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Integrated assessment of urban environment in China *

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Abstract—The principles and procedures for integrated environmental assessment (IEA) based on the specific urban conditions and Chinese characteristics have been developed. The development processes and the general principles and procedures are presented in this paper. Indicators and methods for IEA may vary from case to case, but guidelines for selection of indicators and methods may be applicable for a specific case, so they are also introduced. Although great progress has been made in IEA, there is still a lot for future development. Prospects are presented as follows: (1) IEA at strategic level; (2) mechanisms for public involvement; (3) post-project analysis; (4) cumulative impact assessment; and (5) application of new approaches such as expert system and GIS in IEA.
Keywords: integrated assessment, urban environment, environmental assessment, China.

1 Introduction

Integrated environmental assessment (IEA) is a fundamental means for comprehensive environmental management and for coordinating the relationship between economic development and environmental protection. IEA aims to identify the main environmental problems in a region or a city and to find out the laws of development and spatial distribution of environmental quality on the basis of analysis and processing of surveying and monitoring data.

IEA is very significant to urban environmental management. The excessive urban expansion has been leading to crowded population, heavy traffic and serious environmental pollution. Integrated assessment of urban natural, economic and social environment will help avoid blindness in urban development and make timely adjustment to the urban development policies.

Some work on legislation and research of integrated environmental assessment has been done in China. But it has yet to be perfect because of regionality and complexity of environmental problems and variety of environmental factors. In this paper, regulations, development process, principles, procedures, indicators, methods of IEA in China are introduced. And some existing problems are also analyzed and summarized and future development is then proposed.

2 Development process of environmental assessment in China

Environmental impact assessment (EIA) was put forward in Regulations on Promoting Previous Work of Basic Construction Project issued in 1978 and became an important part of the feasibility study report of capital construction project. This document became a law when the Environmental Protection Act of the People's Republic of China (draft) was enacted in 1979. Since then, some regulations on environmental assessment have been issued by the legislature or legal engforcement bodies. At present, environmental assessment is explicitly stipulated in Ocean Environmental Protection Act of the People's Republic of China, Water Pollution Prevention and Control Act of the People's Republic of China, Air Pollution Prevention and Control Act of the People's Republic of China, Regulations on Environmental Noise Prevention and Control and particularly in the Environmental Protection Act of the People's Republic of China(He, 1996). In the Eighth Five-Year Plan period from 1990 to 1995, indicators and management methods were

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formulated for quantitative assessment of integrated rectification of urban environment. And then they were further improved. Up to 1996, environmental qualities of totally 46 important cities in China were assessed and put in order based on 21 indices. This work is conducted in China every year and will be continued in the future(China environment yearbook, 1990—1997). The major laws and regulations concerning with urban environmental assessment in China are shown in Table 1 and the development process of environmental assessment in China is shown in Table 2.

Environmental assessment was begun with individual indicator (air and noise, etc.) assessment and then developed into individual sector assessment (project based assessment). And it is required widely to make integrated assessment in the context of sustainable development.

Table 1 Major laws and regulations concerning with urban environmental assessment in China

Year	Type	Title	Field
1982	Constitution	Constitution	General
1985	Regulation	Management of landscape and resort areas	Landscape
1987	Regulation	Regulations on environmental design of construction projects	Environment design
1987	Act	Land management act	Land
1988	Act	Air pollution prevention and control act	Air
1988	Regulation	On environmental management of construction projects	General
1988	Standard	Environmental standards for surface water	Water
1989	Act	Environmental protection act	General
1989	Regulation	Regulations on noise pollution prevention and control	Noise
1990	Act	Urban planning act	Planning
1993	Guideline	Technical guidelines for EIA	General
1993	Standard	Regional noise standards for cities	Noise
1996	Act	Water pollution prevention and control act	Water
1996	Act	Solid wastes pollution prevention and control act	Waste
1996	Standard	Environmental standards for air quality	Air
1996	Standard	Air pollutants emission standards	Air
1997	Act	Noise pollution prevention and control act	Noise

