate their willingness to pay for access to that site and its facilities (OECD 1989). This information can then be used to construct a demand curve for the site and estimate aggregate benefits by computing the relevant consumer surplus. TCM relies on the household production function theory, which was originally advanced by Becker (1965) and Lancaster (1966), and developed to value unpriced goods such as outdoor recreation.

The U.S. Water Resources Council (1979) adopted TCM (along with contingent valuation) as an approved method for measuring benefits of outdoor recreation facilities and services at federal water resource projects. Since then, federal water resource agencies such as the U.S. Army Corps of Engineers commonly use TCM in their benefit-cost analyses of water-based recreation.

Smith and Kaoru (1988) examined over 200 travel cost studies to identify patterns of demand for specific types of recreation sites and their values. They identified 77 studies with sufficient information to develop consumer surplus estimates. According to their findings, demands consistently vary by type of recreation site (lake, river, forest, state park, national park), and key modeling decisions—such as treatment of travel time, effects of substitutes, and selection of a functional form—greatly affect results.

Most TCM applications have been in the United States, largely in nonurban areas and for recreation sites and facilities. One Asian application, discussed further in section 3.4, estimated the benefits of access to Lumpinee Public Park in Bangkok (Grandstaff and Dixon 1986).

The travel cost method has the following advantages and disadvantages (V. Smith 1988, OECD 1989, and Cummings, Cox, and Freeman 1986).

Advantages

- TCM is a revealed preference technique that focuses on observable purchases.
- The method is robust and reliable. Its application techniques have steadily improved, and its results are broadly similar to those obtained through other methods such as contingent valuation.
- Simple applications and relatively small samples can generate inexpensive order-of-magnitude estimates for single-site benefits.

Disadvantages

- It is difficult to value or cost travel time to a recreation site, especially for very short trips as in urban areas.
- It is difficult to adjust costs to reflect multipurpose, multisite trips.
- TCM method can measure only direct use benefits; it cannot measure nonuse benefits, including existence and option values.
- A substantial amount of data may be required to assess the relationship between price, quantity, and site for alternative sites.

The travel cost method is particularly suited to estimating user willingness to pay for access to single outdoor recreation sites, especially in rural settings. TCM works best when applied to valuation of a single site with unchanged characteristics where conditions at alternative sites are expected to be unchanged (Cummings, Cox, and Freeman 1986).

2.4.2 Stated Preference Methods

The contingent valuation method can be used to determine what people are willing to pay or willing to accept for specified amenities or ecological values. It compensates for the lack of markets for such public goods by presenting consumers with hypothetical markets. If the sample is carefully selected using random sampling procedures, the response rate is high enough, and appropriate adjustments are made to compensate for nonresponse and poor data, CVM sample results can be generalized—with a known margin of error—to the population from which respondents were sampled (Mitchell and Carson 1989).

CVM was first applied in the 1960s to estimate the benefits of outdoor recreational amenities such as waterfowl hunting, parks, and wilderness areas. Since the early 1970s, the technique has been applied to a wide variety of environmental amenities including water quality, air quality, location of hazardous waste storage sites, and outdoor recreational sites. Mitchell and Carson (1989) identified over 100 contingent valuation studies as of 1986. Almost all of these were conducted in the United States; only five involved urban amenities. CVM has, however, been used in the Netherlands to estimate the value of travel time (access amenity) to motorists in congested urban traffic situations. As noted above, the U.S. Water Resources Council uses CVM to measure benefits from water resources projects. The U.S. Department of the Interior uses this method to measure Superfund benefits and damages.

Table 2-9 compares CVM to the travel cost and hedonic pricing methods for valuing various amenities in the United States. CVM has also been compared to property value methods in measuring demand for noise reduction in Basel, Switzerland (Pommerehne 1988). The results of these studies show that CVM generates values for amenities that generally compare well with those obtained from alternative market-based or revealed preference methods.

To date, only a few such applications have been made in developing countries. As noted above and detailed in section 3.4, Grandstaff and Dixon (1986) applied CVM (along with the travel cost method) to estimate willingness to pay for access to an urban park in Bangkok. Hsu and Li (1990) used CVM to estimate willingness to pay for improvements in the quality of the Keelung River in Taipei; this study is discussed in section 3.3. Whittington et al. (1990) and Whittington, Lauria, and Mu (1991) used contingent valuation to estimate willingness to pay for water services in a village in southern Haiti and in a city of 700,000 people in southern Nigeria. Their results show that it is possible to conduct a CVM survey among a very poor, illiterate population and obtain reasonable, consistent answers. Their research also "suggests that contingent valuation surveys may prove to be a viable method of collecting information on individuals' willingness to pay for a wide range of public infrastructure projects and public services in developing countries" (Whittington et al. 1990).

CVM may be the only feasible approach to use in obtaining nonuse ecological values—apart from measuring people's revealed willingness to contribute to wildlife preservation efforts (Turner 1991). However, the technique suffers from a strong information bias. In a survey by Samples, Dixon, and Gowen (1986), as in many other studies (e.g., Hsu and Li 1990), the stated WTP for the preservation of certain species was directly related to the amount and type of information given to survey respondents.

Table 2-9. Summary of Results from Comparison Studies

Study	CVM results		Indirect market study	
	Commodity	Value[a]	Method	Value[c]
Knetsch & Davis (1966)	Recreation days	US$1.71 per household per day	TCM	US$1.66 per household per day
Bishop & Heberlein (1979)	Hunting permits	US$21.00 per permit	TCM value of time = 0 value of time = ¼ median income value of time = ½ median income	 US$11.00 US$28.00 US$45.00
Desvousges, Smith & McGivney (1983)	Water quality improvements: (1) loss of use (2) boatable to fishable (3) boatable to swimmable	User values: average (across question format)[b] US$21.41 US$12.26 US$29.64	TCM	User values: US$82.65 US$7.01 US$14.71
Seller, Stoll & Chavas (1984)	Boat permit to: Lake Conroe Lake Livingston Lake Houston	Close-ended consumer surplus US$39.38 US$35.21 US$13.01	TCM	Consumer surplus: US$32.06 US$102.09 US$13.81
Thayer (1981)	Recreation site	Population value per household per day: US$2.54	Site substitution	Population value per household per day: US$2.04
Brookshire et al. (1982)	Air quality improvements: (1) poor to fair (2) fair to good	Monthly value[c] US$14.54 US$20.31	HPM (property values)	Monthly value: US$45.92 US$59.09
Cummings et al. (1983)	Municipal infrastructure in: (1) Grants, NM (2) Farmington, NM (3) Sheridan, WY	Elasticity of substitution of wages for infrastructure -0.037 -0.040 -0.042	HPM (wages)	Elasticity of substitution of wages for infrastructure; 29 municipalities: -0.035
Brookshire et al. (1985)	Natural hazards (earthquakes) information	US$47 per month	HPM (property values)	US$37 per month

[a]Mean values among respondents.

[b]Values apply to post-iteration bids for users of the recreation sites.

[c]Values for sample population.

Source: Cummings, Brookshire, and Schulze (1986).

CVM may also be subject to an instrument bias in that most surveys focus on individual preferences and therefore may not be suitable for some public goods. Randall (1991) advocates the newly developed referendum methods for contingent valuation, which he says "appeal to the public perception of public goods, such as biodiversity; and they rely on scenarios built around political rather than market institutions and should, therefore, be more readily adaptable to international contexts."

CVM has the following advantages and disadvantages (Cummings, Brookshire, and Schulze 1986; Mitchell and Carson 1989; OECD 1989).

Advantages

- CVM does not have the secondary data requirements of such revealed preference methods as hedonic pricing or travel cost. This allows the method to be applied to a wide range of public good and quasi-private amenities.

- In contrast to the travel cost method, CVM is well-suited to measuring nonuse benefits such as existence and option values.
- CVM generates credible values that compare well with those obtained from alternative market-based or revealed preference methods.

Disadvantages

- Various biases can lead to false values for willingness to pay or willingness to accept compensation.
- Respondents may have difficulty ranking their true preferences in hypothetical situations, especially when they are unfamiliar with the public good in question.
- There is a great disparity between results of surveys of willingness to pay and willingness to accept compensation.

The major challenges in using CVM are to design appropriate surveys and ensure their intelligent application to the specific situation.

2.5 Institutional and Property Rights Approaches

The task of assigning a value to environmental damages is fundamentally institutional in nature. Most components of environmental quality are public goods. Where property rights are not clearly defined, cheaply defended, and transferable at low costs, the market does not provide (locally) Pareto-efficient values (Coase 1960). Table 2-10 categorizes goods based on two fundamental dimensions related to property rights: (1) congestibility (or rivalry), which measures the degree to which one person's consumption of a good deprives others of its use; and (2) exclusion costs, which are costs incurred in controlling access.

Table 2-10. Typology of Goods

Congestion	Exclusion cost		
	Negligible	**Moderate**	**Significant**
None	**Public goods with exclusion** Books Computer programs	**Public goods with moderate exclusion costs** Public demonstrations	**Pure public goods** Contagious disease eradication General tax reduction Air quality Quiet
Some	**Club goods/local public goods** Parking lots Toll bridges Country clubs	**Mixed public/club goods** Beaches Zoned neighborhoods Toll highways Municipal water systems Urban parks Museums Fire protection	**Common property resources** Public waterways Including water quality City streets
High	**Pure private goods** Clothing Food Drinking water Plantations	**Closed access natural resources** Irrigation canals Health clinic services Species habitats Village forests	**Open access natural resources** Minerals on the ocean floor Satellite orbits Some public forests

Source: Adapted from Nabli and Nugent (1989), p. 82.

Pure public goods are those that can be jointly consumed without congestion. That is, except in extreme cases, one person's use of the resource does not diminish availability to others; and it is impossible—technically, economically, and morally—to exclude would-be users. Enjoying air quality by breathing constitutes such a pure good, but using air as a receptacle for waste does not. Unfortunately, it is not practical to devise a system in which well-defined rights to air quality can be established and sold to those who wanted to infringe on them.

On the other hand, pure private goods (which may be owned by public bodies) are fully Coasean: definable, excludable, and transferable. One person's use is mutually exclusive from another's, and ownership is clear. Most environmental goods lie between these two extremes, especially those with some but not extreme levels of congestion and exclusion costs. For example, "club goods" have low exclusion costs, high fixed costs, and low variable costs. Adding new members reduces the average cost to others until congestion raises the marginal cost up to or above the average cost (Buchanan 1965, Mueller 1989). This typology allows consideration of a much richer texture of good characteristics than does the traditional public good/private good dichotomy.

Comparative studies of privatization indicate that the property rights regime has economic consequences both for performance and, through performance, for values expressed in the market. For example, in many areas traditionally considered the domain of public management, the private sector is proving that it can provide comparable or improved levels of service more efficiently than can public authorities (Mueller 1989, Bartone et al. 1990). Hence the economic value (opportunity cost) of public services may not be observable directly, either through public charges or costs, but may have to be derived from costs of comparable private supply.

The private sector is not always the low-cost provider, however. Donahue (1989), surveying studies based on North American and Western European data, found public management as efficient or more efficient than private in electric and water utilities. For garbage collection, public agencies were a higher cost provider than private contractors, but lower than competitive private hauling. Therefore, the presence or absence of competition is more important than ownership type, but "meaningful competition is often far easier to praise than to arrange" (Donahue 1989, p. 78). Where the costs of excluding competitive suppliers are negligible, private management may not be superior (see table 2-10).

Water supply in low- and middle-income urban areas provides another illustration of the fact that private supply may not always be more efficient than public and that other correlated factors may overwhelm the ownership effect. Water supplied by private vendors, primarily to the urban poor, is almost universally much more expensive than water from public utilities (see table 2-11). The ratios indicated, up to 100 to 1, imply a surprising absence of arbitrage. Further investigation should uncover a number of institutional blockages.

Studies of the net effects of zoning, almost entirely U.S.-based, are less conclusive in showing a relationship between institutional form and value, depending to a large extent on model specification (Pogodzinski and Sass 1990). Most of these studies, which include those dealing with amenity and Tiebout effects, use hedonic price approaches.

Table 2-11. Ratio between Prices Charged by Vendor and Public Utilities

Country	City	Ratio
Bangladesh	Dacca	12-25
Columbia	Cali	10
Ecuador	Guayaquil	20
Haiti	Port-au-Prince	17-100
Honduras	Tegucigalpa	16-34
Indonesia	DKI Jakarta Surabaya	4-60 20-60
Ivory Coast	Abidjan	5
Kenya	Nairobi	7-11
Mauritania	Nouakchott	100
Nigeria	Lagos Onitsha	4-10 6-38
Pakistan	Karachi	28-83
Peru	Lima	17
Togo	Lome	7-10
Turkey	Istanbul	10
Uganda	Kampala	4-9

Source: Bhatia and Falkenmark (1991).

All of the valuation techniques surveyed here so far are based on neoclassical economic thought. Implicit in these approaches is the emphasis on individual choice over collective choice, and market allocation of resources over public intervention. The neoclassical school presumes that the principles of private property rights can be naturally extended to common property resources. The contingent valuation method—which is widely regarded as the only way to estimate consumer surplus from public goods—is also based on this rationale. Yet where exclusion costs are high, there is a strong incentive for people to take a "free ride" because the benefits of collective action can be enjoyed without contributing to its costs. Such free riding can lead to conscious or subconscious distortion of revealed preferences, or strategic bias. The importance of this bias is still disputed. For example, in surveying the results of CVM analyses, Rowe and Chestnut (1983) and Mitchell and Carson (1989) found that strategic bias is not a significant problem.

An alternative to individual preference approaches is to develop a "social preference function," by examining institutional arrangements that reveal and aggregate individual preferences (Siebert 1988). Harris and McGowen (1990) hold that "political activities are valued ways of expressing one's values, and political outcomes are valid sources of information about what people want." Of course, the same caveats that apply to market functioning should be applied here as well: complete information, low transaction costs, etc. Thus, the preferences revealed by citizen organizations, the outcomes of public referenda, and the behavior of government itself (assuming it is attempting to maximize a social welfare function, in which environmental quality is a variable) can be examined. Existing expenditures on urban infrastructure may provide a minimum bound for social willingness to pay.

The theories of transaction costs and collective action have been applied in a few developing economies (Nabli and Nugent 1989). While these studies did not directly address environmental and valuation issues, they do—when considered together with recent developments in the collective action theories of collective action (Hardin 1982 and Ostrom 1990), public choice (Mueller 1989), and institutional analysis (Williamson 1985, Eggertsson 1990)—provide a hopeful basis for application to environmental valuation.

At this point, institutional and property rights approaches are more suited to problem setting and implementation analyses than to valuation. With limited state of knowledge, it is hard to provide detailed guidance on how to factor institutional variables into economic valuation. Their presence and probable effects should be acknowledged in assessments, however, given their probable significance. This is especially true when exclusion costs are high and when close substitutes cannot be found due to the localized nature of a good (e.g., land) or its intrinsic and universal properties (e.g., open access water and air). Until suitable methodological approaches are developed for more reliable quantification, however, adjustment for institutional factors may best be done through expert judgment.

3. INCIDENCE, IMPACTS, AND VALUATION OF URBAN ENVIRONMENTAL PROBLEMS IN ASIA

3.1 Urbanization in Asia

In 1950, the world's only megalopolises (cities with populations of more than 8 million) were New York and London, both located in more developed regions of the world. By 1970, 5 of the 10 largest urban agglomerations were in the world's less developed regions (see table 3-1). In 1990, 14 of 20 megalopolises were located in these regions. Eleven are Asian cities—two in the more developed regions (Japan) and nine in the less developed regions (China, South Asia, and Southeast Asia). By the year 2000, there may be 28 megalopolises in all. Of these, 17 will be located in Asia—15 in its less developed countries. Thus, cities in less developed regions are growing faster than those in more developed regions, and population growth rates are fastest in the cities of South and Southeast Asia.

Table 3-1. Urban Agglomerations of 8 Million or More Persons, by Development Region

1950		1970		1990		2000	
More developed	**Less developed**	**More developed**	**Less developed**	**More developed**	**Less developed**	**More developed**	**Less developed**
New York		New York	Mexico City	New York	Mexico City	New York	Mexico City
London		London	Sao Paulo	Tokyo	Sao Paulo	Tokyo	Sao Paulo
		Tokyo	Shanghai	Los Angeles	Shanghai	Los Angeles	Shanghai
		Los Angeles	Beijing	Paris	Beijing	Paris	Beijing
		Paris	Buenos Aires	Moscow	Buenos Aires	Moscow	Buenos Aires
				Osaka	Calcutta	Osaka	Calcutta
					Bombay		Bombay
					Jakarta		Jakarta
					Delhi		Delhi
					Tianjin		Tianjin
					Seoul		Seoul
					Rio de Janeiro		Rio de Janeiro
					Cairo		Cairo
					Manila		Manila
							Lagos
							Dacca
							Karachi
							Bangkok
							Istanbul
							Tehran
							Bangalore
							Lima

Source: UN (1991).

Yet the current level of urbanization in Asian developing countries is not high by global standards. The percentage of the world's population living in urban areas is 45 percent, according to 1994 data from the United Nations. The urbanization rate is 72 percent in Latin America, 33 percent in Africa, and 30 percent in Asia (Pernia 1991). Asia is vast and heterogeneous, however, and this relatively low average urbanization level masks pronounced variations among subregions and countries. The total, urban, and rural population growth rates for East, South, and Southeast Asia are shown in table 3-2. Both the total and rural growth rates peaked in 1965-70 and are now declining. Rural growth rates are even expected to become negative in the future. However, urban growth rates—which were substantially higher than rural growth rates even in the 1950s—continued to accelerate up to and during the 1980s, and are currently at their peak. The annual urban growth rates of 4.3 percent in South Asia and 4.0 percent in Southeast Asia far surpass any previous rates in currently developed countries.

Table 3-2. Average Annual Rates of Growth in Asia's Total, Urban, and Rural Populations

Growth rate	Average annual rate of growth (%)														
	1950-55	1955-60	1960-65	1965-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-2000	2000-05	2005-10	2010-15	2015-20	2020-25
East Asia															
Total	1.8	1.5	2.0	2.4	2.1	1.4	1.2	1.3	1.3	1.1	0.8	0.6	0.5	0.5	0.4
Urban	4.6	6.7	3.0	2.9	2.6	1.8	1.6	1.9	2.2	2.3	2.4	2.4	2.2	2.1	1.9
Rural	1.1	0.1	1.6	2.3	1.9	1.3	1.1	1.1	0.9	0.5	0.0	-0.5	-0.6	-0.8	-0.9
Urb. rate[a]	2.8	5.2	1.0	0.5	0.5	0.4	0.4	0.6	0.9	1.2	1.6	1.8	1.7	1.7	1.4
South Asia															
Total	2.0	2.3	2.3	2.4	2.4	2.2	2.4	2.4	2.3	2.2	1.9	1.7	1.5	1.2	1.1
Urban	2.9	3.1	3.5	3.7	4.2	4.0	4.2	4.3	4.3	4.2	4.0	3.7	3.3	2.9	2.6
Rural	1.9	2.1	2.1	2.1	1.9	1.7	1.9	1.7	1.5	1.2	0.8	0.4	0.1	-0.2	-0.4
Urb. rate[a]	0.9	0.8	1.2	1.3	1.8	1.7	1.7	1.9	1.9	2.0	2.0	2.0	1.8	1.6	1.5
Southeast Asia															
Total	1.9	2.3	2.4	2.5	2.4	2.2	2.2	1.9	1.8	1.7	1.5	1.3	1.2	1.0	0.9
Urban	3.7	3.9	3.8	3.9	4.2	4.0	4.0	4.0	3.9	3.7	3.5	3.2	2.9	2.6	2.3
Rural	1.6	1.9	2.1	2.2	2.0	1.6	1.5	1.2	0.9	0.6	0.3	0.0	-0.2	-0.4	-0.6
Urb. rate[a]	1.8	1.6	1.4	1.4	1.7	1.8	1.8	2.0	2.1	2.0	2.1	1.9	1.7	1.5	1.4

[a]Rate of urbanization is the average annual exponential rate of growth of the percent urban.

Source: UN (1989a, 1989b).

The striking variations in urban growth rates among Asian countries are shown in table 3-3. In 1985-90, they were as high as 6.9 percent for Nepal, 5.4 percent for Bangladesh, and 4.9 percent for Pakistan, but only 0.5 percent for Japan. At these rates, urban population would double in 10 years in Nepal, 13 years in Bangladesh, and 14 years in Pakistan. High urban growth rates are expected to continue into the next two decades for most Asian countries.

Table 3-3. Growth of Urban Population in Selected Countries of East, South, and Southeast Asia

Region/country	Percent urban (1990)	Average annual urban growth rate (%)		
		1965-70	1985-90	2005-10
East Asia	29.4	2.9	1.9	2.4
China	21.4	2.8	2.2	3.2
Japan	77.0	2.2	0.5	0.2
Republic of Korea	72.0	6.8	3.1	1.0
Mongolia	51.2	4.4	3.3	3.7
South Asia	27.8	3.7	4.3	3.7
Bangladesh	13.6	6.7	5.4	5.0
India	28.0	3.3	3.9	3.5
Nepal	9.6	4.3	6.9	4.9
Pakistan	32.0	3.9	4.9	4.1
Sri Lanka	21.4	4.2	1.6	3.6
Southeast Asia	29.0	3.9	4.0	3.2
Burma	24.6	4.0	2.7	4.0
Indonesia	28.8	3.9	4.2	2.9
Malaysia	42.3	3.3	4.3	2.5
Philippines	42.4	4.0	3.8	3.0
Singapore	100.0	2.0	1.1	0.5
Thailand	22.6	3.7	4.2	3.4
Vietnam	21.9	4.3	3.8	3.9

Note: Regional rates are the average growth rates of all countries in that region (7 for East Asia, 9 for South Asia, 11 for Southeast Asia).

