

# Land-use Planning Based on Ecological Infrastructure in Metropolitan Urban Fringe: A Case Study on Dongsanxiang Area, Beijing

## 1 Introduction

### 1.1 Higher requirements on land-use planning

Land-use planning is an overall or special arrangement on land-use in a certain range of time and space, according to land resources, land suitability and demands of economic and social development (Zheng Weiyuan, 2000).

Since the Land Administration Bureau was established in 1986, China has carried out the national land-use planning twice, of which the first was focused on "serving for social and economic development", and the second converted to "protecting arable land". At present a new round of land-use planning is ongoing (2005-2020), but the aims and requirements are even more and higher (Zheng Weiyuan, 2000; Cai Yumei, Zhang Wenxin, Zhao Wenyan, 2007).

Nowadays, the demand of construction land is increasing continuously because of the rapid urbanization; conflicts between huge population and limited land resources become increasingly prominent. Meanwhile, the land-use planning is no longer keeping eyes on "serving for social and economic development" and "protecting arable land". It must be changed to promote coordinately the development of population, resources, environment, and social economy. Land-use planning must shoulder the social responsibility of solving the conflicts on the spatial strategy between social development, resource utilization and ecological protection.

### 1.2 Ecological problems in the current land-use planning

As the theory and method of land-use planning is imperfect, the current land-use planning can't meet the demand of sustainable land using and higher requirement on ecological protection in the new era.

(1) The fundamental starting point of all conventional land-use planning is the direct purpose of land-use. Although ecological functions were started to be considered recently, there is still no systematic way to reflect the concept of nature services in the land-use planning. Land-use planning, as its name said, still focuses on land utilization instead of land protection.

(2) The conventional land-use planning cares more about indicators, quantities and zoning. Actually, land is an organic system, which is structural, rather than homogeneous or medley. It even has its own pulse and flow. Therefore, we must establish the meridians of land.

### 1.3 Research Focuses

This paper takes Dongsanxiang, which locates in Chaoyang District of Beijing, as an example to study the methods of land-use planning based on ecological infrastructure (EI), which also under the guidance of the "negative planning" theory. It tries to find a possible way to combine the ecological infrastructure and land-use planning, which can provide a theoretical and methodological reference to the ongoing land-use planning.

## 2 Theories and Method

### 2.1 "negative planning", landscape security pattern (SP) and ecological infrastructure (EI)

The concept of the "negative planning" is first proposed by Professor Kongjian Yu in 2001. It is a new planning ideology responding to the disordered and fast urban expansion in China, the core principle of which is urban planning and design should be started with the planning and design of the non-construction land, rather than the traditional construction land planning. It is

further stated that the scale of city and the function of construction land can be constantly changing, but the ecological infrastructure composed by the river system, green corridors, woodlands and wetlands, is always necessary for the city and needs to remain the same constantly. Therefore, in the face of the rapid urban expansion, we need a new urban planning methodology by reverse thinking, keeping calm to any change and challenge. That is planning and consummating the non-construction land at the regional scale to establish the urban ecological infrastructure (Yu Kongjian, 2005).

Ecological Infrastructure (EI) is the natural system on which regions or cities survive healthily. It integrates various functions of nature services, including water conservation, drought and flood regulation, biodiversity conservation, local culture protection, leisure and the aesthetic experience, and lays on the land as a whole network pattern.

“Negative planning” is the ideology, and ecological infrastructure is the outcome. The bridge connected the two is landscape security pattern, which is also first proposed by Kongjian Yu. Since the theory was formally proposed, it has been widely practiced in urban master planning, such as the master plans of Taizhou, WeiHai, Yuanjiang, Heze and so on (Yu Kongjian, Li Dihua, Liu Hailong, 2005; Peng Desheng, 2005; Yu Kongjian, Xi Xuesong, Wang Sisi, 2008; Yu Kongjian, Zhang Lei, 2007). The realistic significance of “negative planning” lies in the protection of the ecological system on which cities depend. Therefore the critical pattern of natural system could be sustained and integrated during the expansion of cities, realizing the harmonious coexistence between human and land. It can be said that “negative planning” is an effective approach to solve the conflicts between social development, resource utilization and ecological protection on the spatial strategy.

