Ecological Infrastructure First:

A Case Study of Urban New Developing Zone of Hefei City, Anhui Province

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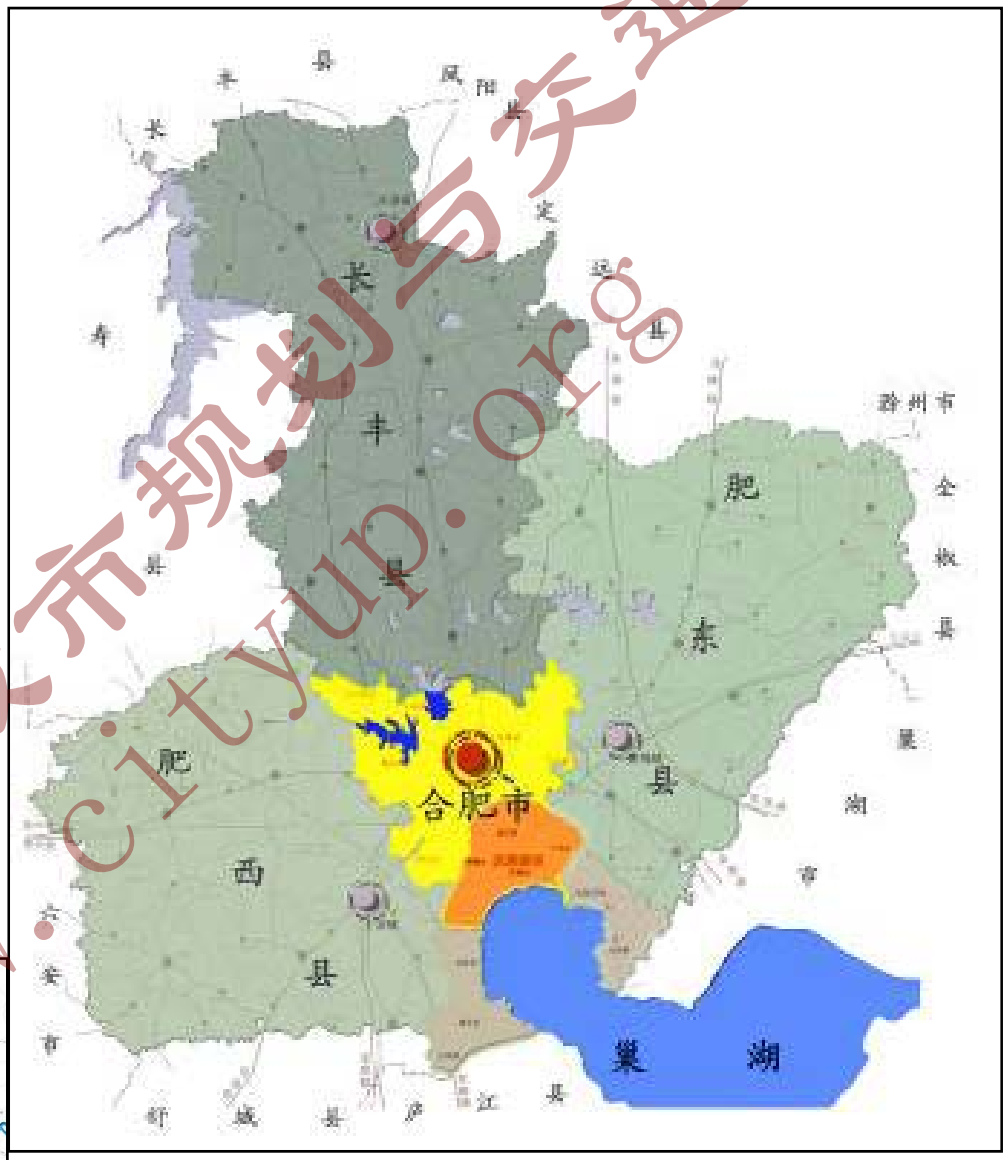


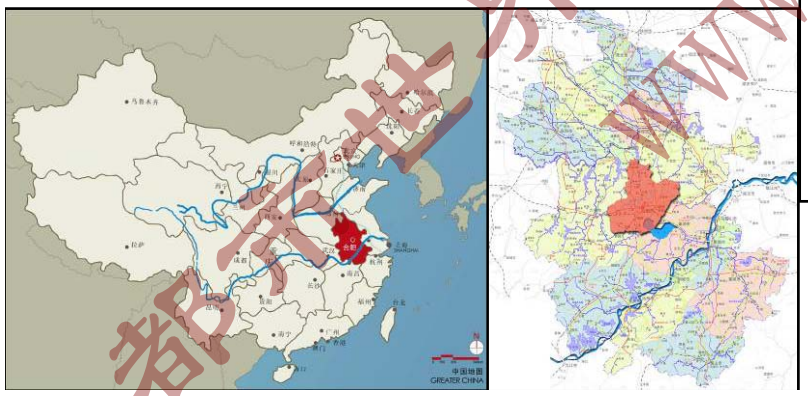


Fig: Location of UNDZ of Hefei City

1. Introduction

- Aim of research: maintaining sustaining ecological functions and processes during rapid urbanization
- Case study: UNDZ of Hefei City, Anhui Province, China
- (1) size: 190 km2
- (2) Facing key problems: Balance the relationship among development, flood control and protection of hydrological and ecological processes