Source: UN (1989b).

A distinctive phenomenon in Asian developing countries is "urban primacy," the marked concentration of population and economic activities in one or a few large cities. Thailand is known to have the highest spatial concentration in Asia, with about two-thirds of its urban population and a preponderant share of economic activities located in the Bangkok metropolitan region. Other Asian countries exhibiting high urban primacy include Korea, which has 41 percent of its urban population in Seoul; the Philippines, with 30 percent in Manila; and Bangladesh, with 30 percent in Dhaka (Pernia 1991).

With the large population movements to cities, the burden of poverty in developing countries is shifting to urban areas. There were about 40 million urban households living in poverty in 1980, compared to about 80 million rural households. By the year 2000, the number of urban households living in absolute poverty should increase by 76 percent to 72 million, whereas that of poor rural households is expected to fall by 29 percent to 56 million (UNDP 1990). Table 3-4 shows the incidence of poverty and other indicators of physical quality of life for four Asian metropolises. It also shows that large proportions of these populations live in slums and squatter settlements—residential areas that are grossly substandard, overcrowded, and environmentally degraded.

Table 3-4. The Incidence of Poverty and Marginal Settlements in Four Asian Metropolises

Indicator	Manila	Jakarta	Calcutta	Madras
Total population (millions of persons)	6.4	8.0[a]	9.2	5.0
Area (square kilometers)	646.0	550.0	800.0	1,170.0
Urban density (persons per hectare)	98.0	200.0	115.0	43.0
Urban growth rate (percent)	3.8	4.0	3.0[b]	3.5[a]
Average household size (number of persons)	5.4	5.0	5.1	5.2
Average annual income (US$ per capita per year)	296.0[b]	132.0[d]	104.0[a]	104.0[a]
Absolute poverty level (US$ per capita per year)	266.0[b]	124.0	132.0	132.0
Percentage below absolute poverty level	35.0	60.0	60.0	45.0
Percentage of population in substandard housing (slums)	45.0	40.0	33.0	60.0
Percentage living in squatter or illegal settlements	30.0	NA	NA	25.0
Education levels (literacy rates)	85.0	78.0	65.0	66.0
Percentage of labor force in the informal sector	50.0	65.0	54.0	60.0
Percentage with access to water (house connection)	43.0	47.0	48.0	40.0
Percentage of garbage collected daily	70.0	25.0	55.0	78.0
Percentage with access to human waste disposal systems	60.0	42.0	45.0	58.0

Notes: Data may not be comparable due to a lack of standardized definitions. NA = not available.

[a]1975.

[b]1980.

[c]1983.

[d]1984.

Source: Lea and Courtney (1986).

There is not necessarily a strong correlation between rapid urban growth and urban environmental problems, and it is misleading to suggest that population growth is the leading problem. Many cities have not grown rapidly, yet they have major problems with poverty and environmental degradation. Also, most serious problems of environmental degradation in and around cities would not have arisen if per capita incomes were higher and more equally distributed, and if the necessary investments had been made (Hardoy and Satterthwaite 1989). New productive investments are usually highly concentrated in cities as a result of macroeconomic and sectoral policies, but these tend to benefit only industrial and commercial interests and upper income groups; the lower income majorities—particularly in most South Asian and some Southeast Asian cities—receive little or no benefit from public sector urban investments. Most slums and squatter settlements remain beyond the reach of public water supply services, have low sewerage connection rates, and lack such services as refuse collection and electricity (see table 3-4). Because these settlements lack even the most basic facilities and services, their immediate and surrounding physical environment is heavily polluted, which in turn threatens the continued livability of cities.

Urban environmental problems such as pollution, congestion, and the degradation of natural support systems will probably worsen without appropriate public interventions, and a disproportionate share of the adverse impacts will fall upon the urban poor. Effective and cost-effective strategies for managing the urban environment require, among other things, a thorough if preliminary understanding of the incidence and impacts of urban environmental problems. The following sections present available information on Asian cities, including rough estimates of the economic costs of some of the major impacts. These were derived using the valuation techniques discussed in chapter 2.

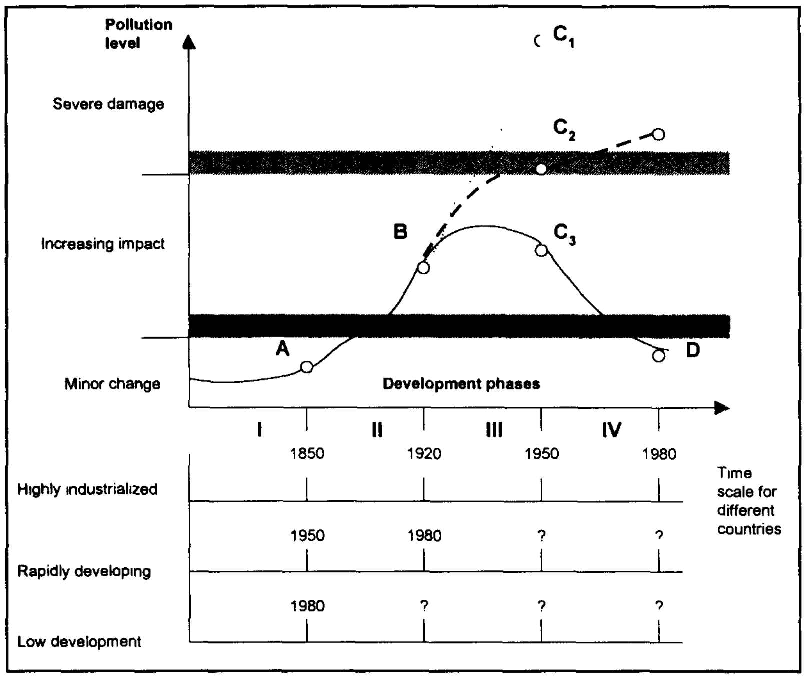
Note that throughout this report, discussion is strictly confined to urban environments; urban-rural and intercity effects—which are, of course, also very important—are not addressed here.

3.2 Pollution: Incidence, Impacts, and Valuation

Pollution occurs when residuals exceed the environment's assimilative capacity. In metropolises, the concentration of people, motor vehicles, industries, and so on quickly overtaxes the local ecosystem's self-purification capabilities unless extraordinary preventive measures are taken (see figure 3-1).

Gaseous, liquid, and solid wastes pollute air, water, and land, respectively. They also interact with each other. For instance, polluted air leads to acid rain, which affects water quality; rain transports pollutants from land to surface waters and groundwater. And urbanization itself reduces the assimilative capacities of the environment by removing vegetation, slowing air and water flows, generating heat, and reducing the land's infiltration capacity.

Figure 3-1. Conceptual Model of Pollution Occurrence and Control: Domestic Sewage Pollution in Europe



A pollution increase linear with population increase (rural society)
A-B exponential increase of pollution with industrialization
B-C_1 no pollution control enacted
B-C_2 some controls installed (e.g., mechanical sewage treatment)
B-C_3 effective controls consistently employed (e.g., mechanical-biological wastewater treatment)
C_3-D recovery of pollution situation to a tolerable environmental status due to effective source control and/or tertiary treatment of effluents

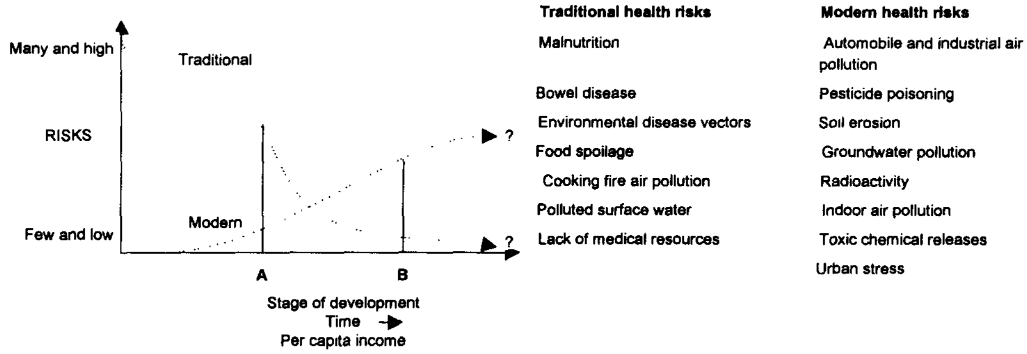
Source: Meybeck, Chapman, and Helmer (1989).

3.2.1 Incidence in Asian Cities

Normally urban development is accompanied by a "risk transition"—that is, a decline in traditional health risks followed by a rise in the modern risks associated with industrialization (see figure 3-2). When modern risks are introduced at relatively early stages of development, people are exposed to many types of pollution at once (Smith 1990c). According to Jamieson and Li (1988), "history has trapped much of Southeast Asia in a 'risk transition' phase of development. Essentially . . . people have the worst of both [traditional and modern] worlds."

Many Asian cities have a wide spectrum of pollution problems, ranging from human excreta to hazardous manmade chemicals. Although far from complete, the data presented here give some indication of the magnitude of Asia's pollution problems.

Figure 3-2. The Risk Transition



Source: Smith (1990c).

Indoor Air Pollution

Indoor air pollution occurs in both the home and workplace. If tobacco smoke is included, indoor air pollution constitutes a greater threat to human health than outdoor air pollution in both developed and developing countries, especially because people spend most of their time indoors (K. Smith 1988). Studies in Chinese cities (Krupnick and Sebastian 1990; ESCAP 1990a) showed high levels of particulates, sulfur dioxide (SO_2), carbon monoxide (CO), and benzopyrenes in households that use coal stoves for heating and/or cooking. Suspended particulate concentrations in coal-burning urban households in India measured 25,000 micrograms per cubic meter ($\mu g/m^3$). Where wood and dung are used as cooking fuel in poorly ventilated households, particulate concentrations as high as 15,000 to 20,000 $\mu g/m^3$ have been measured, and benzo(alpha)pyrene levels as high as 9,000 nanograms (ng) per m^3 (IIED and WRI 1987, K. Smith 1988). Other sources of household air pollution are building materials and chemical products; these are more prevalent in high-income cities and neighborhoods.

Air pollutants discovered in the workplace include toxic chemicals and heavy concentrations of dust. In Bombay, workers in asbestos factories are exposed to asbestos; textile mill workers inhale large quantities of cotton dust; and workers in the chemical industry and at the Bombay Gas Company are exposed to hazardous fumes (CSE 1989). Workers at a smelter in Shenyang, China, are exposed to inorganic arsenic (ESCAP 1990a). In Bangkok, workers appear to be exposed to high levels of manganese and lead in dry cell and lead-acid battery factories, respectively. Workers in pesticide manufacturing plants are exposed to organophosphorus chemicals (Cirillo et al. 1988).

Ambient Air Pollution

Ambient air pollution depends not only on the quantity of pollutants emitted, but also on wind, rain, and susceptibility to atmospheric temperature inversions. Table 3-5 shows the number of days per year that ambient concentrations of SO_2, total suspended particulates (TSP), and smoke exceeded the upper limits of World Health Organization (WHO) guidelines in selected Asian cities. These data "point to the special risk for people living in the developing countries of Asia in large cities such as Shenyang and Calcutta. In contrast, even Sao Paulo and Santiago appear healthful" (WRI 1990). Japan's relatively low levels of SO_2 are largely attributable to major investments in fuel desulfurization, pollution control devices, and energy efficiency.

Other important factors in ambient air quality are hydrocarbons, CO, nitrogen oxides (NO_x), ozone, and lead. Table 3-6 provides some recent data on air quality in a number of Asian cities, along with WHO guidelines. To compare the data to the guidelines, first refer to the footnotes for the measures used (e.g., 8-hour, 24-hour, mean daily, or annual average). Boldfaced numbers exceed WHO guidelines.

Air pollution is closely related to the energy resources used. Except in China, where very large amounts of coal are burned, ambient lead is almost exclusively generated by motor vehicles burning leaded gasoline. In Jakarta, motor vehicles emitted 4,300 kilograms (kg) of lead per day in 1987 (Hadiwinoto and Clarke 1990); in Delhi, the amount is estimated at 600 kg per day (*New Straits Times* 7 January 1989). China, Hong Kong, Japan, Korea, Malaysia, and Thailand have begun using unleaded and/or less leaded gasoline; Taiwan has also begun a gradual transition.

Information on factors that contribute to the "greenhouse effect" (global warming)—now thought to include fossil fuel burning, cement production, deforestation, methane emissions, and chlorofluorocarbon use—are generally only found in countrywide data, not by city nor even by urban/rural distinctions. China leads Asian countries with a net total atmospheric increase for 1987 of 380 million tons of carbon, followed by India with 230 million tons, Japan with 220 million, and Indonesia with 140 million (WRI 1990). The remaining Asian countries were responsible for much less than 100 million tons of carbon each. By contrast, the United States contributes 1 billion tons of greenhouse gases.

This information has not been well-received in developing countries, which have been campaigning, along with development banks, for an environmental fine to be levied on industrialized nations. Further, the Centre for Science and Environment claims that the CO_2 from deforestation and methane from rice fields and livestock have been exaggerated, and criticizes the methods used to calculate the airborne portion. Other criticisms of the World Resources Institute findings include the study's failure to distinguish between "survival" emissions by poor countries and "luxury" emissions by richer ones (McCully 1991); Smith (1991) also notes that since CO_2 is a long-lived pollutant, current emission levels are far less relevant than the cumulative CO_2 generated since the turn of the century. This widens the gap between developed and developing countries, especially in calculating on a per capita basis (e.g., 260 tons/capita for U.S. citizens compared to 6 tons for the average resident of India).

Apart from common air pollutants, other harmful substances are released occasionally in industrial disasters, such as the release of methyl isocyanate from the Union Carbide plant in Bhopal, India (CSE 1985 and 1989) and in the Klong Toey explosions of 1989 and 1991 (see box 3-1).

Table 3-5. Air Pollution in Selected Cities

Country/city	SO_2 - No. days over 150 $\mu g/m^3$				TSP[a] - No. days over 230 $\mu g/m^3$				Smoke - No. days over 150 $\mu g/m^3$			
	Site years	Min.	Avg.	Max.	Site years	Min.	Avg.	Max.	Site years	Min.	Avg.	Max.
North America												
Canada - Hamilton	8	0	3	7	10	0	8	14	x	x	x	x
Montreal	10	0	10	32	15	0	0	6	x	x	x	x
Toronto	9	0	1	3	14	0	1	7	x	x	x	x
Vancouver	5	0	0	0	12	0	0	7	x	x	x	x
U.S. - Birmingham	x	x	x	x	9	0	7	28	x	x	x	x
Chattanooga	x	x	x	x	16	0	1	17	x	x	x	x
Chicago	4	0	1	2	7	0	6	14	x	x	x	x
Fairfield	x	x	x	x	5	0	0	0	x	x	x	x
Houston	3	0	0	0	7	0	0	0	x	x	x	x
New York	12	1	8	22	12	0	0	0	x	x	x	x
St. Louis	3	1	3	8	x	x	x	x	x	x	x	x
South America												
Brazil - Rio de Janeiro	x	x	x	x	6	0	11	35	x	x	x	x
Sao Paulo	11	0	12	32	x	x	x	x	11	16	31	52
Chile - Santiago	9	0	19	55	x	x	x	x	9	11	102	299
Colombia - Cali	1	0	0	0	x	x	x	x	x	x	x	x
Medellin	3	0	0	0	3	0	0	0	x	x	x	x
Venezuela - Caracas	8	0	0	0	x	x	x	x	8	0	0	0
Asia												
China - Beijing	8	0	68	157	8	145	272	338	x	x	x	x
Guangzhou	12	0	30	74	10	7	123	283	x	x	x	x
Shanghai	10	0	16	32	10	19	133	277	x	x	x	x
Shenyang	7	43	146	236	13	117	219	347	x	x	x	x
Xian	7	4	71	114	10	189	273	327	x	x	x	x
Hong Kong	10	0	15	74	x	x	x	x	11	0	3	18
India - Bombay	13	0	3	32	12	23	100	207	x	x	x	x
Calcutta	8	0	25	85	8	189	268	330	x	x	x	x
Delhi	12	0	6	49	12	212	294	338	x	x	x	x
Indonesia - Jakarta	x	x	x	x	7	4	173	268	x	x	x	x
Iran - Tehran	15	6	104	163	15	8	174	347	15	12	122	249
Israel - Tel Aviv	9	0	3	24	x	x	x	x	x	x	x	x
Japan - Osaka	20	0	0	0	20	0	0	2	x	x	x	x
Tokyo	15	0	0	0	15	0	2	4	x	x	x	x
Malaysia - K. Lumpur	1	0	0	0	5	10	37	59	x	x	x	x
Philippines - Manila	4	3	24	60	7	0	14	225	x	x	x	x
Rep. of Korea - Seoul	6	5	87	121	x	x	x	x	x	x	x	x
Thailand - Bangkok	3	0	0	0	12	5	97	209	x	x	x	x
Europe												
Belgium - Brussels	13	0	12	32	x	x	x	x	13	0	0	2
Denmark - Copenhagen	3	0	0	0	6	0	0	1	6	0	0	0
Finland - Helsinki	8	0	2	7	11	0	19	75	x	x	x	x
France - Gourdon	4	27	46	64	x	x	x	x	9	0	3	7
Germany - Frankfurt	6	8	20	38	3	0	0	0	x	x	x	x
Munich	3	0	0	1	x	x	x	x	x	x	x	x
Greece - Athens	3	1	9	15	x	x	x	x	x	x	x	x
Ireland - Dublin	6	0	1	3	x	x	x	x	6	0	6	15
Italy - Milan	8	6	29	167	x	x	x	x	x	x	x	x
Netherlands - Amsterdam	10	0	1	5	x	x	x	x	x	x	x	x
Poland - Warsaw	13	3	10	19	x	x	x	x	14	4	17	33
Wroclaw	15	1	8	22	x	x	x	x	15	9	30	73
Portugal - Lisbon	x	x	x	x	7	4	12	28	x	x	x	x
Spain - Madrid	7	0	35	95	x	x	x	x	4	4	60	126
U.K. - Glasgow	5	4	14	21	x	x	x	x	5	2	6	8
London	6	0	7	17	x	x	x	x	6	0	0	0
Yugoslavia - Zagreb	15	3	30	80	15	13	34	57	x	x	x	x
Oceania												
Australia - Melbourne	13	0	0	0	4	0	0	0	x	x	x	x
Sydney	12	0	2	11	10	0	3	19	x	x	x	x
New Zealand - Auckland	12	0	0	0	x	x	x	x	12	0	0	0
Christchurch	12	0	0	2	x	x	x	x	12	0	8	25

Key: 0 = zero or less than half the unit of measure, x = not available

[a]Gravimetrically determined suspended particulate matter.

Source: UNEP and WHO (1988), as reproduced in WRI (1990)

Table 3-6. Ambient Air Quality Data ($\mu g/m^3$)

City/year	SO_2	TSP	NO_x	CO	Lead
Bangkok 1985[a]	18	**110**		5,000	0.3
1986[b]		80 - **200**			0.23 - 0.44
1989[c]		**570**			
1989[b]		**302 - 687**		1,300 - **14,400**	1.3 - 3.0
Beijing 1983-88[b]		**268 - 462**			
1985[a]	**75**	**130**			
1988		**600**[c]	118[d]	3,400[d]	
Bombay 1983-88[b]		140 - 267			
1985[a]	30	**110**	20		
1990[e]	10 - **106**	**299 - 610**	39-130		
Calcutta 1983-88[b]		**333 - 426**			
Delhi 1985[a]	40	**131**	32		
1988[f]		200 - **1,000**	240-**480**	4,500 - 6,000	
1989[g]		**300**			
Hong Kong 1983-88[b]		21 - 48			
1985[a]	45	43			0.14
Jakarta 1985[a]		**115**			
1991[h]		315 - 550			**90**
Kuala Lumpur 1983-88[b]		96 - 112			
1985[a]	22	**105**			
1990[i]		80 - **400**			
Manila 1985[a]	**65**				
Seoul 1985[a]	**105**				
Shanghai 1983-88[b]		152 - **285**			
1985[a]	50	**111**			
Shenyang 1983-88[b]		**258 - 529**			
Singapore 1985[a]			46		0.9
Tianjin 1989[j]	130	**360**			
Tokyo 1985[a]	35	60			

WHO guidelines:[a]

- SO_2 annual mean: 40-60 $\mu g/m^3$
  98% of daily averages: 100-150 $\mu g/m^3$; 10 minutes: 500 $\mu g/m^3$; 1 hour: 350 $\mu g/m^3$
- TSP annual mean: 60-90 $\mu g/m^3$; 98% of daily averages: 150-230 $\mu g/m^3$
- NO_x 1 hour: 400 $\mu g/m^3$; 24 hours: 150 $\mu g/m^3$
- CO 15 minutes: 100 mg/m^3 (100,000 $\mu g/m^3$); 30 minutes: 60 mg/m^3 (60,000 $\mu g/m^3$); 1 hour: 30 mg/m^3 (30,000 $\mu g/m^3$); 8 hours: 10 mg/m^3 (10,000 $\mu g/m^3$)
- Lead Annual mean: 0.5-1.0 $\mu g/m^3$

Note: Values exceeding standards are in boldface.

