Ecological Infrastructure as a Tool for Smart Preservation and Smart Growth：The Negative Approach

The conventional approach for economic centered urban development planning, failed to meet the challenges of swift urbanization and sustainability issues in China. The “negative approach” defines an urban growth pattern and urban form, through the identification and planning of Ecological Infrastructure, instead of reviewing through the projection of population and planning of civil infrastructure in the conventional approach.

The negative approach has its roots in landscape urbanism and has evolved from the pre-scientific model of *Feng-shui* as the backbone of human settlement. The 19th century notion of greenways as recreational infrastructure, the early 20th century idea of green belts as urban form makers, and the late 20th century notion of ecological networks and Ecological Infrastructure (EI) as a biological preservation framework. EI is composed of critical landscape structure that are strategically identified and planned to safeguard the various natural, biological, cultural and recreational processes across the landscape, securing natural assets and ecosystems services, essential for sustaining human society. EI functions as an effective tool for smart growth in the context of rapid urbanization, and is planned ahead of time, anticipating the scale, context and configuration of future urban development patterns. EI is strategically planned and developed using less land but more efficiently preserving the ecosystems services. Using Taizhou City as a case study, this paper demonstrates how to use EI as a tool to guide and frame sustainable urban development.

1 Introduction

1.1 Urbanization in China Challenges Physical and Spiritual Sustainability.

China’s urbanization has been considered as an unprecedented phenomenon in Chinese history as it is in the world. According to the UN report (UN, 2007), at the end of 2006, China's total population was 1.3 billion, 44 percent of it reside in urban areas, this number will reach 70 percent by 2035. Three facts make this projection more meaningful: (1) Spatially unbalanced: about 94 percent of population lives on approximately 46 percent land in the east part of China; (2) The scarcity of natural resources: China posses 21 percent of the world population but only 7 percent of the world fresh water and other natural resources; The water volume consumption per capita in China is one fourth of the world average; (3) A landscape with rich heritages: China has un-disconnected civilization history of more than five thousand years, and virtually any inch of the land is a cultural heritage.

These facts have imposed two challenges to landscape and urban planning:

(1) Sustainability: While thousands of dams lay across almost all rivers in this country, more than ever, a broader population is exposed to disastrous natural forces, as demonstrated by China’s numerous floods and droughts each year. At present, the total area of desertification accounts for about 20 percent of the whole country, furthermore, about 5 billion tons of soil erode yearly into the ocean (Gao, et al ,2004; Jiang and Liu, 20, 04; Zhao, et al, 2004). Statistics show that in the past 50 years, 50 percent of the China’s wetlands have disappeared, and 40 percent of the surviving wetlands have been polluted (Chen, Lü and Yong, 2004).The under ground water level drops every day. In Beijing for example, the

underground water over use is 110 percent, and each year the underground water level drops by one meter. Two thirds of the 662 cities now lack of sufficient water, and not a single river in the urban and suburban areas runs unpolluted. While the GDP growth rate in the past twenty years is impressive in most of Chinese cities, the annual loss caused by the environmental and ecological degradation is now between seven and twenty percent of the GDP. This is equal to, or even higher than annual GDP growth (Guo, 2004).

One can only ask: Is this sustainable? How can landscape and urban planners play a role to meet these unprecedented challenges?

(2) Cultural and spiritual integrity: The second challenge is the loss of our spiritual homeland. Every piece of land, and all elements in the landscape are inhabited by various spirits, where our ancestors were buried. The trend toward materialism is taking over China at a rapid rate. The Dragon Hills (sacred hills) that secured numerous villages in rural China have been bulldozed. Meaningful and sacred streams and ponds in front of the villages have been filled or channeled in the name of flood control. Landscapes have become commercialized. Gradually, we have lost our spiritual connection to our land and to earth.

How can urban planners assume the role to protect and rebuild such spiritual connections through the design of our physical environment?