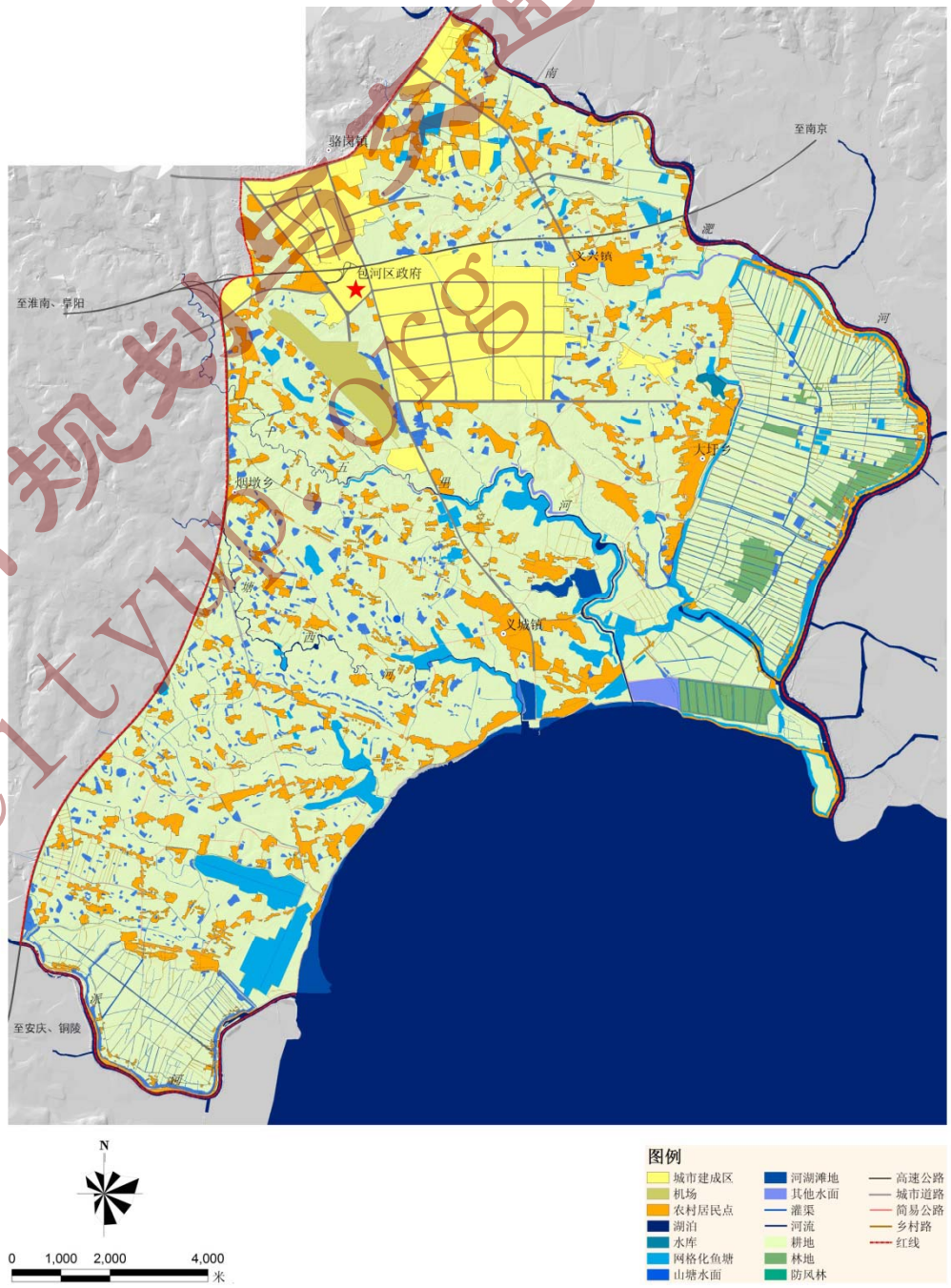


Fig. Landuse and landcover

2. Theories and approaches

- ***2.1 Theories & Concept***

- **Ecological infrastructure (EI)** is defined as the structural landscape network that is composed of the essential landscape elements and both existing and potential spatial patterns that are of strategic significance in safeguarding the critical natural, biological and cultural processes, which are critical in securing the integrity and identity of the natural and cultural landscapes, and in securing natural capital that support sustainable ecosystem services (Yu et al., 2001, 2005, 2005).
- **Landscape security patterns (SPs)** are identified for the individual targeted processes. SPs are composed of elements and spatial positions that are strategically important in safeguarding the different processes of the landscape. Models including suitability analysis, minimum cost distance and surface analysis were used in the identification of security patterns for the individual processes (Yu, 1995, 1996). Alternative security levels - low, medium and high - are used to define the quality of the SPs in safeguarding each of the targeted processes.