[a]Faiz et al. (1990). Figures in table represent annual average concentrations, except for CO, which is maximum 8-hour concentration.
[b]USAID (1990a). 1986 Bangkok TSP and lead: range of annual average concentrations from various monitoring stations. Other cities TSP: mean daily concentration. 1989 Bangkok: CO is minimum and maximum 8-hour mean at curbside monitors; TSP and lead are 24-hour concentrations at curbside monitors.
[c]*Indonesian Observer* 4 November 1990. Average curbside level for Bangkok TSP; occasional occurrence for Beijing TSP.
[d]Krupnick and Sebastian (1990). Quarterly average for CO and NO_2.
[e]"Bombay Environmental Profile" (1990). Range of annual average values over 22 monitors.
[f]*New Straits Times* 7 January 1989. Range of values at 50 curbside monitors during rush hour.
[g]*India Today* 31 August 1990. Average level.
[h]*Bangkok Post* 2 April 1991. Concentrations during rush hours.
[i]*New Straits Times* 20 March 1991. 24-hour level; range represents difference between inverted atmospheric temperature and normal conditions.
[j]Leitmann (1991b). Daily average.

Water Pollution

Rivers that flow through many Asian cities arrive laden with nutrients (nitrogen and phosphorus), pathogens, sediment, and pesticide residues from the watershed. In the cities, the water becomes increasingly polluted with sewage, industrial effluents, and—in some cases—solid wastes. According to CSE (1989), "it is within the cities themselves that the environmental effects of uncontrolled industrial development and inadequate investments in basic infrastructure (drainage and sewage systems, treatment plants) are the most evident." In Delhi, for instance, the coliform count (mostly from fecal pollution) is 7,500 per 100 milliliters (ml) when the Yamuna enters Delhi, and a stunning 24 million per 100 ml when it leaves the city. That stretch of the Yamuna also receives about 20 million liters of industrial effluents, including 500,000 liters of DDT wastes per day (CSE 1982 and 1989). Some stretches of rivers in Asian cities are "dead"—black in color and foul smelling because of a complete lack of dissolved oxygen (DO). Most of these rivers could be revived, however, with proper treatment.

Box 3-1. Hazardous Chemicals Threaten Slum-Dwellers in Bangkok

On March 2, 1991, five people died and over 3,000 were made homeless by fires from a massive chemical explosion in Bangkok's Klong Toey port. First, large sacks of phosphorus caught fire, then some 200-liter tanks of liquid alcohol exploded, then three tanks of chemical gas exploded. In all, three of five warehouses owned by the Port Authority of Thailand and housing stores of about 30 dangerous chemicals—including hydrogen peroxide, aluminum powder, polyurethane, and DDT—were destroyed. According to newspaper reports, the explosions "spewed fireballs" at the nearby slum area and created an "eerie black cloud" visible for 20 miles. Damage to goods and warehouses was estimated at least Bt40 million (US$1.55 million).

This was the second time in just two months that this slum was burned by a chemical fire; a similar incident had occurred in 1989 as well. Many of the victims were taken to hospitals for testing. All but a few had blood levels of methyl bromide above the acceptable safe level. Some reported strong physical reactions to the subsequent rainfall, such as "burning pain on the skin, congested breathing, and a sore throat." Former Member of Parliament Dr. Pichit Rattakul, leader of the Anti Toxic-Smoke Club, visited the site and warned the people not to drink the rainwater. It is feared that some of the unborn children whose mothers inhaled the toxic fumes and/or were exposed to the contaminated rainfall will have deformities, as occurred in 1989.

Victims were urged to sue the Port Authority of Thailand, but none of them were willing to do so for fear of eviction from their homes; the site is owned by the Port Authority.

The chemical waste left over from the fire was eventually buried in Kanchanaburi Province and, according to local residents, it seeped into waterways to cause foul odors and skin ailments. Protest posters and banners appeared in front of homes and shops. But here, as in Bangkok, there is a sensitive situation involving property rights: The army, which was charged with burying the wastes, has been trying to evict the "trespassers" in this area, since it was declared the property of the Ninth Infantry Regiment in 1978. Villagers without proper documents are trying to prove that they have been on this land for generations.

Incidences such as these suggest that the USAID (1990a) estimate of fewer than one cancer per year as the health effect of hazardous wastes may be much too low.

Sources: Bangkok Post *3 March 1991, 4 March 1991, 25 March 1991, 14 July 1991;* The Nation *4 March 1991, 15 March 1991.*

Table 3-7 indicates the effects of various standard pollutants on water quality, as reported in the literature. The broad ranges reflect the use of different monitoring stations as well as seasonal variations. For comparison, water quality standards for Seoul are given in table 3-8. Tables 3-9 and 3-10 list concentrations of organochlorine pesticides for Bangkok and Manila—clearly, some standards are exceeded in both cities. Although the Global Environmental Monitoring System does not provide data on specific cities, it has reported extremely high levels of dieldrin in Malaysia, DDT in India, hexachlorocyclohexane (HCH) in China, and polychlorinated biphenyls (PCBs) in Japan and Indonesia (UNEP and WHO 1988b).

Table 3-7. Water Pollution in Asian Cities

	Bangkok			Colombo			Jakarta					
	Chao Phraya	Canal	Ground-water	Kelani River	Canal	Delhi		Jakarta Bay	Manila		Seoul	Tianjin
Pollution type	1989	1989	1989	1990	1986	1982	1986	1990	1984	1985	1986	1989
BOD (mg/l)	0.58 - 8.5	5.2 - 8.6					5 - 200			3 - 350	2.5 - 4.2	
COD (mg/l)				5 - 40			10 - 400	18 - 81			4.0 - 5.3	6
Dissolved oxygen	1 - 5	0 - 3		6 - 13	0 - 6		1.2 - 5.8			0 -8.5	7.6 - 9.9	
Fecal coliform (MPN/100 ml)	11,000 - 194,000	14,000 - 550,000				7,500 - 24 mil.	10 mil. - 100 mil.			3,332 - 512,120		
pH	7.1 - 7.7	7.5 - 8.1	6.5 - 8.2	6 - 7	6.2 - 7.6							
Copper (mg/l)	0 - 0.01	0 009 - 0.01	0 - 0.009						0 - 0.91	0 - 0.06		
Lead (mg/l)	0 - 0.04	0.02	0 - 0.05									
Cadmium (mg/l)	0.002 - 0.006	0.004	0 - 0.004						0 - 0.05			
Nitrogen — NO_3 (mg/l)	0.2 - 2	0.6 - 0.9	0.2 - 3.2	0.02 - .2								
Nitrogen — NH_3 (mg/l)	0.06 - 0.8	0.26 - 1.3		0.04 - 6.07	0.5 - 7							
Phosphorus — PO_4 (mg/l)	0.2 - 1	0.4 - 0.6										

Notes: BOD = biochemical oxygen demand; COD = chemical oxygen demand; MPN = most probable number; pH = acidity (7 = neutral, <7 = acidic).

Sources: Bangkok: USAID (1990a); Colombo: "Colombo City Profile" (1990); Delhi: CSE (1982); Jakarta: Pusat Litbang Pengairan and Delft Hydraulics Laboratory (1986) and Hechanova (1990); Manila: Jimenez and Velasquez (1989) and ESCAP (1990b); Seoul: Shin 1989; and Tianjin: Leitmann (1991b).

Table 3-8. Water Quality Standards (River and Lake) Korea 1989

		Standard					
Class	**Purpose**	**Hydrogen ion (pH)**	**BOD (mg/l)**	**COD (mg/l)**	**SS (mg/l)**	**DO (mg/l)**	**Bacillus (MPN/100ml)**
I	Waterworks grade 1 Natural environmental preservation	6.5 - 8.5	Below 1	Below 1	Below 25	Over 7.5	Below 500
II	Waterworks grade 2 Aquaculture grade 1 Swim	6.5 - 8.5	Below 3	Below 3	Below 25	Over 5	Below 1,000
III	Waterworks grade 3 Aquaculture grade 2 Industrial grade 1	6.5 - 8.5	Below 6	Below 6	Below 25	Over 5	Below 5,000
IV	Industrial grade 2 Agricultural use	6.0 - 8.5	Below 8	Below 8	Below 100	Over 5	—
V	Industrial grade 3 Living environment preservation	6.0 - 8.5	Below 10	Below 10	No hard wastes	Over 2	—

Notes: BOD = biochemical oxygen demand; COD = chemical oxygen demand; SS = suspended solids; DO = dissolved oxygen: MPN = most probably number.

Source: Shin (1989).

Table 3-9. Concentrations of Organochlorine Pesticides in the Chao Phraya River, Bangkok: April and October 1984

Pesticide	April			October			Water qual. standard (µg/l)
	Frequency (%)	Max. (µ g/l)	Med. (µg/l)	Frequency (%)	Max. (µg/l)	Med. (µg/l)	
Alpha BHC	95	0.056	0.002	100	0.035	0.007	0.02
Beta BHC	5	0.024	ND	0	ND	ND	ND
Gamma BHC (Lindane)	27	0.021	ND	72	0.032	0.003	ND
Heptachlor	41	0.015	ND	27	0.166	ND	0.2
Heptachlor epoxide	32	trace	ND	18	trace	ND	ND
Chlordane	0	ND	ND	0	ND	ND	ND
Aldrin	100	0.284	0.126	100	0.028	0.008	0.1
Dieldrin	100	0.289	0.080	88	0.442	0.029	0.1
Endrin	0	ND	ND	0	ND	ND	0
p,p' -DDE	36	0.031	ND	18	0.030	ND	ND
o,p' -DDT	0	ND	ND	0	ND	ND	1.0
p,p' -DDD	9	0.025	ND	18	0.03	ND	ND
p,p' -DDT	13	0.015	ND	9	0.271	ND	1.0

Note: ND = not detectable.

Source: Thailand Natural Resources Profile (1987), as reproduced in Cirillo et al. (1988).

Table 3-10. Pesticide Levels (µg/1) in Selected Metro Manila River Systems

Pesticide	Pasig-Marikina	Paranaque Zapote	San Juan
Alpha BHC	0.012 - 0.026	0.011 - 0.028	0.012 - 0.026
Gamma BHCC	0.013 - 0.24	0.014 - 0.024	0.016 - 0.022
Heptachlor	0.008 - 0.016	—	0.008 - 0.010
Epoxide	trace - 0.026	0.006 - 0.012	trace - 0.010
Aldrin	trace - 0.008	trace - 0.012	0.008 - 0.012
Dieldrin	—	trace - 0.012	—

Source: Jimenez and Velasquez (1989).

High levels of mercury were reported for Bangkok, Bombay, Jakarta, and Manila. Other pollutants found in the surface waters of Asian cities include:

- **Bangkok:** Distillery wastes, oil, solvents (TDRI 1987, Phantumvanit and Panayotou 1990).
- **Jakarta:** Chromium, nickel, zinc (*Indonesian Observer* 7 June 1990, Hadiwinoto and Clarke 1990).
- **Kuala Lumpur:** Solvents, paints, oil, rubbish, and an unidentified effluent from a paper company "colouring the water blue and green for about two kilometres." Inflammable paint wastes near a metalworks factory are thought to have caused "the fiery death of schoolboy V. Govinathan in a drain" (*New Straits Times* 7 January 1991).
- **Manila:** Oil, zinc, silver (Hechanova 1990, ESCAP 1990b, Jimenez and Velasquez 1989).
- **Osaka:** Dioxin (*Japan Times* 3 December 1990).
- **Seoul:** Manganese, cadmium, copper, lead, zinc (Cirillo et al. 1988, Ranee 1990).

Solid Wastes

Residents of low-income Asian cities generate about 0.4 to 0.7 kg/capita/day of solid waste; middle-income residents generate 0.5 to 1.0 kg; and high-income residents generate 0.8 to 1.5 kg (ESCAP 1990a).

Disposal methods are apparently related to the ability to pay for them, and range from no garbage collection at all, to landfills, to composting and recycling plants and incinerators. Most of the waste generated in Kitakyushu, Nagoya, Singapore, and Tokyo is incinerated. On the other hand, all solid waste collected in Beijing, Bombay, Colombo, Kuala Lumpur, and Manila goes to landfills. Except in Kuala Lumpur, these are generally open dumps rather than sanitary landfills. In very poor areas, solid wastes are "recycled" by scavengers. In Manila, for instance, the approximately 20,000 people who live around the dump known as "Smokey Mountain" "refuse to be relocated since they claim that they would lose their sources of livelihood by doing so" (Jimenez and Velasquez 1989). Several thousand scavengers live in Bangkok (USAID 1990a); they are also common in the cities of India and China (CSE 1985, Bo 1990).

Where garbage collection services do not exist, much solid waste is dumped into waterways: In Manila, for example, 2,034 m^3/day is disposed of in this way (Jimenez and Velasquez 1989). Besides contributing to water pollution problems, this causes drains to become blocked and increases flooding.

Many environmental problems are associated with dumpsites: They take up increasingly large portions of valuable land area; have an unpleasant appearance and odor; are plagued by smoke from fires; permit chemicals to leach into surface and groundwaters; and breed rats, flies, and mosquitoes. In Bombay, landfills are sprayed with insecticide, which may be leaching into the groundwater ("Bombay Environmental Profile" 1990). Methane gas at landfills poses an explosion risk (Hadiwinoto and Clarke 1990); incinerators create air pollution and ash disposal problems.

Hazardous Wastes

There is no generally agreed-upon definition of hazardous wastes as a separate pollution category. Typically, however, these include reactive, toxic, ignitable, infectious, and corrosive wastes. Some countries count radioactive wastes as hazardous, but most put these in a separate category because of their special nature and handling procedures (Cirillo et al. 1988).

Few cities have the capability to manage hazardous wastes. Even where industries have wastewater treatment facilities, such as in Manila, there are usually no facilities for secure disposal of concentrates and sludges. Often, solid hazardous wastes are disposed of in regular public dumpsites or in waterways (Hechanova 1990, Diaz 1991). To alleviate this problem, Bangkok's Department of Industrial Works has built one hazardous waste treatment center; three others are planned (Phantumvanit and Liengcharernsit 1989, ESCAP 1990a). Malaysia and Indonesia are also studying the feasibility of centralized hazardous waste treatment facilities. The first step in most cases, however, is separation and "temporary storage." China and Japan appear to have made some progress in devising methods for detoxifying hazardous wastes and subsequently turning them into bricks, glass, etc. (Cirillo et al. 1988).

The disposal of hazardous wastes engenders many other problems as well: inappropriate site selection; inadequate security, data collection, and waste treatment techniques; and poor formulation and enforcement of regulations. Government agencies in developing countries tend to be short on funding and are reluctant to offend industries that earn foreign exchange (Batstone and Bartone n.d., Bartone

1989). The lure of foreign exchange earnings has also caused some cities to accept hazardous waste from other countries.

As of 1988, total accumulated radioactive wastes from nuclear power plants were: Taiwan, 900 tons (254.2 kg/1,000 ha); Japan, 5,600 tons (148.7 kg/1000 ha); Korea, 700 tons (71.3 kg/1000 ha) (WRI 1990).

Noise Pollution

Noise is generated by traffic (including boats and aircraft), industry, construction activities, and the like. As for other forms of pollution, information on noise pollution in Asian cities is incomplete, but scattered data are available:

- **Bangkok:** 72-95 decibels (dB) (Phantumvanit and Liengcharernsit 1989).
- **Beijing:** 72.1 dB average (Beijing Municipal Environmental Protection Bureau 1990).
- **Bombay, Calcutta, and Delhi:** Average level 90 dB (CSE 1989).
- **Kuala Lumpur:** 108 dB during jet takeoffs and landings (Padman 1991) (for comparison purposes).
- **Manila:** 41-79 dB (Hechanova 1990).
- **Tianjin:** 62 dB average daytime noise level; 72 dB average on major roads (Leitmann 1991b).

No information was found on thermal pollution or radiation in Asian cities.

3.2.2 Impacts of Pollution

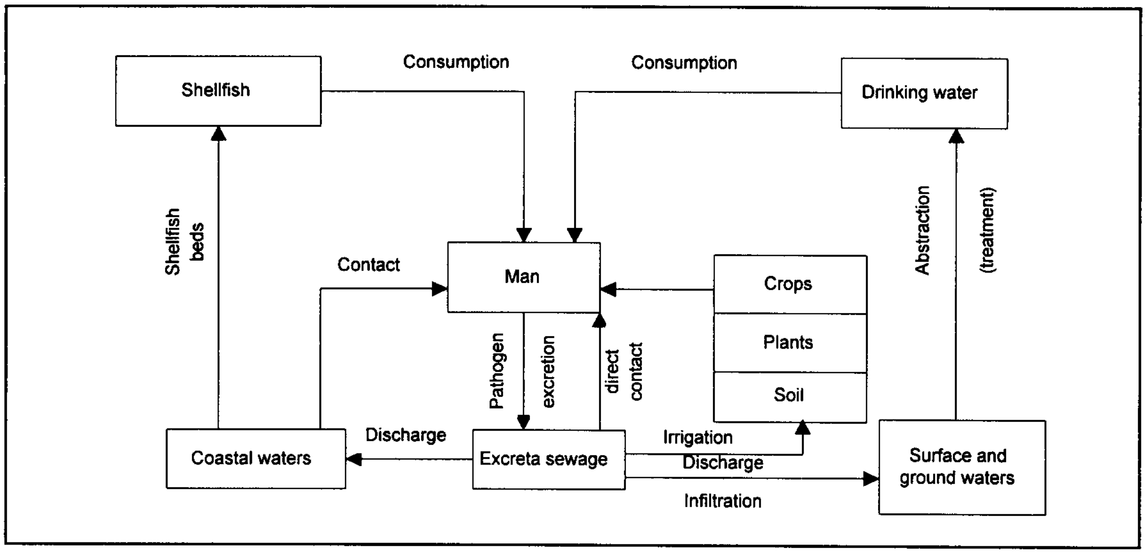
As noted in table 1-1, pollution has adverse effects on human health and safety, the physical productivity of the urban economy, and amenity and ecological values of the urban environment. Unfortunately, much of the available information on pollution impacts is anecdotal rather than statistical; very little can be found on amenity and ecological values.

Health and Safety

"In the cities such as Jakarta and Bandung the rivers are used as open sewers . . . Many people use the rivers for bathing, washing, dumping garbage and as a toilet, while they withdraw drinking water from them at the same time. Consequently, water borne and water washed diseases are a major threat to public health" (Pusat Litbang Pengairan and Delft Hydraulics Laboratory 1986).

Conditions are similar in other developing countries of Asia. In fact, water-related disease (which includes diseases associated with sanitation, drinking water, and mosquitoes) is the leading cause of death in developing countries. About 35,000 children die each day from waterborne diseases, accounting for 80 percent of infant deaths worldwide ("ADB Water Conference" 1990). Most of these deaths stem from bacteria and viruses, whose spread is, in large part, due to inadequate sanitation (see figure 3-3). Longer term health effects can be attributed to toxic chemicals in the water, as shown in table 3-11. In Jakarta, some children show signs of mercury poisoning ("Poisons in the Stream" 1991).

Figure 3-3. The Main Pathways of Human Exposure to Pathogens in the Aquatic Environment



Note: "Direct Contact" added.

Source: Meybeck, Chapman, and Helmer (1989).

Table 3-11. Selected Effects of 21 Toxic Chemicals on Health and the Environment

Chemical	Human health effects			Environmental effects
	Carcinogen	Fetal risk	Other	
Aldrin/dieldrin	✓		Tremors, convulsions, kidney damage	Toxic to aquatic organisms, reproductive failure in birds and fish, bioaccumulates in aquatic organisms
Arsenic	✓	✓	Vomiting, poisoning, liver and kidney damage	Toxic to legume crops
Benzene	✓		Anemia, bone marrow damage	Toxic to some fish and aquatic invertebrates
Bis-(2-ethyl-hexyl) phthalate	✓	✓	Central nervous system damage	Eggshell thinning in birds, toxic to fish
Cadmium	✓	✓	Suspected causal factor in many human pathologies: tumors, renal dysfunction, hypertension, arteriosclerosis, Itai-itai disease (weakened bones)	Toxic to fish, bioaccumulates in aquatic organisms
Carbon tetrachloride	✓		Kidney and liver damage, heart failure	Ozone-depleting effects
Chloroform	✓		Kidney and liver damage	Ozone-depleting effects
Copper			Gastrointestinal irritant, liver damage	Toxic to fish
Cyanide			Acutely toxic	Kills fish, retards growth and development of fish
DDT	✓	✓	Tremors, convulsions, kidney damage	Reproductive failure in birds and fish, bioaccumulates in aquatic organisms, biomagnifies in food chain
Di-n-butyl phthalate			Central nervous system damage	Eggshell thinning in birds, toxic to fish
Dioxin	✓	✓	Acute skin rashes	Bioaccumulates
Lead	✓	✓	Convulsions, anemia, kidney and brain damage	Toxic to domestic plants and animals, biomagnifies in food chain
Mercury		✓	Irritability, depression, kidney and liver damage, Minamata disease	Reproductive failure in fish, inhibits growth of and kills fish, methyl-mercury biomagnifies

Chemical	Human health effects: Carcinogen	Human health effects: Fetal risk	Human health effects: Other	Environmental effects
Nickel	✓		Gastrointestinal and central nervous system effects	Impairs reproduction of aquatic species
Polychlorinated biphenyls (PCBs)	✓	✓	Vomiting, abdominal pain, temporary blindness	Liver damage in mammals, kidney damage and eggshell thinning in birds, suspected reproductive failure in fish
Phenol				Reproductive effects in aquatic organisms, toxic to fish
Silver				Toxic to aquatic organisms
Tetrachloro-ethylene	✓		Central nervous system effects	Ozone-depleting effects
Toluene	✓			Toxic to aquatic organisms at high concentrations
Toxaphene	✓	✓		Decreased productivity of phytoplankton communities, birth defects in fish and birds

Note: Checkmarks indicate known effects of substance.

Source: U.S. Council on Environmental Quality (1983), as cited in Lee (1985).