## 2.2 land-use planning based on the “negative planning”

According to the “negative planning” theory, introducing the EI research to and as the basis of land-use planning work could control land using and development intensity within the permitted range of ecological security pattern. It makes land-use planning satisfy the needs of social and economic development, avoiding the destruction of the environment as well.

The fundamental distinction between the land-use planning based on EI and the conventional planning lies in different planning concepts: (1) Land-use planning based on EI is carried out in the name of land ecological security and sustainable development, rather than the planning layout catering to the needs of short-term development, even the interests of developers. (2) It doesn’t heavily rely on the prediction of urbanization and population as the basis for land-use, but to maintain ecological functions as the prerequisite for land-use layout (Table 1).

**Table 1 Differences between land-use planning based on EI and the conventional land-use planning**

	Traditional land-use planning	Land-use planning based on EI
Planning goals	"Serving for social and economic development" and "protecting arable land"; Aiming at maximum of economic benefit from land resources.	Based on the ecological processes, land-use planning is supposed to promote the coordinative development of population, resources and environment, and exert economic, social and ecological benefits.
Land-use status analysis	Contents: Land-use degree, structure, layout and benefits; More vertical process analysis.	Besides traditional analysis, ecological process is also analyzed; Both vertical and horizontal process analysis.
Land-use assessment	Mainly focus on the economy of development and construction activity, construction land quality assessment (e.g.); The assessment factors include landform, geology, foundation bearing capacity, slope, geological hazard distribution, hydrological conditions, etc.	Comprehensive assessment for land protection; Considering not only land characteristics but also effects of land-use layout on ecological functions.
Construction land scale	Usually predict the scale of construction land based on land demands which is decided by predicting population, farmland demand, etc.	Besides traditional ways of demand prediction, also predict the restriction in terms of ecological bearing capacity by EI research.
Land-use layout	It is a process from quantity to layout; Firstly, balance the demand quantities of all types of land, then arrange the land-use layout.	Confirm land-use scale and adjust land-use layout at the same time; Land-use layout considers not only land suitability, but also spatial relationship between different

		land-use types.
Land-use zoning	Through the combination of land-use district planning and land-use control indicators, implement the measures of planning goals, contents, adjustment of land-use structure and layout to spatial zoning.	Not only consider the coordination and control of internal function within districts, but also achieve the horizontal contacts of all districts through crucial corridors planning.