2. Theories and approaches

- ***2.1 Theories & Concept***

- Taking all these hydrological processes and biological processes of the security patterns, an integrated regional ecological infrastructure will be established. They all together guarantee the health and security of regional ecosystem services. For the security patterns of various processes differ because of security standards, the overall EI formatted by their integration will also have a variety of spatial structure corresponding to different security standards, which is a group of multiple solutions between the highest (when the security standards of all SPs are the highest) and the lowest standards (when the security standards of all SPs are the lowest).
- On the basis of EI, the growth processes of urban built-up area under the influence of the flood, biology and other factors could be further simulated. The results reflect the development trend of the city in the framework provided by EI, such as the size and scope of urban development area and its relationship with natural elements. The current urban built-up area can be the sources of the simulation, in which the accessibility surface is established, based on the floods, biological security patterns, the current land use, roads and so on.

2.2 Approaches

- *2.2.1 Hydrological processes and security patterns for flood control*
- the purpose of flood security patterns: to build spatial patterns in accordance with natural water cycle
- A complete flood control system is composed of anabranch, wetland, reservoir and bottomland, which have the significant adjustive effect on the flood disaster and offer diversified ecosystem.
- Methods: with the help of GIS, using the runoff model and digital elevation model (DEM) to simulate the processes of the flood

2.2.2 Urban biological processes and security patterns for biodiversity conservation

- **(1) Selection of indicator species**
- **(2) Suitability analysis for habitats**
- **(3) Security patterns for urban biological processes**

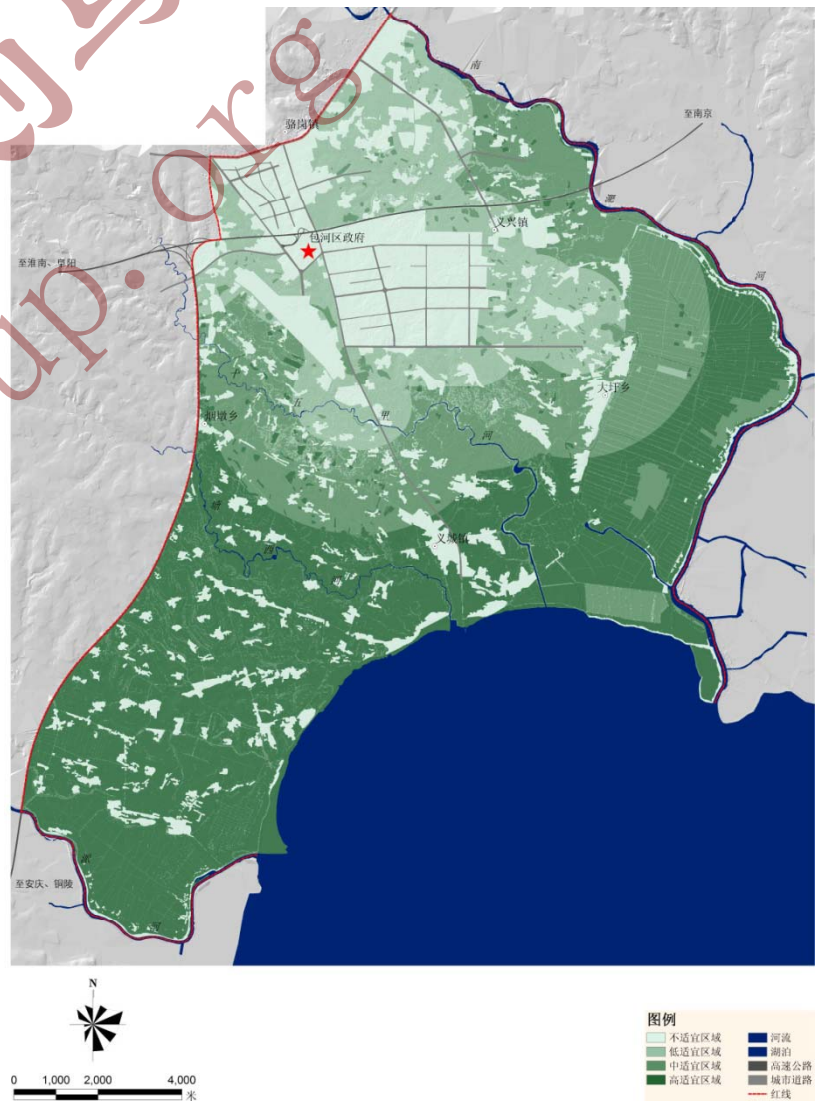


Fig. Suitable habitat for Ardeidae

3. Results

- ***3.1 Analyses of water***
- The Chaohu Lake and the riverside water logging area, ancient river channels, bottomland, pond and paddy field are the key factors to manage the flood.
- Based on the elevation data and map, the potential accumulative areas can be recognized:
- (1) the areas tend to water logging, such as polder area along the Nanfei river and the Shiwuli river. These polders' elevations are below 9m, and they are planned as the flood storage place when the flood comes.
- (2) Using the unconstraint surface runoff analysis, calculating the storage of water in the bottomland, they are the potential areas to store the flood.