In order to meet these two challenges, the methodology of planning has to be reversed.

1.2 The Failure of Conventional Approach to Urban Development Planning.

Aside from other social and political reasons, the physical planning approach in the urban development planning field is responsible for the ecological and environmental degradation as well as the loss of cultural and spiritual landscape. The Chinese system of urban planning was a heritage from the former socialism Soviet Union. The physical planning of urban development was an extension of social and economic development planning exercise. The single most important basis for urban development planning is population projection, upon which urban land use, resources allocation, functional zoning and built infrastructure plan are based. In most of the cases, the population projection for the long-term (20 years) and even in short term (5 years) never comes to the right or near to the right, partly due to government policy changing.

For example, in 1986 Shenzhen population was estimated to be 1.1 millions in 2000, but actual numbers turn out to be 7 millions by the end of 2000. The same is true for Beijing and Shanghai (Yu, et al, 2005a,b). This model of urban development planning initiated large-scale technocratic projects and mono-functional simplification. Nature was not considered as a system, and zoning was directed by economic principles. As noticed in other Soviet influenced countries: “Destruction of traditional landscape systems and ecological destabilization of landscapes, with extensive erosion, soil salinization, forest dieback and water and soil pollution, were visible results of this process,” (Jongman, 2001). As a result, planning of land use and facilities and infrastructure can never catch up the ever expanding population, and the urban boundary, following the extension of infrastructure, just keep crouching the unplanned rural land indiscriminately. Critical cultural heritages and natural habitats are getting lost before any conservation plans are carried out. Because in this conventional approach, any environmental conservation planning, historical protection

planning and green system planning , or even the flood control planning was subordinate to the comprehensive master planning, which does not cover the rural area beyond the urban development boundary. This shortcoming of the conventional planning system has recently been widely noticed (Yu, et al, 2005a,b; Yu and Mary, 2006), but changes occur slowly.

In addition to the technical failure of this economic development oriented planning system, the shift of systems from a planned central economy to a market one, weakens urban planning power. Physical planning is being subordinated to a socialist reference, as results are observed in a “fried egg” city form. After the reform in the 1980’s, “Leap Forward” type of city was able to show new development zones, a science center and new university cities, which are virtually leap out of the master plan area and beyond the former greenbelt, or any comprehensive plan.

It is well recognized that urban planning is playing a less important role in development control and it has been widely recognized that the conventional economic oriented approach to urban development planning failed (Gaubatz, 1999; Yeh and Wu ,1999; Cheng and Masser,2003; Jim and Chen, 2003) . As a result, Chinese urban planners are facing a huge challenge, and are required to modify the urban planning system from a centrally planned, to a transitional economy reform. Action of a revolutionary change on planning method was called upon in the past decade (Yeh and Wu, 1999; Wu, 2003 ; Yu, et al, 2005a,b ; Zhao, 2003 ,2004 ;Yang, 2003; Zhang, 2003). Among them, the “negative approach” was proposed (Yu, et al, 2005a,b; Yu and Mary, 2006), as a counterpart of the conventional “positive” approach in the sense of economic urban development.

The key in the “negative approach” is planning EI and its subsequent application to shape the urban growth.

2. The Negative Approach: Methodology

The goal of the negative approach to landscape and urban planning is to meet the challenges of sustainability, including to have a sustainable landscape and sustainable urban form, also allow land to be developed without losing its ecological, cultural and spiritual integrity. Instead of using population projection as the basis of economic development planning, the negative approach looks for the ecological and cultural sustainability and integrity as the solid base for development planning. Instead of planning civil infrastructure as the framework for urban development and architectural urbanism, the negative approach considers Ecological Infrastructure (EI) to shape urban form and frame urban development. The overall goals and objectives are Smart Preservation and Smart Growth.

