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Smart Growth and Sustainable Development

Selected Papers from the 9th International Association for China Planning Conference, Chongqing, China, June 19–21, 2015

Springer

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Volume 122

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ISSN 0924-5499 ISSN 2215-0072 (electronic)
GeoJournal Library
ISBN 978-3-319-48295-8 ISBN 978-3-319-48296-5 (eBook)
DOI 10.1007/978-3-319-48296-5

Library of Congress Control Number: 2016957147

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

During the past three decades, China has made remarkable progress with respect to its urbanization. This has not been without its consequences, however, as China is also experiencing a series of urban problems, including low-density and inefficient suburban development, deepening regional imbalances, a Hukou and social welfare system, an aging population, wholesale environmental degradation, traffic congestion, inadequate natural and cultural heritage preservation, and the loss of identity of existing communities.

To address these imminent urban issues, on March 16, 2014, the Chinese government launched its first official urbanization plan, "National New-type Urbanization Plan (2014–2020)." The plan sets numerical goals for China's long-term urbanization. It aims to increase China's urbanization rate to 60 % by 2020. It emphasizes the leading role of major cities, while promoting the growth of small and medium-scale cities. It also highlights the dominance of high-density, mixed-use, and transit-oriented compact communities in future development patterns. The plan aims to create a harmonious and pleasant urban environment with basic public services accessible by all permanent urbanites. It also calls for reforms to remove the barriers related to household registration, land management, social security, finance and taxation, institutional management, as well as ecologies and the environment. It is clear that urban planners and scholars face enormous challenges including implementation, financing, protection of the vulnerable groups, and social justice induced by the plan.

This book aims to tackle these challenges and urban problems by applying the international lessons learned on the subject of smart growth. It includes 15 peer-reviewed and rigorously edited papers, which were presented at the 9th International Association for China Planning (IACP) Conference held June 19–21, 2015, at Chongqing University in Chongqing, China, on the theme: New Urbanization: Smart Growth and Sustainable Development.

In Chapter "Distinguishing Characteristics of Urban Form from Evolutionary Perspective—The Case of Chengdu in China," Xu Li et al. identified historical structure of urban forms and examined the characteristics of the existing city. They employed Chengdu in China as an empirical case and collected satellite data, historical literatures and maps, integrated history investigation, geographic information, and morphologic analysis to study the evolution of historical urban forms. The characteristics of the environments, cultures, and urban spatial structure can help planners and designers to maintain cultural continuity of the city.

In Chapter "The China Paradox of Migrant Labor Shortage Amidst Surplus Rural Laborers: An Alternative View," Chen Chen offered an alternative view on the simultaneous existence of a migrant labor shortage and surplus rural laborers in China's recent urban development. By examining the national-level household survey data, he found that the age cohorts of laborers affect the migration choices of individuals. The role of local off-farm work in migrant-sending areas and housing conditions in migrant-receiving areas have limited rural-urban migration. The findings of the research have important implications for policy makers to turn temporary migration into permanent settlement in urban areas as proposed by China's New-type Urbanization Program.

Dongzhu Chu and Shuxiang Wei examined the spatial range and temporal patterns of riders within radiation realm of the rail transit stations in Chapter "From Polysemous Affect to City Integration: The Definition Thinking and Frontier Method to Radiation Realm of City Rail Transit Station." They introduced the concept of the influenced urban realm around station and proposed a theoretical model to measure it. The rail transit stations in the city of Chongqing were selected for empirical demonstrations. Their research highlighted the effects of the influenced urban realm around station in the integrated development of land use and transit system.

In Chapter "The Optimizing Strategies of Three-Dimensional Walking System in Mountainous Cities: Take Chongqing Yuzhong District for Example," Xiyue Li and Ling Huang examined the components, structures, and life features of walking system in Chongqing city. They also conducted a residents' satisfaction survey for mountain trails in Hong Kong and found that the main propose of the walking system design is to satisfy the different needs of various citizens. Based on the findings, they proposed some optimal strategies for developing three-dimensional walking trail system for mountainous cities.

