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Assessing the Environmental Impact of Urban Development

Cities in less-developed countries are growing at unprecedented rates. Municipal authorities are struggling to keep up with the pace of urbanization and increasing demands for infrastructure and services such as water and sanitation, roads, schools, power systems, and waste collection. In many cities, the demand far outstrips the capacity to supply. The urbanization process, and the urban investments resulting from it, tend to generate many complex environmental problems. This Update *discusses how environmental assessment (EA) can contribute to improved urban development and environmental planning at the project and policy levels. It also introduces analytical tools to support such planning.*

This Update *expands on Volume II, pages 153–167 of the EA Sourcebook, and provides background for a forthcoming* Update *on urban environmental auditing, a tool to determine baseline environmental conditions in urban areas.*

Urbanization and environment

Since 1950, the urban population has increased globally from under 300 million to 1.3 billion people. By the year 2005, there will be 3.35 billion urban residents, over 50% of the world's population. By 2025, two-thirds of the world population is expected to be living in urban areas. Another striking trend is the steady increase in the number of large cities in less-developed countries. Presently half of the world's urban population is located in some 394 cities, each having populations of over half a million. By the year 2000, 21 cities in the world will have more than 10 million inhabitants, and 17 of these will be in less-developed countries.

Rapid urban growth is not in itself a negative phenomenon. As cities grow, productive activities tend to concentrate in urban centers where 60 percent of gross domestic product (GDP) is generated. Between now and the year 2000, about 80 percent of GDP growth in less-developed countries is expected to originate in cities and towns, with higher productivity in cities than in rural areas and higher productivity in large cities than in small towns (World Bank, 1991). Cities also can provide stimulating environments conducive to family life, child development, and social and cultural interaction.

Nonetheless, rapid growth can threaten health and seriously constrain urban productivity and economic development when it occurs on land ill-suited for development, or where municipal authorities cannot either provide or facilitate investment in the necessary housing, infrastructure, and services to accommodate the growth. For many countries, poorly managed growth imposes high costs. According to some reports, the cost of pollution problems alone can add up to an equivalent of five percent of GDP. Examples of city-specific impacts are presented in box 1.

Rapid urbanization has two sets of environmental consequences. The first arises from specific investments in urban development that typically receive a good deal of attention from environmental professionals. More important, though, are the broad range of environmental issues stemming from the resource consumption and waste disposal patterns of growing urban populations. Both are briefly described below.

Environmental consequences of urbanization. The critical environmental problems facing rapidly growing cities in developing countries are deteriorating living conditions and increasingly serious health problems caused by inadequate water, sanitation, drainage, and solid waste services, poor urban and industrial waste management, and air pollution (indoor and outdoor).

Box 1. The social and environmental costs of urbanization

- **Bangkok** currently loses about one-third of its potential gross domestic product due to congestion-induced travel delays, and experts warn that this could rise to 60 percent if no corrective actions are taken.
- In **Mexico City**, abnormally high levels of suspended particulates have caused an average of 2.4 lost work days per person and 6,400 deaths every year, 29 percent of all children have unhealthy lead levels in their blood, and lead exposure may contribute as much as 20 percent of the incidence of hypertension in adults. Annual health costs from air pollution are estimated to exceed US$1.5 billion.
- In **Jakarta**, the estimated cost for 1990 of the health effects of pollution is more than US$500 million, the equivalent of one percent of the city's gross domestic product, more than US$50 million of which is spent each year by households to boil impure water.
- The cholera epidemic of 1991 in **Lima**, which resulted from inadequate sanitation, caused an estimated US$1 billion in losses from reduced agricultural and fisheries exports and tourism in just the first ten weeks following the outbreak.
- In many **Latin American cities**, dengue fever, a vector-borne disease, has reached epidemic proportions largely due to the failure to provide adequate solid waste management and water services for rapidly growing urban populations.