- According to the different flood risk frequencies of Chaohu Lake, we combined digital elevation model with GIS-based analysis to stimulate flooding range and to establish diverse wetland scales and patterns under the condition of five different flood control security patterns defined by five frequencies (one in 10 years, one in 20 years, one in 50 years, one in 100 years, and one in 200 years). And we also calculated the flooded areas and detention volumes within given flood risk frequencies (Tab.1).

Tab.1 Different water levels, flooded areas and detention volumes within given flood risk frequencies (without embankments)

risk frequency	Water level(m)	flooded area(km^2)	detention volume(100 million m^3)
1 in 10 year flood	11.6*	70.20	1.79
1 in 20 year flood	12.5*	82.00	2.48
1 in 50 year flood	12.75*	85.28	2.69
1 in 100 year flood	13.3**	92.05	3.18
1 in 200 year flood	14.5**	103.90	4.35

The water level data sources:* Wang Yongchang (2000). ** The interview with Planning Bureau of Hefei City.

3. Results: *3.1 Analyses of water*

- The standard of flood control for the UNDZ of Hefei city will be one in 50 years on the lower level of flood security patterns, one in 100 years on the medium level, and one in 200 years on the higher level.

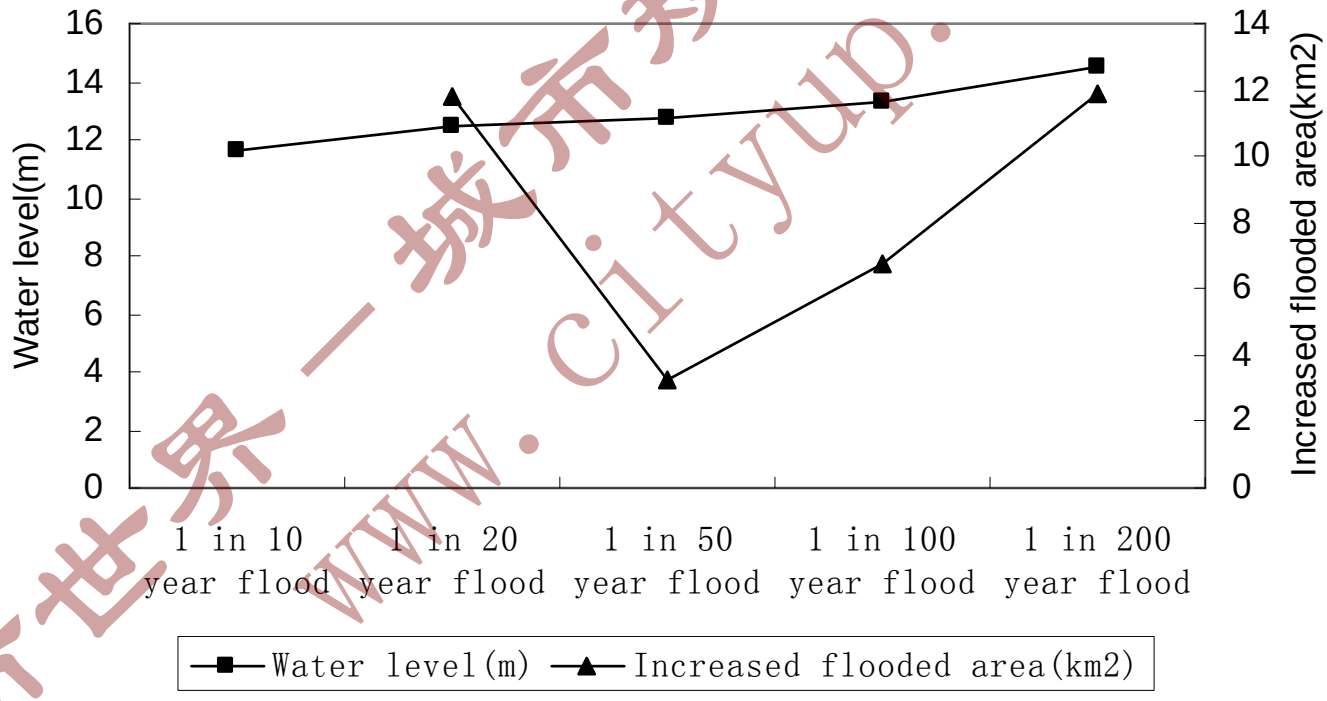


Fig: Changes of flooded areas within given flood risk frequencies

3. Results:

3.1 Analyses of water

- The regional flood plain wetlands and river networks with corresponding scales and patterns together with regional reservoirs, lakes and other landscape elements compose an overall security patterns for hydrological process (Fig.4).