Zhenlong Zhang addressed job housing balance in Chapter "A Study on Urban Spatial Structure in the Context of the Jobs-Housing Balance: A Case of Suzhou, China." He explored the spatial structure of Suzhou City, China, using job housing balance index, independent index, average commuting distance, average commuting time, etc. The job housing balance characteristics at both district level and street level were explored. He found that overall job housing balance index in Suzhou is in a reasonable range, but its spatial distribution is very different and its structure is under a rapid reorganization.

In Chapter "Analysis on the Spatial Impact Factors of Poverty and Its Planning Suggestions: A Case Study of Guizhou Counties," Zhengxu Zhou and Wenning Zhao explored the spatial characteristics of poverty in Guizhou Province, the poorest region of China. They intended to develop a theoretical framework to find the connection between poverty and space. Based on the results using a partial least squares regression (PLSR) model with empirical data from 75 counties in Guizhou

Province, they found that several spatial factors have significant impacts on poverty generation, including the contradictions between people and land, the lower level of county economic and urbanization development, and weak infrastructure. They argued that poverty management policies should focus on these spatial factors.

A key element for transportation planning is to evaluate and forecast road traffic conditions. Chapter "Research for Increasing FCD Map Matching Accuracy Based on Feature Extraction of Continuous Traffic Flow and Interrupted Traffic Flow" by Zhiping Zhang and Hangfei Lin intended to improve the accuracy of GPS floating car devices (FCDs) installed on a vehicle for recognizing real traffic conditions. They obtained the FCD data from taxi on-board devices in Shanghai and applied both gray relational analysis approaches and fuzzy pattern recognition methods to extract features of both continuous traffic flow and interrupted traffic flow. They found that their feature extraction mechanisms can effectively improve the accuracy of map matching and path recognition under the parallel road network.

In Chapter "Visual Impact Analysis and Control Method of Building Height for Landscape Preservation of the Traditional Gardens: A Case Study on the Suizenji Jōjuen in Kumamoto City," Li Lin, Riken Homma, and Kazuhisa Iki constructed a 3D urban model and selected main view points as observation points to simulate real vision of observers. They measured the degree of landscape destruction caused by high-rise buildings and explored how to control the height of buildings for preserving landscape of the traditional gardens. Suizenji Jōjuen, a traditional Japanese strolling garden located in Kumamoto city, was selected for the empirical study.

Liuchangyue Li, Xin Dong, and Zhu Jing analyzed the relationship between the status of Internet usage among elderly people in urban communities and the degree of elderly life satisfaction in Chapter "Satisfaction Level of Elderly People's Life in Urban Communities Based on the Status of Internet Usage—A Survey Covering Different Types of Communities in Xi'an." They conducted a random sampling survey on Internet usage of elderly people in Xi'an's different communities. They employed logistic regression to measure the correlation of Internet usage status and degree of elderly life satisfaction. They found that Internet services can effectively mitigate the prevailing problems of inadequate community eldercare service facilities.

Chapter "Study on Characteristics and Policy Recommendations of Small Towns in View of Regional Development Strategy in the Coastal Area of Jiangsu Province, China" by Shuping Cui and Wei Fu investigated the changing characteristics of small towns in the coastal areas of Jiangsu Province, China, after the implementation of the coastal development strategy. They found that these small towns have experienced some improvement in economy, society, and environment at different degrees, but they are also facing challenges of a lack of comprehensive planning, unreasonable industrial structure, and low capacity and attraction. They made some policy suggestions for the small towns to avoid shrinking in the rapid urbanization process at the regional level.

Yong Huang and Jie Feng introduced slow mode transportation as an inevitable trend of green sustainable urban transportation development in Chapter "Space

Design of Slow Mode Transportation System of Mountainous City." They focused on a mountainous city and explored the design of slow transportation space elements, including slow mode node, slow mode corridor, and slow mode unit. They also examined slow mode transportation and fast mode transportation transfer design. Their discussion and summary of space form design for slow transportation may offer some beneficial references to develop and improve mountain cities' slow mode transportation system.