### 2.3 Framework

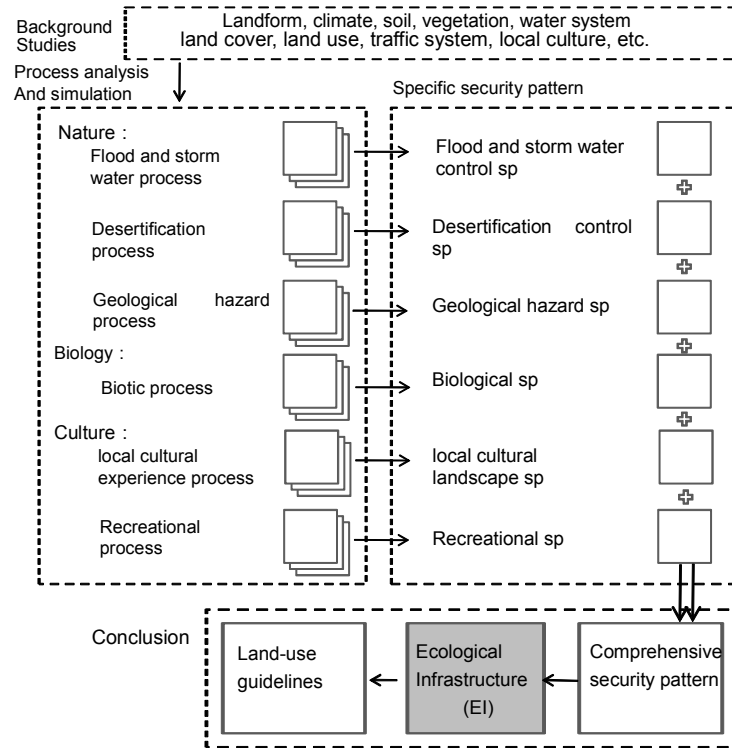


Figure 1 Framework of EI

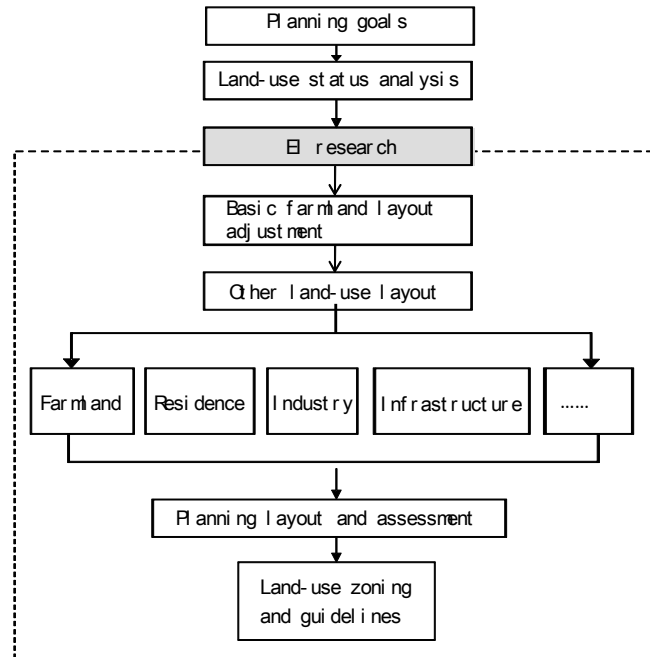


Figure 2 Framework of land-use planning based on EI

On the basis of traditional land-use planning, land-use planning based on the "negative planning" starts with the study of EI. Land-use structural adjustment, land-use spatial layout and land-use zoning, etc. are all based on it, so that the thought of ecological planning goes throughout the whole planning process (Figure 1, Figure 2).

### 3 Case studies: land-use planning of Dongsanxiang, Beijing

#### 3.1 Why the land-use planning of Dongsanxiang should be done based on EI



Figure 3 location of Dongsanxiang

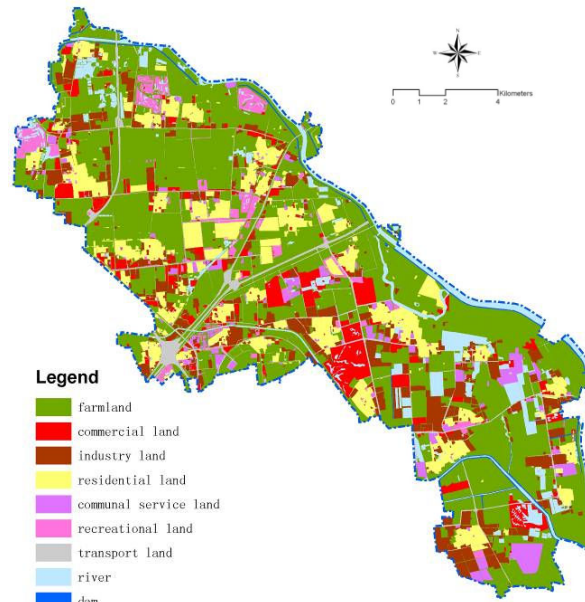


Figure 4 land-use in Dongsanxiang, 2006

Dongsanxiang area locates in the northeast of Chaoyang district, with Wenyu River flowing along the north border. The total area of Dongsanxiang is 116.36 Km<sup>2</sup>. It includes 3 townships:

Cuigezhuang, Sunhe and Jinzhan (Figure 3, Figure 4).