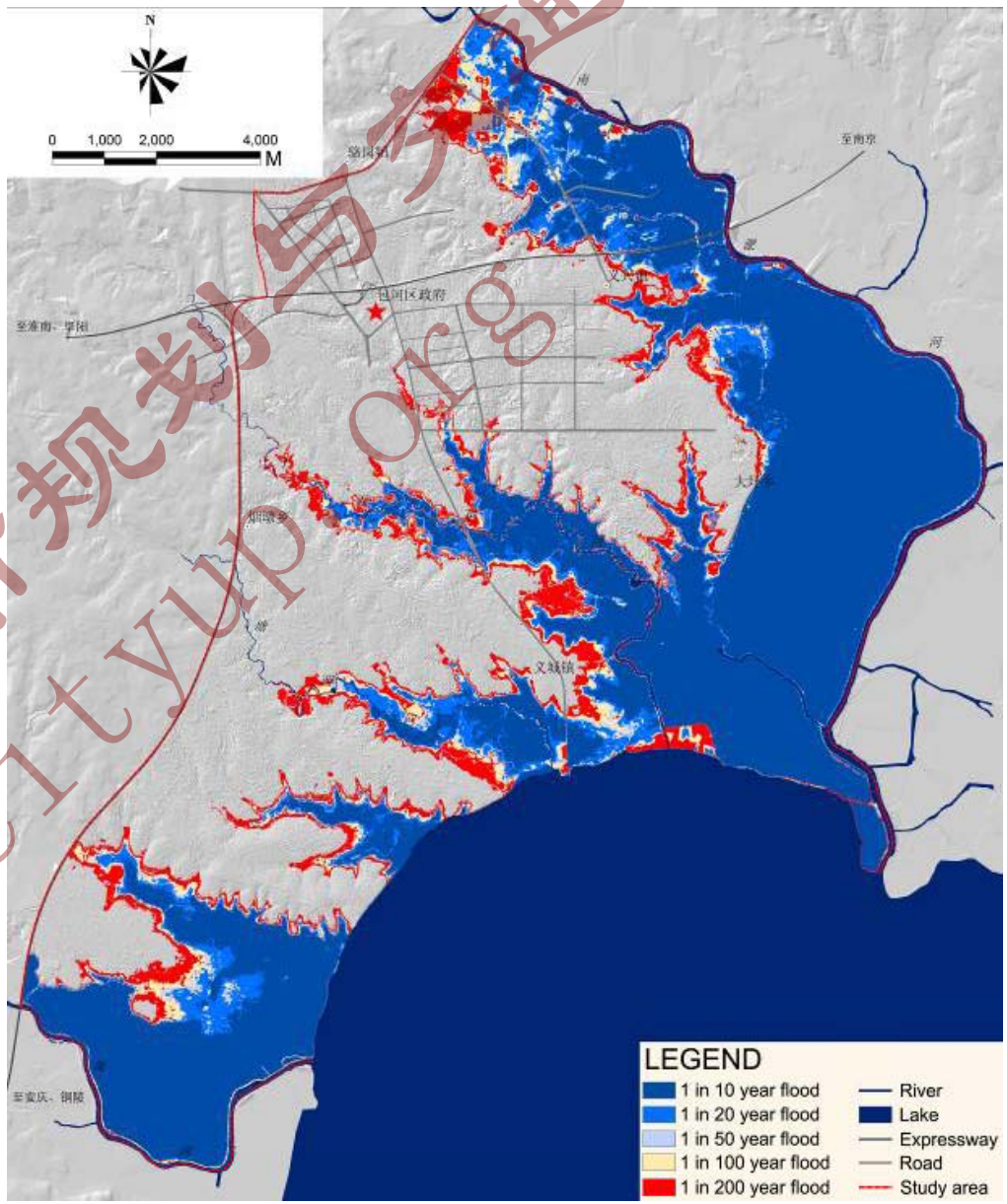


Fig4. SPs for hydrological processes

3.2 Analyses of biology

- Some Ardeidae is initially selected as the indicator species of the UNDZ of Hefei city, including egret, intermediate egret, great egrets, herons, purpleheron, Night Heron, Chinese pond heron, cattle egret, green backed herons. The feeding radius of most Ardeidae is 7~15km, the habitat radius is 2km, the flush distance is about 30m, and other habits is as the following table (Tab. 2). Herons habitats are similar. Compositing the situation of field observation, egret is finally chosen as the indicator specie of the UNDZ of Hefei city.