In Chapter "Combined Commuting Mode for Residents in Big Cities by Public Health—A Case Study of Xi'an," Zirui Lyu and Jing Zhu addressed healthy urban planning for commuters of large cities in China. They collected random samples from questionnaire survey and interviewed commuters in Xi'an, one of the largest cities in Northwest China. They examined commuting distance, commuting time, and the body energy consumption of those commuters. A hierarchical analysis model was employed to measure the healthy levels for different commuting modes, and the factors associated with commuters' mode choice were examined. Finally, they sorted out the healthy combined commuting mode and made policy suggestions to promote healthy commuting for commuters in large cities.

Fan Yang investigated the major problems of industrial land use planning in urban and rural areas of Shanghai in Chapter "Problem Analysis of Urban-Rural Industrial Land Use in Metropolitan Areas Under the New Urbanization Policy—A Case Study of Shanghai." First, he reviewed some relevant research on industrial land renewal in China and pointed out some drawbacks of existing studies. Next, he used Shanghai as an empirical case to analyze the problems in urban-rural industrial land use. Then, he discussed some possible improvement for the studies on urban-rural industrial land use. Finally, he highlighted the values of urban regeneration theory and called for the setup of a performance evaluation system of industrial space.

In Chapter "Following Natural Features—Planning Method Research on the Spatial Arrangement of Blue-Green Webs Around Urban Core Areas," Zhong Xing, Xizi Tang, Qiao Yu, and Xiaobo Xu explored the planning method to create blue-green spatial patterns around urban core areas. They expected the method to be instructive for efficiently conserving and managing natural blue-green spaces within central urban authority areas, which is required as one of the main tasks for "improving construction ability" enabling new urbanization.

Urban greenbelt has been employed as an important containment policy for preventing urban sprawl. However, there are many debates about its effects. In Chapter "A Comparative Study of the Evolution of Greenbelts in London and Beijing," Mingfei Ma intended to find the differences in the approaches by comparing the greenbelts in London and Beijing. He first reviewed the ongoing debate regarding greenbelt policies and their role in managing urban expansion. A comparison of the urban expansion history of London and Beijing showed the differences in greenbelt policy designs which resulted in different policy performances. This research identified the factors that led to the success of London's greenbelt and also pointed out the inappropriate planning policies that caused Beijing's persistent difficulties.

As the proceedings of the 2015 IACP annual conference, the key contribution of the book is to present cutting-edge strategies for smart growth and sustainable development. The audiences of the book include, but are not limited to, the faculty members, students, practitioners, and the general public interested in the subjects of urban and regional planning, urban studies, urban design, housing and community development, infrastructure planning, geographic information system (GIS) technology and applications, climate change and ecological planning, environmental planning, social equity, disaster planning, and others. The discussion will contribute to the advancement of urban planning in China as well as the world.

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Contents

Description and Purpose of the Work

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During the past three decades, China has made remarkable progress with respect to its urbanization. This has not been without its consequences, however, as China is also experiencing a series of urban problems, including low-density and inefficient suburban development, deepening regional imbalances, a Hukou and social welfare system, an aging population, wholesale environmental degradation, traffic congestion, inadequate natural and cultural heritage preservation, and the loss of identity of existing communities. To address these imminent urban issues, on March 16, 2014, the Chinese government launched its first official urbanization plan, "National New-type Urbanization Plan (2014–2020)." The plan sets numerical goals for China's long-term urbanization. It aims to increase China's urbanization rate to 60 % by 2020. It emphasizes the leading role of major cities, while promoting the growth of small and medium-scale cities. It also highlights the dominance of high-density, mixed-use, and transit-oriented compact communities in future development patterns. The plan aims to create a harmonious and pleasant urban environment with basic public services accessible by all permanent urbanites. It also calls for reforms to remove the barriers related to household registration, land management, social security, finance and taxation, institutional management, as well as ecologies and the environment. It is clear that urban planners and scholars face enormous challenges including implementation, financing, protection of the vulnerable groups, and social justice induced by the plan.

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Distinguishing Characteristics of Urban Form from Evolutionary Perspective—The Case of Chengdu in China

Xu Li, Ling Xu and Zeng Hanmei

1 Introduction

Historical urban forms keep the memory and represent local characteristics of a city. During the city's long evolution, they have been proved to be durable and resilient. At present, it is still important for urban planning to respect the tradition of a city, not sticking to old ways but exploring the eternal vitality in them.