### 3.1.1 An important ecological area of Beijing

Due to its location and resources, the whole area of Dongsanxiang is regarded as an important part of the second greenbelt of Beijing, which aims to separate the new town from city center. Meanwhile, it is one of the nearest ecological sensitive areas and the restrained-construction area according to the Master Plan of Beijing City (2004-2020).

### 3.1.2 A golden developing area of Beijing

As a typical urban fringe area, with the total population of 280,000, Dongsanxiang has burdened floating people three times more than local people. It will absorb more people from city center in the next 15 years. Golden location and convenient traffic condition make the local government treat it as a golden developing area in future. All of these factors will induce more land demand for construction, which leads to more and more outstanding a conflict between development and conservation.

### 3.1.3 An efficient restriction to land-use by EI

An efficient restriction of land-use must be considered during the planning process in such a complex area, not a restriction of development but a balance between development and conservation. Before the layout of construction land, the ecological conservation area should be recognized in space, and an integrated ecological network should be established. The results of the negative planning should be optional according to different development goals, while to avoid unnecessary negative influence on economic development by excessive protection. All above is what EI does.

## **3.2 Establishment of EI**

To protect the integrality of ecological system in Dongsanxiang, some key landscape processes must be considered: flood and storm water process, biological process, cultural process and recreational process. The master plan of EI is made by uniting all these landscape patterns.

### 3.2.1 Flood and storm water security pattern

Dongsanxiang area lays on the downstream of the North Canal. Because of the low-lying situation, the flat terrain, and poor surface drainage capacity, Dongsanxiang has repeatedly suffered from the floods and waterlogging in history. In recent years, with the damage to vegetation along upper reaches and increment of impervious area, this area has to face more flood risk and waterlogging problems. The establishment of flood and storm water security pattern is of respect for the natural surface runoff process. It would conserve enough retention and storage areas for flood and storm water, and use natural rivers, channels and ditches to link lakes, wetlands and ponds as a network, which could finally help to release flood and solve the waterlogging problems.

The planning method of flood and storm water security pattern is based on runoff simulation and storm water submerging analysis by using programs such as ArcGIS9.0 and HEC-RAS.

For the flood submerging analysis, 10-year, 20-year, 50-year recurrence interval floods are used to delineate the potential inundant area, while in storm water submerging analysis, four levels of rainfall intensity, including 50 mm / d, 100mm / d, 200mm / d and maximum intensity in history, are utilized to identify the waterlogging vulnerable areas. Finally, uniting the two results, the flood and storm water security pattern of three levels could be established.

### 3.2.2 Biological security pattern

Strategies for the biological security pattern are as follows: core areas of habitat should be protected strictly; buffer zone and continuous corridors should be constructed. Protecting biological security pattern is helpful to reduce disturbance to habitats and ensure the integrity of wildlife migration.

Firstly, the Indicative species of Dongsanxiang are chosen; secondly, the key habitats for these species should be recognized in space as the “source”. Based on these “sources”, then comes the horizontal cost distance analysis which can find out the buffer zones, corridors and ecological strategic points. These are the biological security patterns of the indicative species. Finally, the integrated biological security pattern is established by uniting all indicative species security patterns.

### 3.2.3 Local cultural landscape security pattern

Experience of local cultural landscape is a visual and experiencing process for an experiencer travelling along certain paths and places. It can also be understood as a network consisting of a number of points and corridors. Local cultural landscape security pattern focuses on these experience “sources” and links, which can achieve the overall protection on the local cultural landscape network.

The analyzing method learns from the surface analysis of GIS. Local cultural heritage and important linear cultural elements are chosen as sources, and the local culture experience is treated as some process of extending along linear elements. Finally the routes with the minimum cost come out as local culture experiencing corridors.

### 3.2.4 Recreational security pattern

Recreation also is a process of experiencing. Recreational security pattern focuses on key landscape elements during the recreational process and its links. The influential factors include land cover, recreation route, historical and cultural landscape. In the scope of EI, the recreation means the natural elements for public to get fun of, such as woods, rivers, wetland, and so on. The method is also the same as that of local cultural landscape security pattern. The difference is choosing cultural heritages and high-valued natural landscape elements as the source.