Tab. 2 Habits and habitats of indicator species to be selected

Species	Latin genera name	Residence status	Habits
Egret	*Egretta garzetta*	Resident or migratory bird	Paddy field \ lake \ river \ marshland, nesting in tree or reed
Intermediat eegret	*Mesophoyx intermedia*	Migratory bird	Paddy field \ lake \ marshland \ mangrove \ coastal mudflat, nesting with other water birds
Great egrets	*Casmerodius albus*	Migratory bird	Humid or shallow water area
Herons	*Ardea cinerea*	Migratory bird	Unsociability, predation in shallow water area. Sometimes in group in Winter. Habitat in the tree.
Purpleheron	*Ardea purpurea*	Resident bird	Paddy field \reed\ lake \ river, nesting in big group
Night Heron	*Nycticorax nycticorax*	Migratory bird	Habitat in the tree in daytime, eating dispersion in the evening in the paddy field\ grass and sides of water channel
Chinese pond heron	*Ardeola bacchus*	Migratory bird	Paddy field or shallow water，eating alone or in small groups. nesting with other water birds
Cattle egret	*Bubulcus ibis*	Migratory bird	Predat flies coming from grassland drawing by livestock or buffalo. Nesting in groups on the water.
Green backed herons	*Butorides striatus*	Migratory bird	Pond\river\paddy field\reed\shrub\mangrove, where have thick cover. Nesting in small group.

3.2 Analyses of biology

- In the processes of establishing biological security patterns, it is not realistic to protect all paddy field, one of the Egret favorite habitats, since there will be a great deal development needs in future. However, most of the southeastern land is paddy fields, wetlands and low-lying under the greater threat of floods, so it takes the land under the water level of one in 100 year flood as sources, the Egret future habitat conservation areas. Then, the accessibility surface is established according to the types of land cover and habitat suitability analysis. Finally, security patterns for biological processes are established on different security level (Fig.5).