Table 2 Development stages of EA in China

Year	Development stage
1973—1978	Preparation stage: theoretical, technical, human resources
1979—1985	Implementation stage: Requirements from EP act (draft, 1979); Management methods for EP of basic construction projects (1981)
1986—1990	Full development stage: Environmental management of construction projects (1986); Management of EIS for construction projects (draft, 1986) Other relevant laws, regulations, and guidelines
1991—	Matching with international standards and guidelines requirements from WB, ADB, and other international organizations

3 Principles and procedures for IEA

Integrated assessment of urban environment should objectively describe and make decision-makers and the public know: (1) the environmental status; (2) quality of living standards; (3) impacts on public health caused by the current environmental pollution and potential pollution; (4) urban image including its landscape and social status. And it should help find out the main

environmental problems and provide feasible solutions and policy direction for sustainable urban development based on the current and potential technical and economic conditions.

General procedures for integrated environmental assessment is shown in Fig.1. General steps include: (1) data collection and field survey; (2) assessment criteria; (3) indicators and interaction pattern; (4) environmental impacts; (5) cost-benefit analysis; (6) mitigation measures; and (7) policy options.

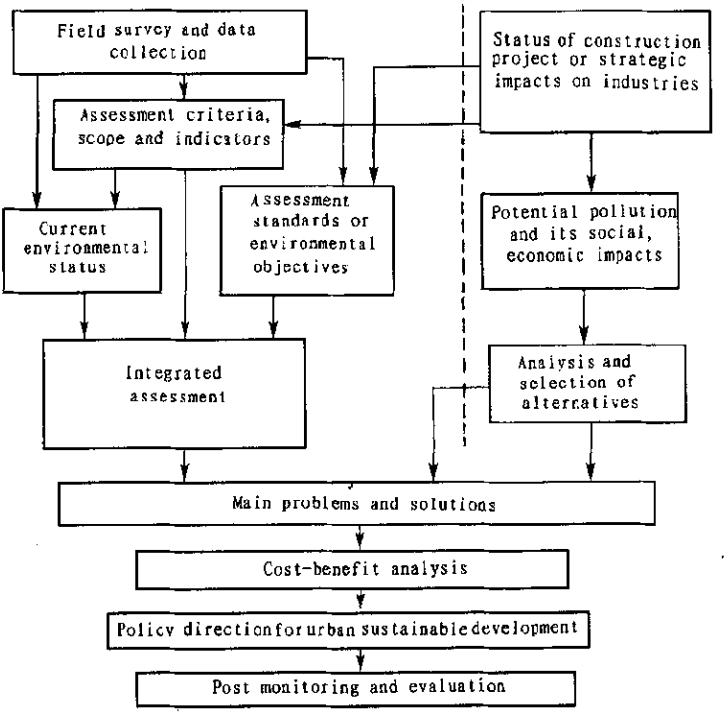

Fig.1 Procedures for integrated assessment of urban environment

4 Indicators for integrated environmental assessment

Urban environment consists of natural, economic and social environment. Its quality is referred to as the quality of the comprehensive environment of residential living and social and economic development. Indicators for integrated environmental assessment must be selected and established according to the following principles:

They must be typical and able to describe and assess urban environmental quality concisely and explicitly;

They must be of comparability between different cities with various natural conditions, and functional levels of economic and technical development;

They must be able to accurately describe the different pollution effects.

In general, indicators for integrated assessment of urban environment concern with of urban environmental status and development level. For urban environmental status, indicators are classified into five aspects: natural environment and pollution status of atmosphere, water, solid wastes and noise. The main problem of Chinese urban air quality is smoke pollution. Pollution from transportation is making greater impact on big cities. Dust pollution is very obvious in northern cities. And southern cities are in trouble of acid deposition(Cheng, 1995). In China, urban surface

water pollution is mostly represented by organic pollution indicators, including permanganate index, biochemical oxygen demand, volatile phenols, petroleum products and so on. In addition, the pollution of dissolved oxygen and nitrite nitrogen is also more serious, while other pollutions such as heavy metal pollution is not obvious(Zhou, 1995). Moreover, pollution caused by solid waste and noise should not be neglected in most cites of China(Duan, 1995; Zhu, 1995). The indicators for IEA are shown in Table 3.