"Relatively few deaths can be attributed directly to air pollution but millions suffer from respiratory infections and many will die of some form of cancer caused or exacerbated by air pollution" (CSE 1989). For instance, tourists in Bangkok consistently complain of sore throats, skin rashes, bad sinuses, and perpetual tiredness (*Bangkok Post* 13 November 1990). These and other health effects of common air pollutants are summarized in table 3-12.

Table 3-12. Health Effects of Pollutants from Motor Vehicles

Pollutant	Health effects
Carbon monoxide	Interferes with absorption of oxygen by hemoglobin (red blood cells); impairs perception and thinking, slows reflexes, causes drowsiness, brings on angina, and can cause unconsciousness and death; affects fetal growth in pregnant women and tissue development of young children. It has a synergistic action with other pollutants to promote morbidity in people with respiratory or circulatory problems; associated with less worker productivity and general discomfort.
Nitrogen oxides	Can increase susceptibility to viral infections such as influenza; irritate the lungs and cause edema, bronchitis, and pneumonia; and result in increased sensitivity to dust and pollen in asthmatics. Most serious health effects are in combination with other air pollutants.
Hydrocarbons	Low-molecular weight compounds cause unpleasant effects such as eye irritation, coughing, sneezing, drowsiness, and symptoms akin to drunkenness; heavy-molecular weight compounds may have carcinogenic or mutagenic effects. Some hydrocarbons have a close affinity for diesel particulates and may contribute to lung disease.
Ozone (precursors: HC and NO_x)	Irritates mucous membranes of respiratory system causing coughing, choking, and impaired lung function; causes eye irritation, headaches, and physical discomfort; reduces resistance to colds and pneumonia; can aggravate chronic heart disease, asthma, bronchitis, and emphysema.
Lead	Affects circulatory, reproductive, nervous, and kidney systems; linked to hyperactivity and lowered learning ability in children; hazardous even after exposure ends. Lead is ingested through the lungs and the gastrointestinal tract.
Sulfur dioxide	A harsh irritant; exacerbates asthma, bronchitis, and emphysema; causes coughing and impaired lung functions.
Particulate matter	Irritates mucous membranes and may initiate a variety of respiratory diseases; fine particles may cause lung cancer and exacerbate morbidity and mortality from respiratory dysfunctions. A strong correlation exists between suspended particulates and infant mortality in urban areas. Suspended particulates have the ability to adhere to carcinogens emitted by motor vehicles.
Toxic substances	Suspected of causing cancer, reproductive problems, and birth defects. Benzene and asbestos are known carcinogens linked to leukemia and lung cancer; aldehydes and ketones irritate the eyes, cause short-term respiratory and skin irritation, and may be carcinogenic.

Note: There is growing evidence that the synergistic effects of these pollutants in combination may be far more serious than the adverse effects of individual pollutants. This is particularly the case where NO_x and SO_x coexist or occur in association with particulate matter.

Source: Faiz and Carbajo (1991).

Indoor air pollution is a particular concern because of relatively high concentrations and long exposure times. In the home, women who cook on wood stoves are particularly susceptible to chronic respiratory ailments. The impacts of air pollution (and other exposure pathways) in workplaces are also very serious. For workers in quarries, cement plants, and rubber product factories, major occupational health hazards are silicosis, talcosis, and stenosis—incurable lung diseases that may be fatal. Wheeler (1991) notes that in the decade 1978-87, Thailand experienced a tenfold increase in occupational diseases attributable to toxic substance exposure. In addition, an enormous number of cases of ill health, disability, and death to which industrial pollution has contributed go unreported, especially for long-term illnesses. The next 20 to 30 years will likely show that the health impacts of air and water pollution in developing countries—through direct exposure in the home or workplace—have been greatly underestimated (Hardoy and Satterthwaite 1989).

Table 3-13 summarizes information on pollution-related health effects found in the literature and in Asian newspaper articles. While much information is available on air and water pollution in Asia, very little has been said about the health and safety effects of solid and hazardous wastes; there is no mention at all of the effects of noise pollution.

Table 3-13. Health Impacts of Urban Pollution in Asia

City	Type of pollution	Impact on health
Bangkok 1989[a]	Ambient TSP	51 million restricted activity days/year; 1,400 excess mortalities/year
	Ambient CO	20,000-50,000 people at risk of increased angina pain/day; 900,000-2,300,000/day at risk of minor effects such as headaches
	Lead, all sources	200,000-500,000 cases of hypertension/year; 300-900 first heart attacks/strokes, with 200-400 deaths/year; 400,000-700,000 IQ points lost in children
	Air toxics (mobile sources)	90-100 cancer cases/year[b]
	Pesticides in food	14 cancer cases/year
	Water pollution	3 cancer cases/year
	Hazardous wastes	<1 cancer case/year
Bangkok[c]	Air pollution	900,000 cases of respiratory illness
Beijing[d]	Air pollution	Lung cancer rates increased 145% from 1949 to 1979
Bhopal[e]	Industrial accident	2,800 people dead and 40,000 disabled
Bombay[f]	Air pollution	Tuberculosis and respiratory diseases are the major killers in the city; between 1971 and 1979, deaths from tuberculosis went up from 83 to 101 per 100,000 people
Bombay[e]	Air pollution, indoor	10 - 16% incidence of byssinosis among textile mill workers
Calcutta[f]	Air pollution	60% of residents suffer from respiratory diseases
Chinese cities[f]	Air pollution	Lung cancer mortality is 4-7 times higher in cities than in the nation as whole
Chinese cities[d]	Air pollution	High rates of chronic bronchitis/chronic respiratory infections in cities vs. rural areas
Delhi[g]	Air pollution	30% of the population suffers from respiratory diseases, 12 times the national average
Manila[h]	Water pollution	8 deaths from contaminated shellfish; total 73 cases of poisoning
Manila[i]	Air pollution	471,100 cases of upper respiratory tract infection and 79,400 cases of bronchitis reported
	Water pollution	74,390 cases of gastrointestinal diseases
Nagpur[j]	Water pollution	40 deaths in one year
Shenyang[k]	Indoor air	Lung cancer risk 50 - 70% higher for those spending most of their lives inside the home

[a]USAID (1990a).
[b]Recalculated based on authors' adjusted unit price (vol. 2, p. A-19).
[c]*Bangkok Post* 11 September 1990.
[d]Krupnick and Sebastian (1990).
[e]CSE (1989).
[f]Hardoy and Satterthwaite (1989), WHO (1988).
[g]*India Today* 31 August 1991.
[h]Jimenez and Velasquez (1989).
[i]Hechanova (1990).
[j]*Times of India* 16 June 1990.
[k]ESCAP (1990a).

Most of these impacts affect the rich and poor differently. In Manila, for example, diarrhea among the urban poor has been observed to be twice as common as in the rest of the city. The infant mortality rate in the old city (slum area) of Kabul, Afghanistan, is 1.5 times that of the rest of the city (Hardoy, Cairncross, and Satterthwaite 1990). And in Delhi and Calcutta, various diseases occur at a higher rate in the slum areas and last longer per illness (CSE 1985). It is said that the poor in Bangkok are much more likely to fall ill from air pollution than the wealthy, since they must travel in public transport that is not air-conditioned (*Bangkok Post* 11 September 1990). People living on or near dumpsites are likely to have high rates of respiratory, diarrheal, and skin disease owing to their constant exposure to pathogens, insects, rodents, and particulate emissions from burning wastes (USAID 1990a, Bo 1990). In areas such as Bangkok, slum-dwellers are highly vulnerable to a variety of toxic chemical hazards (see box 3-1).

To make matters worse, "sickness impoverishes already poor households, which are plunged into a progressive spiral of declining health and economic status." This is known as the "poverty ratchet." The poor tend to remain sick because the time and money they would have to spend seeking medical treatment would lead them to deeper poverty and destitution (Corbett 1989).

Productivity

Environmental pollution leads to many types of productivity losses, including degradation of living systems such as forests, fisheries, and agriculture. Examples of the productivity impacts of urban pollution in Asia, as reported in the literature and local newspapers, are summarized in table 3-14.

Table 3-14. Productivity Impacts of Urban Pollution in Asia

City/country	Type of pollution	Impact on productivity
Delhi	Air	30% decrease in crop yield and poor quality of grains; millions of rupees lost in engineering materials, textiles, building materials, and leather goods
Jakarta	Water	US$20 million - $US30 million per year to boil water for home use
Kanpur, India	Water	Average fish catch has declined by more than 50%
Kuala Gula, Malaysia	Water	Palm oil mill wastes killed US$300,000 worth of fish; firm was required to pay fishermen US$400,000 in compensation
Manila	Water	Shellfish production of 3,430 tons in danger of being eliminated; fishery yield of Manila Bay declined by 39%, Laguna Lake by 79% from 1975 to 1988
Penang	Water	Cockle mortality valued at US$750/day
Taipei	Water	Copper in the river kills oysters

Sources: Delhi: *India Today* 31 August 1991; Jakarta: World Bank (1991b); Kanpur: CSE (1989); Kuala Gula: *The Star* 19 April 1990; Manila: Hechanova (1990); Penang: *The Sunday Star* 22 January 1989; Taipei: personal communication from Shih-Min Huang, Deputy Director General, Taiwan Environmental Protection Agency.

Amenities and Ecological Value

Many urban environments in Asia are aesthetically offensive because of the pollution problems described above. And, as it spreads, pollution degrades urban ecosystems. Very little explicit data on these impacts are available, however.

3.2.3 Economic Valuation of Pollution Impacts

Health and Safety

We used information from the USAID Bangkok risk-ranking study (USAID 1990a) to conduct the following exercises in economic valuation. In our analysis, three criteria air pollutants—TSP, CO, and lead were considered; the health effects of SO_2, NO_x, and ozone were not addressed.

Total Suspended Particulates. To estimate the effects of ambient TSP on morbidity in the USAID Bangkok study, equations developed by Ostro (1983) were applied to derive work loss days (WLD) and restricted activity days (RAD). WLD is defined as the excess number of days that illness or injury prevent an individual from working. The WLD equation, developed from a survey of 50,000 individuals in the United States, is:

$$0.00145 \times 26\ [\mathrm{dTSP} \times \mathrm{POP}]$$

RAD includes any condition of acute illness; it was calculated with the following equation:

$$0.00282 \times 26\ [\mathrm{dTSP} \times \mathrm{POP}]$$

The U.S. standard for annual average particulate concentration, 75 $\mu g/m^3$, was used as a reference level—that is, dTSP is the annual average actual TSP minus 75 $\mu g/m^3$. POP is the estimated exposed population.

The economic value of work loss days was calculated by multiplying the number of WLD/year given in USAID (1990a), average hourly wage rate (US$1.25), and the number of work hours per day (8). This estimate was not adjusted for inflation.

Next, since RAD includes WLD, RAD-WLD is the number of days that activity was restricted but the person worked anyway. The economic value was estimated by assuming a 50 percent wage loss. By this calculation, the total economic value of WLD and RAD-WLD from ambient TSP equaled almost US$390 million in 1989 (see table 3-15).

Table 3-15. Economic Value of Morbidity and Mortality Effects of Ambient TSP in Bangkok

	1983	1984	1985	1986	1989
Morbidity					
Work loss days (million days per year)	5.81	7.39	4.77	9.86	26.46
Economic value (millions of 1989 US$)	58.1	73.9	47.7	98.6	264.6
RAD - WLD[a] (million days per year)	5.44	6.91	4.46	9.24	24.78
Economic value (millions of 1989 US$)	27.2	34.6	22.3	46.2	123.9
Total value (millions of 1989 US$)	85.3	108.5	70.0	144.8	388.5
Mortality					
Population (in millions)	5.02	5.17	5.36	5.47	5.86
Mortality	308	392	253	523	1,404
Economic value (millions of 1989 US$)	13.8	17.5	11.3	23.4	62.7
Total (morbidity + mortality) (millions of 1989 US$)	99.1	126.0	81.3	168.2	451.2

[a]RAD - WLD = restricted activity days - work loss days.

Note: 1989 data were from a different source than the 1983-86 data, and thus are not strictly comparable (also, note the three-year gap).

An equation developed by Oskaynak was used for excess mortality in the Bangkok study:

$$[0.2/100{,}000] \times [dTSP \times POP]$$

Again, the U.S. standard for TSP is used as a minimum level. If the value of a statistical life is estimated, then mortality is easily convertible to monetary value. The following assumptions were made in estimating the value of a statistical life in Bangkok:

Average age of population	26
Life expectancy at birth	65
Years in labor force remaining	39
Discount rate	5%
Annual income	US$2,500

The value of a statistical life is the discounted value of expected future income at age 26. This amounts to US$44,682/life for Bangkok using the above assumptions. The economic cost of mortality from TSP in human capital terms is calculated as shown in table 3-15.

Carbon Monoxide. Following the methodology of a U.S. Environmental Protection Agency (EPA) study (U.S. EPA 1988), the risks of ambient CO were expressed in terms of the number of people who have chronic heart diseases (moderate risk of angina pain) and those who do not (low risk of headaches, excess fatigue, etc.). Then the number of people at risk is estimated for the cases when the ambient CO level exceeds the U.S. standard for an eight-hour average concentration of 10 $\mu g/m^3$. To estimate economic value, we assumed that moderate risk results in seven workdays lost in a year, and low risk results in one day lost. The estimation procedure is the same as that for TSP morbidity effects. Results are shown in table 3-16. Note that here, as in the previous section, medical expenditures are not included; if these were taken into account, economic costs would be considerably greater.

Table 3-16. Economic Value of Health Effects of Carbon Monoxide Pollution in Bangkok

	Risk level		
	Moderate	Low	Total
Persons at risk (thousands)			
Average	20	934	
Worst day	50	2,335	
Economic value (millions of US$)			
Average	1.4	9.3	10.7
Worst day	3.5	23.4	26.9

Lead. The health effects of lead exposure are expressed by the number of cases of hypertension, heart attack, stroke, and death for adults. For children, high lead levels in blood (PbB) can result in neurological damage and loss of IQ points. The USAID study assumed that air pollution is responsible for 8 to 40 percent of total lead exposure for adults and 10 to 70 percent for children. The U.S. average blood lead levels of 5 $\mu g/dl$ for children and 6.7 $\mu g/dl$ for adult males were used as the minimum levels to estimate the benefits of lead reduction.

A methodology developed by U.S. EPA (1989b) was used to estimate the health effects of lead exposure in Bangkok. Estimates 1 through 4 are based on data for adult males; 5 and 6 are for children.

1. **Hypertension.** Four kinds of costs are associated with hypertension. In the United States, these are physician charges (US$133.7/year), cost of medication (US$74/year/case), hospitalization cost (US$31.63), and the cost of lost workdays (US$36.95). This amounts to US$276.28 per case per year. To arrive at a rough estimate for Bangkok, the U.S. figure is multiplied by relative gross national product (GNP) for 1989 (US$2,552/US$20,910) and by relative medical share of GNP (4.6/5.3) for the two countries. This results in US$29.3/case/year for Bangkok. The same method is used for the other effects, as follows.

2. **Cardiovascular heart disease.** EPA estimated the cost of cardiovascular heart disease to be US$20,045 for medical costs and US$52,209 for lost earnings, yielding a total of US$72,254/case in the United States. For Bangkok, the adjusted cost for heart attack is estimated at US$7,659/case.

3. **Stroke.** The EPA estimate of US$52,200/case in the United States is converted to US$5,533/case for Bangkok.

4. **Death.** The number of deaths was multiplied by the value of a statistical life, US$44,682, to obtain the total cost of lead-related deaths.

5. **CDC Group IV.** The U.S. Centers for Disease Control (CDC) defines four categories of health effects from lead exposure according to blood lead level and erythrocyte protoporphyrin. Children in Group IV (although asymptomatic) require immediate medical treatment to prevent severe and permanent brain damage. The estimated cost for children in this group is US$3,171/case in the United States, and US$336/case in Bangkok.

6. **Lost IQ in children.** With a loss of IQ in childhood, the present value of expected lifetime earnings declines, and the educational resources expended for a child increase. The U.S. EPA study suggests that a one-point IQ loss by age seven will result in a total loss of US$471 in a lifetime. The present value of future expenditure for remedial education of each child with an IQ of less than 70 is US$2,043. The number of children with an IQ less than 70 is not shown in the Bangkok study; therefore, only lost future earnings can be considered here. US$50 per IQ point lost is used as a conversion factor.

EPA estimates that lead reduction in the United States yielded benefits of between US$10 million and US$40 million in terms of reduced infant mortality. Since comparable data are not available for Bangkok, this important effect was not considered. Table 3-17 shows the economic values calculated for health effects associated with three blood lead levels. Depending on the background level, the cost of lead exposure through air pollution in Bangkok is estimated at about US$20 million to US$60 million.

Table 3-17. Economic Cost of Health Effects of Lead Exposure in Bangkok (millions of US$)

	16μg/dl PbB bkgd level		23μg/dl PbB bkgd level		45μg/dl PbB bkgd level	
	Number/yr	Cost	Number/yr	Cost	Number/yr	Cost
Adults - Hypertension cases	210,000	6.2	320,000	9.4	530,000	15.5
Heart attack	210	1.6	320	2.5	430	3.3
Stroke	110	0.6	210	1.2	430	2.4
Death	210	9.4	210	9.4	430	19.2
Children - CDC group IV cases	530	0.2	7,500	2.5	64,000	21.5
Lost IQ points	430,000	21.5	530,000	26.5	750,000	37.5
Total economic cost		39.5		51.5		99.4
Amount attributable to air pollution[a]		22.3		29.5		57.6

[a]Air pollution is assumed to be responsible for 40% of blood lead level (PbB) for adults and 70% for children.

In addition, the USAID report projects 70 to 80 excess cancers caused by air toxics from mobile sources (chiefly fuel additives). If these are counted the same as mortalities from TSP, costs rise an additional US$3 million to US$4 million. The total health-related costs of ambient TSP, CO, lead, and air toxics in Bangkok can be summarized in round figures as follows:

TSP	US$330 - 450 million
CO	US$10 - 30 million
Lead	US$20 - 60 million
Air toxics	US$3 - 4 million
Total	US$360 -540 million

It could be argued that these values are overestimated because the relatively stringent U.S. air quality standards were used. Also, the average mortality from air pollution exposure probably does not occur at age 26. However, most of our other assumptions were conservative, and many effects were omitted due to lack of data. Also, had we used purchasing power parity rather than the exchange rate and nominal per capita GNP in the calculations, the figures would have been about three times higher (Summers and Heston 1988).

Lost earnings and medical expenses can only be taken as a lower bound for damages to health and loss of life. An upper bound would be figures derived from revealed and stated preferences, as discussed in chapter 2. This would make our figures many times higher. For instance, the value of a statistical life was empirically found to be US$1.6 million to US$8.5 million in 1986 dollars (Fisher, Chestnut, and Violette 1989), or US$2 million to $US10 million in 1992 dollars. Multiplying by a simple per capita GNP ratio of 0.122, this would be US$244,000 to US$1.2 million per life in Thailand, compared to a lost earnings value of US$44,682. Mortalities from air pollution and microbiological diseases would add up to US$800 million to US$4 billion.

Morbidity can also be calculated this way. For instance, on an average day in Bangkok, there are about 900,000 people exposed to excessive levels of CO and therefore at risk of experiencing such symptoms as fatigue and headaches (USAID 1990a). The willingness to pay (WTP) for a reduction of a single day of such symptoms—according to Tolley et al. 1986 (see table 2-6)—is about US$30 to US$40 in 1984 prices in the United States, or about US$40 to US$50 in 1989 prices. Bangkok WTP might amount to US$5 to US$6/symptom-day. If we assume that 10 percent of the people at risk are actually experiencing the symptoms—or 90,000 people—the WTP for relief amounts to US$450,000 to US$540,000 per day, or US$160 to US$200 million per year, for the average-day effects of CO alone. On the worst day, 2.3 million people are at risk, and the WTP amounts to US$1.1 million to US$1.3 million per day. Willingness to accept payment is several times higher. Note, too, that the other pollutants mentioned above—TSP, lead, and air toxics—have far worse health effects than CO.

For the sake of comparison to other Asian cities, Ostro's and Oskaynak's equations for particulates were applied, using 1985 annual average concentrations found in Faiz et al. (1990) and assuming the entire population was exposed to this level. The results were as follows:

	WLD	RAD	Mortalities
Bangkok	4,765,000	9,227,000	253
Beijing	20,735,000	40,326,000	1,100
Bombay	11,876,000	23,096,000	630
Delhi	12,667,000	24,636,000	672
Hong Kong	0	0	0
Jakarta	12,818,000	24,929,000	680
Kuala Lumpur	1,357,000	2,640,000	72
Shanghai	17,644,000	34,314,000	936
Tokyo	0	0	0

Hong Kong and Tokyo score zeroes because average annual concentrations of particulates did not exceed the U.S. standard. Bangkok's scores appear relatively low: This is partly because USAID (1990a) disaggregated the data for seven air pollution monitors to calculate exposed population more accurately, but it is mainly due to lower pollution levels and a relatively small population.

Unfortunately, there are no handy U.S. formulas for the types of water-related diseases found in Asian cities. According to USAID (1990a), "despite the evidence that a relationship between illness rate and the presence of coliform bacteria exists, there are no dose-response functions from which numerical risk estimates can be made." However, microbiological diseases were characterized as a "high" health risk because of their very high incidence in Bangkok: There were an estimated 850,000 to 1,700,000 cases of environmentally related microbiological diseases per year in 1987-89. Some of these diseases are carried by mosquitoes (see box 3-2) and other insects. The others are related to water supply and sanitation. Among these latter diseases, average annual inpatient cases numbered as follows:

- acute diarrhea—7,466;
- dysentery—620;
- enteric fever (typhoid)—233;
- cholera—164;
- hepatitis A—47;
- poliomyelitis—29;
- leptospirosis—27; and
- typhus and other rickettsioses—15.