Important underlying causes of pollution include inappropriate land use, precarious housing, deficient public transportation, and road congestion and accidents. These are collectively dubbed the "brown agenda" since they are primarily related to pollution. However, urbanization also affects natural resource use and management in and around cities, causing pressures such as extensive depletion of water and forest resources and conversion of environmentally fragile lands (the "green agenda"). In turn, these developments tend to exacerbate water and air pollution problems within the urban area. The environmental and social consequences of urbanization are closely linked. For example, occupation of areas prone to flooding or landslides represents a major risk to human health and safety, and overcrowding and pollution cause degradation or loss of historical and cultural property. Looking beyond the city itself, the pollution emissions of cities from energy use for cooking, heating, industry, and transport contribute significantly to global climate change and acid rain.

Growing congestion and pollution in major urban centers make it increasingly difficult for some countries to compete for foreign investment, especially in the high-technology industries that would contribute more to the productivity of the labor force. In Jakarta, for example, where the urban population is expected to double over the next 25 years, growing community resistance to uncontrolled pollution will likely lead to pressure to slow the expansion of industrial output in the areas where future growth is most likely to occur.

The challenge of rapid urbanization is to sustain economic growth while at the same time avoiding or minimizing environmental problems that can arise from growth. In confronting these problems, however, there are no stock solutions. Each city should formulate its own environmental strategy depending on the nature and severity of its problems, which in turn depend on: (a) the density and patterns of development, particularly existing infrastructure; (b) the population size and rate of growth; (c) the level of income and economic development; (d) the type of climate and regional ecosystem; and (e) the roles and interactions of numerous public and private actors. The existence of an overarching planning framework for urban investments, which takes environmental and social constraints into consideration, can significantly reduce the occurrence of environmental and social impacts as cities develop.

Environmental impacts of urban development investments. Developers of urban projects (for example, water supply, sewerage and other sanitation, drainage, solid waste management, electrification, and land development) must be concerned with a number of adverse environmental impacts that could occur if the investments are not properly planned, sited, designed, constructed, operated, and / or maintained. Site selection for urban projects should take into account the potential environmental effects of development, for example soil and slope stability, the risk of flooding in low-lying sites, damage to sensitive ecosystems such as wetlands, the implications for human resettlement, and conflict with culturally-valued land uses.

Water supply projects will increase the volumes of wastewater, which can give rise to deleterious health impacts if not properly managed. They may also result in groundwater depletion if the aquifer is tapped, and surface water abstraction can affect aquatic and bird life. Some of the potential negative impacts of ***sanitation and sewerage systems*** include interference with other utilities, impacts from sludge disposal, subsurface leaching to groundwater, degradation of water quality from overflows of, or improperly treated, sewage, and health and safety hazards associated with sewers (trench cave-in during construction, toxic gas buildup, and exposure to pathogens in sewage and sludge).

The potentially adverse effects of ***solid waste management*** arise from poorly sited or managed dumps or sanitary landfills, aquifer contamination, improper disposal of hazardous wastes, air pollution from burning wastes, landfill gas migration, subsurface leaching, increased human exposure to disease vectors, and landscape degradation. ***Road construction*** and ***drainage works*** can result in the involuntary resettlement of households and, if drains are not maintained, possible contamination with solid and liquid wastes, floods and the resulting spread of pathogens. ***Electrification*** at the community and household levels poses health and safety risks from improper in-house wiring and collapse of overhead wiring during heavy weather. There may also be impacts that result from significant increases in demand for electricity, depending on how the power is generated.

