

Ecological planning of land use in the central area of Tianjin, China*

Lu Yonglong

Research Center for Eco-Environmental Sciences, Chinese
Academy of Sciences, Beijing 100085, China

Zong Yaoguang

Department of Resources and Environment, Beijing Normal
University, Beijing 100875, China

Abstract—— This paper is attempted to develop a set of suitable principles and methodologies for urban ecological planning of land use, to analyze the ecological suitability of different kinds of land use patterns of Tianjin City, to help local decision makers to work out concrete ecological strategies for promoting a sound development of the city and for improving the life quality of the citizens, and to provide the decision makers with a new approach for solving the environmental problems brought about by the improper mixture of industry and residence.

Keywords, ecological planning; land use; ecological suitability analysis.

1 Introduction

The continuous acceleration of urbanization process coupled with improper land use planning and management has often resulted in negative effects on urban life such as deterioration of environmental quality, depletion of natural resources and overcrowding of downtown areas. This is the case of Tianjin. Tianjin is the third largest industrial city in China and also an old historical city. The city expansion has been extremely rapid for the last few years and tends to continue. The spatial pattern of the city and its land use can not suit to its further development and the physical and psychological needs of the citizens. The old town has to be reconstructed and new areas have to be developed on an ecologically sound basis which entails much more than a "simple" work of land use planning. An integrated planning approach is needed which involves not only the natural ecological factors but also human ecological factors. Eco-dynamics and eco-cybernetics of urban land use from the technical, institutional and behavioural aspects have to be analyzed and investigated.

* This paper is a part of CERP (Cooperative Ecological Research Project) C-1 project coordinated by UNESCO/MAB.

A number of studies on the environmental assessment and management of Tianjin City have been undertaken since 1981. A study on "Ecological Strategies for the Development of Tianjin City" was carried out from 1987 to 1990. During that period, a systematic understanding of the structure and function of the Tianjin urban ecosystem has been obtained, the dynamics of the ecosystem simulated, and several strategies for the sustainable development of Tianjin City proposed. But the emphasis of the above studies was not put on the rational and practical land use management. Consequently, a gap between these strategies and their practical implementation still exists. However, the theories, methodologies, computer techniques and research experience gained have laid a good foundation, especially the establishment of a computer aided decision support system.

This paper attempts to develop a set of suitable principles and methodologies for urban ecological planning of land use, to analyze the ecological suitability of different kinds of land use patterns of Tianjin City, to help local decision makers to work out concrete ecological strategies for promoting a sound development of the city and for improving the life quality of the citizens, and to provide the decision makers with a decision support system so that they can regulate land use patterns according to the changes in policy and environmental conditions.

2 Environmental problems resulted from the improper land use planning: improper mixture of industry and residence

With the rapid urbanization in Tianjin, some problems, such as housing shortage, pollution and traffic congestion, have become serious in the downtown area. One of the reasons for the problems is the improper mixture of industry with residence in some parts of the city. Such problems as subsidence in the downtown area, water pollution, people's exposure to industrial pollution and traffic jams are directly related to this irrational land use pattern. Furthermore, it has made both industry and residence short of space to develop. This situation has exerted a negative influence on the city development.

To improve the people's living quality and environmental conditions, the improper land use structure should be adjusted. For this purpose, some strategies and measures have been proposed and taken by the municipality and the related governmental departments. The following are the main measures taken:

(1) Removing some factories from the downtown area to the suburbs

It would be suitable for the small-sized and new factories, but it is very difficult for the large factories to successfully follow this policy. There are several reasons: moving factories from the downtown area to the suburbs would be extremely expensive; most of the factory workers are accustomed to living in the downtown area and would be very reluctant to relocate their homes and families; and the traffic congestion in the city would be further increased with the increase of commuters.

(2) Technological innovation for reducing pollution

It is unlikely to be fully effective. Some old problems could be solved but new ones would take their place due to the rapid urbanization and unreasonable land use.