Outpatient cases are about 10 times higher; unreported cases might make actual magnitudes 5 to 10 times higher than that.

These diseases are responsible for about 6 percent of all deaths in Bangkok (USAID 1990a), or 1,600 mortalities per year for 1987-88 (Thailand National Statistical Office 1990). These should generally be valued higher than mortalities from air pollution because the latter usually occur late in life whereas waterborne disease is a primary cause of infant and child mortality. For nonfatal cases, restricted activity days range from 3 to 5 per case for diarrhea, 14 to 28 days/case for typhoid, and over 3,000 days/case for poliomyelitis (Walsh and Warren 1979). Unfortunately, there is not enough information to calculate the costs of all microbiological diseases.

Box 3-2. Mosquitoes

A survey (Jamieson and Li 1988) revealed that mosquitoes are the most prevalent environmental problem perceived by slum-dwellers in Indonesian cities, followed by rats, flies, and flooding. This should come as no surprise, since mosquitoes and rats carry deadly diseases that will kill a person much faster than problems such as air pollution would. Among mosquito-related diseases, Bangkok reported an average of 5,312 inpatient cases of dengue fever, 287 cases of malaria, and 160 cases of encephalitis per year, 1987-1989. Outpatient cases make the figures about ten times higher—and not even considering unreported cases—these three diseases alone might be responsible for 300,000 to 400,000 restricted activity days as well as hundreds of deaths.

Mosquitoes present some interesting dilemmas. Because of them, some countries still allow the use of the toxin DDT, although it has serious longer term health effects for humans and other animals. People in developing countries also say that mosquito repellence is a major health benefit of indoor air pollution. Even women who have adopted improved cookstoves burn small amounts of biomass such as neem leaves in the home to repel mosquitoes.

Large outbreaks of mosquito-borne diseases are directly correlated to incidents of flooding. In some Asian cities, it may be wise to make flood control and improved drainage a priority in tackling environmental problems. Flooding in neighborhoods that lack sanitation results in a high number of fatalities from waterborne diseases as well.

Sources: *Jamieson and Li (1988), K. Smith (1990a), USAID (1990a), Walsh and Warren (1979).*

For India as a whole, waterborne diseases were estimated to cause 73 million work loss days per year in 1982, valued at £250 million (US$428 million) (CSE 1982, 1989, Ahmed 1990). Unfortunately, the method used to calculate this figure was not explained in the references at hand.

For hazardous wastes, Thailand's hazardous wastes management plan applied a risk ranking and cost-effectiveness analysis to its proposed waste treatment facilities, as shown in table 3-18. The method is relatively simple: Waste quantity was multiplied by a relative risk factor and the exposed population to obtain an "environmental risk factor." Then, using the costs of waste treatment, the risk reduction per million baht was calculated (environmental risk factor divided by cost of treatment) and the results ranked. As shown in the table, treating heavy metal sludges and solids will have by far the greatest benefits in reduced environmental risks from hazardous wastes per million baht invested. Note, however, that the 136,810 tons of heavy metals to be treated does not include the very sizable 1,311,811 tons of heavy metals generated by smelters. It is assumed (perhaps optimistically) that these are treated and contained on-site (NEB 1988, Phantumvanit and Panayotou 1990).

Table 3-18. Hazardous Waste: Environmental Risk Factors and Cost Effectiveness of Treatment, Thailand 1991

Hazardous waste type	Waste tons[a]	Relative risk factor	Exposed pop. (mil)[b]	Environmental risk factor[c]	Cost of treatment: Baht per ton	Cost of treatment: 1,000 baht	Risk reduction: Per million baht	Risk reduction: Rank
Oils	219,467	1	57	13,000	637	139,822	100	9
Liquid organic residues-NH	21	1	17	0	577	12	0	12
Liquid organic residues-H	290	1,000	17	5,000	8,343	2,419	2,100	6
Organic sludges-NH	1,563	1	16	0	577	902	0	11
Organic solids-NH	1,759	1	16	0	8,343	14,675	0	11
Organic sludges and solids-H	3,352	1,000	16	54,000	8,343	27,966	2,000	7
Inorganic sludges and solids	19,254	1	42	1,000	146	2,811	500	8
Heavy metal sludges & solids	136,810	10,000	13	17,785,000	158	21,616	823,000	1
Solvents-H	6,806	100	41	28,000	1,976	13,449	2,100	6
Solvents-NH	29,357	10	41	12,000	3,195	93,796	100	10
Acid waste	125,428	100	32	401,000	257	32,235	12,500	4
Alkaline wastes	34,235	100	33	112,000	77	2,636	42,800	3
Off-spec products	25	1	7	0	2,907	73	0	11
PCBs[d]	247	10,000	11	27,000	—	—	—	—
Aqueous organic residues	242	100	10	0	146	35	0	11
Photo wastes	16,345	100	52	85,000	54	883	96,300	2
Municipal wastes	11,757	1	75	1,000	2,410	28,334	10	10
Infectious wastes	76,075	100	57	434,000	577	43,895	9,900	5
Total	683,003	—	—	—	626	427,620	—	—

Notes: H = halogenated; NH = nonhalogenated.

[a]Projected quantities sent to treatment plants in 1991.

[b]1991 population in provinces where specific waste type is being generated.

[c]Waste quantity x relative risk factor x exposed population/1,000 rounded off to nearest 1,000.

[d]Thailand stopped importing PCBs in 1985. PCB waste from past imports is currently sent abroad for treatment.

Source: Engineering Science, Inc. (1989) (final version of NEB 1988), as reproduced in Phantumvanit and Panayotou (1990).

Productivity

The direct productivity impacts noted in table 3-14—fish mortality, etc.—are relatively easy to calculate in monetary terms, since they usually involve marketed goods and services. Many of the impacts were already expressed in monetary terms, and the valuation techniques are straightforward. Therefore, we do not discuss any particular applications of the methodology. It should be noted, however, that exchange rates, transaction costs, and other market imperfections tend to distort values; and the use of "shadow prices" is frequently necessary.

Indirect productivity impacts are also important, including the opportunity cost of capital invested in pollution monitoring and clean-up. Many of the Asian cities that do not have adequate sanitation are currently conducting feasibility studies on alternative sewerage systems. The costs are high, and in most cases require increasing already heavy foreign debt burdens. In Bangkok, for instance, more than a dozen sewage system studies have been conducted over the last 30 years, and they seem to keep getting more expensive. Box 3-3 explains some costs associated with water pollution in Seoul.

Box 3-3. Revealed Willingness to Pay for Clean Water in Seoul

Because of water pollution, the city of Seoul was forced to abandon two water supply intakes and divert more water from an upstream reservoir. This same pollution increases the cost of drinking water treatment. A 1983 study found that chemical and labor costs (the relevant variables) were 7.286 won/m^3 higher for the Bokwangdong purification plant inside the city than for the Paldang plant upstream from Seoul. With a capacity of 300,000 m^3/day, this cost amounts to 2,185,800 won/day (US$3,279/day) for just one of Seoul's nine water purification plants.

Fortunately, in planning for the 1988 Olympics, the government attempted to improve the quality and appearance of the Han River. A sewage pipe system and three new sewage treatment plants were built. River water quality improved markedly. At the Bokwangdong intake station, biological oxygen demand levels fell from 7 to 3 mg/l between 1984 and 1986; this probably resulted in some reduction of the above-mentioned treatment costs.

Still, city drinking water has a very bad reputation in Seoul. The government insists it is safe to drink, but a 1987 survey of residents showed that 78.7 percent believe its sanitary condition is "bad." Large proportions also reported "uncomfortable experiences" due to rust, odor, sediment, or a combination of these. Only about 6 percent dare to drink the tapwater without boiling it.

Higher income families use water purification devices or buy bottled water. Korean law prohibits the sale of bottled water to Korean nationals; it was previously purchased only by foreigners, but a black market for residents has developed. The price is thousands of times higher than the price of city water—184,210 won/ton vs. 60 won/ton. Water companies are frequently fined by the Ministry of Health and/or ordered to suspend business for certain periods. There is also the risk of groundwater depletion. For lower income people, costs include the energy needed to boil the water (this kills bacteria but has no effect on other harmful substances).

Actually, consumers having to pay the costs of water pollution is a violation of the "polluter pays principle" that results from applying the "political status quo" rather than the "ecological status quo." Unfortunately, polluters are not "willing" to pay; they have to be forced. Since mid-1983, the Seoul Pollution Control Service Corporation has been collecting fees from industries that violate water pollution standards, and the money is in turn loaned to industries for acquisition or improvement of pollution control equipment.

***Sources:** Bromley (1988), Shin (1989), Shin (1990).*

For the hazardous waste treatment plant described above, the total cost was projected to be about Bt428 million (US$16.5 million) which, according to Phantumvanit and Panayotou (1990), is only 0.3 percent of the gross domestic product (GDP) produced by the offending industries. They also note that treating 70 percent of the current biological oxygen demand (BOD) load would cost only 1 percent of the output value of BOD-generating industries (Bt361 million).

Amenities

A contingent valuation study for improved water quality in the Keelung River, Taipei (Hsu and Li 1990) showed that people were willing to pay an average of US$8 per year (±0.95), or a total of US$16 million per year for the whole city. However, the study also reveals some problems inherent in contingent valuation: Of 250 surveys, 64 responses were deemed "invalid questionnaires." Thirty-three of these said the government should pay for treatment through its annual budget; 10 said that factories causing pollution should pay; 7 said they did not believe the treatment project could be carried out effectively. An additional 14 persons were excluded for potential strategic bias, since they were willing to pay more than US$15 or less than US$3.

In a survey conducted by Mahidol University in 1990, three-fourths of the 211 Bangkok klong (canal) residents interviewed, and the same proportion of a random sample of restaurant owners near the canals, said they would be willing to pay a service fee for wastewater treatment (*Bangkok Post* 22 April 1991). The amount was not specified in the article.

Ecological value is discussed in more detail in section 3.4, as the impact of pollution on the ecology is inseparable from destruction of the natural support system.

3.3 Congestion: Incidence, Impacts, and Valuation

Congestion in urban areas includes traffic jams, overcrowded parks and beaches, and waiting lines for entrance to public facilities as well as interruptions to essential electric, telephone, and water services. Clearly, congestion imposes economic and social costs on all those affected (Lee and Anas 1989). Crowding is a special form of congestion in low-income high-density urban communities, and has adverse health impacts on the inhabitants—for example, through higher incidence of communicable diseases.

In economic terms, congestion costs are externalities imposed on users of a facility by additional users when the capacity of the facility is exceeded. The classic economic solution to the problem of congestion is "peak load pricing" where tolls or entry fees are levied, ideally set at the marginal congestion costs imposed by the users (Mohring 1976).

Congestion is readily apparent in Asian cities in the overcrowded conditions of public spaces and of private facilities open to the public. The most pervasive and problematic type of congestion, that of traffic on urban streets, is discussed here.

3.3.1 Incidence in Asian Cities

Urban traffic congestion is reported to be a problem in 13 major Asian cities for which data were available (World Bank 1991a). The extent and degree of congestion is directly related to the number of vehicles, including trucks, cars, taxis, and motorcycles. More specifically, congestion is a function of the number of cars and taxis per capita, which is in turn related to the per capita gross national product. As shown in table 3-19, Singapore, Kuala Lumpur, and Bangkok, which rank among the top five cities in GNP per capita, also have the highest per capita number of cars and taxis. Conversely, the six cities with the lowest per capita GNP have the lowest per capita number of cars and taxis.

Table 3-19. Population, per Capita GNP, and Number and per Capita Ownership of Cars and Taxis in Selected Asian Cities

			Cars and taxis	
City	Population (thousands)	GNP per capita (US$)	Number	Per 1,000 population
Hong Kong (1987)	5,613	8,425	194,000	34.6
Singapore	2,558	7,610	223,000	87.2
Seoul (1987)	10,140	3,635	394,000	38.9
Kuala Lumpur	1,215	2,855	148,000	121.8
Bangkok (1987)	7,230	1,778	587,000	81.2
Manila (1987)	7,267	1,005	239,000	32.9
Jakarta (1987)	8,578	880	380,000	44.3
Beijing	5,550	550	48,000	8.6
Shanghai	7,800	550	18,000	2.3
Karachi	6,200	523	109,000	17.6
Bombay	8,790	464	217,000	24.7
Calcutta	10,000	464	95,000	9.5
Madras	5,460	464	35,000	6.4

Note: Populations are as of 1985, unless otherwise indicated.

Source: World Bank (1987).

As population and per capita GNP rise in Asian cities, car ownership will continue to increase and traffic congestion will become worse. For example, for six cities in South and Southeast Asia, the projected increase in number of cars and taxis by the year 2000 ranges from 100 percent in Bombay to 63 percent in Bangkok. In absolute terms, projected population increase of 30 million by the year 2000 will be accompanied by a projected increase of over 1.1 million cars and taxis (see table 3-20).

Table 3-20. Projections of Population, per Capita GNP, and Numbers of Cars and Taxis in Selected Asian Cities

	Population (millions)		Per capita GNP (US$)		Number of cars and taxis		
City	1985	2000	1985	2000[a]	1985	2000[b]	% increase
Bangkok (1987)	7.2	10.7	1,778	2,223	587,000	956,000	63
Manila (1987)	7.3	11.1	1,005	1,256	239,000	402,000	68
Jakarta (1987)	8.6	13.3	880	1,100	380,000	648,000	71
Calcutta	10.0	16.5	464	580	95,000	172,000	81
Madras	5.5	8.2	464	580	35,000	58,000	66
Bombay	8.8	16.0	464	580	217,000	434,000	100

Note: Base year data are for 1985 unless otherwise indicated.

[a]Projection for 2000 assumes a 25% increase over base year prices.

[b]Projection for 2000 is 1.1 times the base year per capita car and taxi ownership rate.

Source: World Bank (1987).

According to Heggie (1991), road congestion in developing country cities falls into two categories. The first category consists of cities in which motor vehicle rates are low, and where simple traffic management measures and minor road improvements would largely eliminate traffic congestion.

The second category consists of cities with high rates of motor vehicle ownership and/or constraining physical features such as waterways or hills, resulting in serious congestion problems that cannot be solved only by simple traffic management and road construction. There are simply too many cars, and explicit traffic and parking restraint measures are required in these cases. Most of the Asian cities listed in table 3-19 belong in this category.

3.3.2 Adverse Impacts of Congestion

Increased Air Pollution, Accidents, and Noise

The volume of air pollutants from motor vehicles is a function of the number of vehicles, technical design, age, fuel, operating time of each vehicle, and operating conditions. Furthermore, ambient concentrations of pollutants are a function of the density of motor vehicles on the streets and weather conditions. Traffic congestion can cause serious increases in both total quantity and concentration of air pollutants, with adverse health effects depending on population concentration. As noted in the previous section, pollutants from motor vehicles (CO, NO_x, SO_x, particulates, and lead) exceed air quality standards in nearly all the megacities of Asia. Specifics on Delhi are given in box 3-4.

Box 3-4. Delhi under Siege

Air pollution in Delhi is among the worst in the world's major cities. Almost half of the air pollution in Delhi comes from motor vehicle traffic. Measurements at 50 heavy traffic junctions during rush hour in Delhi show that pollution concentrations are far in excess of prescribed safe limits. For suspended particulates, concentrations are from one to five times the safe limit; for carbon monoxide, two and one-half to three times the limit; and for nitrogen oxides, three to six times the permissible safe limit. Worst polluting offenders are diesel-powered buses and trucks, although lighter vehicles—scooters, auto rickshaws, motorcycles, and mopeds—also release large quantities of unburnt hydrocarbons. According to conservative estimates, 500 kg of hydrocarbons are emitted during peak traffic hours. In addition, about 600 kg of highly toxic lead are emitted every day by motor vehicles and industry.

By 1994, Delhi had a population of about 10 million. At the present rate of increase, the population could reach 15 million by the year 2000. This could lead to a doubling of the estimated 1.2 million cars, trucks, buses, motorcycles, and scooters that use the city streets each day.

Source: New Straits Times *7 January 1989.*

Congestion—together with related factors, such as undisciplined user behavior, mixed traffic conditions, inadequate vehicle maintenance, poor road conditions, and insufficient road markings—is one reason for the high road accident rates in Asian cities. Manila, Kuala Lumpur, and Bangkok have reported accident death rates per 10,000 vehicles of 11.23, 22.7, and 10.3, respectively, compared to Tokyo's rate of 1.21 (Dimitriau and Banjo 1990).

In a WHO study of safety problems in developing countries, it was reported that in India one-third of all accidents take place in 12 metropolitan areas of more than 1 million inhabitants. In Thailand, two-thirds of accidents occur in Bangkok, which has about 15 percent of the country's population.

Increased congestion also exacerbates the serious noise problem in Asian cities; more roads and streets are filled with motor vehicles for longer periods of time.

Increased Travel Time

Although traffic congestion increases air pollution loads, its major economic impact is the increase in travel time imposed on motorists. The computation of increases in travel time due to congestion requires detailed urban traffic studies. According to Gronau (1990), this involves the development of empirical speed functions for different congestion conditions on urban roads of the form:

$$S = A - BX$$

where

A is the free-flow speed (in km/hr) for the specific highway involved,

B is a congestion factor, determined empirically for the specific highway,

X is the number of vehicles per hour, and

S is the speed in km/hour.

Application of this formula for different levels of traffic provides the marginal time delay imposed on the rest of the traffic by each additional vehicle.

Gronau applied this approach to urban traffic in Accra, Ghana, to derive a marginal time delay of 0.23 minutes for each additional vehicle. Information on traffic composition by type of vehicle—e.g., cars, taxis, buses, trucks—and by average occupancy by type of vehicle allows computation of time delay per person. With information on time delay per vehicle, traffic composition, and time delay per vehicle occupant, it is possible to compute increases in vehicle operating costs (e.g., fuel costs) due to time delays and economic costs of time lost by vehicle occupants.

3.3.3 Economic Valuation of Congestion Impacts

Air pollution impacts of urban traffic congestion are valued, along with air pollution from other sources, in terms of human health (morbidity and mortality), productivity, and amenity value. Costs of increased accidents due to urban traffic congestion are also valued in terms of human injuries and mortality, and of economic cost of repair or replacement of damaged vehicles, using market prices. Increased vehicle operating costs are valued at the market prices of additional fuel and other variable inputs required for vehicle operation.

Valuation of Travel Time

A social cost of Bt108.7 million (US$4,350,000) per day was calculated for traffic jams in Bangkok, using the following method (*Bangkok Post* 26 June 1991): It was assumed that half the city's 870,000 cars (1989 figure) are on the road each day—i.e., 435,000 cars. Average vehicle occupancy is two persons, and each vehicle spends two hours per day in traffic jams. The average monthly income is Bt10,000 (US$400), or US$2.50 per hour. These assumptions yield 435,000 cars × 2 people × 2 hours × US$2.50 = US$4,350,000 per day. The calculation does not include cars registered outside Bangkok but driven into the city, people traveling by bus, and people who make more than two car trips per day.

Using the full wage rate of the traveler is generally considered the upper bound for value of travel time. An alternative approach is the opportunity cost of the traveler's nonwork time, which was taken as some fraction—one-third to one-half—of the wage rate. According to Mohring (1976),

> For commuters the value of travel time appears to be closely related to their wage rates or hourly equivalent of their annual salaries. Workers with low to medium wage or salary rates appear willing to pay about 25 to 30 percent of their hourly wage rate to save travel time, while higher income workers are willing to pay about 50 percent of their wage rate.

Gronau (1990), in his case study of road-user costs in Ghana, reports that "it is customary to assume that the value of time of passengers is 25-33 percent of their hourly earnings." In discussing the valuation of travel time savings for transit trips, Armstrong-Wright (1990) notes: "Some authorities consider that no value should be placed on the time saved in taking nonbusiness trips, while others suggest that it is 25 percent-30 percent of the income earnings rate. (Business trips are usually assessed at the full earning rate.)" The practice in Hong Kong has been to value travel time for business trips at current wage rates of travelers, and time for nonbusiness trips (including commuting) at values "substantially lower" than current wage rates of travelers (Thomson 1982).

The Bangkok study described above can also be considered an upper bound of travel costs due to congestion because the entire two hours spent in traffic was counted and a high value of Bt10,000 for average monthly income was used. If only half this travel time (one hour per person) was due to congestion per se, and if a lower wage rate of Bt31 (US$1.25) per hour—based on Thai Government statistics (Thailand National Statistical Office 1989)—were used, the related cost would be reduced to US$1,087,500 per day, or US$272 million per year, assuming 250 workdays/year.

Using the technique applied in Bangkok, but assuming a constant congestion time delay of one hour per day per person, yields the following annual congestion costs for other Asian cities:

City	Annual Costs of Time Delay (US$)
Hong Kong	293 million
Singapore	305 million
Seoul	154 million
Kuala Lumpur	68 million
Manila	51 million
Jakarta	68 million

These figures are based on data in table 3-19, showing the number of cars and taxis and per capita gross national product in each city. The figures are only rough estimates based on arbitrary assumptions, but they give general magnitudes and comparative values among cities. It is clear that economic losses due to traffic congestion are significant.

In recent years, increasing attention has been given to the stated preference approach to estimating willingness to pay for savings in travel time. The U.K. Department of Transport (1988) recommended valuation of nonbusiness travel time savings on the basis of people's willingness to pay obtained from surveys of their preferences. Bradley and Gunn (1990), reporting on a study of stated preference analysis of values of motorists' travel time in the Netherlands, cited close correspondence of their results with those obtained from earlier stated preference studies in the United Kingdom. In addition, they found that values of travel time obtained by the stated preference method were similar to values derived from revealed preference studies for commuters and other nonbusiness travelers.