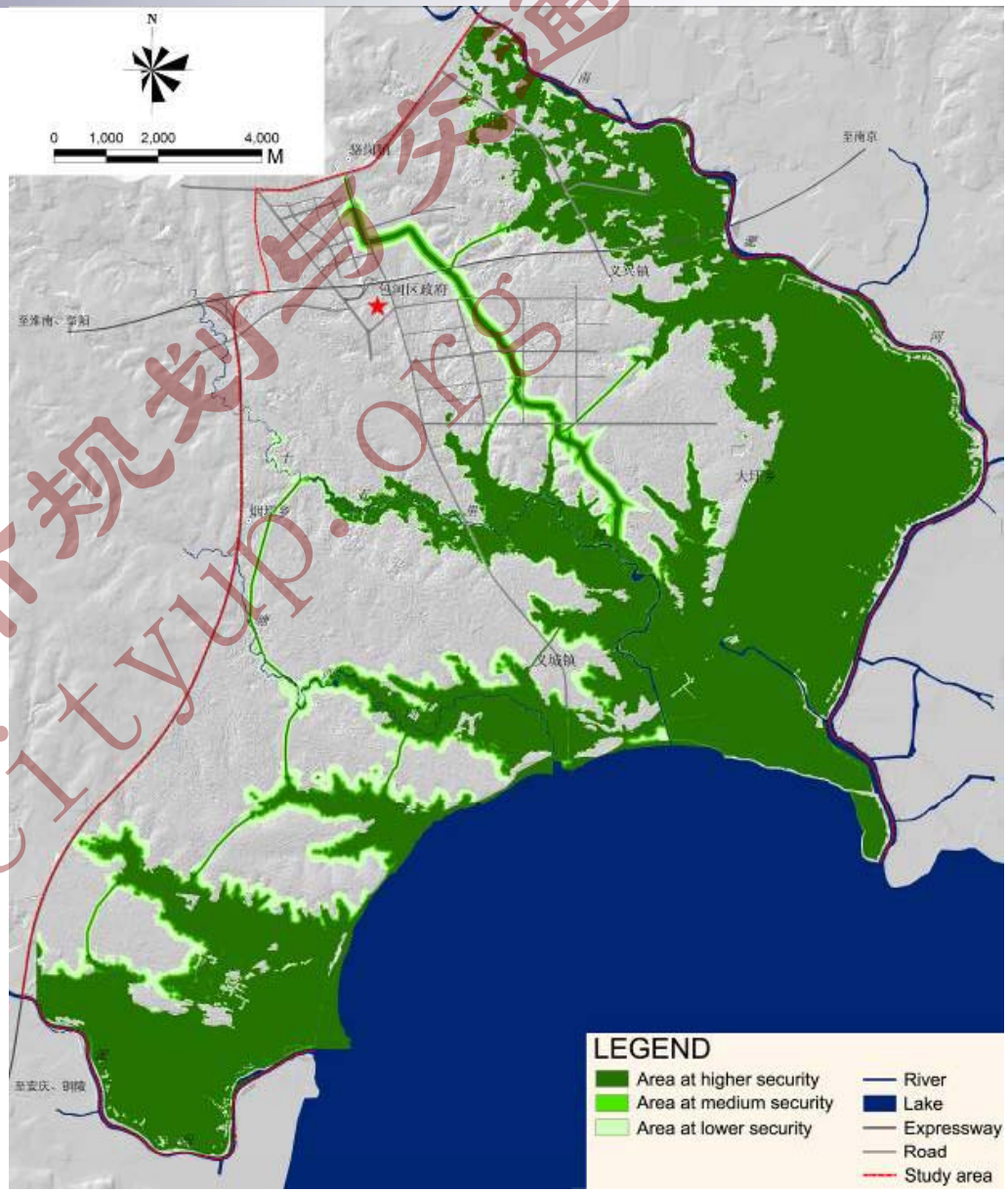


Fig. 5 SPs for biological processes

3.3 Establishment of EI

- Based on security standards of higher, medium and lower level, EI providing integrated ecosystem services is established to maintain the processes of hydrology and biology, by integrating security patterns for hydrological and biological processes, and an image of *the city of aigrette* for UNDZ of Hefei City is developed. Furthermore, the quantity of aigrette inhabiting here would be one of important indicators for monitoring the extent of urban ecological security. Hopefully people are going to live with aigrette in UNDZ in future while the EI is established.
- The EI based on the medium level is recommended according to the demands of protection and development. It also shows the EI based on the higher level and lower level to refer (Fig.6).