### 3.2.5 Master plan of EI

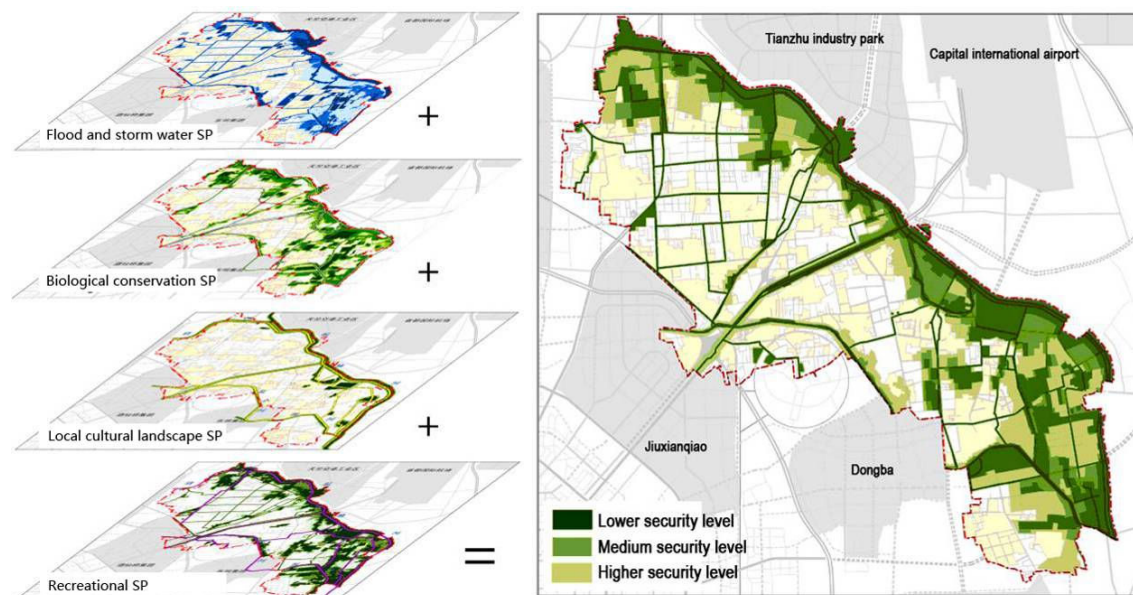


Figure 5 Master plan of EI in Dongsanxiang

As the figure above (Figure 5) shows, the master plan of EI is established by uniting all the security patterns above. EI in space is a network consisting of patches and corridors with high ecological value. The concentrated ecological patches, including woodland, ponds and water fields, are mainly distributing in eastern and southern regions along the Wenyu River, and the ecological corridors contain the main rivers and shelterbelt along the main road.

### 3.3 Land-use planning based on EI

#### 3.3.1 Construction land scale controlled by the EI pattern

In conventional land-use planning, the prediction of construction land scale which according to the future population size and GDP could be the key in the whole process. But it has two disadvantages: 1 ) the fact that population growth and economic development are uncertain leads to an unreliable prediction result of the construction land scale. In this way , the plan is hard to adapt to the change of social and economic development. 2 ) the conventional land-use planning oriented by the demand of social and economic development always ignores the demand of natural process in space , which induces the ecological space decreasing. Therefore, it can only be one of the methods to predict the construction land scale.

To solve these problems above ,the land-use planning in Dongsanxiang is based on EI pattern to control the construction land scale. Firstly , the result of EI research has ensured the amount and spatial pattern of non-construction area; Then it comes the conventional prediction of the construction land based on the population size. As a result, the final construction land amount is controlled both by development demand and by ecological protection. The planning has been converted from construction land oriented to non-construction land oriented, which reduces the destruction of ecosystem caused by uncertainty of the economic development process.