With this objectives in mind, the negative approach to planning are composed of the following steps (Figure 1):

2.2 Defining Landscape Security Patterns

Landscape Security Patterns (SP’s) are identified for the individual targeted processes. SP’s are composed of elements and spatial positions that are strategically important in safeguarding the different processes across 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 attributes of the SP's in safeguarding each of the targeted processes.

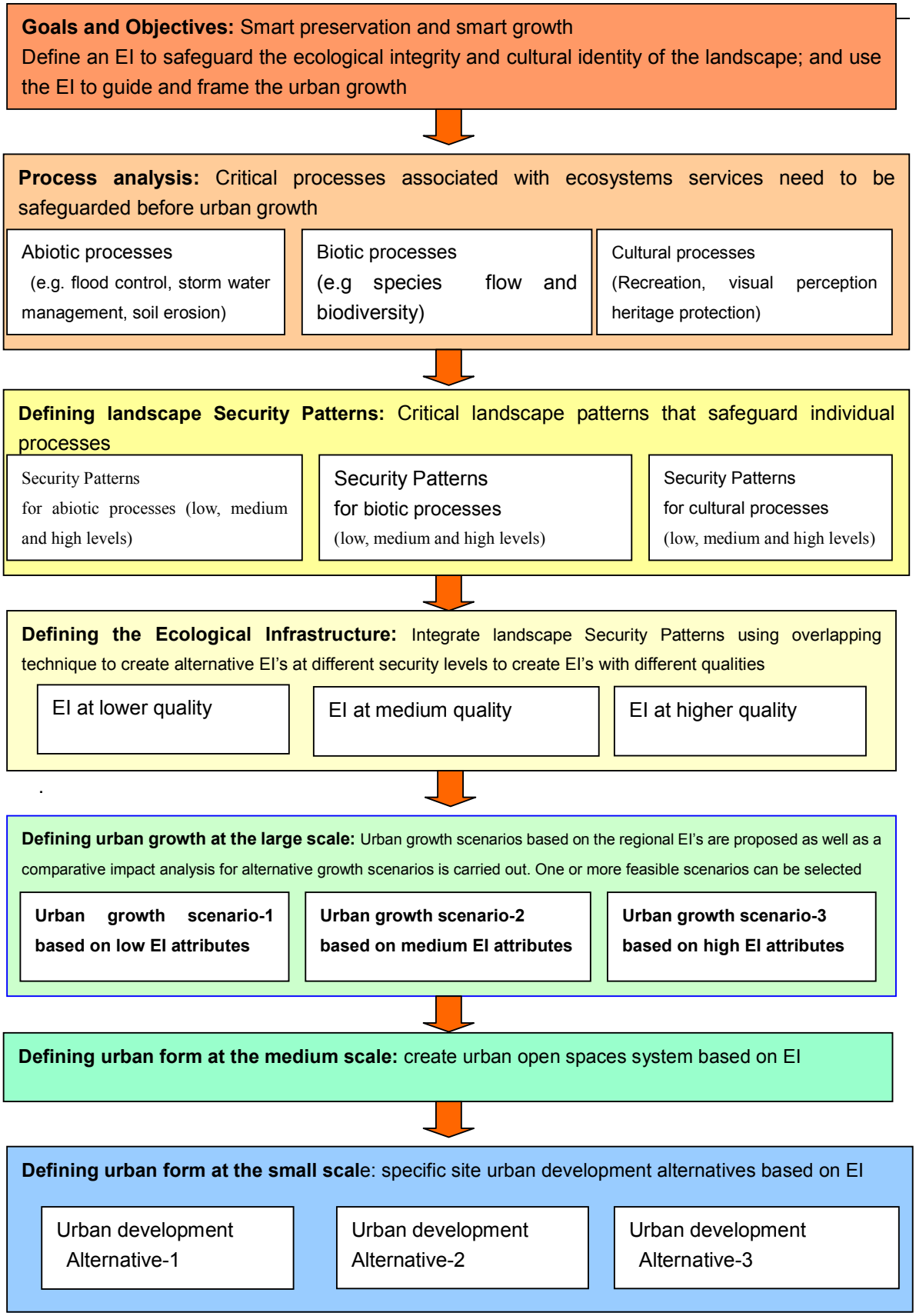
Goals and Objectives: Smart preservation and smart growth
Define an EI to safeguard the ecological integrity and cultural identity of the landscape; and use the EI to guide and frame the urban growth
Process analysis: Critical processes associated with ecosystems services need to be safeguarded before urban growth
Abiotic processes (e.g. flood control, storm water management, soil erosion)
Biotic processes (e.g species flow and biodiversity)
Cultural processes (Recreation, visual perception heritage protection)
Defining landscape Security Patterns: Critical landscape patterns that safeguard individual processes
Security Patterns for abiotic processes (low, medium and high levels)
Security Patterns for biotic processes (low, medium and high levels)
Security Patterns for cultural processes (low, medium and high levels)
Defining the Ecological Infrastructure: Integrate landscape Security Patterns using overlapping technique to create alternative EI's at different security levels to create EI's with different qualities
EI at lower quality
EI at medium quality
EI at higher quality
Defining urban growth at the large scale: Urban growth scenarios based on the regional EI's are proposed as well as a comparative impact analysis for alternative growth scenarios is carried out. One or more feasible scenarios can be selected
Urban growth scenario-1 based on low EI attributes
Urban growth scenario-2 based on medium EI attributes
Urban growth scenario-3 based on high EI attributes
Defining urban form at the medium scale: create urban open spaces system based on EI
Defining urban form at the small scale: specific site urban development alternatives based on EI
Urban development Alternative-1
Urban development Alternative-2
Urban development Alternative-3