Good practice in urban EA

The Bank has accumulated several years of experience developing environmental assessments in the context of its urban investments. This experience has revealed that good practice in environmental assessment has at least three benefits beyond the avoidance or mitigation of adverse environmental impacts:

- *Early identification of potential conflicts.* EA can identify or clarify issues early in the project cycle before they develop into full-fledged problems. For example, EA procedures in the Second Solid Waste Management Project in Mexico helped to identify the role and concerns of scavengers and informal waste collectors. These findings led to a change in project design that addresses both the economic and social needs of this informal sector.
- *Integration of environmental concerns into project design.* The results of an EA can add to, or even change, the objectives of an urban project. As a result of the findings of an EA for the Second Shanghai Metropolitan Transport Project in China, a program for monitoring pollution levels on the new road and development of a city-wide plan to control vehicular emissions were added to the project's implementation plans. Similarly, the Water Quality and Pollution Control Project in Brazil adopted a watershed management approach to internalize both upstream and downstream (defined spatially and temporally) environmental impacts revealed by the EA.
- *Increased institutional capacity for environmental management.* In countries that had no specific requirements for environmental assessments at the time of the project's identification, for instance Egypt and Sri Lanka, EAs for Bank-financed projects helped stimulate environmental measures that would otherwise have been absent. In countries that have instituted environmental regulations, such as Brazil, China, Indonesia, and Mexico, EAs for Bank-financed urban projects have considerably expanded the scope of national environmental assessment procedures. Many new urban projects include capacity-building components to assist and upgrade local agencies that will implement or monitor environmental management plans. These agencies may include environmental agencies, departments of public works, sanitation or transportation departments, or water and sewer utilities.

Ultimately, these benefits result in better projects with a higher likelihood of successfully achieving their economic, social and environmental objectives.

Characteristics of good practice EA

Lessons from recent experience in environmental assessment suggest that: (a) the EA should take into account cumulative impacts; (b) the pros and cons of different technical alternatives should be identified and evaluated, ideally in a strategic framework; (c) the EA should become an intrinsic part of the project design process; (d) a range of key variables should be routinely included in the assessment; and (e) the EA process should incorporate effective consultations with affected communities.

Cumulative upstream and downstream impacts. Urban EA needs to cast a wide net, both spatially and temporally, in order to minimize the possibility of overlooking major impacts. For example, the Second Shanghai Metropolitan Transport Project EA concluded that the environmental impacts of the project were construction nuisance (dust, social and traffic disruption) and changes in air quality in a one-kilometer corridor around the proposed roadwork. The potentially greater environmental consequences of changes in land use and overall traffic patterns were not taken into account. In contrast, the EA for Brazil's Espirito Santo Water and Coastal Pollution Management Project (see box 2) considered changes in population, urban growth and land use, and where those changes were unacceptably deleterious, special mitigation and compensation measures were incorporated in the project's design. In China's Liaoning Environment Project (also box 2), the EA used an "urban bubble" approach to assess the *positive* cumulative impacts

Box 2. Using EA to help design urban environmental projects in Brazil and China

The Espirito Santo Water and Coastal Pollution Management Project in Brazil and the Liaoning Environment Project in China are good examples of the proactive use of EA in project design.

Espirito Santo, Brazil: This project will increase the water supply for 640,000 people and provide sewage collection and treatment for 770,000 people in the Brazilian state of Espirito Santo. This should lead to major improvements in river and coastal water quality resulting in substantial benefits of improved health, increased tourism earnings, improved recreational opportunities, and greater biodiversity.

The EA evaluated the project's design in terms of desired water quality, siting issues, and construction and operational impacts, and provided guidelines for the environmental assessment of future project subcomponents. Water quality scenarios were modeled quantitatively in order to determine the best use of the assimilative capacity of water affected, and the least-cost treatment alternative that complied with the desired quality standards.

Special features of the EA method included the incorporation of urban growth concerns and community participation in the project design process. Urban growth, along with present and future land uses, played an important role in the EA discussion of siting issues. Some locations were ruled out because they would conflict with the future expansion of urban areas. The EA also recognized urban-wide links where project outcomes were dependent on exogenous factors (for example, pollution discharge upstream) or required the simultaneous solution of related problems (for example, riverside dumping of solid wastes). Public consultation played an important role in site selection and mitigation measures.

Liaoning Province, China: With 25 million urban dwellers, Liaoning has acute water supply problems as well as air and water pollution. The Environment Project will invest in improving air and water quality, municipal solid waste management, industrial pollution control, resource use, and environmental management and training.