Summary

Travel time delays account for the largest share of economic costs of traffic congestion. In a study of traffic congestion cost in Oslo, Ramjerdi and Larsen (1991) report that increased vehicle operating costs due to congestion range from 2 to 8.3 percent of costs from time delays. Because of higher fuel costs relative to wage rates in Asian cities, vehicle operating costs are likely to be a higher percentage of travel time costs than in Oslo.

Strategies for dealing with urban road congestion in Asian cities would start by focusing on improved traffic management (including parking regulation and charges) and minor road improvements, followed by some form of congestion charges. Detailed information on the economic costs of congestion is a necessary input to development of economically efficient and equitable strategies.

It is clear that economic losses due to traffic congestion are of important policy significance. It may be appropriate to use supplementary measures such as parking regulations and charges, and other congestion charge schemes. These include the area licensing scheme, as in Singapore; the automatic vehicle identification scheme installed in Singapore; and manual or mixed manual/electronic cordon pricing schemes which appear to be appropriate for cities such as Bangkok, Jakarta, Bombay, and Seoul (Heggie 1990).

3.4 Degradation of Natural Support Systems: Incidence, Impacts, and Valuation

Degradation of natural support systems implies unsustainable development. In extreme cases, important environmental services are irreversibly lost with no hope of restoration. In less severe cases of degradation, restoration may be technically and economically feasible—but it is nearly always better and cheaper to prevent degradation than to repair it.

The natural support systems examined here in the context of Asian cities include forests and agricultural lands, wetlands, groundwater, and coral reefs. Each is a complex system, and they are interconnected. For instance, deforestation will increase harmful sedimentation of wetlands and coral reefs.

3.4.1 Incidence of Degradation in Asian Cities

Forests and Agricultural Lands

Table 3-21 shows projections for increases in the built-up areas of various Asian cities. "The main victim of this massive expansion is prime agricultural land" (ESCAP 1990a). In Bangkok, not only is prime agricultural land being converted to other uses, but also high-quality topsoil—which, as TDRI (1990) notes, "had taken years to accumulate appropriately for agricultural production"—is mined from suburban areas to serve as landfill.

Table 3-21. Projected Increases in the Built-up Area of Selected Cities in ESCAP Region by Year 2000

City	Initial period				Year 2000 increases in built-up areas			Avg annual compound growth rate (%)
	Year	Population (000s)	Built-up area (hectares)	Gross density	Population (000s)	Built-up area (hectares)	Annual (hectares)	
Hong Kong	1973	3,691	11,749	314	5,210	16,590	180	1.29
Ahmadabad, India	1980	2,451	10,073	243	5,196	21,380	565	3.83
Jakarta, Indonesia	1979	6,500	31,304	208	16,591	79,760	2,307	4.55
Colombo, Sri Lanka	1980	586	3,803	154	1,125	7,310	175	3.32
Tehran, Iran I.R.	1966	2,720	18,000	151	11,329	75,030	1,677	4.29
Bangkok, Thailand	1981	5,331	44,428	120	11,936	99,470	2,897	4.33

Note: In calculating the estimated built-up area for the year 2000, densities are assumed to remain the same during the intervening period. Densities for regions were independently estimated based on existing densities in towns of different areas.

Source: ESCAP (1990a).

Forests suffer a similar fate, being cleared to make way for housing, industry, roads, etc., as well as being harvested for construction materials. In countries such as India, where there is still heavy reliance on wood as a energy source, urban fuelwood demand is another major factor in deforestation around cities. Wood still provides over 50 percent of cooking energy in Indian cities, as well as energy for small businesses and crematoria (CSE 1985 and 1989). As table 3-22 shows, forest cover around major cities in India declined by 15 percent to 60 percent between 1972 and 1982. Fuelwood prices have increased dramatically, but the urban poor are unable to acquire alternatives such as kerosene stoves (CSE 1985).

Table 3-22. Changes in Closed Forest Cover around Major Cities in India 1972-75 to 1980-82

City	1972-75 (sq. km)	1980-82 (sq. km)	Percentage change
Bangalore	3,853	2,762	-28
Bombay	3,649	3,672 (?)	-35
Calcutta	55	41	-25
Coimbatore	5,525	4,700	-15
Delhi	254	101	-60
Hyderabad	40	26	-35
Jaipur	1,534	786	-49
Madras	918	568	-38
Nagpur	3,116	2,601	-34

Note: For Bombay, a 35% reduction from 3,649 would be 2,372.

Source: ESCAP (1990a).

Jakarta, by contrast, has a strong policy of shifting from wood to natural gas. The rate of deforestation has declined, and a new 50-hectare forest reserve and 100-hectare forest park are to be added to Jakarta's natural amenities. Indonesia is favorably situated in this regard, because kerosene and natural gas are readily available and wood-based construction materials can be brought to Jakarta from neighboring islands (Hadiwinoto and Clarke 1990).

Wetlands

> Wetlands, in aggregate, provide . . . "flood storage," flood protection, important wildlife habitats, nutrient cycling/storage and related pollution control, landscape and amenity services, recreational services, nonuse existence value benefits, agricultural output, other commercial output, shoreline protection and storm buffer zones, and extended food-web control (Turner 1991).

Unfortunately, many of these environmental services are not fully recognized by decisionmakers. Pakistan, Japan, India, Nepal, Vietnam, and Sri Lanka are parties to the Ramsar Convention on wetlands of international importance; altogether, they have designated 21 sites for preservation (Parish and Tsuji 1990). Elsewhere, however, wetlands (including marshes, fishponds, and coastal mangrove forests) are routinely reclaimed for "higher value" residential and industrial uses. Virtually all of Singapore's and Hong Kong's mangroves have been reclaimed for urban development, as have 35 percent of those in the Malaysian state of Selangor (Kuala Lumpur) (Hamilton and Snedaker 1984; Burbridge 1988). In East Calcutta, 4,000 hectares of lagoons and wetlands were filled in to provide housing for 100,000 middle-class families (CSE 1989). The Republic of Korea's National Plan for Land Development identifies over 450,000 hectares of coastal intertidal wetland as being suitable for land reclamation (Poole 1990).

Groundwater

Exploitation of groundwater resources beyond the safe yield has led to saltwater intrusion and land subsidence in Bangkok (see box 3-5), Jakarta, Tianjin, Shanghai, and Dhaka (Hadiwinoto and Clarke 1990, Srivardhana 1990, Milliman et al. 1989). Moreover, groundwater recharge is hampered because "the immediate surface of the capital [Jakarta] has been covered with asphalt and concrete and thus lost its absorption capacity for rainwater" (Donner 1987).

Box 3-5. Bangkok: A Sinking City

Bangkok's population has grown dramatically, and so has the demand for water. Excessive groundwater exploitation has led to drastic reductions in groundwater levels and sinking of the overlying land surface. Between 1960 and 1988, portions of the city had sunk about 1.6 meters; the current rate for some sections of the city is about 5 centimeters per year. This groundwater depletion and land subsidence has led to saltwater intrusion; increased flooding; and damage to buildings, highways, bridges, and underground pipelines and sewer systems—as well as to increased pumping costs. The present governmental strategy is to stop land subsidence by reducing groundwater abstraction by both public and private users to a level below the natural aquifer recharge rate, and by providing the needed water from alternative surface sources. This will be extremely costly. Decisionmakers should know the magnitude of the economic benefits (or costs avoided) of stopping groundwater depletion and further land subsidence. Depletion costs—the increased costs of (1) pumping water as groundwater levels recede and (2) providing surface water to substitute for salinized groundwater—can be readily estimated using prevailing prices for electricity, materials, and labor; and correcting for market distortions by using shadow prices. Land subsidence costs are damages to structures; streets; and underground water, sewer, electric, and telephone lines; and the increased risk of damages for flooding. Structural damage costs can be derived by estimating replacement and repair costs, using market prices with appropriate adjustments. Costs of increased risk from flooding can be derived by estimating costs of cleanup, repair, and replacement of facilities and equipment; and value of lost production. Past damage costs of subsidence and increased flooding can be derived from a hedonic pricing study of variations in property values between affected and unaffected areas.

Sources: *Phantumvanit and Liengcharernsit (1989), Srivardhana (1990).*

Coral Reefs

Coral reefs, like wetlands, are often deliberately filled in to create new land. Also, because of silt and other pollutants washing into the sea, as well as coral mining and tourism, the reefs around Asia "are rapidly becoming vast graveyards of the sea." This problem was reported for Singapore, Indonesia, Japan (Okinawa), Sri Lanka, and the Philippines, and may exist elsewhere also (Donner 1987).

3.4.2 Impacts of Natural Systems Degradation

Direct Productivity Effects

Before they were partially filled, the fishponds in the Salt Water Lakes area of East Calcutta served for natural flood control and as a sewage treatment plant, in addition to producing 25,000 tons of fish per year (CSE 1989). Also, the city's solid wastes were dumped in this area—in carefully placed mounds that, after a year and a half of decomposition, were cultivated to yield more than 60,000 tons of fresh vegetables annually. According to Sarkar (1990),

> Further development will destroy the remaining wetlands ecology and render the sewage fisheries uneconomic, depriving the vegetable gardens and rice fields of fish-pond water. Yet the city has no alternative working sewage treatment plant worth the name . . . expensive new canals will have to be excavated to remove the untreated sewage with its heavy sludge load. And garbage will have to be carried farther and farther out by rail, road, or barge, making Calcutta's waste expensive to dispose of.

When mangroves are destroyed, the direct productivity impacts usually include loss of aquaculture sites, wood for fuel and timber, food, medicine, raw materials for household items, and various types of paper—as well as on-site ecosystem services such as land accretion, storm protection, and water purification (Hamilton and Snedaker 1984).

Coastal Fisheries

Coastal wetlands (in particular mangrove forests) and coral reefs are essential to the productivity of coastal fisheries. For coral reefs, Hodgson and Dixon (1988) found from field work in the Philippines that for every additional 400 tons/km^2 of annual sediment deposition, there is an annual decrease in coral cover of 1 percent, which leads to reduced fish biomass of 2.4 percent. In Singapore, filling in mangrove swamps and other coastal reclamation activities has led to the near-disappearance of coastal prawn ponds and fish traps which once provided abundant harvests (Chia 1979). Most other estimates found are broad national figures—e.g., 32 percent of Malaysian fish catch is associated with mangroves; "intertidal wetlands on Korea's south and west coasts have recently been found to be ecologically among the richest in Asia, supporting a coastal fishery worth an estimated US$640 million per annum" (Paw and Chua 1988, Poole 1990).

Flooding

The filling of wetlands, plus reduced water infiltration, land subsidence, sedimentation of rivers, water table rise from the construction of large impervious buildings, and the clogging of drains from silt and solid wastes, all conspire to increase the incidence of flooding. Available data include the following.

- **Bombay.** Flooding disrupts traffic and commercial activities ("Bombay Environmental Profile" 1990).
- **Colombo (Sri Lanka).** Filling of wetlands over the past 15 years is blamed for a surface drainage problem that causes roads to become inundated after heavy rains ("Colombo City Profile" 1990).
- **Jakarta.** Approximately 5 percent of the city area is flooded on average twice per year. These regular floods are characterized by water depths of 0.1 to 0.5 meters over the ground level and last for 1 to 18 hours. At a frequency of once in 40 years, approximately 17 percent of the city area is covered by 0.2 to 2.0 meters of water for 2 to 238 hours (Hadiwinoto and Clarke 1990).
- **Manila.** Conversion of traditional fishponds along the shore to residential areas has increased the incidence of flooding (Jimenez and Velasquez 1989). Some 4,400 hectares are flooded annually; this is 7 percent of the total land area (Hechanova 1990).
- **Tianjin.** Frequent flooding results in factory shutdowns. The problem has been traced to discharge canals that have not been widened in more than 20 years, consequently not having kept pace with demand (Leitmann 1991b).

The degree to which human activity contributes to flooding is of course debatable and varies widely among cities. In Hawaii, the government was found liable for flooding resulting from improper maintenance of wetlands and drainage channels (*Honolulu Star-Bulletin* 14 September 1991).

Health and Amenities

The reduction of Bombay's tree cover to only 5 percent of total area is believed to aggravate the serious air pollution problems of that city (Chandra 1991). Besides absorbing carbon dioxide and releasing beneficial oxygen, trees provide a surface for dust and particulates to settle, thus removing them, at least temporarily, from the air. Trees also absorb gaseous air pollutants such as NO_x, SO_x, and ozone through leaf pores. More research is needed on this matter, but it appears that relatively dispersed trees in urban areas cannot remove a significant quantity of these oxidants without suffering damage. An important function of trees is the uptake of heavy metals which prevents their leaching into surface and groundwaters (W. Smith 1982, 1991). Trees are also important for absorbing noise, making shade, and generally enhancing the aesthetic quality of the urban environment. Parks, in particular, have high amenity value.

Lost recreational uses of wetlands include boating, fishing, hunting, swimming, and wildlife observation (Hamilton and Snedaker 1984).

Loss of Biodiversity

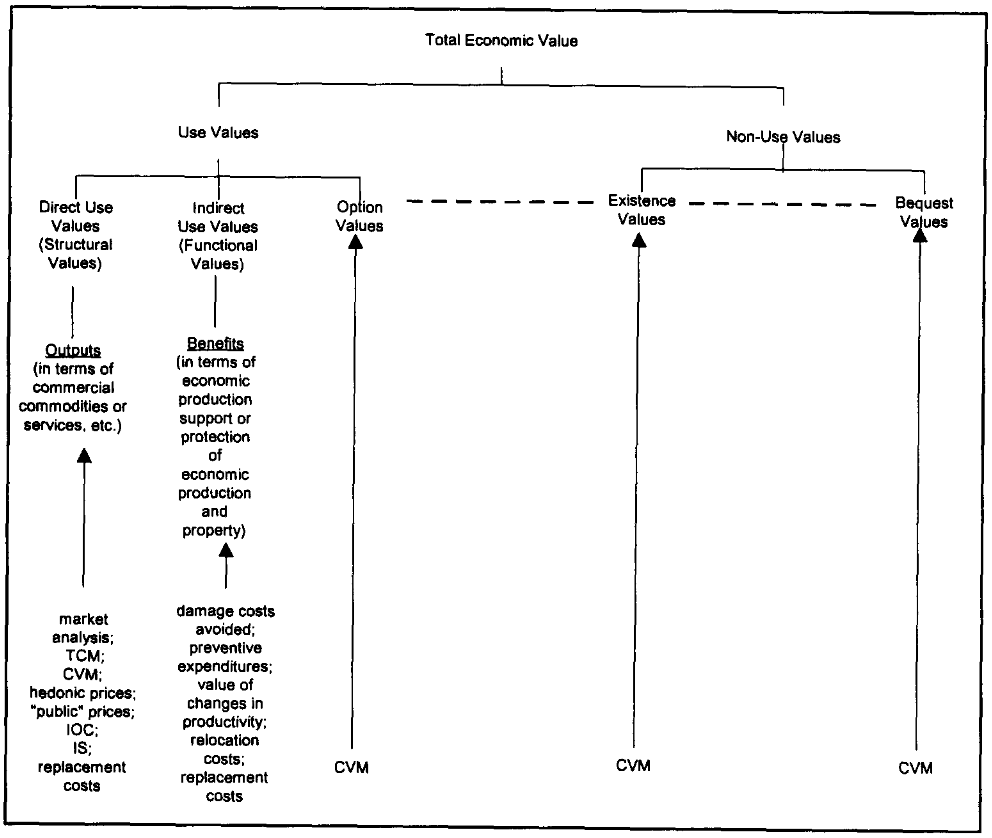
Removal of natural vegetation not only reduces the biodiversity of plants, but also has repercussions for insects, birds, and other animal populations that depend on those flora (Myers 1988). Wetlands destruction has particularly severe effects, because many endangered species are found in Asian wetlands (Hamilton and Snedaker 1984). Soil erosion is believed to have caused the disappearance of 10 fish species in Kuala Lumpur (*New Straits Times* 4 April 1991). And "conversion of natural terrestrial and marine ecosystems has probably been responsible for several hundred extinctions" in Philippine coastal waters (Cleave 1986).

3.4.3 Valuation of Natural Systems Degradation

Appropriate economic valuation techniques for wetlands—and, by extension, for natural support systems in general—are shown in figure 3-4. Most of these were discussed in detail earlier in this report. According to Turner (1991),

> in practice, the lack of appropriate price data is a major constraint. The problem is further complicated by the conditions of underdevelopment which usually preclude the use of the more sophisticated valuation techniques such as hedonic pricing, travel cost and contingent valuation . . . these circumstances, second-best approaches to valuation, such as indirect substitute, indirect opportunity cost, relocation costs and replacement cost methods (all of which do not relate uniquely to WTP) will have to be deployed. Approximate minimum estimates of the environmental values involved can be derived with these approaches, at least for a limited range of circumstances.

Figure 3-4. Wetland Benefits Valuation



Notes: CVM = contingent valuation method; TCM = travel cost method; IOC = indirect opportunity cost; IS = indirect substitute.
Source: Turner (1991).

Turner also recommends rapid assessment techniques, in spite of a loss in analytical precision, because of the urgency of these problems.

According to Costanza et al. (1989), physical linkage valuations based on scientific information tend to be more appropriate than willingness to pay methods for ecosystem services because "the public is most likely far from being fully informed about the ecosystem's true contribution to their own well-being," and "the absence of efficient markets for these outputs is the major cause of what can be called 'inefficient' habitat modification."

Productivity

For Jakarta, US$50 million to US$100 million would be required to replace the productive capacity of lost agricultural land (World Bank 1990).

In a Tokyo Bay fisheries study (Hufschmidt and Dixon 1986), the lost value of fish was estimated using two methods: physical output declines and compensation paid to fishermen. The physical output losses amounted to ¥475 billion (US$3.65 billion, present value in perpetuity); while compensation to fishermen totaled ¥650 billion (US$5 billion, 1979 prices). Japan is unique in this regard: Because the fishermen's unions have well-established rights to begin with, their ex ante willingness to accept compensation for these rights is relatively easy to measure.

Flooding caused Bt6,600 million (US$264 million) of damage in Bangkok in 1982 (Phantumvanit and Liengcharernsit 1989). Annual flooding in Manila affects 1.9 million people (23 percent of the population) and causes P900 million (US$45 million) of damages (Hechanova 1990, Jimenez and Velasquez 1989). Many human activities contribute to the severity of this flooding in varying degrees. The correlations are still ambiguous, and each location is different. Accelerated land subsidence (a severe problem in Bangkok, as described in box 3-5) might be responsible for 10 to 30 percent of inundations.

A well-managed mangrove forest in Malaysia is said to yield up to US$1,100 per hectare in forest and fish products (Turner 1991); this is the value that would be lost due to conversion. In addition, for the loss of mangroves and other wetlands, the replacement costs of environmental services include manmade sewage treatment, flood control, and storm protection structures (Sarkar 1990, Turner 1991); no monetary valuations were found for these in the literature.

Nair et al. (1979) conducted a multi-objective analysis for a Malaysian mangrove forest. Three alternative uses—preservation, woodchips production for Japan, and milkfish culture—were examined using three criteria—income, foreign exchange, and employment. The results showed that mangrove preservation for the sake of offshore shrimp trawling was most beneficial in terms of income and foreign exchange, but that woodchip production was superior for employment. Milkfish culture fell behind in all aspects. The results were weighted according to the relative importance of each criterion. Using a tradeoff frontier model, it was found that an economically optimal solution would be a combination of preservation and woodchip production. Table 3-23 shows the resource use results of different biases in weighting the three criteria. Milkfish might have fared better if food production and poverty alleviation had been used as criteria.

Table 3-23. Optimal Allocation of the Mangrove Resource Base under Different Preference Functions

Preference function ($y + f + e = 1$)	Annual mangrove logging (acres)	Prawn landings (tons)
Alternative A - income bias: $y = 1$; $f = 0$; $e = 0$	3,300	660
Alternative B - foreign exchange bias: $f = 1$; $y = 0$; $e = 0$	3,000	680
Alternative C - employment bias: $e = 1$; $y = 0$; $f = 0$	6,100	440

Source: Nair et al. (1979).

Costanza, Farber, and Maxwell (1989) conducted a thorough analysis of the value of Louisiana wetlands—including commercial fisheries, fur trapping, recreational values, and storm protection functions—using both willingness to pay and energy analysis techniques. They found that "the discount rate makes more difference in the final result than any other one factor," and argue for low discount rates for such analyses. There is considerable controversy on this matter because, while low discount rates have the effect of expanding time horizons, they may also lead to more development overall, which might have detrimental effects.

Amenities

Grandstaff and Dixon (1986) used both travel cost and contingent valuation to value Lumpinee Public Park in Bangkok. The travel cost method yielded a value of Bt13.2 million for 1980 (US$660,000 at 1980 exchange rates). Surveys of park users gave results of Bt13.0 million. But when a wider range of Bangkok residents were interviewed in their homes as a "social hypothetical valuation," the results were much higher—over Bt116 million (US$5.8 million) for 1980. It was thought that this higher value includes the option value of people who do not use the park but may wish to do so in the future; it may also be the product of a hypothetical bias—i.e., people overstated their willingness to pay since they felt they would not actually be required to pay. Similarly, park users surveyed may have suspected that they would be assessed a user fee in the future, and therefore understated their WTP. The hedonic pricing method does not appear to have been used to derive amenity value in Asian cities.

The first Sunday of November is Tree Planting Day in Singapore. In 1989, "about 2,500 citizens including members of Parliament and community leaders planted some 2,300 trees, palms and shrubs in 55 constituencies. This brings the number planted on the tree planting days since 1971 to about 271,700." It is expected that the trees will attract birds, act as "green lungs" for the city, improve recreation sites, provide shade, and generally enhance Singapore's attractiveness (ESCAP 1990a). No cost data were given, but information like this can give some indication of the amenity value of trees.