Figure 01 The framework of the Negative Approach of urban development planning based on Ecological Infrastructure

2.3 Defining Ecological Infrastructure

The overlaying technique is used to integrate the SPs for individual processes. Alternatives of EI are developed at various quality levels: high, medium and low. Green lines were drawn to define and protect the EI.

The EI is planned at three scales (Figure 02):

(1) The regional scale (hundreds to thousands of square kilometers): At the regional scale, green lines are drawn to define the structural elements as corridors and restricted areas for construction.

(2) The intermediate scale (tens of square kilometers): At this scale, the overall design and management guidelines are developed for EI, and especially for the green corridors that work as critical EI elements in water management, biodiversity conservation, heritage protection and recreation.

(3) The small scale (less than ten square kilometers): At a specific site, urban green network is designed to allow ecosystem services to be delivered into the urban fabric.

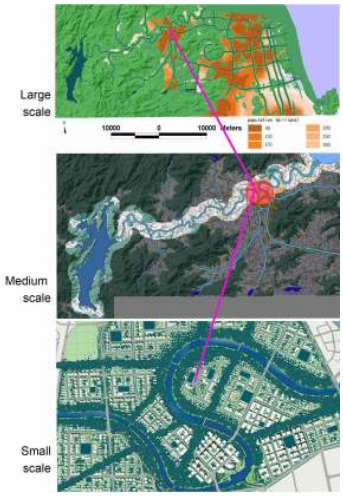

Figure 02 Build an EI at three scales

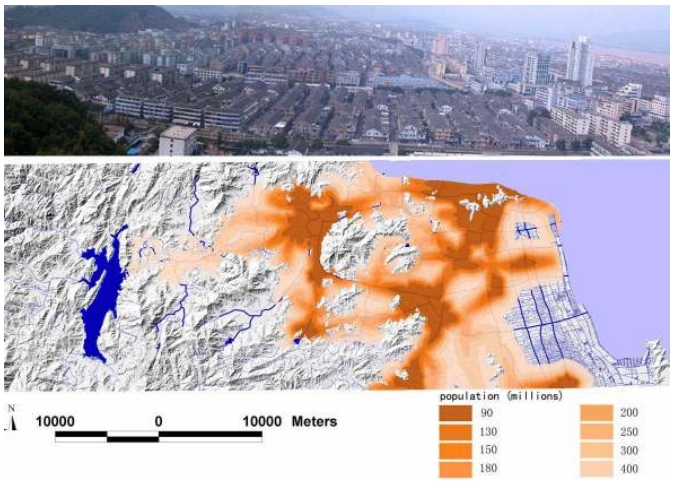

Figure 03 The simulation of urban sprawl of Taizhou city based on economic and development oriented model: urban sprawl indiscriminately takes over and destroys the integrity and identity of the landscape.

2.4 Defining urban form at the large scale: Urban growth alternatives based on regional EI

Urban development patterns are defined at regional scale based on regional EI. Using the multiple EI alternatives as framing structures, scenarios of regional urban growth patterns are developed. A planning committee represented by decision makers of the city, planning experts and stakeholders, makes impact assessment for these scenarios. The decision makers, based on a balanced evaluation of economical, ecological and social benefits, can finally select one of the scenarios.

2.5 Defining urban form at the intermediate scale: urban open spaces system based on

EI

At the intermediate scale, the regional EI is to be integrated inside the urban structure, and become the urban green space system which integrates various functions of ecological conservation, heritage protection and recreational activities, commute and cycling.

2.6 Defining urban form at the small scale: site specific urban development alternatives based on EI

At an individual site and neighborhood, following EI guidelines developed above for the site, alternative urban development models are designed. In these urban development alternatives, ecosystem services safeguarded by EI are delivered into the urban fabric so that the conventional urban sprawl can be avoided. Building the EI into the site specific land use schemes, as a new way of development, will not only help the whole city, but will also benefit the site specific development ecologically and economically.