An urban-wide approach was used in the environmental assessment to quantify gains from different pollution reduction options (employing the "urban bubble" concept). The "bubble" concept was also used to identify pollution control measures that will be needed to fully reap the benefits of the project. This led to the inclusion of an environmental rehabilitation and reconstruction component for four historical and archaeological sites.

The EA studied nine physical components located in three subregions. In each of the 27 components, the EA focused on three issues: (a) environmental improvements achievable by the proposed measures, including a discussion of technical alternatives for each component; (b) construction-related environmental problems and mitigation measures (for example, the need to resettle several hundred families); and (c) operational environmental problems (such as the disposal of sludge and ashes).

that could be expected from reduced human exposure to pollutants within the Liaoning metropolitan area. Regional environmental assessment (see below, and *Update* No. 15: *Regional Environmental Assessment*) is particularly well-suited to addressing cumulative impacts from a spatial and temporal perspective.

Strategic assessment of alternatives. The EA process can improve project outcomes by aiding the process of selection of technology, design and location so that environmentally benign or even beneficial choices are made. This has been done effectively in the field of sanitation where different sanitation technologies

Box 3. Strategic sanitation planning in Kumasi, Ghana

The strategic sanitation planning process being used in Kumasi matches technical solutions with the needs of the city's individual neighborhoods. It is based on demand, where user preference and willingness-to-pay determine technology choice in consultation with the municipality's choice of how best to use government subsidies to achieve the greatest health, environmental and other benefits.

First, various technologies are fitted to the economic conditions and housing types in different parts of the city. Second, a relatively short planning horizon of 10–15 years is used, emphasizing actions that can be taken immediately. Third, municipal personnel, rather than outside consultants, are more involved in the planning process. Fourth, capacity is developed through a learning-by-doing process that starts small and scales up as experience is gained.

This approach resulted in a plan according to which a range of options are being pursued, including low-cost sewers for the city's tenement area, latrines and septic tanks in the low-density traditional areas, and septic tanks in the new government and high-cost areas.

have been employed in different parts of a city according to varying physical requirements and the residents' willingness to pay (see box 3). This approach can be applied to different types of urban environmental services, including solid waste collection, water supply, drainage, and industrial pollution control (see also *Update* No. 17: *Analysis of Alternatives*).

EA as an intrinsic part of good project design. EA can be most effective when it converges with project design. For example, the EA for the Bombay Sewerage Project in India evolved from minimizing the environmental impact of the project's construction and subsequent operation, to assessing the project's ability to achieve proposed environmental goals, thereby making the EA central to project design. This revised approach led to significant changes in the project, including: (a) the elimination of a major project component because it would not achieve the water quality target in the recipient stream; (b) the incorpora- tion of an entirely new component for slum sanitation; and (c) the redesign of the marine outfall component.

Incorporation of key variables in the analysis. Urban EAs have been improved by including key variables that allow for a dynamic evaluation of environmental impacts. In the Solid Waste / Environmental Management Project in Lebanon, population growth, land use, waste generation, and socioeconomic variables were incorporated in the analysis for the siting of waste disposal facilities. The Organization of Eastern Caribbean States (OECS) Solid Waste Management Project employed an even larger list of variables including industrial activities, tourism growth and changes in household consumption patterns in relation to waste generation, as well as opportunities for waste minimization, domestic recycling and composting. The ability to include these and other important variables will depend on the extent to which data are available or obtainable.

Benefits of community participation. The advantages of stakeholder involvement have been demonstrated in several urban EAs (see also *Update* No. 5: *Public Involvement in Environmental Assessment*). For example, in Brazil's Espirito Santo Water and Coastal Pollution Management Project, public discussions revealed that the siting of one of the sewage treatment plants would foreclose access to a clay deposit used by local artisans. An alternative site, representing a significant improvement on the initial proposal, was worked out with the participation of the affected population.