From the late 19th to date, urban forms have been a typical cross-disciplinary subject spanning the fields of history, architecture, planning, geography and the economy (Kai 2001). The most influential theories are as follows: the urban history research (Mumford 1961; Morris 1994; Kostof 1999), the five elements of urban form derived from observation of cities (Lynch 1960); the typology to interpret architectural composition (Rossi 1982); and "Town planning analysis" to reveal the process of urban forms (Conzen 1969).

For the study of urban forms, a universal definition and a set of analyzing systems has not yet been formed. Researchers have applied various methods from traditional spatial analyses to quantitative methods aided by computers (Bosselmann 2008; Salat 2012) according to their different fields and actual problems.

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_1

Studies within China mainly fell into two parts: theoretical research about methods, elements, structures and patterns; and empirical research about characteristics of urban forms, evolutionary principles and mechanisms. Methods applied are different according to researchers' objectives and available data.

However, most of research in China focuses mainly on capital cities and a few cities in the east part of China. Data, especially the historical and spatial data, is not adequate; and analyses of historical maps are still quite weak. The contents and results have little linkage with contemporary urban planning. Therefore, it cannot provide substantial theories of urban form for planning.

Taking the case of Chengdu, a national historic city in southwest China, this paper collects satellite data, historical literatures and maps, uses Geographic Information System(GIS) to form unified maps of different periods; then identifies what historical urban forms have remained in the existing city, how they composed, and how and why they have shaped and evolved.

This research can provide planners a tool to study the historical structure of other cities and explore their characteristics and principles. It can help to form localized theories about urban forms which can aid planners when they explore different approaches to built characteristic and sustainable cities.

2 Methods

2.1 Case Study Area

Chengdu is situated in southwest China, on the middle reaches of the Min River, whose name and location have not been changed for more than two thousand years since it was founded in the fifth century B.C. At present, urban forms of different period interweave in contemporary Chengdu. The study area is within the main city, with a focus on the inner-city. The "historical urban form" refers to the urban form built before 1949 (Fig. 1).

2.2 Framework

This paper analyzes historical literature and maps to identify the historical structure of urban forms (Table 1) from the existing city, and then integrates analysis of history, geographic information and geometric form to reveal the characteristics and principles of historical forms. It also explores the determinants, the local experience and wisdoms during their evolution and discuses influences and inspirations to city planning (Fig. 1).

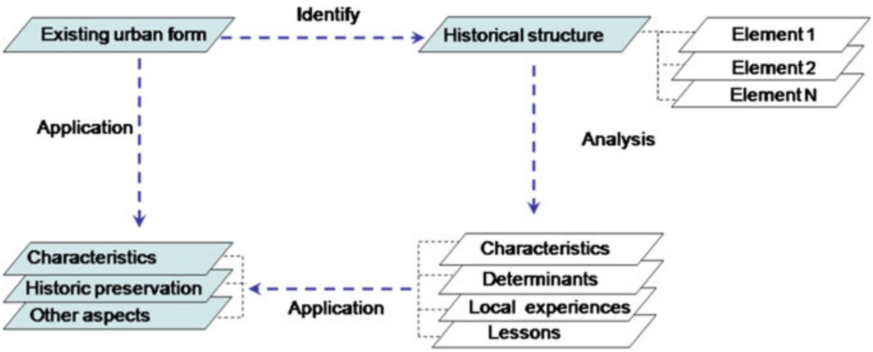

Fig. 1 Research framework

Table 1 Structure of urban forms

Scale	Elements	Contents of analysis
Macroscopic	Situation	Relationship between environment
	Contour	Shape of outline, skyline
The middle	Axis	Location, orientation
	Street	Pattern, orientation, configuration
Microscopic	Building cluster	Type, function, texture
	Nodes	Type, location, relationship to surroundings

2.3 *Data Collection and Procedures*

Collection of data: historical maps and literatures, digital maps, satellite images, and overall city plans were collected. Fieldwork and observations of the city were conducted.

Translation of historical maps: Productions of ancient maps are different from survey maps.[1] Based on GIS, by analyzing historical literatures and maps, information of urban forms in different periods are overlapped on the present digital maps to get a translated ancient map.

Identification of historical urban forms: the translated ancient map is compared with the present city map, and then the elements and structure of historical urban form are identified from the existing city.