In order to fully solve the problem of the improper mixture of industry with residence, the industry and residence should be relocated where they are suitable in light of their land use suitability. On the basis of the in-depth analyses of the characteristics of different kinds of land use, their requirements for and sensitivities to the natural environment and the environmental supply (environmental capacity), land use suitability options are presented, through the comparison of the costs and benefits of the options, a satisfactory implementation option for the specific land use is obtained.

In this paper, residential suitability analysis is given as an example of the ecological land use planning. Industrial suitability analysis can be made in the same way.

3 Theoretical aspects of ecological land use planning

3.1 Main guidelines and principles for ecological land use planning

Ecological planning is the planning that is concerned with the interrelationships of an organism to its environment. For residential and industry land use, the organism of primary concern is human, objective of the planning is human ecosystem. Ecological planning is thus application of ecological concepts, an ecological approach, to the ordering of the human environment. As F. Steiner, G. Young and E. Zube (Steiner, 1990) summarized, ecological planning is (1) concerned with the character of land and environment and of the natural inhabitants thereon; (2) at its best is holistic, expressed, for example, in its application in a comprehensive way at the regional level; (3) indicates awareness of the need to integrate human activities with place and environment; (4) is interdisciplinary, recognizing that no single discipline is capable of comprehending or ordering all the elements of person-place complexities; and (5) in its final expression or ordering is applied human ecology.

Human ecological planning has emerged during the past three decades in the world from the work of McHarg and his colleagues in the Department of Landscape Architecture and Regional Planning at the University of Pennsylvania, the U. S. A. (McHarg, 1966; 1969; 1981; Giliomee, 1977; Steiner, 1981; Johnson, 1982; Zube, 1986). Human ecological concepts and principles have also been applied to urban planning in China, as stipulated in the City Planning Act of the People's Republic of China that, "in the compilation of city planning, attention should be paid to the protection and improvement of the city's ecological environment, the prevention of pollution and other public hazards, the development of greening and afforestation".

In ecological planning, importance of the planned city and region should be deeply analyzed. Functional areas should be rationally divided, and different kinds of overall land uses which are suitable not only for production but also for living arranged.

Such natural conditions as rivers and lakes, hills, green areas and climate should be fully used to create a hygienic, comfortable and tranquil living environment for urban residents.

A satisfactory plan should not only give the limit to urban growth, but also provide direction and leave space for further development of the city. Economic feasibility of urban construction and management should be put into full consideration (Lu, 1995).

3.2 Indicator system for ecological land use planning

For ecological suitability analysis of residential land use in Tianjin City, social, economic and environmental factors, the residents' requirements for improved living quality and residential environment in particular, should be taken into full consideration. Through the discussions with the decision makers, urban planners and scientists from the Tianjin Administrative Bureau of Urban Planning and Land Use Management, the Municipal Environmental Protection Agency and the Municipal Research Center for Social and Economic Development of Tianjin, in terms of the local conditions and requirements for urban planning, an indicator system of residence requirements is established for the ecological planning of the residential land use (Table 1);

Table 1 Factors considered for the residential land use planning

Social requirements	Living and service facilities
	Culture and education
	Sports and recreation
	Historical tradition of the community culture
Economic requirements	Convenience in traffic and communication
	Convenience in shopping and services
	Construction cost and housing rent
	Expenditure on basic infrastructure
Environmental requirements	Hydrology and water supply
	Impacts of environmental pollution
	Vegetation coverage and natural landscape
	Seismic resistance intensity and other geological features
	Microclimate

4 Methods and procedure for ecological land use planning

The study uses urban planning techniques, system analysis methods and a computer aided decision support system. The setting up of an ecological information system with data and maps about the natural environment and the social and economic conditions is necessary for the analysis of the ecological suitability and economic feasibility of land use, thus providing useful information for local planners and decision makers. Electronic data processing with image displays is used for comparative analysis.

The environmental capacity and sensitivity of land use are analyzed by means of field investigation, experiments and computer simulation analysis, and interviews with experts. The interrelationships and relative weight between environmental factors are studied by means of artificial intelligence techniques. A flexible man-computer interface for the analysis

of ecological suitability of land use is set up.