Shortcomings of project-specific EA

While project-specific EAs can help improve project design, there are limitations in their effectiveness in tackling urban environmental problems. The major limitations of project-specific EAs are that they are generally *ex post* and *ad hoc*. They are *ex post* in that they analyze environmental issues only after the project has been identified, and they are *ad hoc* in that they are undertaken only in reference to individual investments. Thus, while they may enhance a project's potential for having positive environmental effects, or help mitigate the potential for negative ones, the EA exercise is not designed to actually identify projects that would address priority urban environmental problems. A further shortcoming of project-specific EAs is that unless the EA explicitly addresses policy, legal and regulatory issues, the result will likely be neglect of site-specific impacts such as unsustainable resource consumption, detrimental living conditions caused by mixing of residential and commercial development, soil erosion, and biodiversity losses.

Methods of analysis have been developed that are somewhat or wholly detached from specific project proposals or can be applied to comprehensive urban investment programs, focusing on the environmental challenges of the urban area as a whole, and contributing to strategic urban development planning. Regional EA is one such method, and in the urban context is sometimes referred to as strategic urban environmental assessment.

Regional EA for urban areas

Regional EA, or strategic urban environmental assessment, is a relatively new tool that offers several advantages over the project-specific, impact-mitigation approach of classical EA. Regional EA can be used in two ways, either to understand the environmental consequences of a set of proposed investments within a given geographical area, or to identify problems within a given area, and propose projects that will improve urban environmental quality. The first method analyzes the interaction of investments in different sectors, and can lead to coordinated investments in order to improve an ecological region such as a watershed, river basin, coastal zone, or airshed. The second approach results in projects that are environmentally beneficial by design and that maximize scarce resources. Each approach is described below.

Regional EA of proposed investments

This approach may be undertaken either out of necessity or by design. For example, the Hubei Urban Environmental Project in China involved separate assessments for thirteen subprojects. The results of these individual assessments were then aggregated so that the regional consequences of the project for surface water quality, groundwater, public health, ecosystems, and nuisances (odor and noise) could be understood. Thus, a regional assessment arose out of the necessity of having to assess a multitude of subprojects.

A regional assessment can also be carried out by design. For example, the Brazil Water Quality and Pollution Management Project established urban watersheds as the basis of its EA. This allowed for the analysis of the environmental consequences of existing investments within an ecological region and the design of multisectoral projects to improve regional environmental quality. As a result, the project component for the Sao Paulo urban watershed (the Guarapiranga Basin) includes integrated service provision, the upgrading and resettlement of slums, improvements in urban infrastructure, rationalization of land use, creation of parks, and the revision of policies, among other things, all towards the overriding objective of improving environmental quality in a particular ecological region.

Regional EA for urban planning

The second approach (regional assessment by design) is more strategic. It can be used to select or rank policies, programs and projects according to environmental priorities. Each city or region needs a process for determining the most appropriate mix of actions and investments that respond to its own environmental concerns. Cities and regions exhibit different degrees of awareness, political commitment, and capacity to mobilize resources. This approach to urban environmental planning and management has been tested in both more- and less-developed countries, and found to be a viable approach in decentralizing environmental planning from the national to the local level.

The strategic approach should work towards strengthening local capacity through:

- *Informed consultation* with key stakeholders in rapidly assessing and clarifying environmental issues and priority measures
- The formulation of an integrated *urban environmental management strategy* that embodies long-term goals and phased targets for meeting the goals
- Agreement on both the *issues* that cut across the concerns of various stakeholders, and *action plans* that cut across various issues for achieving the targets
- *Follow-up and consolidation* of the plan, in which programs and projects are begun, policy reforms and institutional arrangements are formalized, and monitoring and evaluation procedures are put in place.