Analysis of historical urban forms: logical reasoning, historical investigations, and spatial analyses are used to reveal the characteristics of historical urban forms (the relation between different elements, determinants, and principles). This method also explored local experience and wisdoms embedded in the durable urban forms.

[1]The shape and location of urban forms are not accurate, but their relative positions to the topography are correct.

3 Analysis of Characteristics of Historical Urban Forms and Their Evolution

Based on GIS, through integrating and translating historical information, this paper identifies a historical skeleton which is characterized as “central axis, multiple enclosures, three different street patterns, and two surrounding rivers”. It also recognizes some historic blocks, buildings, and remains. These interconnected elements are analyzed, and include “water systems and the city, the axis and streets, historic blocks and buildings”, to reveal their characteristics and evolution.

3.1 Water Systems and the City

The pattern that the city is surrounded by two rivers, the distinctive characteristic of Chengdu’s historical urban form, is not natural. It is the result of human beings’ active practices to adapt or change the environment. It is also an evolutionary process with up and downs, which represents the dynamic adaptable relationship between rivers and the city.

In the ancient times, the area of present Chengdu was a big Ba-shu lake surrounded by mountains; and after a series of geological changes, the water flew through the Three Gorges (Zhao and Li 2004). As the center of Chengdu plain gradually turned from swamps to lands, the central city moved from the upper reaches of the Min River in the northwest to the center of the plain, and eventually settled down in Chengdu.

The topography of Chengdu plain is higher in the north and west, lower in the South and East; and the original Chengdu city was situated in the center of the plain, on the east bank of the Pi River for convenient water supply and draining (Fig. 2a).

In the Qin Dynasty, new walls were built adjacent to the former city walls to the south; then two enclosures formed side by side (Sichuan Research Institute of Culture and History 2006). The “big one” is the center of government and military (1.7 km^2), whose outline is an irregular rectangle. Compared with the former city, the city walls of Qin were closer to the river line for defensive purpose and convenient water transport (Fig. 2b). Since Qin the Dujiangyan project has influenced Chengdu significantly.[2] It took the advantage of nature and the energy of water itself to realize flood discharge and irrigation. The two rivers beside Chengdu are the major watercourses, parts of Dujiangyan project, conducting water to irrigation.

[2]Before the Qin Dynasty, there were frequent floods in the Min River and droughts in the Chengdu pain. Libing built Dujiangyan to solve this problem. They divided the Ming River into an outer river and an inner river. Though making good use of the topography, they conducted the floods to the outer river, the necessary water to the inner river. After that, the flood can be controlled well and enough water can be obtained to irrigation.

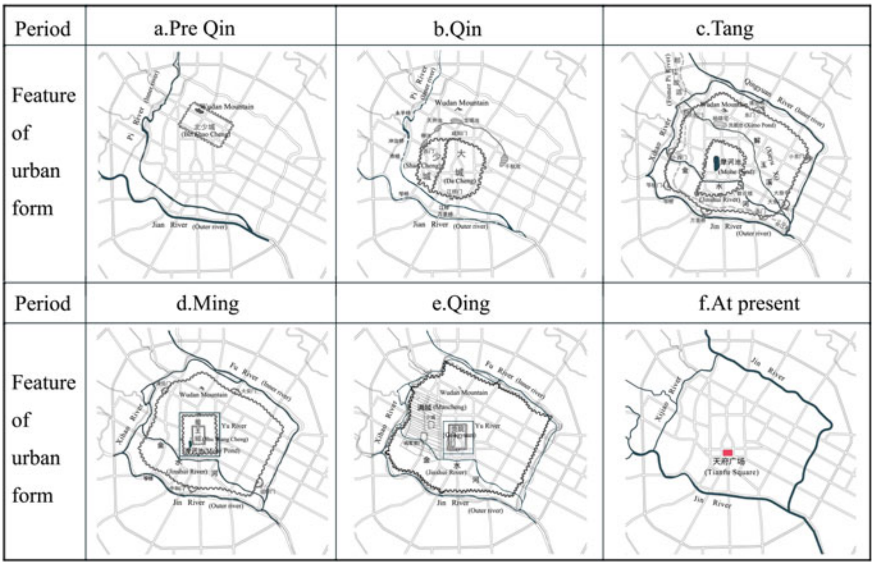

Fig. 2 Analysis of the relationship between the water and the City in different periods. *Legend* City walls; Rivers; Former river line

In the Han Dynasty, several enclosures were built to the southwest of the big city, and then most of the walls except the big city were destroyed during the war.