3 A Case Study: Taizhou City in Zhejiang Province

Taizhou is located at the South East coast of China, with a total area of 9,411 square kilometers, and a population of 5.5 million. From the population, only 0.7 million live in urban areas; the urban population is expected to increase to 0.9 million in 2010, 1.3 million in 2020, and 1.5 million in 2030. Although it has a quite rural and agricultural character, it is now one of the fastest growing areas in China due to a boom of small private industries (Figure 03).

Under the influence of the monsoon climate and being adjacent to the east sea, flood has been a major hazard. As an adaptation to the storm water and flood problem, the landscape has been shaped into a unique form featured with a network of water courses that integrate natural water systems, wetlands and man made ditches, as well as cultural heritages such as bridges, dikes, dams, and vernacular landscapes. This area has long been famous for the rice, fishery and citrus production. Arable and land plains available for development are very limited in this area.

This water network landscape, which has been effective in preserving the agricultural processes in the past thousands of years, is now facing the challenge of being destroyed by the swift urbanization process that had begun in the earlier 1990s. The wetlands have been filled, rivers have been straightened and channeled, cultural heritages (not listed as protected historical relics), have been destroyed as well as visual and recreational experiences have been totally ignored.

Addressing the above situations, the Negative Approach to urban growth planning was taken to safeguard sustainability of the landscape.

3.1. Critical Landscape Processes

Three categories of processes are targeted:

(1) The abiotic processes: In Taizhou area, the monsoon storms frequently causes floods and waterlog, and the main focus of the process analysis is flood control and storm water management.

(2) Biotic processes: Native biodiversity conservation is the focus of the biotic analysis. Birds are the main concern for this area due to the rich fluvial and inter-tide wetland ecosystems. This area has been listed as one of the important bird areas both in the nation

and in the world. Feeding, nesting and immigration processes, are the main focus for the purpose of protection of habitats and biodiversity.

(3) Cultural processes: The targeted cultural processes include historical processes of cultural heritage sites and cultural landscape, and the process of recreational use of the landscape.