Box 4. Strategic approach to urban environmental assessment

Urban environment and pollution management projects now account for over 60% of the Bank's total lending for the environment. These investments increasingly use a strategic regional approach of environmental assessment. Examples include the:

- ***Colombo Environmental Improvement Project*** (Sri Lanka), which seeks regional solutions through investment in solid waste management, industrial wastewater treatment, slum upgrading, institutional support and public awareness, based on an environmental management strategy prepared under the Metropolitan Environmental Improvement Program (MEIP)

- ***Liaoning Environment Project*** (China), which puts in place urban investments in water supply, water conservation, wastewater treatment, solid wastes, air quality, energy efficiency, industrial pollution control, and capacity building;

- ***Lobito Benguela Urban Environment Rehabilitation*** (Angola), which seeks to improve low-income sanitation, watershed management, water supply, and local environmental planning and management capacity in the predominantly urban region

- ***Northern Border Environment Project*** (Mexico), designed to improve environmental quality through city-specific investments in water supply and sanitation, solid waste and hazardous waste management, air quality, urban transport, and institutional strengthening.

The elements of a strategic approach, and examples of its application, are more fully described in *Toward Environmental Strategies for Cities* (Bartone and others 1994). Some examples of where this process is being used in Bank projects are provided in box 4.

Techniques in support of urban EA

Regardless of whether the project-specific or regional assessment approach is used, a number of techniques are increasingly being employed in urban EA analysis. This section briefly reviews a number of analytical tools or techniques, including data questionnaires, environmental indicators, health risk assessment, economic valuation, household and community survey, contingent valuation and rapid participatory appraisal, geographic information systems (GIS), and urban environmental auditing. Their utility, limitations and costs are summarized in table 1.

Table 1. Comparison of environmental assessment tools

TOOL	APPLICATIONS	LIMITATIONS	$[a]	TIME
Data questionnaire	• assemble secondary data • identification of data gaps	• not prescriptive • data usually not comparable over time, areas and population groups • variable reliability	$	as little as one staff-month
Indicators	• development of baseline information • monitoring and evaluation • comparative analysis	• not prescriptive • garbage in, garbage out (GIGO)	$	depends on frequency & level of detail
Health risk assessment	• ranking problems & options • prediction of outcomes • input for economic valuation • identification of causal factors	• variable validity depending on source of assumptions • identifies problems but not solutions • weak on factors not related to pollution	$ - $$$	months (dose/response model) - years (epidemiology)
Economic valuation	• ranking problems & options • input to cost/benefit or cost effectiveness analysis • investment planning	• "valuation of human life" controversy • GIGO • all costs cannot be captured in economic terms	$ - $$	months
Random sample surveys	• development of baseline data • monitoring changing conditions over time • problem identification	• only provides snapshot • not prescriptive • issues are often predetermined by survey designers	$	depends on experience & sample size
Contingent valuation	• determination of pricing policy for service utility • choice of technology • valuation of amenity	• provides individual perspective, not societal value • useful only for issues that can be monetarily valued • limited application	$	months
Participatory rapid appraisal	• problem identification • consensus building • community awareness	• not necessarily representative (non-random) • subject to political manipulation	$	days to months
GIS	• physical information • correlation analysis • monitoring • problem investigation	• takes time to understand hardware and software • potential for limited transparency • data requirements are high	$ - $$$	variable depending on data required
Urban environmental audit	• identification & prioritization of issues & options • data & methodology for decision-making • input to strategic process	• requires political commitment for follow-up • can be subject to political manipulation	$	months

Note: [a]$ signifies up to US$20,000; $$ signifies US$20-50,000; $$$ signifies above US$50,000.

Data questionnaire. An urban environmental data questionnaire has been designed for use in less-developed countries by the UN Centre for Human Settlements (UNCHS) / World Bank / UN Development Programme (UNDP) Urban Management Program. The questionnaire covers a comprehensive range of topics, and is available on diskette, with help screens. Data can be entered at the level of city, metropolitan area, and / or urban agglomeration. The questionnaire is meant to support the preparation of an urban environmental profile and to inform a consultative process as part of an urban environmental audit (see below, and a forthcoming *Update* on urban environmental auditing).