In the Sui Dynasty, because of the increasing population, walls were built surrounding the north and west side of the big city again. A twin city reappeared. A pond named Moke formed in the center of the city, because soil there was taken away to build walls.

In the Tang Dynasty, to strengthen the defenses, outer city walls were built, and the Pi River was divided to surround the north and east border of the city; the former river line was changed and shaped the west part of the moat (Fig. 2c). The big city was surrounded wholly by the outer city, enclosed by two moats (the Pi River and the Jian River). Within the city, two channels were built and connected with the outer rivers and the pond in the city (Wu 2008). The water system improved the defense, the transportation, the water supply and drain system, and the environment of the city significantly; furthermore the city could control flood and drought in the city better than before.

In the Ming Dynasty, the prince Shu set up a palace in the center of the city. Then trenches were built surrounding the palace (Fig. 2d). Flood controlling and drain system of the city center were improved. But because of the building of the palace, most area of the Moke pond was filled (Cai 1990); And one of the channels, Xieyuxi, which gradually ran run dry a was filled.

In the Qing Dynasty, the Shu Palace was changed to examination compound; and an enclosure was built in the big city; while the water system had little changes (Fig. 2e).

Fig. 3 Relation between the Location of Chengdu and the topography and river. *Source* Sichuan Research Institute of Culture and History (2006, 95)

During the period of the Republic of China, the Moke Pond was filled to be a military site; and in 1970s, the channels and trenches were dried and filled to build anti-aircraft defense (Cai 1990). The city walls were demolished to build a road. Only the two rivers surrounding the old city can be recognized in present Chengdu (Fig. 2f).

The evolution of the pattern in which the city surrounded by two rivers represented that these characteristics came from the unique local environment and the comprehensive requirements of the city, such as the defense, transportation, water supply, and flood controlling. Firstly, supported by the Dujiangyan project, adequate water had been provided and ensued, and then the river line was changed according to the characteristics of the topography (Fig. 3) to adapt the growth of the city and satisfy the comprehensive requirements of the city. It is crucial that local people made the best use of or changed the environment according to laws of nature. But it is unfortunately that the system of channel and pond that flourishing in Tang dynasty had disappeared for various reasons.

3.2 Axis and Streets

Axis is related to the orientation of buildings, and streets are often parallel or perpendicular to the axis. The two elements form the main skeleton of a city.

The pattern of “central axis, multiple enclosures, and three different street networks” is the most influential characteristics of historical urban forms which affect the development of Chengdu.

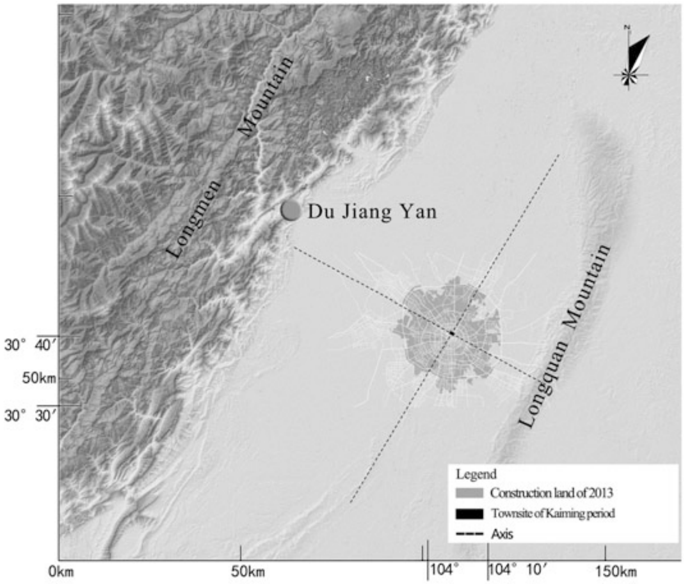

Fig. 4 Relation between the circumstance and the ancient axis of Chengdu

A cardinal orientation which is 30° east of north can be recognized in the original Chengdu city.