The procedure for ecological land use planning is shown in Fig. 1.

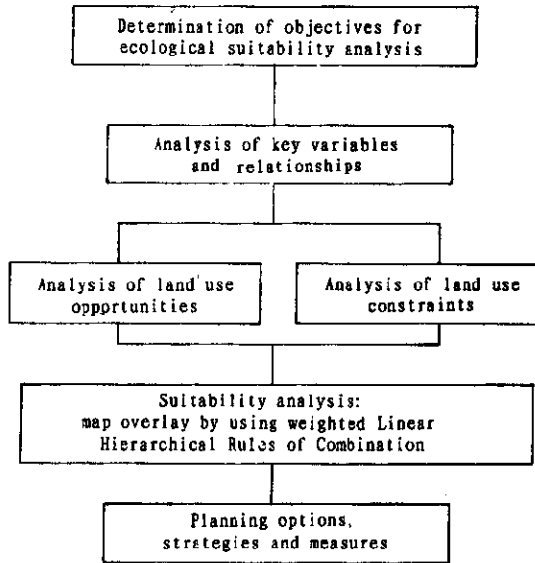


Fig. 1 Procedure for ecological land use planning

4.1 Analysis of key factors and relationships

There are many social, economic and natural factors affecting the choices of the residential areas, only those factors which play a dominant role in the functioning of the ecosystem may be put into full consideration. These dominant factors are called key factors, the relationships between them are called key relationships. Table 2 lists the most important factors for the residential suitability analysis.

Table 2 Key factors and relationships

Key factor	Key relationships
Geology	Earth-quake resistance and housing costs
Environmental quality	Impacts on residential environment
Local accessibility	Shopping, travelling and communication convenience
Service industry development	Improved living conditions

4.2 Analysis of ecological capacity and constraint

Ecological capacity for land use is the development opportunity provided by the comprehensive environment (combination of social, economic and natural factors) for the specific land use, while ecological constraint is the constraint provided by the comprehensive environment for the specific land use. For analysis of ecological capacity, the beneficial factors are divided into four classes with class I most beneficial and class IV least beneficial, as listed in Table 3. For analysis of ecological constraint, the constraint factors are also categorized into

four classes, with class I least constraint and class IV most constraint, as listed in Table 4.

Table 3 Classes of ecological capacity

Factor: distance to meters	Class			
	I	II	III	IV
Business center	<600	600—2000	2000—3000	>3000
Education center	<1200	1200—3000	3000—4000	>4000
Medical center	<750	750—2300	2300—3000	>3000
Recreation center	<1000	1000—1500	1500—2000	>2000
Circle roads	<130	130—600	600—1200	>1200
Ray roads	<130	130—500	500—800	>800

Table 4 Categorization of ecological constraint

Factor	Class I	Class II	Class III	Class IV
Existing land use pattern	Unclaimed land	Reconstructed area	Existing crowded residential area	Mixture use or other land use purposes
Geological and hydrographical conditions	Strong earth-quake resistance and good water reten- tion and drainage capacity	Strong earth-quake resistance but average water reten- tion and drainage capacity	Average earth-quake resistance and bad retention and drainage capacity	Bad earth-quake resis- tence and bad water retention and drainage capacity
Vegetation and environmental conditions	Large vegetation coverage and good environment	Average vegetation coverage and clean environment	Little vegetation coverage but clean environment	Little or no vegetation and bad environment
Preservation of cultural relics	No preservation area	No preservation area	Little preservation area	Little or much preserva- tion area

4.3 Ecological suitability analysis

Since the 1960s, McHarg and his followers have developed a number of methods for suitability analysis such as Gestalt method, mathematical combination methods (including ordinal combination, linear and non-linear combination methods), identification of regions (including factor combination and cluster analysis) and logical combination (including rules of combination method and hierarchical combination method). Each method has its own advantages and disadvantages. In this paper, linear combination and hierarchical combination methods with the aid of expert knowledge are used for the analysis of ecological suitability, which is called weighted linear combination of hierarchical rules.