Urban indicators. There have been a number of efforts to develop indicators of urban environmental quality. These indicators allow for a static assessment of conditions, monitoring of changes over time, and ranking within or between cities. The World Bank and UNCHS originally developed a set of urban indicators in order to improve their operations and contribute to the 1996 Habitat II Conference (see box 5). They include indicators of urban poverty, productivity and employment (including health, housing and other social indicators), the status of infrastructure and more particularly transport, and conditions of local government, and of environmental management capabilities. The environmental indicators are linked to policy goals, such as improved access to basic infrastructure and services, pollution prevention or abatement, sustainable environmental practices, and minimization of vulnerability to hazards.

Box 5. Urban environmental indicators

The Bank and UNCHS have developed urban environmental indicators for use in city-wide evaluations. The following are some indicators linked to the reduction or prevention of pollution:

- Percentage of biochemical oxygen demand (BOD) removed from urban wastewater
- Annual death rate of children under five years of age from intestinal infectious diseases (deaths / 100,000 / year)
- Annual death rate from respiratory diseases (deaths / 100,000 / year)
- Percentage of all municipal solid waste that is collected and adequately disposed of (for example placed in a sanitary landfill, recycled or incinerated in a modern incinerator).

Two other models that are more country-specific are nevertheless useful as resources for developing indicators. China has been using its own set of urban environmental indicators to monitor progress in individual cities over time, make comparisons among cities, prepare comparative rankings, and reward good performance with financial incentives. The World Resources Institute collects environmental data for the 75 largest metropolitan areas in the U.S., and ranks the areas on the basis of nine indicators (moderate air pollution days, unhealthy air pollution days, drinking water quality, toxic releases and transfers, number of toxic waste sites, solid waste collected per capita, heating and cooling degree days, vehicle miles traveled per capita, mass transit passenger miles traveled per capita). Other indicators collected in this survey include population density, percentage of urban area devoted to park land, percentage of waste recycled, water use per capita, percentage of groundwater dependence, and miles of bike paths.

Health risk assessment. Urban environmental problems can be ranked according to the degree of risk that they pose to human health. Health risk assessment consists of four steps: (a) hazard identification; (b) exposure assessment; (c) dose-response assessment; and (d) risk characterization (see *Update* No. 18: *Health Aspects of Environmental Assessment* and the forthcoming *Update*: *Environmental Hazard and Risk Assessment)*. Hazard identification is a qualitative determination of whether human exposure to an agent might result in adverse health effects. Exposure assessment involves a quantitative or qualitative estimation of the level and duration of a population's exposure to a hazard. The dose-response assessment uses a mathematical model to estimate the probability of occurrence of a health effect based on human exposure to a hazard. Characterizing risk means estimating the incidence of an adverse effect on a population.

This method of analysis has been used in several less-developed countries to rank environmental problems according to their effects on human health. For example, in Bangkok, exposure to lead was found to be the top environmental health problem, resulting in up to 400 deaths, 500,000 cases of hypertension, 800 heart attacks and strokes, and 700,000 lost IQ points in children per year. The Government of Thailand reacted by phasing out the sale of leaded gasoline over five years, resulting in a dramatic reduction of the ambient levels of lead in Bangkok air. In Quito, Ecuador, food contamination from micro-organisms and outdoor air pollution was determined to be the most serious environmental health risk.

Economic valuation. Urban environmental problems have real economic costs that are linked to lowered productivity, congestion, and additional expenses on health care. For example, annual productivity losses from waterborne contamination in Manila are estimated at US$100 million, Bangkok currently loses one-third of its potential gross city product due to congestion-induced travel delays, and annual health care costs due to air pollution in Mexico City are estimated to exceed $1.5 billion. A number of economic valuation techniques exist to estimate these costs, as well as the costs of lower ecological productivity and loss of amenities. These analyses can also include an equity dimension to determine the share of costs borne by the poor. Economic valuation techniques will be discussed in a forthcoming *Update* on economic analysis in EA.