The orientation is related to the topography and climate. It is parallel to the mountains on the west and east sides, corresponding to the topography which is higher in the north and west, lower in the south and east (Fig. 4). Different from the climate in northern regions of China, therefore this orientation is better for lighting, ventilation, and solar collection. From then on, this orientation lasted more than one thousand years till the Ming Dynasty. At present, streets of this orientation make up about 75 % of total streets in the old city, and about 36 % in the main city (Figs. 5 Left, Top-right and 6 Left. Streets of this orientation can hardly be recognized in Beijing, the capital city of China (Fig. 5 Middle, Bottom-right). This orientation not only dominates the old city, but also affects the development of the main city.

In the Ming Dynasty, the orientation of the city was changed distinctively. Because the war destroyed Chengdu seriously, most part of the city was rebuilt according to the previous patter, but an orthodox north-south oriented palace was built in the city center to show the power of the Ming. (The government thought the north-south orientation was the symbol of orthodox China). The palace was encased by the middle city walls, and then outer city walls. In the ancient times, the north-south oriented and the perpendicular streets can only be found in the palace; while in modern times, the wall of the palace was removed and turned to roads. Therefore the north-south oriented and the perpendicular streets in existing Chengdu represent the contour and streets of the palace and the middle city. At present, streets of this orientation make up about 24 % of total streets in the old city,

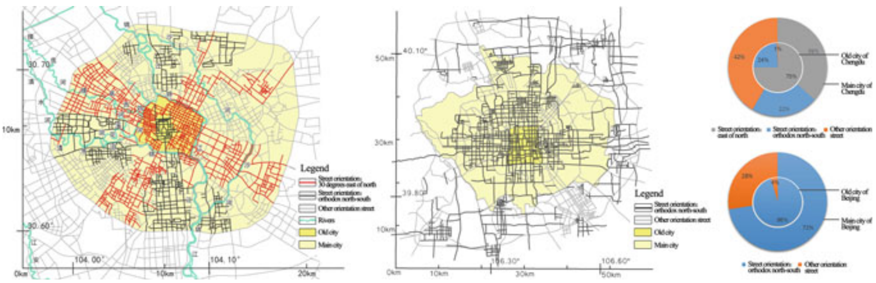

Fig. 5 Analysis of streets orientation. *Left* Streets of Chengdu; *Middle* Streets of Beijing; *Top-right* Proportion of different oriented streets in Chengdu; *Bottom-right* Proportion of different oriented streets in Beijing

Fig. 6 Scenery of streets in Chengdu. *Left* Street oriented 30° east of north; *Middle* Streets oriented north-south; *Right* The Tianfu Square in the center of the cross axis. Photograph by author

and about 22 % in the main city (Fig. 5 Left, Top-right). In Beijing, streets of this orientation make up about 96 % in the old city, and about 72 % in the main city (Fig. 5 Middle, Bottom-right). Since it was set up, the north-south oriented axis has dominated the development of Chengdu, and continued in the existing city (Fig. 6 Middle), moreover, it is the cardinal axis in the urban planning.

In the Qing Dynasty, a new city, “Mancheng”, was built in the west part of the city, between the outer city and the palace, therefore it only built the walls in the north and south. The orientation of the streets is 30° east of north according to the streets to the north and south. These Streets constitute approximately 15 % of the total streets in the old city (Fig. 5 Left). They reflected the coexistence of different cultures. From then on, Chengdu had been a multiple enclosed city with a north-south cardinal axis and three different patterns of streets. These characteristics reflect wisdoms and experience of ancient people to adapt to local environments; they also indicate the interaction between urban form, power and culture. Moreover, as the skeleton of urban form, the axis and streets can last for thousands of years and left a clear impression in the present city, which keeps the city’s memory and influence its’ development (Fig. 7).