Table 3 Indicators for integrated assessment of urban environment

Integrated indicator	Classified indicator(I)	Classified indicator(II)	Detailed individual indicator
Integrated urban environ. quality	Environmental status	Natural environment	Land use Vegetation coverage Hydrology Soil type Geology
		Atmospheric pollution	SO_2 NO_x TSP pH of precipitation
		Water pollution	DO Permanganate index BOD_5 Non-ion ammonia Volatile phenols Cyanide Petroleum products Anionics(anionic surface active agent) Chlorophyll-a Benthonic animals Total cliform bacteria
		Solid wastes	Land occupation Residents affected Volume
		Noise	Average noise values in different functional areas: (1) residential area; (2) mixed area; (3) industrial area; (4) road side.
	Development level	Environmental improvement	Public green area per capita Vegetation coverage ratio Up to standard emission ratio Up to standard waste water ratio Up to standard drinking water ratio Industrial waste water per 10,000 RMB Yuan product Recycling/reuse of industrial solid wastes Disposition rate of industrial solid wastes Clearance of domestic solid waste
		Economic development	GNI per capita Economic growth rate Economic structure
		Social progress	Population density Gasification rate Communication: telephones per 10000 residents Medicine and health: hospital beds per 10000 residents Transportation: roadlength/total urban area Education: highly educated/total population

5 Methods for integrated environmental assessment

At the initial stage environment assessment is based on individual indicator assessment. Since Horton *et al*. proposed water quality index in 1965 and Green proposed integrated index for air pollution in 1966, many other environmental quality indices have been developed and widely used in environmental assessment. In these index models, status and main problems of integrated environmental quality are determined according to the classification, calculation, analysis and integration of individual indices. Analysis of individual indicators is based on the pollutant concentration over the specific assessment standards.

With the development of environmental assessment, many mathematical methods are introduced into this field, such as fuzzy assessment (fuzzy mathematical modeling)(FA) (Fan, 1995), gray cluster analysis(GCA) (Lan, 1995), Gray correlation analysis(GRA) (Feng, 1996), analytical hierarchical process (AHP)(Xiao, 1998), artificial neural networks(ANN)(Lu, 1995; Guo, 1997), life cycle assessment(LCA), cost-benefit analysis(CBA) and matter element analysis (MEA; Li, 1997; Wang, 1997).

Major methods and their applications in China are listed in Table 4.

Table 4 Methods for IEA and their application in China

Method	Application	References
FA	Urban eco-environmental quality assessment	Fan, 1995
	Integrated assessment of urban development level	Pei, 1988
	Water environmental quality assessment	Song, 1997
Integrated FA & GRA	Atmospheric environmental quality assessment	Xu, 1997
	Landscape eco-environmental quality assessment	Yan, 1994
GRA	Atmospheric environmental quality assessment	Feng, 1996
	EIA	Zeng, 1998
Integrated GRA & GCA	Atmospheric environmental quality assessment	Xiao, 1997
GCA	Integrated assessment of urban environmental quality	Zhang, 1994
	Atmospheric environmental quality assessment	Lan, 1995
AHP	Assessment of integrated renovation of urban environment	Duan, 1995
	Eco-environmental quality assessment	Yao, 1998; Xiao, 1998
ANN	Integrated assessment of urban environmental quality	Guo, 1997; Li, 1995
	Water environmental quality assessment	Lu, 1995
	Atmospheric environmental quality assessment	Li, 1995
MEA	Integrated assessment of urban environmental quality	Li, 1997
	Water environmental quality assessment	Wang, 1997

6 Future development

Although a lot of studies and practices on IEA have been done and it has made a great contribution to the environmental management, experience in IEA has also resulted in the identification of several problems and future developments.