Bergstrom et al. (1990) used surveys to determine the recreational value (including hunting and fishing) of Louisiana wetlands. They added expenditures (travel costs, etc.) of US$89.30 per hectare and a consumer surplus of US$20.73 per hectare for a total gross economic value of US$110.03 per hectare, or US$145 million for the 1.32 million hectare area. (They caution against analysis on a per hectare basis because it "ignores the holistic value of wetland ecosystems.") It is unclear how these results could be applied in the Asian setting; in lower income Asian countries, hunting and fishing in wetlands might better be valued in terms of food production rather than recreation. But it should be noted that recreational value does have a strong impact on income from tourism. Hodgson and Dixon (1988) calculated that continued degradation of water quality and coral reefs caused by logging activity in Palawan (Philippines) would reduce the gross revenue of diving resorts there by US$39 million during the decade 1987-96.

Ecological Values

Leitmann (1991a) cites his earlier study of environmental pricing of charcoal in Haiti. To derive marginal opportunity cost pricing for charcoal, the following estimates were incorporated:

> The marginal economic cost of wood was estimated at US$6/ton. The marginal environmental cost consisted of three elements: soil improvement value (US$5/ton), soil erosion control value (US$14/ton), and sedimentation control value (US$3/ton). This environmental value of wood at

US$28/ton was then used as the basis for building up the environmental price of charcoal to the urban consumer.

His calculation of the replacement costs to grow new trees resulted in a similar figure, US$30/ton. And a study of urban trees in arid Tucson, Arizona, found that "for every dollar spent to maintain trees, US$2.62 worth of benefits were returned from air-conditioning energy savings, dust reduction, and the slowing of stormwater runoff" (Rodbell et al. 1991).

According to Goodland (1989), "possibly the single most influential change towards sustainability is to revamp neo-classical economics to accommodate environmental sustainability, including ethical and non-anthropocentric values." Figure 3-5 offers some ideas, i.e., new sustainability principles, that can be used in economic analyses.

Figure 3-5. Principles and Practice of Sustainable Development in the Wetlands Context

Global Ongoing Loss of Temperate and Tropic Wetlands

Sustainability Principles	**Practice**
Efficiency and equity within and between generations; efficiency and equity objectives are secured by actual compensation; rejection of potential welfare concept	Balance to be struck between wetland conservation, sustainable utilization, and economic development; *sustainable utilization* the key concept for tropical wetlands in developing economies; population growth control and an expansion of the set of economic opportunities available to poor people is essential (intragenerational equity); aim should be to foster sustainable income flows
Much environmental degradation is due to a combination of information, market, and intervention failures	Wetlands loss rate is high and has been caused by natural resource use conflict together with information, market, and intervention failures—i.e., lack of awareness and appreciation of the full value of wetlands; pollution damage and overutilization because of open access; and inefficient or inconsistent policy
Actual compensation is operationalized via three types of capital transfer in order to pass on a portfolio of productive opportunities of equal or greater value to the next generation "CRITICAL" NATURAL CAPITAL OTHER NATURAL CAPITAL MANMADE CAPITAL K_N^C <VERY LIMITED SUBSTITUTION> K_N <GREATER SUBSTITUTION> K_M $K_N^C + K_N + K_M$ = TOTAL CAPITAL STOCK	Wetlands to be differentiated in terms of their structural and functional value; not all wetlands are equally valuable, but most are multifunctional assets with extensive environmental capacities/infrastructures; wetlands inventory (regional, national, and international) required; identification of actual and potential threats to wetlands, because they are open systems, off-site water basin-wide analysis is required
Valuation of the capital stock: Total Economic Value = Use + Option + Existence Values Management of the multifunctional natural capital stock to ensure sustainable flow of income	Topical wetlands use values (direct and indirect) very high; valuation methods and techniques available more limited in developing economy context; safe minimum standards approach will require international compensation, e.g., debt for nature swaps, etc.
Extended cost-benefit analysis can provide a sound methodological base for sustainable resource management	Ongoing and anticipatory assessment process; standard project appraisal methods augmented by shadow project analysis—wetland creation, transfer and restoration possibilities and costs; integrated water basin management is the longer term objective, which will require CBA plus other nonmonetary assessment methods

Source: Turner (1991).

Perhaps most important is a change in the assumption that manmade capital can always be substituted for natural capital; and that if the sum of all capital grows, development is sustainable. Intergenerational equity is also very important.

Many see the preservation of species as ethically an end in itself—that it is unacceptable to make any species extinct. The replacement cost approach leads to similar results. Extinct species—and "dead" natural support systems—can never be replaced, which makes their cost infinite. Turner (1991) argues that "Even if the ethical justification for the conservation of biological diversity, based on intrinsic value in nature, is rejected, there is still a stewardship argument to reckon with. Thus the eradication of other species amounts to the foreclosure of options for future generations and a breach of the stewardship principle."

As mentioned earlier, apart from the valuable life-support services offered by natural systems such as wetlands, there are option values and nonuse values. Option or quasi-option values are often associated with biodiversity because of the potential loss of very valuable, but as yet unknown, species. Existence values, on the other hand, are not based on actual use of a resource.

As shown in figure 3-4 and corroborated by Randall (1991), for option values and nonuse values, contingent valuation "seems destined to play a major role in benefit estimation for biodiversity." However, contingent valuation methods have been criticized as containing various biases. Beyond a strong information bias, Samples, Dixon, and Gowen (1986) found a significant bias in the types of species people were willing to save—i.e., they prefer to save monkey-like animals rather than rabbit- or rat-like ones. If questioned, people would probably have a very low WTP to save spiders and snakes, although in some instances, these are crucial to the proper functioning of an ecosystem ("Spider-Bets and Deforestation" 1989). In addition, by focusing on individual preferences, contingent valuation does little to promote sustainable development, for which broader horizons of time and space are necessary. But there is the possibility of making improvements—for example, by using public referendum methods that would attempt to determine, for instance, the willingness to be taxed as a citizen along with other citizens (Costanza, Daly, and Bartholomew 1991; Randall 1991).

According to Randall (1991), travel costs and hedonic pricing could play a "limited but nontrivial role" in assessing ecological values because of the increasing importance of adventure travel (ecotourism) and retirement homes in and around "exotic environments."

Another way to derive a minimum estimate of amenity and ecological values would be to calculate the time and money dedicated to environmental nongovernmental organizations (NGOs). Table 3-24 lists such NGOs found in Manila and Jakarta. Other Asian countries—e.g., India, Thailand, and Malaysia—also have an abundance of such organizations. ESCAP (1990a) reports that India has at least 500 environmental NGOs. They are especially suitable for revealed preference evaluations because most of the time and money involved is invested solely for the purpose of environmental improvement.

Table 3-24. Environmental NGOs in Manila and Jakarta

Manila	Jakarta
Alternative Development Center for Advocacy, Training and Education	Nature Lovers Club, University of Indonesia
Ateneo Center for Social Policy and Public Affairs	Bandung City Regreening Group
Bishop's-Businessmen's Conference Committee on Ecology	Volunteer Network against the Misuse of Pesticides
Center for Environmental Concerns	Legal Aid Institute
Community Extension and Research Development., Inc.	Center for Marine Studies and Development
Ecological Society of the Philippines	Volunteer Network for Forest Conservation
Environmental Science Society	Volunteer Network for the Control of Pollution
Green Party	Indonesian Environmental Forum
Lingkod Tao-Kalikasan	Foundation for Use of Traditional Medicines
National Action for the Transformation and Rehabilitation of the Environment	Consumer Association
Nuclear Free Philippines Coalition	Panca Bakti Foundation
Philippine Education and Awareness Campaign for the Environment	
Philippine Institute of Environmental Planners	
Solid Alliance of Vigilant Environmentalists	
Society for a Better Environment	
Save the Children Foundation	
Wildlife Foundation of the Philippines	
Work Against Trash for Ecological Rebirth	
World Environmentalists for Clean Air Network	

Sources: Hechanova (1990), Tarrant et al. (1987).

4. SUMMARY AND CONCLUSION

4.1 Summary of Urban Environmental Problems in Asian Cities

As discussed in the previous chapter, almost all of Asia's major cities are plagued by worsening environmental problems. Table 4-1 lists major environmental problems and their associated impacts.

Table 4-1. Major Environmental Problems/Impacts and Damages

Problem	Impact	Damages
I. Pollution		
Air pollution (particulates, SO_x, smog, etc.) *Ambient air pollution*	• Respiratory illness (H) • Respiratory death (H) • Materials damage (P) • Vegetation (P) • Soiling (P) • Aesthetics (A) • Ecosystems (E)	• Morbidity: WLD, RAD, med. expense, suffering • Mortality • Physical deterioration • Crop losses • Cleaning/washing costs • Visibility loss; odor • Degradation; loss of biodiversity
Indoor air pollution	• Respiratory illness (H) • Respiratory death (H)	• Morbidity: WLD, RAD, med. expense, suffering • Mortality
Water pollution (biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, etc.)	• Waterborne disease (H) • Commercial fishery (P) • Domestic, commercial & industrial water (P) • Recreation uses (A) • Aesthetics (A) • Ecosystems (E)	• Morbidity and mortality • Stock loss • Increased treatment cost • Loss of swimming, fishing, boating, etc. • Turbidity; odor • Degradation; loss of biodiversity
Solid wastes; hazardous wastes (lead, mercury, PCBs, asbestos, pesticides, hazardous chemicals, etc.)	• Illness (H) • Death (H) • Accident (H) • Vegetation and animals (P) • Aesthetics (A) • Ecosystems (E)	• Morbidity: WLD, RAD, med. expense, suffering • Mortality • Morbidity and mortality • Crop and stock loss • Visual blight; odor • Degradation; loss of biodiversity
Noise (aircraft, traffic, etc.)	• Mental and hearing disorders (H) • Nuisance (A)	• Morbidity • Personal stress; loss of property value
II. Congestion		
Traffic congestion	• Accelerated wear and tear (P) • Increased use of fuel (P) • Increased travel time (P) (A) • Increased accident rate (H) • Air pollution (H)	• Maintenance/repair costs • Fuel cost • Time cost • Morbidity and mortality • Secondary health effects
III. Degradation of natural support systems		
Forests and agricultural lands	• Shortage of trees (P) • Loss of agricultural productivity (P) • Lost environmental services from trees (A) • Ecosystem effects (E)	• Higher fuelwood cost; increased travel time to gather fuelwood • Higher cost of food; malnutrition • Increased soil erosion/flooding; more noise; less shade; reduced air quality, aesthetic appearance, and property values • Loss of biodiversity; reduced option values
Wetlands and coral reefs	• Marine fisheries (P) • Reduced flood control & storm protection (P) • Recreational uses (A) • Ecosystem effects (E)	• Reduced catch • Higher flood/storm damages; higher defensive expenditures • Loss of tourism value • Loss of biodiversity
Groundwater depletion	• Lowering of water table (P) • Saline water intrusion (P) • Land subsidence (P) (A)	• Increased pumping costs • Loss of freshwater resource • Physical damage to structures and utility lines; increased risk of flood damage

Notes: H = health & safety; P = productivity loss; A = amenity value; E = ecological value; WLD = work loss days; RAD = restricted activity days.

The calculations performed in the previous chapter were mainly intended to demonstrate the various valuation techniques, and we cannot provide a summary of costs in monetary terms for the different cities. However, we attempted to assess the relative severity of the urban environmental problems for the region as a whole, as shown in table 4-2.

Table 4-2. Summary Assessment of the Severity of Impacts of Environmental Degradation in Asian Cities

Impact	Pollution		Congestion	Degradation of natural support systems			
	Air	Water	Traffic congestion	Deforestation	Diminishing agricultural lands	Wetlands destruction	Groundwater depletion
Health and safety	Very high*	Very high*	Medium	Medium	Low	Medium	Medium
Productivity	Medium*	High*	High*	Medium	Medium	Medium	Medium
Amenity value	High	High	High	Medium	Medium	Medium	Low
Ecological value	Medium	Medium	Low	High	Medium	High	Low

Note: Entries with an * are relatively objective, because there are more data on these impacts.

The major impacts on health and safety come from air and water pollution. Ambient air pollution impairs the health of almost all urban residents in many Asian cities. Indoor air pollution, on the other hand, poses a significant health problem particularly for women and children of low-income households who are regularly exposed to high concentrations of air pollutants from cooking and heating sources in poorly ventilated dwellings. Waterborne diseases are found most commonly in low-income neighborhoods as a consequence of inadequate sanitation, drainage, and solid waste collection services. Pesticides and industrial effluents (especially heavy metals) also contribute to health risks. These health effects deserve priority attention in any effort to correct or mitigate Asia's urban environmental degradation.

Productivity is most affected by traffic congestion and water pollution. The total productive time wasted in traffic and the associated increase in vehicle operating and maintenance costs are imposing significant negative impacts on the productivity of many Asian cities. The increasing costs needed to treat polluted water for industrial and domestic consumption are hurting the productivity of urban economies. Also, fisheries are severely damaged by water pollution.

Amenity value—the overall pleasantness of a place—is adversely affected mostly by air and water pollution and traffic congestion. Also, the widespread removal of vegetation in urban areas (deforestation, diminishing agricultural lands and wetlands) has a negative impact on amenity value.

Ecological value, which includes basic ecosystem services as well as existence or nonuse values, naturally suffers most from the degradation of natural support systems. In many cities, there is an irreversible loss of critical ecosystem functions as well as of biodiversity.

This overall assessment, to be sure, is made on the basis of order-of-magnitude estimates rather than exact figures calculated with refined techniques and full access to information. More systematic studies and substantive evidence exist on health and productivity impacts than on amenity and ecological values in Asian cities; therefore, we are more confident of our assessments of the former.

4.1.1 Consideration of Equity

Usually economic valuations measure only the economic efficiency effects of environmental problems and programs to alleviate them and take little account of the distribution of such effects among the population. Yet it is well-known that environmental problems in Asian cities affect the poor and the nonpoor differently. In particular, people living in slums suffer the most from urban environmental problems. Indoor air pollution, poor sanitation, contaminated drinking water, and flooding all have very high effects on the health and safety conditions of the poor, but are of less significance to the remainder of the urban population. Because of these differences in incidence between poor and nonpoor, and because of the need to measure equity effects, it is necessary to disaggregate them to the extent possible.

Table 4-3 summarizes estimates of the relative magnitudes of poor/nonpoor effects of environmental problems on health and safety, productivity, amenity value, and ecological value. This table only presents the incidence and impacts of environmental problems; an economic valuation will tend to distort these magnitudes. For instance, for amenity value, the poor are more affected, but the nonpoor are more willing to pay. Willingness to pay is often inversely related to ability to pay. Income effects alone will ensure that the demand for environmental improvements is measured as much less among the poor than among the rest of the population. Yet the poor are often willing to pay a much higher proportion of their income—say, for drinking water or sewage disposal—than the nonpoor. These differences would be masked in an aggregate economic analysis; hence separate environmental and economic analyses should be made of the poor and the nonpoor in Asian cities. Bertraud and Young (1991) have taken a step in this direction by using housing type as a binary surrogate for poverty in a study of environmental health in Tianjin.

Table 4-3. Incidence of Environmental Problems and Impacts on the Poor and Nonpoor in Asian Cities

Impact	Air pollution	Water pollution	Congestion	Degradation of natural support systems
Health and safety	Poor: Very high Nonpoor: High	Poor: Very high Nonpoor: Medium	Poor: High Nonpoor: Medium	Poor: Medium Nonpoor: Low
Productivity	Poor: Medium Nonpoor: Medium	Poor: High Nonpoor: High	Poor: High Nonpoor: High	Poor: Medium Nonpoor: Medium
Amenity value	Poor: High Nonpoor: Medium	Poor: High Nonpoor: Medium	Poor: High Nonpoor: High	Poor: Medium Nonpoor: Medium
Ecological value	Poor: Medium Nonpoor: Medium	Poor: Medium Nonpoor: Medium	Poor: Low Nonpoor: Low	Poor: High Nonpoor: High

Note: The distinction between poor and nonpoor is irrelevant with regard to ecological values, since these impacts affect the entire urban population.

4.2 Summary Assessment of Valuation Techniques

The techniques for economic valuation of environmental effects discussed in this report have evolved over a period of 30 years. When benefit-cost analysis first became widely known in the early 1960s, it relied almost entirely on the use of market prices to estimate benefits and costs (Dorfman 1965). Because there were no markets for public goods such as air and water quality or public outdoor recreation sites, conventional benefit-cost analysis techniques were of little use; this led environmental and natural resource economists to search for new techniques to supplement the market value approach. Beginning with development of the travel cost approach in the early 1960s, several behavioral-linked valuation techniques were developed and extensively tested in the 1970s and 1980s. As discussed earlier in this report, the hedonic pricing and travel cost techniques measure revealed preferences, while the contingent valuation techniques rely on stated preferences. Experience with these techniques over the past 20 years—largely in the United States, but increasingly in Europe—has provided a good basis for evaluating their advantages and disadvantages and their general suitability for application at least in developed countries. The results of three such evaluations are summarized below.

4.2.1 Organisation for Economic Co-operation and Development (OECD) Evaluation

OECD (1989) analyzed five benefit estimation techniques—hedonic property prices, hedonic wages, travel cost, contingent valuation, and market price oriented dose-response/damage cost—for applicability to air pollution, water pollution, toxic substances, radiation, marine pollution, and noise (tables 4-4 and 4-5).

Table 4-4. Matrix of Benefit Techniques by Environmental Sector

Pollution	Type of effect	Benefit impact	Benefit estimation technique: Hedonic property	Hedonic wages	Travel cost	CV	Dose-response	Other	Comments
Air pollution									
Conventional pollutants (TSP, SO_2, NO_2)	Respiratory illness	WLD, RAD, medical expenses, suffering	O	L	O	X	X	Health capital model	
	Respiratory death	Death	L	X	O	O	X		
	Aesthetics	Visual, sensory	X	L	O	X	O		Some wage valuation experience
	Recreation	Visits, especially to forests	O	O	X	X	O		
	Materials	Maintenance/repair	O	O	?	?	X		For historic monuments
	Vegetation	Crop losses	O	O	O	O	X		Forest reclamation
Water pollution									
Conventional pollutants (BOD, etc.)	Recreation: fishing, boating, etc.	Visit behavior	L	O	X	X	O		
	Commercial fisheries	Stock losses	O	O	O	O	X		
	Aesthetics	Turbidity, odor, unsightliness	X	O	L	X	O		
	Ecosystem	Habitat/species loss	O	O	O	X	X		
Trace concentrations	Drinking water	Illness, mortality	O	O	O	?	X		
	Fisheries	Stock	O	O	O	O	X		
Toxic substances									
Air (benzene, PCBs, pesticides)	Illness and mortality	WLD, RAD, medical expenses, suffering	?	X	O	X	X		
Hazardous chemicals to land	Aesthetics	Unsightliness	X	O	O	X	O		
	Ecosystem	Health, anxiety, ecosystem losses	O	O	O	X	X		
Radiation	Illness, mortality	WLD, RAD, lives lost	?	X	O	L	X		
Marine pollution									
Oil, radioactive substances, sewage	Aesthetics, swimming	Unsightliness, visit behavior, illness, fish stock losses	?	O	X	X	X		
Noise	Nuisance	Annoyance	X	O	O	X	L		

Key: X = used technique; O = nonusable technique; L = very limited application; ? = not developed, but possible.

Note: CV = contingent valuation; WLD = work loss days; RAD = restricted activity days; BOD = biochemical oxygen demand.

Source: OECD (1989).

Table 4-5. Assessment of Benefit Estimation Techniques

	Hedonic property prices	Hedonic wages	Travel cost	Contingent valuation	Dose-response/damage cost
Physical data problems	No	Yes	Yes	No	Yes
Benefit function	Yes	Yes	Yes	Yes	Assumed
Sophistication	High	High	High	High	High
Relation to behavioral theory	Yes	Yes	Yes	Yes	No
Problems	Sensitivity to model-specification Free markets important		Sensitivity to model-specification Travel time cost measurement Influence of site substitutes	Hypothetical bias WTP/WTA disparity	Sensitivity to model-specification
Special features	Main technique for workplace Can be cross-checked with contingent valuation		Use limited to recreation Can be cross-checked with contingent valuation	Can cover existence Only method for many issues	Only method for many issues Requires separate valuation technique

Source: OECD (1989).

As shown in tables 4-4 and 4-5, the contingent valuation and dose-response approaches have very wide applicability. OECD rates their reliability as "fairly high," and each is the "only method for many issues." The contingent valuation technique requires little if any physical data and is held to be :

- applicable for a greater number of environmental effects than any other technique,
- the only technique that can handle nonuse values of public goods, and
- the only practical method for many amenity goods.

In contrast, hedonic pricing techniques are applicable primarily to aesthetic effects and site-specific health effects. Hedonic pricing is also limited because it accepts existing prices as competitively determined, and is sensitive to model specification.

4.2.2 Cummings, Cox, and Freeman Evaluation

The Cummings, Cox, and Freeman (1986) study focused on five methods of monetary evaluation of nonmarket goods: contingent valuation, contingent ranking, petition, hedonic pricing, and travel cost. Their summary of the techniques is shown here as table 4-6. Data requirements are greatest for the hedonic pricing and travel cost methods. The contingent valuation method is broadly applicable to many public goods, while the hedonic pricing method is principally suited to small changes in environmental quality, and the travel cost method, to outdoor recreational sites. The contingent valuation method generally yields order-of-magnitude estimates of values; and, in some limited applications, well-structured questionnaires may yield reasonably precise estimates. Contingent valuation is most appropriate for measuring amenity value:

- when the respondent is familiar with the public good in question,

- when there is relative certainty associated with the public good, and
- when measuring willingness to pay rather than willingness to accept compensation.