Arc/Info GIS was used to store, overlay and analyze layers of natural, cultural and social economic data.

3.2 Defining Landscape Security Patterns for the Targeted Processes

Borrowing the security pattern model from the biological conservation, the general spatial model for the SP's for all the horizontal processes across the landscape are composed of the following elements (Yu, 1995,1996).

Sources: The core area and the origin of the of the target process, such as core habitats for the targeted species, heritage sites for preservation and fishing ponds for recreation.

Buffer zones: the areas around the sources, which are potentially important in protecting the sources.

Linkages: the connecting linear elements that link two or more of the sources.

Radiating routes (for biological processes): from the sources, which are the potential network for species to take control of the landscape. Here, the target species are taken as active and initiative forces of control over the landscape.

Strategic points: the spatial location that potentially controls the movement and connectivity of the target process.

SP's for any individual process are composed of more than one of the elements, but not necessary all of them:

Three security levels - low, medium and high - are used to define the quality of the SP's in safeguarding each of the targeted processes. The security levels are classified according to the area, number and quality of the landscape elements that make up the Security Patterns.

(1) Security Patterns for floods

Various hydrological models are used to simulate floods based on rainfalls, tides, terrain and wetlands. Floodable areas are calculated for 10 years, 20 years and 100 years frequencies, which are used as the criteria for the definition of security level of floods. Flood SP's include the existing water channel network, wetland, and potential wetlands and flood vulnerable areas.

(2) Security Patterns for biodiversity conservation

The Focal Species Approach for biodiversity conservation is widely accepted and used to identify critical landscape elements and location of biodiversity conservation (Caro, 2000; Opdam, Verboom,et al.,2003 ; Brooks, and Kennedy, 2004; Lambeck, 1997; Eycott, Watts et al, 2007). Birds are the main concern for this area due to the rich fluvial and inter-tide wetland ecosystems. Nationally ranked endangered birds (in the red list) are selected as the Focal Species to identify native habitats and biodiversity protection.

The Security Patterns are identified based on two overlaid analysis (Yu, 1996): the suitability analysis of the habitats (sources) for the focal species, and the potential surface

analysis based on the least-cost analysis and surface models (Knaapen et al., 1992; Yu, 1995, 1996, 1998; Ferreras, 2001; Graham, 2001; Michels et al., 2001; Schadt et al., 2002, Adriaensen , 2003). On the potential surface, buffer zones, potential linkages, radiating routes and strategic points were able to be identified.

(3) Security Patterns for the cultural processes

Both heritage sites and linkages that connect, or potentially connect, theses sites, are included in the construction of SP's for heritage protection. Recreational sources are then referred to recreational resources (e.g. water body for fishing, forest for hiking, and historical site for sightseeing) and the linkages between these resources are based on the least-distance model result.

3.3. Defining the Ecological Infrastructure At The Regional Scale

The overlaying technique is used to integrate the individual SP's for various processes. Alternatives of regional EI are developed at diverse quality levels: high, medium and low. Green lines were drawn to define protected areas. The People's Congress of Taizhou City is now approving these basic green lines for legislation (Figure 04).