According to EI research, the amounts of construction land under the high, medium and low security level are respectively 59.8km<sup>2</sup>、 80.26 km<sup>2</sup> and 92.61 km<sup>2</sup>. Based on that, the calculation of the population size shows that Dongsanxiang area can burden more people than that urban planning calculates. It also proves that there exists opportunities for us to solve the irreconcilable conflict between protection and development at least in space (Table 2).

**Table 2 Available area for construction and accommodated population\* at three security levels**

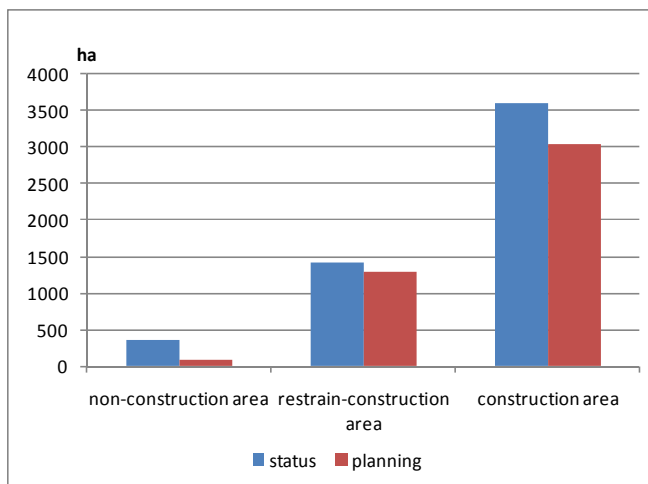
High security level		Medium security level		Low security level	
Available area for construction	Accommodated Population	Available area for construction	Accommodated population	Available area for construction	Accommodated population
59.8 km <sup>2</sup>	400 thousand	80.26 km <sup>2</sup>	540 thousand	92.61 km <sup>2</sup>	620 thousand

\*The size of accommodated population is calculated according to the standard of per capita construction land for townships (150m<sup>2</sup>)

#### 3.3.2 Demarcation of non-construction area and restrained-construction area according to EI

According to the EI pattern, the non-construction area and the restrained-construction area has been demarcated. Generally, the medium security pattern would be chosen as the non-construction area. But complicated as Dongsanxiang, the low security pattern would be chosen as the non-construction area. It is also the least ecological safeguard of Dongsanxiang. So it comes the land-use rules for the non-construction area as follows:

- Strictly protect current rivers, wetland, nature ponds and woodland around.
- Reserve farmland, pounds for agricultural productive land of a proper size, while avoiding the farming behavior from destroying the environment.
- Forbid any large-scale construction for urban and village development; carry out necessary ecological protective measures for indispensable public infrastructure constructions to reduce the negative influence to the environment.
- Restore the channelized rivers by rebuilding the eco-bank and purifying the polluted water, and make the riverbed back to the natural form.



**Figure 6 area of construction land in non-construction, restrain-construction and construction area**

The high security pattern is the buffer zone of the core protective area. It is also chosen as the restrained-construction area. The land-use rules for the restrained-construction area are as follows:

- Allow proper construction projects which must be low density and non-polluting.
- Restore the key artificial spots on the ecological network step by step to guarantee the integrity of the regional ecological process.
- Regulate the land-use structure and use the ecological function of plantation sufficiently to achieve the goal of natural-like green system which provides plenty of habitats for animals, especially for birds.
- Avoid taking up the ecological land in the future development; construct the ecological separation between the main city and the satellite towns.

As the result of the control on land-use in terms of EI pattern, the amount and the density of the construction land is quite different in the non-construction area, restrained-construction area and construction area.