Table 4-6. Summary of Benefits Assessment Methods

Method	Data requirements	Assumptions	Output	Principal application areas
Contingent valuation	Survey sample data Cardinal preference data (e.g., WTP/WTA)	Coherent preferences, truthfully expressed WTP/WTA values can be aggregated meaningfully	"Simulated market" demand curve	Any public good for which people have well-defined holistic preferences
Contingent ranking	Survey sample data Ordinal preference data (e.g., ranking)	Random utility preference structure Behaviorally accurate responses	Estimated utility functions	Public goods with discrete alternative levels
Petition	Survey sample data Binary choice data	Responses reflect intended behavior	Data for logistic or other regression model	Public goods for which petitions are credible
Hedonic price	Extensive market price data on diverse set of attribute combinations	Full value of public good is expressed through revealed preferences Assumed utility function form for nonmarginal changes	Implicit prices for attributes	Small changes in environmental quality
Travel cost	Secondary data on travel costs, site attributes Primary data on visitor characteristics	Sole purpose site visits Marginal trip cost = marginal site benefit	Site-specific demand curve	Recreational sites

Source: Cummings, Cox, and Freeman (1986).

4.2.3 Mitchell and Carson Evaluation

Mitchell and Carson (1989) make a distinction between physical linkage methods using market prices and behavioral linkage methods using surrogate market prices. They classify behavioral linkage methods into four categories: direct and indirect observed market behavior, and direct and indirect hypothetical market behavior. (See table 4-7.) In the observed/indirect market behavior category, the authors place hedonic pricing and the travel cost method (as a variant of the household production function method); they locate the contingent valuation method in the hypothetical/direct market category.

Table 4-7. Behavior-Based Methods of Valuing Public Goods

	Direct	Indirect
Observed market behavior	**Observed/direct** Referenda Simulated markets Parallel private markets	**Observed/indirect** Household production Hedonic pricing Actions of bureaucrats or politicians
Responses to hypothetical markets	**Hypothetical/direct** Contingent valuation Allocation game with tax refund Spend more-same-less survey question	**Hypothetical/indirect** Contingent ranking Willingness-to-(behavior) Allocation games Priority evaluation technique Conjoint analysis Indifference curve mapping

Source: Mitchell and Carson (1989).

Mitchell and Carson point to the exacting data requirements and other limitations of the hedonic pricing technique and to the problems of limited applicability of the travel cost method. In contrast, they emphasize the advantages of the contingent valuation technique, including its flexibility and ability to measure option-price and existence-class benefits. According to them, the method "shows promise as a powerful and versatile tool for measuring the economic benefits of the provision of nonmarketed goods. It is potentially capable of directly measuring a broad range of economic benefits for a wide range of goods . . . " They also conclude that contingent valuation surveys can actually measure values that are sufficiently reliable and valid for use in benefit estimation. In their view, neither strategic nor hypothetical biases are necessarily impediments to the technique's usefulness. They report an emerging consensus that it can measure meaningful values for familiar goods such as local recreational amenities. Even for less familiar goods, they note, such as air quality improvements, the technique shows promise.

4.2.4 Summary

Experience with these environmental and public good valuation techniques largely in the United States has led to increased acceptance of many of these techniques by economists and policymakers, and in judicial proceedings (Kopp and Smith 1989), in making regulatory and public investment decisions. Greatest confidence continues to be placed on mainstream benefit-cost techniques using market prices along with damage and dose-response functions. Of the three major behavior-oriented techniques, the contingent valuation technique is conceded to be the most broadly applicable to different types of public goods, while the travel cost method is considered to be the most reliable for estimating the use values of outdoor recreation sites. The hedonic pricing methods—both property value and wage differential—continue to be problematic, because of exacting data requirements and reliance on smoothly functioning markets.

4.2.5 Applicability to Asian Cities

The techniques described in this paper were designed in the United States and Europe to address developed country problems. Approaches to major developing country problems—unsafe drinking water, lack of sanitation, severe degradation of natural systems, etc.—were conspicuously absent. Also, the valuation techniques were designed and applied in situations where poverty was not explicitly addressed. They are therefore far more suitable for high-income than low-income Asian countries. Nevertheless, some applications have been tried. For pollution, techniques that were actually applied include cost of illness, defensive expenditures, and stated preferences, as well as cost-effectiveness analysis. For congestion, the time cost has been calculated, at least in Bangkok. For natural support systems degradation, physical linkage and contingent valuation were applied, as was multi-objective analysis. Bangkok was the most-studied city in all three categories.

Following is an overview of the techniques in terms of a set of nine criteria, including applicability to conditions of poverty ("flexibility"). The results are summarized in table 4-8.

1. **Theoretical validity.** Many economic theorists consider the human capital approach and other physical linkage methods to be theoretically flawed because they are not based on individual preferences. In contrast, all but one of the behavioral linkage methods rank high in theoretical validity, because they seek to measure people's willingness to pay.
2. **Importance of competitive markets.** This criterion concerns the reliance of the technique on the existence of competitive markets. This is highly relevant in Asia where considerable variability exists in freedom of markets—North Korea and Burma at one extreme, and Singapore and Hong Kong at the other. The hedonic pricing techniques are highly dependent

on free markets, while the contingent valuation technique is relatively insensitive (in theory) to market structure. The other techniques, including all of the physical linkage techniques, can accommodate market imperfections—for example, by the shadow price approach commonly used in social benefit-cost analysis (Squire and Van der Tak 1975, Sassone and Schaffer 1978, Gittinger 1982).

3. **Data requirements.** This criterion is important in many Asian contexts where relevant physical and economic data are often unavailable or hard to obtain. This is the most important constraint in some developing countries. The contingent valuation technique, because it is survey-based, requires the least physical and economic data. It also allows collection of task-relevant data. On the other hand, it is sensitive to respondents' knowledge of relevant factors. The other techniques, including all of the physical linkage methods, have high requirements for physical data but only medium requirements for economic data.

4. **Sophistication.** The ease of application of a valuation technique is inversely related to its sophistication, especially in most Asian countries where trained environmental and resource economists are scarce. For this criterion, all of the physical linkage techniques as well as the averting behavior technique score well, in that standard social benefit-cost methods can be routinely applied. In contrast, the other behavioral linkage techniques either require elaborate econometric approaches, or, in the case of contingent valuation, sophisticated survey research methods and statistical analysis.

5. **Flexibility.** All of the physical linkage techniques can be applied to a wide variety of cultural and institutional milieus and conditions of poverty or affluence because the damage functions and dose-response relationships are relatively insensitive to these variables. However, the cost-of-illness approach has limited applicability given the widespread absence of local medical expenditure statistics. The human capital approach of valuing future earnings is only appropriate as a nationwide statistical average. Hedonic pricing methods are highly sensitive to different property rights institutions, such as exist in cities with effective land use planning (e.g., zoning) as opposed to large squatter settlements. Contingent valuation can be applied in conditions of poverty with the use of costless choice methods rather than willingness to pay.

6. **Breadth of applicability.** Some techniques are very specific in their application. For example, the cost-of-illness and human capital methods are applicable only to measuring human health and safety values. In contrast, the contingent valuation method has broad applicability to human health and safety, productivity, amenity value, and ecological value. Most of the techniques are intermediate in terms of their applicability.

7. **Robustness.** The robustness of a technique refers to its ability to produce credible outputs under varying conditions of data availability and modeling assumptions. A common tradeoff is between robustness and sophistication. The physical linkage techniques that rank low in sophistication generally rank high in robustness, while the highly sophisticated hedonic pricing techniques score low in robustness.

8. **Special problems.** In general, physical linkage techniques have the special problem of deriving valid damage functions or dose-response functions, and behavioral linkage techniques are sensitive to the specification of econometric models. In addition, the contingent valuation method has various biases and a disparity of results between the willingness-to-pay and willingness-to-accept-compensation tests.

9. **Potential applications.** Just as data and specification sensitivities limit the choice of valuation technique, so does the nature of the problem being investigated. For example, physical linkage techniques are generally more suited to valuating problems affecting the poor than are behavioral linkage techniques.

Table 4-8. Applicability of Selected Valuation Techniques to Asian Cities

Technique \ Criteria	Theoretical validity	Importance of competitive markets	Data requirements		Sophistication	Flexibility[a]	Breadth of applicability	Robustness	Special problems	Potential applications
			Physical	Economic						
Physical linkage - market prices										
Productivity gains/losses	Medium	Medium	High	Medium	Low	High	Medium	High	Requires damage functions	Industrial, commercial, public sectors pollution & congestion
Costs of illness	Medium	Medium	High	Medium	Low	High	Low	High	Requires dose-response functions	Human health & safety pollution & congestion
Human capital	Low	Medium	High	Medium	Low	High	Low	Low	Requires dose-response functions	Human health & safety pollution & congestion
Replacement cost	Medium	Medium	High	Medium	Low	High	Medium	High	Requires damage functions	Household & public sectors pollution & natural support systems
Behavioral linkage										
Revealed preference										
Hedonic pricing - property value	High	High	High	High	High	Low	Medium	Low	Sensitive to model specification	Well-developed housing markets in nonpoor sections of more-developed cities
Hedonic pricing - wage	High	High	Medium	High	High	Low	Medium	Low	Sensitive to model specification	Well-developed labor markets in affluent cities—e.g., Singapore
Travel cost	High	Medium	Medium	Medium	High	Medium	Low	Medium	Requires valuation of travel time	Traffic congestion, recreation sites in more-developed cities
Averting behavior	Medium	Medium	High	Medium	Low	High	Medium	High	—	Household response to congestion, pollution, noise
Stated preference										
Contingent valuation	High	Low	Low	Low	High	Medium-Low	High	Medium	Hypothetical bias; disparity between WTP/WTA	"Familiar" goods—e.g., air quality, water quality, potable water, parks

[a]Refers to socioeconomic/cultural and institutional flexibility, e.g., poor/nonpoor.

4.3 Proposed Strategies for Application

4.3.1 Purposes of Economic Valuation

Economic valuation of environmental effects can play an important role in making decisions on the allocation of scarce resources. Along with information on the distribution of environmental costs and benefits (e.g., among the poor and nonpoor), economic valuation can provide necessary information on the economic efficiency and equity consequences of environmental degradation, and of projects and programs designed to alleviate these consequences.

One important purpose of economic valuation is to obtain information on a macro scale of magnitudes of economic costs for various types of environmental impacts (e.g., ambient air pollution, traffic congestion). Because this information can be used to guide overall environmental policy including general allocation of resources among major environmental categories, absolute magnitudes are less important than relative magnitudes.

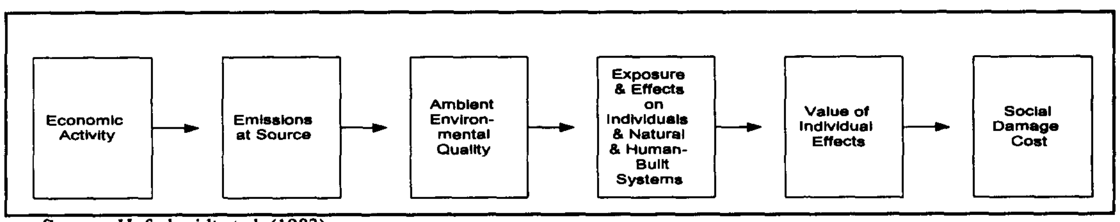
A second major purpose of economic valuation is to obtain information on economic costs and benefits on a micro scale for specific environmental improvement projects, such as water pollution control, drinking water supplies, or urban traffic improvements. Here the absolute magnitudes of the economic costs and benefits are of greater importance than the relative.

Macroeconomic valuation has less stringent data requirements, in terms of damage functions and dose-response relations, than does microeconomic valuation. Skillful adaptation of some physical relationships from developed countries is acceptable. In contrast, microeconomic valuation requires better physical and economic databases; these are more likely to be available, or data may be more readily gathered, for a site-specific project than for a regional or national effort.

4.3.2 Elements of a Strategy

As shown in figure 4-1, economic valuation is the final step in a long process.

Figure 4-1. Estimation of Social Damage Cost



Source: Hufschmidt et al. (1983).

Before a meaningful valuation can be performed, much physical information must be collected and analyzed. Ideally, we would have complete information for all the boxes and the links between them. In fact, however, even in developed countries, information on these physical relationships is inadequate, in spite of extensive programs of air and water quality monitoring and considerable laboratory and epidemiological research on health effects of pollutants. The situation in developing countries is generally worse. For instance, the number of site years of sulfur dioxide monitoring by the Global Environmental Monitoring System was, as shown in table 3-5, 0 for Jakarta, 1 for Kuala Lumpur, and 13 for Bombay, compared to 20 for Osaka. Data limitations in the relatively developed economy of Seoul are described in box 4-1.

Box 4-1. The Example of Seoul

Air Pollution. *Seoul Metropolitan City has 20 automatic air pollution monitoring stations (10 operated by the national Ministry of Environment and 10 by the city government). The data are reported every month. Several studies have applied the damage function approach to measure monetary damage costs of respiratory disease caused by air pollutants. These studies, however, have not attempted to estimate local dose-response functions, but simply applied available dose-response coefficients from developed countries without questioning the validity of doing this. The more significant problem is that no one has seriously attempted to generate data essential to deriving meaningful outcomes from the damage function approach. However, the studies are useful in that they show that the damage function approach can be used to value monetary costs of environmental damage; such costs were previously considered to be unmeasureable in monetary terms. There was also an attempt to apply the damage function approach to value materials loss and property damage, even though it was only a suggestive trial.*

Mortality and morbidity data by source of death and type of disease are reported annually at the national level. However, the data are not broken down by districts in Seoul. Epidemiological studies of air pollution have been performed extensively by various medical schools and research institutes. Impacts of air pollution on crops are also studied by the Agricultural Technology Research Institute.

Korea has air pollution emission factors for various kinds of domestically made automobiles. Data for the number of vehicles and distance (km) traveled per day in each area are also available. In September 1991, the City of Seoul completed a study on the status of traffic congestion in Seoul, which provides essential data for valuing the time cost of congestion.

Water Pollution. *Monitoring of water pollution is performed at various points in each river basin; these data are more dependable than are air pollution data. Several epidemiological studies analyzed the effects of river pollution in an industrial city on the health of nearby residents. No study has yet measured the economic cost of water pollution in urban areas. Several studies have assessed the impacts on commercial fisheries and aquaculture of ocean contamination caused by discharge of toxic wastes from chemical plants.*

Land Pollution. *The City of Seoul investigates the status of soil contamination irregularly, but no study has been made on the social cost of land pollution. Some related studies are on the content of heavy metals such as lead and mercury in crops.*

Other Studies. *A recent study investigated the effect of degraded air quality caused by coal particles from a nearby briquet manufacturing company on property value, income, and morbidity rate. This study gives some clue to the possibility of applying the hedonic pricing technique to the valuation of the amenity value of air quality.*

There are a few hedonic housing demand studies, but these are narrow in scope and the data are acquired through a limited number of questionnaires. There has been no attempt to incorporate any environmental quality variables in the estimation of housing or property value differential equations.

The Korea Transportation Development Institute (1989) estimated the transportation-related social costs expected during the period of 1989-2001 in the absence of transportation investment projects. Four types of social costs were valued—traffic accident costs, vehicle operation costs including fuel cost, commuting time costs, and environmental costs. Following is a brief description of the valuation steps taken.

1. ***Accident costs.*** *The average amount of insurance paid for death and injury in 1987 was used: death: 16.8 million won (US$20,424); injury: 1.7 million won (US$2,067). To calculate vehicle damage, the expected insurance payment was used.*

2. ***Fuel costs.*** *Average daily driving distance by type of vehicle was computed. Total fuel consumption was then calculated. Total fuel costs were calculated, using current fuel prices.*

3. ***Time costs.*** *Average driving distance per trip by each type of vehicle was calculated, as was delay time caused by congestion to reach average driving distance. Time costs were calculated by multiplying the respective wage rates of owners and operators of vehicles by the calculated delay time. In the case of a mass transit system such as a bus or taxi, the time costs of commuters should be measured. Instead, commuter time costs were valued based on the operator's wage rates; this is not an acceptable approach.*

4. ***Environmental costs.*** *Some of the environmental effects from pollution were mentioned, but no attempt was made to value any of these.*

Only a limited number of studies have used the damage function approach in Korea. However, these studies are not based on a solid understanding of valuation methods, and no serious attempt was made to collect or generate necessary data. As these analyses are based on improper data and arbitrarily chosen assumptions, they lack credibility. The results of government-led studies are not generally open to outside evaluation, thus eliminating a major opportunity for improving data and expertise. Most studies are one-time trials and there is no follow-up.

Based on a quick review of data and studies on the valuation of environmental damage in Korea, it is suggested that to improve the understanding of urban environmental problems, the database needs to be continuously improved. An economic valuation team should work cooperatively with local data collection/generation teams for mutual benefits.

A USAID (1990a) Bangkok study uses some ingenuity with limited data to make rough approximations and generate ranges of values within an order of magnitude. Although locally derived models are preferable, damage functions and dose-response relationships derived in developed countries can be adapted to the local situation, at least as a first approximation. For example, Ostro's (1983) work loss days equation, if it is valid, would presumably be widely applicable (USAID 1990a).

A common mistake is to aggregate air quality data into an average for the entire city. It is better, if time permits, to do separate dose-response studies for areas around different monitoring stations, since pollution concentrations and population density vary widely. It is also important to cross-check the results of dose-response models with empirical data to be sure they do not differ greatly. Because dose-response functions for health damage are confined to just a few of many air pollutants, physical linkage methods may capture only a part of total health damage from pollution-related illness. This should be addressed when reporting the estimated damage cost.

It is clear that any attempt to apply economic valuation techniques to environmental problems in Asian cities should involve a multidisciplinary team of environmental scientists, epidemiologists, biologists, chemists, physicists, hydrologists, engineers, and planners to work with economists in generating the information necessary for economic analysis. Practically speaking, it may be best to base the analysis in an existing environmental research institute, because of its familiarity with natural processes and ready access to data. See box 4-2 for examples.

Box 4-2. Potential Study Sites

Examples follow of environmental research institutes and other organizations where indications exist that a second-stage study could be based:

Bandung. *Institute of Ecology*

Bangkok. *Institute of Environmental Research, Chulalongkorn University (in cooperation with the National Environmental Board, Asian Institute of Technology, Thailand Development Research Institute and ESCAP)*

Bombay. *Indira Gandhi Institute of Development Research*

Dhaka. *Development Studies Centre*

Kuala Lumpur. *WHO Regional Centre for the Promotion of Environmental Planning and Applied Studies*

Manila. *Institute of Environmental Science and Management, University of the Philippines at Los Banos*

Delhi. *Centre for Science and Environment*

Seoul. *Yonsei University*

Taipei. *Environmental Protection Agency*

Tianjin. *Municipal Plan Bureau (in cooperation with the Land Bureau and Environmental Bureau, possibly also the Chinese Research Academy of Environmental Sciences)*

Bangkok, Seoul, and Tianjin are probably the best positioned to carry out a study at relatively short notice.

Disaggregation by Poor and Nonpoor

Before conducting economic valuations, basic physical information on pollutants, ambient environmental quality, and effects on receptors should be spatially disaggregated to the extent possible, so that a city's poor districts are analyzed separately from the remainder of the city. In most cases, air and water pollution are initially reported by separate monitors in different parts of the city. This should be possible for indoor air pollution, basic sanitation, water supply, overcrowding, and some aspects of destruction of natural support systems as well. Disaggregation may be more difficult for traffic congestion. In any event, economic analysis should be conducted independently for these two (or more) populations, as it is obvious that the normative significance of the numbers obtained are quite different for each population. Where human health and safety are concerned, it may be more appropriate to focus on the number of mortalities and restricted activity days rather than on lost earnings. It is also important to express willingness to pay in both absolute terms and in terms of percentage of total income.

Within the set of contingent valuation methods, the costless choice techniques appear to be useful for poor populations. Rather than asking willingness to pay, one would offer various sums of money and/or alternative sets of everyday goods and services, on the one hand, and some aspect of environmental quality on the other to determine individual preferences. A detailed example of this technique is found in Hufschmidt et al. (1983).

Selection of Appropriate Valuation Techniques

As discussed earlier, there is very little experience in applying the economic valuation techniques described here to situations in developing countries, including Asian cities. Therefore, an experimental trial-and-error approach would appear to be reasonable. Such an approach would start with techniques that are most reliable and for which data are more readily available. In general, techniques such as replacement cost and averting behavior, which rely on actual costs of labor and materials, are most tractable. Next are the other physical linkage techniques shown in table 4-8, especially the productivity gains and losses and cost-of-illness approaches, which rely on market prices. These are well-tried techniques, whose high reliability compensates for their lesser degree of sophistication and theoretical validity. Finally, behavioral linkage techniques would be applied, especially contingent valuation, possibly used in combination with travel cost or hedonic pricing where this is possible.

Of course, the exact mix of techniques chosen depends on the types of problems (pollution, congestion, degradation of natural support systems) and impacts (health and safety, productivity, amenity value, ecological value) that are important. But we suggest that, where possible, more than one valuation technique be applied to a specific environmental problem/impact. For example, the contingent valuation and cost-of-illness techniques can both be applied to measure economic damages from air pollution. This will allow comparison of results from different approaches and serve as a form of sensitivity analysis.

Applying these valuation techniques to Asian cities must of necessity be an experimental effort, and it cannot be known in advance how successful these applications will be or how much credibility can be given to the numbers thereby generated. Where possible, validation checks should be made. Certainly, the relative values of economic costs and benefits will have more significance than absolute numbers. Nonetheless, if developed and applied with proper caution, the existing set of techniques can make important contributions to the economic analysis of environmental problems of Asian cities.

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