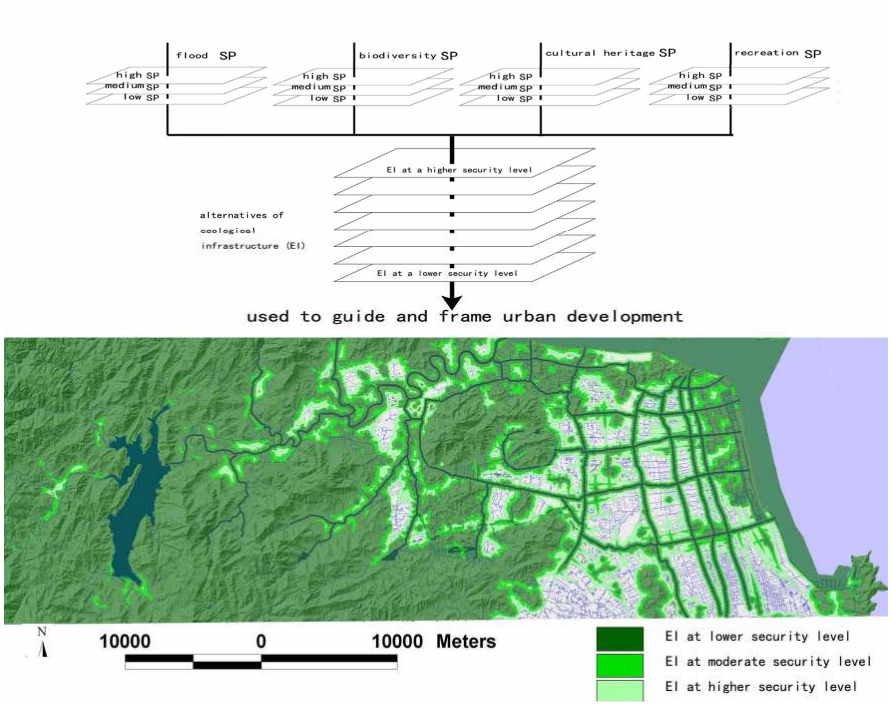

Figure 04 Large scale: The overall regional ecological infrastructure (EI) was an integration of security patterns and plans for flood control, biodiversity conservation, cultural heritage protection and recreation. Three alternatives of EI were developed corresponding to high, medium and low security levels. They will be used to guide and frame regional urban development pattern.

3.4. Scenarios Of Urban Growth Pattern Based On The Regional Ecological Infrastructure

Using the three regional EI alternatives as frame structure, scenarios of regional urban growth patterns were simulated using GIS: the Adjusted Sprawl scenario, the Aggregated

scenario, and the Scattered scenario.

Comparative impact evaluations were made for these scenarios by a planning committee composed of decision makers of the city, planning experts from all over the country, stake holders who are represented by officials from various functional departments of the Taizhou city government (including the departments of agriculture, water management, forestry, industry, tourism, finance, transportation, public affairs, security, culture education, tax, etc.), and representatives of individual villages who originally owned the land, representatives of developers and representatives of investors who are eager to get the right to develop the land.

One of the three urban growth scenarios was finally selected as the most feasible. Decision makers finally selected one of the three urban growth scenarios as the most feasible, after multiple brainstorms among the planning committee. As expected, the Aggregated Scenario, which is based on the medium quality EI, was considered the more balanced and less difficult to be implemented (Figure 05).

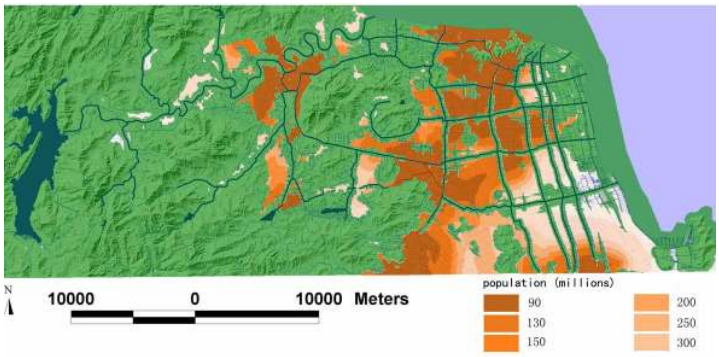

Figure 05 One of the three urban growth scenario: the aggregated urban pattern based on the EI at a medium security level

3.5. Shaping urban form at the intermediate scale

In shaping the urban form and structure at the city scale, an urban open space system is planned connecting the regional EI with the inner city's landscape elements, related to ecological, cultural and recreational values, and also integrated with the commute routes, cycling network and pedestrian network.