### 3.3.3 Construction land-use layout based on EI

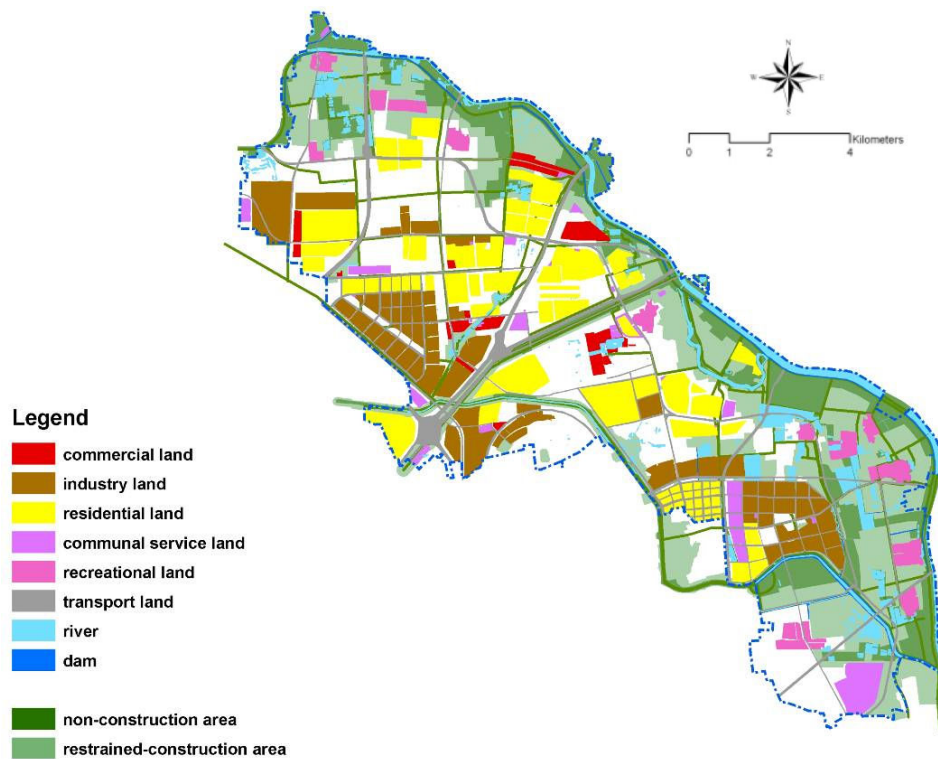
The EI research has analyzed the natural, biological and cultural processes of Dongsanxiang, and also built up the security patterns for each own. So the master plan of EI can guide the layout of industrial land, residential land, and recreational land, etc. (Figure 8).

Industrial land: polluting industries should not be arranged in the whole area; industrial land with high dense development should be arranged out of EI pattern as possible as it can be; factories with high economic and social profits in the low security pattern should be moved to the constructive area.

Residential land: there are two types of residential land. The settlements of medium and high density for local people should be arranged out of EI pattern; the residence of low density for citizens with high income should be arranged in the area of high security pattern, or the constructive place close to the EI of high security level.

Recreational Land: the arrangement of recreational and tourist facilities should be in combination with the local cultural and the recreational security patterns, in order to make tourists easy to access the recreational resources; they are allowed to be arranged in the area of high security pattern.





**Figure 8 construction land planning based on EI**

### 3.3.4 Layout adjustment of basic farmland based on EI

The layout adjustment of basic farmland is an important section of land-use planning in China. The conventional method of basic farmland adjustment always focuses on the farmland quality, in order to guarantee the food security. The productive function of farmland is the main criteria, while the ecological and cultural functions have been ignored. The farmland protection oriented by single function cannot meet the demand of economic and social development in metropolises, which actually leads to the decrease of ecological space and the diminution of farmland.

In Dongsanxiang area, the farmland should have ecological, cultural, recreational and productive function. So protection of basic farmland must be integrated with the EI plan: 1) in EI analysis, some basic farmland with high ecological function or located in key spots of the ecological network has been choose as the “sources” of habitats, water protective area and local cultural landscape; 2) after the master plan of EI, some farmland of high quality located in or near the EI pattern that are not basic farmland at present should be adjusted as basic farmland in the next 10 years.

The advantages of this method are: 1) the basic farmland protection policy will efficiently preserve ecological space in Dongsanxiang area; 2) basic farmland will also function economically and ecologically, besides the basic function of supplying with food.