6.1 Real incorporation into decision-making process

Today, most EA is in relation to specific construction projects in China. And only a limited number of alternatives can be considered at this stage. Almost few strategic EA is done in China. Strategic EA (SEA) is sometimes also called programmatic EA or EA for policies and programs. It is, however, evident that if relatively small engineering projects are subject to EIA, then other

actions such as polices, plans, and programs which have a much wider scope should also be screened for adverse environmental impacts. The USA, Canada, Australia, the Netherlands, France and Germany have been experimenting with SEA. There is, however, no structured SEA process to date, no tested procedure or common methodology(Devuyst, 1993).

6.2 Public involvement

One of the main goals of environmental assessment is to make the political processes more translucent and open for public inspection. This implies that environmental assessment can only work when the views of the public is taken into account(Devuyst, 1993). Moreover the agencies which have exclusively access to environmental information should be more open to the public and especially the researchers working on environmental assessment. However, China is now at the initial application stage of public participation in environmental assessment (Chen, 1996; Li, 1996). There is still little public participation in environmental assessment process(Cui, 1996), though the importance of public involvement has been emphasized by the NEPA officials(Qiao, 1994). Mechanisms should be developed to improve the public participation and the availability of information relevant to the EA process.

6.3 Post-project analysis

Through post-project monitoring and analysis, everyone concerned knows the actual impacts on environment caused by project or strategy implementation, whether the conclusion of EA and suggested mitigation measures are appropriate. Therefore, post-project monitoring and evaluation can ensure necessary mitigation measures. Moreover, a better understanding of likely impacts, gained through the study of post-project analysis done on previous projects, will save a lot of unnecessary trial and error. At present, there is little to no experience in post-project analysis in EA in China, such as what to be monitored, how to monitor them and what management methods to be used(Qiao, 1994; Cui, 1996).

6.4 Cumulative impact assessment

In spite of the recognition of the problem, cumulative effects of human activities are rarely incorporated in current EA. Cumulative impacts are caused by multiple developments within city or a big region and affect a number of ecosystems through terrestrial, aquatic, and atmospheric connections. They change with time and space. Firstly, the effects appear locally and abruptly. But slow changes gradually exaggerate and they are over larger regions. Moreover, they emerge from a growing interdependence and interaction among ecological, economic, social and government regulatory forces (Devuyst, 1993). The above complexity of cumulative impact assessment leads to a host of methodological problems and makes it very difficult to be considered in current EA.

6.5 Application of new approaches

Recently, expert systems have been developed and applied widely in many areas. They are "man-machine systems with specialized problem-solving expertise". They process databases of information about a particular domain or discipline, understanding of the problems addressed within that domain, and skill at solving these problems(Hushon, 1986). They should be very useful in EA due to its complexity and generality in procedure and methodology. Some trials to build expert systems for EA have been made in China(Wang, 1998). But up to now, there is no expert system for integrated assessment of urban environment in China.

In addition, GIS should be powerful to graphically describe spatial distribution of environmental sources and pollutants, and analyze the comprehensive status and changes of various environmental indicators using overlay and network analysis functions.

The development of IEA is calling for the application and integration of expert system and GIS, and it is very promising in IEA.

7 Conclusions

IEA is an effective environmental management tool. As an instrument for preventive environmental protection, it provides a means of objectifying present environmental conflict by quantitative analysis and subsequent assessment of the environmental consequences associated with projects, products, processes or development policies. Therefore, it is helpful for decision-makers to ensure urban sustainable development. However, there is a lot of work needed to be done on IEA in China. Mechanisms are needed to improve public participation, consider cumulative effects, carry out post-project analysis and really incorporate it into decision-making process and promote application of new approaches such as expert system and GIS.

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