Through the analyses of ecological capacity and constraint of land use, capacity and constraint classification maps, which show the distribution of homogeneous regions, are produced. Residential suitability classification maps are obtained by overlaying the capacity and

constraint maps through weighted linear combination of hierarchical rules, as explained in Fig. 2. Residential land use suitability is divided into six classes, with class I the most suitable and class VI the least suitable. Rules for suitability analysis is explained in Table 5. These rules vary from case to case based on specific local conditions and expert knowledge. Table 5 gives special results of the Tianjin case study.

Table 5 Rules for suitability analysis

Ecological suitability matrix		Ecological capacity			
	Class	I	II	III	IV
Ecological constraint	I	I	I	II	II
	II	II	III	III	IV
	III	IV	V	VI	VI
	IV	VI	VI	VI	VI

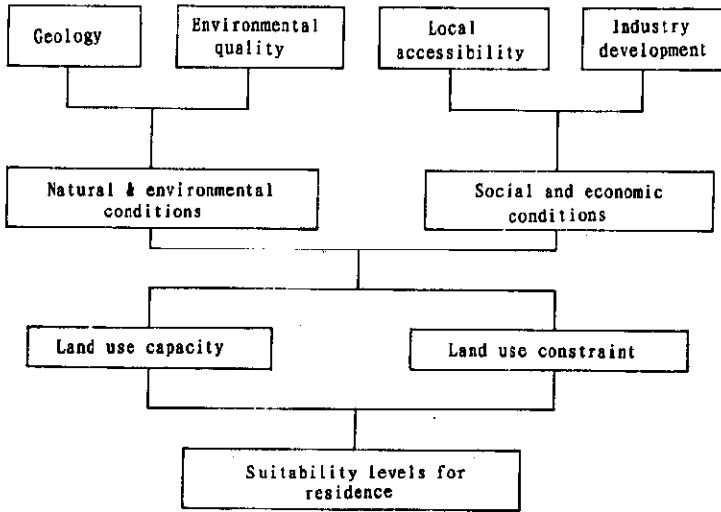


Fig. 2 Map overlay steps for suitability analysis

5 Conclusions

In this paper, residential suitability analysis is taken as an example of ecological land use planning. Suitability analysis of industry land use can be made in the same way.

Improper mixture of industry and residence is one of the reasons for many environmental problems in cities, ecological planning suggested in this paper could be a way of dealing with it. Based on the results of suitability analysis, the rational city development plan can be made. The industry and residence should be relocated where they are most suitable in accordance with the development plan.

Ecological planning process is a dynamic process. With the changes in practical condi-

tions, the planning options should be changed accordingly. With a decision support system (DSS) in place, the planning options can be easily adjusted to the changes if you input the correct corresponding parameters into the decision support system.

In a real-world situation, many environmental problems can be incorporated into this large problem: the relationships between humans and environment. These are, in fact, the questions of integration of fitness. Fitness depends on human adaption of and to place, ecological planning is an useful means for achieving such a fitness.

References

- Gilomee JH. *Landscape Planning*, 1977; 4(2):185
- Johnson AH. *Landscape Planning*, 1982; 8(2):105
- Lu YL. *Journal of Environmental Sciences*, 1995; 7(1):1
- McHarg IL. *Ecological determinism*, in: *Future environments of North America* (Eds. by Fraser Darling, John Niton). Garden City, New York; The Natural History Press. 1966
- McHarg IL. *Design with nature*. Garden City, New York; Doubleday. 1969
- McHarg IL. *Landscape Planning*, 1981; 8(2):102
- Steiner F, Broods K. *Environmental Management*, 1981; 5(6):495
- Steiner F, Young G, Zube EH. *Landscape Journal*, 1990; 9(2):31
- Yang BJ, Wang RS, Lu YL. *Decision support system for urban ecological regulation*. Beijing, China Science and Technology Press. 1992
- Zube EH. *Landscape Planning*, 1986; 13(5-6):367

(Received May 15, 1995)