3.3 *Establishment of EI*

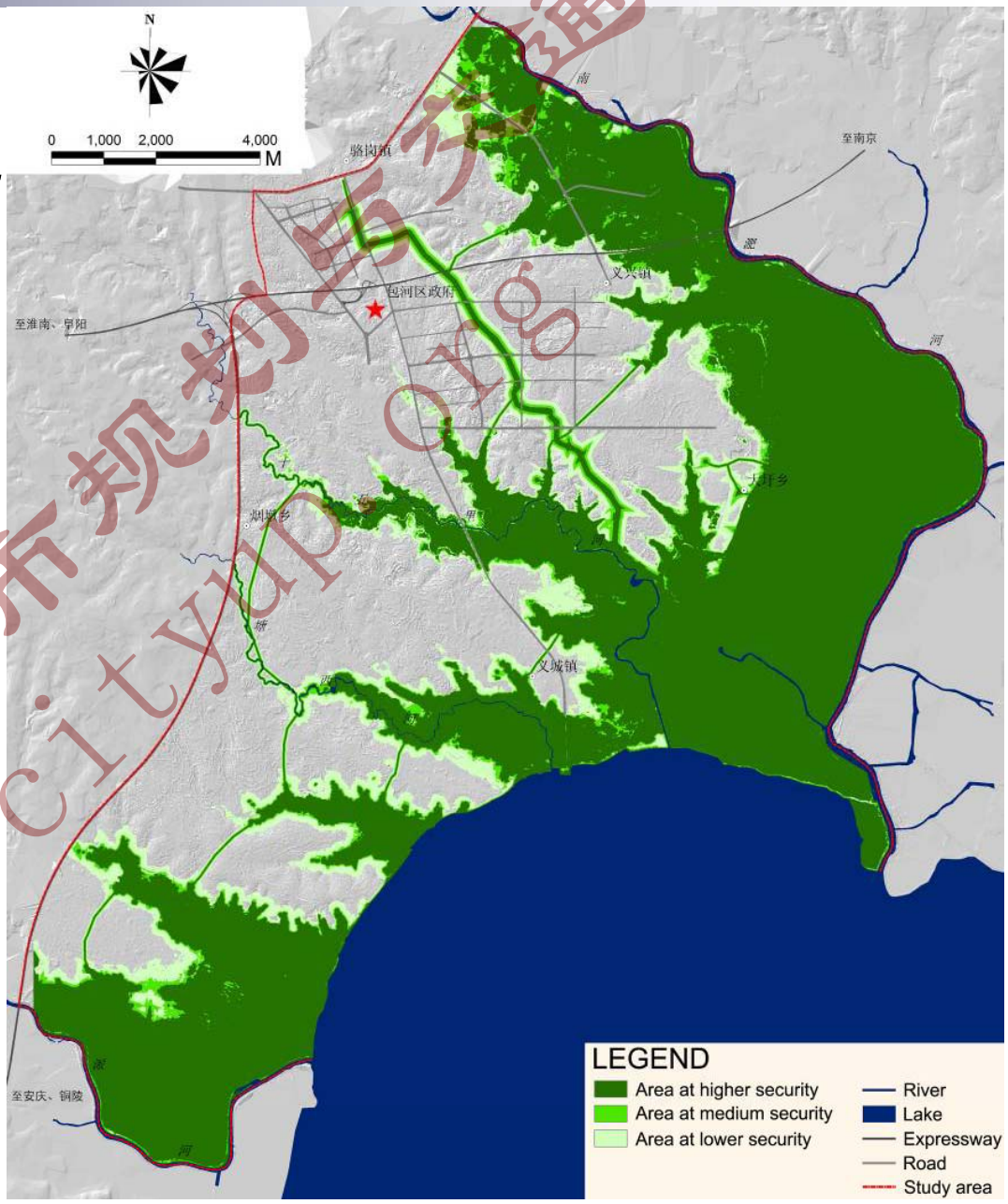


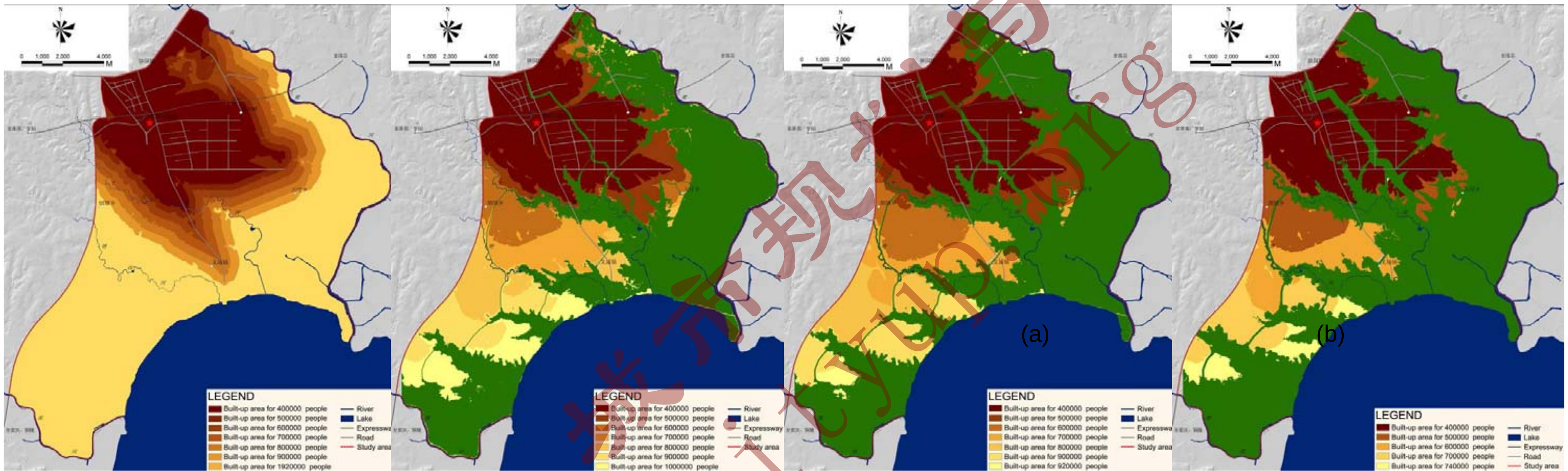
Fig.6 EI

Scenarios of urban growth patterns based on EI

- The size and patterns of urban built-up area vary with EI based on different security level. However, there is a maximum limit for urban built-up area on different security level in theory. According to national standards, constructive land per person in Hefei city is suggested to be 100m^2, so it is possible to calculate the city scale (Tab. 3) and develop scenarios of urban growth patterns (Fig.7).

Tab. 3 City scale under different security level EI

security level EI	Potential urban built-up area (km^2)	Population (10^4 people)	Max percent of urban built-up area in planning area (%)
Lower level	100	100	52.63
Medium level	92	92	48.42
Higher level	74	74	38.95



(a) (b) (c) (d)

Fig.7 Scenarios of urban growth patterns based on EI ((a) without EI ;(b) based on lower level EI ;(c) based on middle level EI ;(d) based on higher level EI)

4. Discussion

- Since the general framework of urban spatial development has been determined basically, the relationship between ecological infrastructure and urban construction land of different types should be taken into consideration comprehensively in UNDZ of Hefei City land use planning, to maximize ecological efficiency. I.e., residential land compatible with EI highly, could be laid neighboring EI in order to not only benefit protecting ecological infrastructure and the function of ecosystem services, but also improve the environment of residential area and add value to the residential land to some extent.
- To assure the function of ecological infrastructure, general coordinating principles are suggested for ecological infrastructure establishing and urban construction:
- urban function and traffic system should be planed reasonably in UNDZ;
- Ecological corridors and patches, having critical value to the integrity of urban and regional ecosystem function, should be protected strictly;
- Each cluster in urban built-up area should be linked to each other and regional ecological infrastructure as a whole by the existing water surface, river system, and terrain.
- Any construction should be ecological and energy-saving.

5. Conclusion

- The urban planning strategy developed herein is to prioritize the arrangement of ecological infrastructure, based on landscape security patterns, by means of topography, hydrological and ecological processes modeling, and to incorporate factors such as urban flood control, stormwater management, and indicator animal of aigrette which is the most representative bird in this area.
- The main conclusions are as follows:
- (1) An image, *the city of aigrette*, is developed for UNDZ of Hefei City. Furthermore, the quantity of aigrette inhabiting here would be one of important indicators for monitoring the extent of urban ecological security. Hopefully people are going to live with aigrette in UNDZ in future while the ecological infrastructure is established.
- (2) The land used for city construction at most is between 38.95% and 52.63% so as to sustain the integrality of the ecological process and the sustainability of ecosystem services.
- (3) Based on the ecological infrastructure in UNDZ urban land use is arranged according to the compatibility of different land use types to maximize ecological benefits.