3.6. Shaping urban land development at the small scale

Using a selected site (ten square kilometers in size) as a demonstration, alternative urban development models were designed to test the possibility of building an EI based city. In these alternatives, ecosystem services safeguarded by EI are delivered into the urban fabric so that the conventional urban development model can be avoided.

These new urban land development alternatives were presented to the developers and investors, as well as the city decision makers, to let them know that the business-as-usual models of land development can be avoided. The new way of development by building the EI into their land use scheme will not only help the whole city, but will also benefit the site development ecologically and economically. These alternative development schemes show how the regional, large and small scales of EI can be realized into land development to

handle the problem of urban growth (Figure 06).

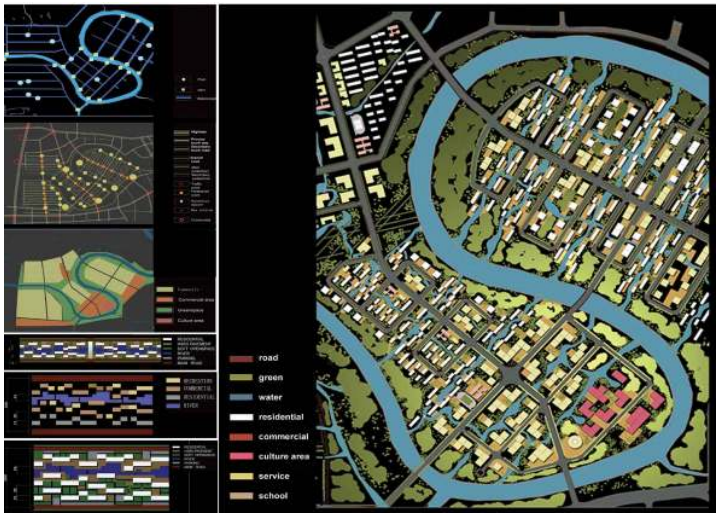

Figure 06 Small scale: The water town alternative. Flood hazard is to be avoided through retaining and diverging water, but not by channelizing and damming. Let one river become ten streams and let the ecological services from the EI penetrate into the urban fabric and individual households.

4. Conclusion

It is argued that, the current urban growth model in China is unsustainable. Recognizing this fact, the Chinese leadership is now calling for ecological civilization (Hu Jingtao, 2007), a totally new concept proposed in Chinese language and especially worded from the top Chinese leader. It reflects an important change in the top Chinese leadership's understanding of development. Rather than emphasizing economic construction as the core of development as it did in the past, the Chinese leadership has come to realize that development, if sustainable, must entail a list of elements including the right relationship between man and nature. The ecological civilization concept is proposed at a time when ecological and environmental issues are at a very serious stage. Facing such a reality, the construction of ecological civilization was absolutely not rhetoric for chest thumping by officials in their speeches. It needs to be transformed into tangible measures that will change the way our economy develops and reshape the landscape that can meet the serious challenges of sustainable development.

Accordingly, it is important to recognize that the conventional approach to urban development planning, which is based on population projection and then built-infrastructure, is unable to meet the challenges and needs of the ecological and sustainable urban development, and certainly unable to meet the goal of ecological civilization. It is in this situation, that the negative approach is proposed. Using the analogy of photography in describing the film and picture, the term "negative" is used to describe the urban development model being negatively en-framed by Ecological Infrastructure, not the other way around. To say it in the other way, the EI is positively defining the urban form and growth pattern. Conventionally, landscape and green elements such as Greenbelt and Greenheart are usually negatively defined by architectural and built infrastructure. By positively defining the EI for the sake of Natural Capital and cultural integrity of the land, the urban growth pattern

and urban form are negatively defined. The negative approach and especially the concept of Ecological Infrastructure build a bridge between landscape urbanism, the disciplines of ecology and especially landscape ecology, the notion of Natural Capital and ecosystems services, and sustainable development. It is a bridge between smart growth and smart conservation.

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