Household and community techniques. Households and neighborhoods are often at the heart of both problems with, and solutions for, the urban environment. Several techniques can be used to better understand the types and priority of environmental problems faced by households and communities. These include: (a) classic random-sample household surveys; (b) contingent valuation to assess a household or a community's willingness to pay for service upgrades or an amenity; and (c) participatory rapid appraisal. These tools, which can be used individually or in tandem, have different applications and limitations that are summarized in table 1.

Geographic information systems (GIS). GIS, often combined with remotely sensed data, is a powerful tool for urban environmental analysis that is increasingly being used throughout the world. Environmental applications of GIS in less-developed countries have included land suitability analysis, hazard and environmental "hot spot" identification, land-use and land-cover mapping, watershed analysis, and siting of environmental services and infrastructure. Other applications of GIS for urban assessment include the preparation of base maps, the analysis of change, the management of infrastructure networks, and for recording housing typologies and other demographic attributes (see *Updates* nos. 3 and 9, which address GIS in environmental assessment).

Urban environmental auditing. The techniques described above are useful for assembling information, analyzing data, portraying problems, and ranking issues. Urban environmental auditing is a process that builds on those techniques in order to clarify issues, involve the stakeholders, set priorities, and achieve political consensus for action. The audit consists of three steps, including: (a) the assembly of existing data; (b) an analysis of environmental conditions and causal relationships; and (c) public consultation. Data are collected using the UNCHS / World Bank / UNDP questionnaire referred to above, and can be derived from a range of sources including routine recordkeeping, information on existing infrastructure and services, epidemiological and other health data, and information on natural resources. This information, combined with data from environmental health risk assessments, the analysis of indicators, and GIS, can be used to prepare an urban environmental profile that reviews environmental quality in an urban area, assesses the interactions between the environment and the development process, and evaluates the appropriateness and capability of the existing institutional setting for environmental management. Information is then shared with a range of stakeholders who are brought together to discuss problems, constraints, priorities, and alternative solutions. Urban environmental auditing is designed to be a rapid and inexpensive tool that can cut across conventional lines of authority, geographical boundaries, and time horizons. It can form part of a regional EA process or be a component of general urban planning.

Comparison of tools

Table 1 provides information on the most appropriate applications for each evaluative tool, its limitations, and both monetary and temporal costs. While the matrix is a generalization, it may help the reader to identify the most appropriate tool or set of instruments, depending on his or her specific needs and resources.

For further reading

For multisectoral urban projects, other sections in the *EA Sourcebook,* as well as relevant *Updates,* provide additional guidance. This includes the sections on roads and highways, port and harbor facilities, housing, solid waste, tourism, water supply, wastewater, industry and energy, coastal zone management, and cultural heritage. Relevant *Updates* are referred to in the text.

Bartone, Carl, J. Bernstein, J. Leitmann & J. Eigen. 1994. *Towards Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management in Less-developed countries.* Urban Management Program Policy Paper No. 18. The World Bank. Washington, D.C.

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Leitmann, Josef. 1994. *Rapid Urban Environmental Assessment: Lessons from Cities in the Developing World* (Volume 1: Methodology and Preliminary Findings; Volume 2: Tools and Outputs). Urban Management Program Papers No. 14 and 15. The World Bank. Washington, D.C.

This *Update* was prepared by Josef Lloyd Leitmann, Senior Urban Planner of the World Bank. The *EA Sourcebook Updates* provide guidance for conducting environmental assessments (EAs) of proposed projects and should be used as a supplement to the *Environmental Assessment Sourcebook.* The Bank is thankful to the Government of Norway for financing the production of the *Updates.* Please address comments and inquiries to Olav Kjørven and Aidan Davy, Managing Editors, *EA Sourcebook Updates*, ENVLW, The World Bank, 1818 H St. NW, Washington, D.C., 20433, Room No. MC-5-111, (202) 473-1297, or send E-mail to: eaupdates@worldbank.org.