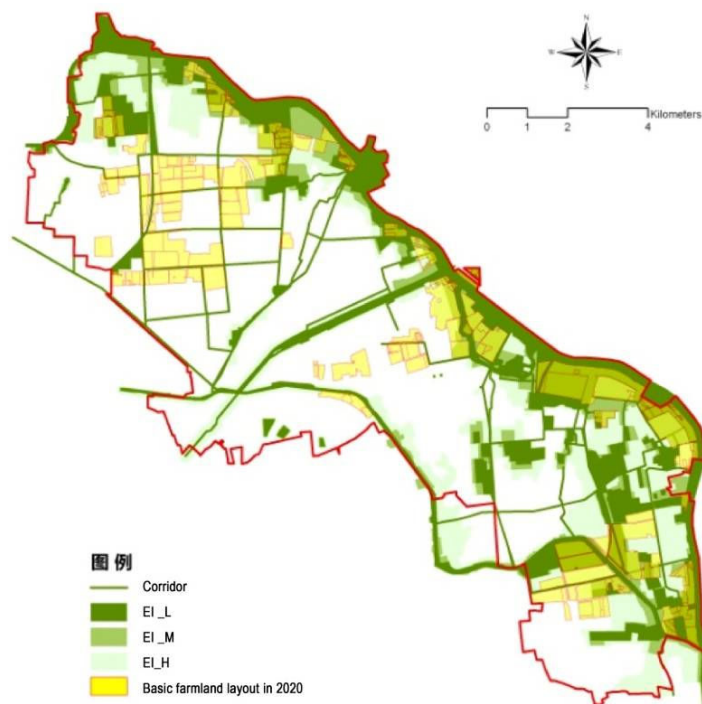


Figure 9 Layout of basic farmland plan

### 3.3.5 Land-use zoning based on EI

After the layout of all types of land use, it is necessary to set down the land-use zoning for land-use management. In conventional land-use planning, zoning always focus on the use and the size control instead of spatial developing intensity control. In Dongsanxiang case, the land-use zoning pays more attention on controlling of developing intensity according to the EI pattern. The whole area is divided into three belts: low density belt, medium density belt and high density belt. The low density belt is recognized based on EI, which consists of the non-construction area together with the restrain-construction area; both the medium density and the high density belts are in the scope of construction area.

Table 3 Land-use zoning and principles of controlling of Dongsanxiang area

Zoning	Land-use direction	Controlling index of using intensity
Ecological protection zone of Wenyu River (Low-density construction area)	Ecological protection belt; Ecological land use as the dominant type.	Population density, population structure, land-use type, area of construction land, area of agricultural land converted to construction land, area of new-added construction land, building density, plot ratio, area of basic farmland, occupied ratio by buildings in EI patches, width of EI corridors, land-use benefits, etc.
Buffer zone for urban development (medium-density construction area)	Eco-industry land as the dominant type; Other types: residence of low and medium density, urban agricultural projects, etc.; Area and density of new construction land should be controlled.	
Urbanization zone (high-density construction area)	Construction land use as dominant types; High-density residences and industrial groups are allowed.	

#### 4 Conclusions

It is proved as an efficient approach to construct EI at the beginning of the land-use planning process, which can lead to sustainable development. The advantages are concluded mainly as follows:

(1) Theory level: directed by the “negative plan” theory, the land-use planning turns to focus on non-construction area by carrying out EI research first. So the land-use planning is converted from “utilization planning” to “protection planning”.

(2) Method level: the ecological methods have been applied in the EI research and in the land-use planning as well. These methods respect the continuity of various ecological processes and nature services existing on land.

(3) Layout level: the layout of the land-use planning based on EI offers different alternatives because of the different levels of ecological security and different spatial patterns. It also makes the plan suitable for the economic and social changes in the future.

(4) Effect level: even in the urban fringe as Dongsanxiang area, the land-use planning based on EI can meet the demand of urban development, as well as that of ecological conservation and local cultural landscape. It is indeed an efficient approach to solve spatially the conflicts between the social development, the resources utilization and the ecological protection.

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