Fig. 7 Comparison of the street in the Qing and modern times. *Left* Survey map in the Qing Dynasty; *Middle* Existing streets in old city; *Right* The historical streets in the existing city. *Source* (*left*) Ying and Fan (2000)

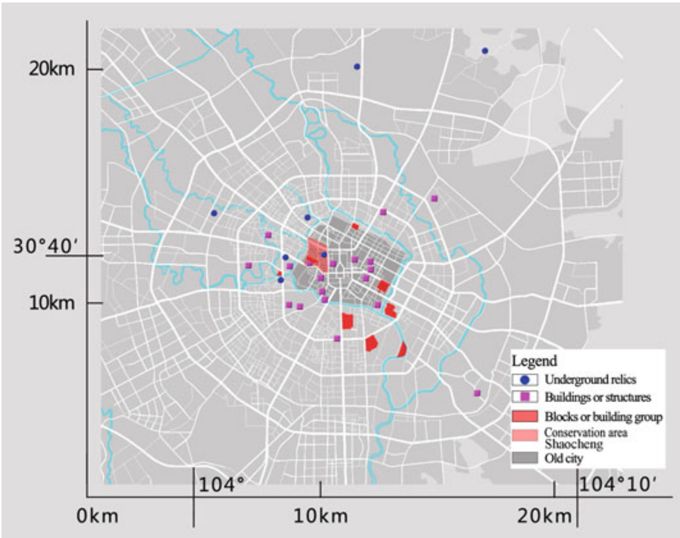

Fig. 8 Distribution of historic sites and buildings

3.3 *Historic Heritages*

Historic heritages, including historic blocks, buildings and heritage sites, mostly concentrated in the old city (Fig. 8). Underground ruins of ancient city were located in the center and the west part of Chengdu; historic blocks, including the Kuanzhai Lane (the "Mancheng") and huge temples, situated in the north and east part, near the Jin River; historic buildings, such as residences of celebrities, churches, temples, were mostly located in the west and east parts of the old city. Judged by their locations and ages, the historic heritages reflected a continuous history, and can be identified easily.

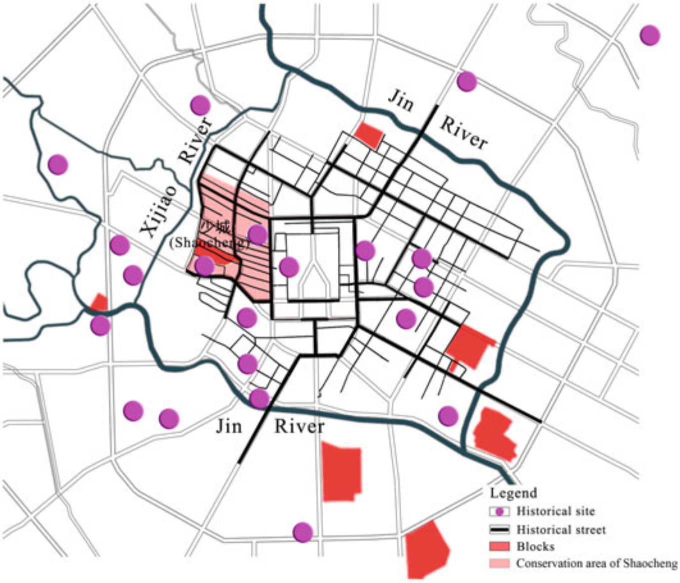

Fig. 9 “Historical structure” of the urban form in Chengdu

Underground ruins were related closely to the history of Chengdu before the Qin Dynasty, reflecting the changes of city site. Historic blocks and buildings were related to local culture, reflecting the tradition and the values of the period. Although the ordinary historical buildings almost disappeared, they remained and represent local historical characteristics of the city.

4 Historical Characteristics of Chengdu

4.1 “Historical Structure” and Historical Characteristics

The structure of urban form is the integrity of elements of urban form combined in certain arrangements. When other urban forms change, the historical structure remained stable, representing the historical characteristics of Chengdu.

Water system, axis, streets, and historic heritages constitute the historical structure (Fig. 9) of Chengdu which is described as “a city surrounded by two rivers, with an orthodox north-south oriented axis, multiple enclosures, and three different street networks”. These elements represented different feature as follows.

The pattern that the city surrounded by rivers, the axis, and the street networks are the skeleton of the historical structure which adapted to environments well. It came from human beings’ activities to change environments, according to the laws

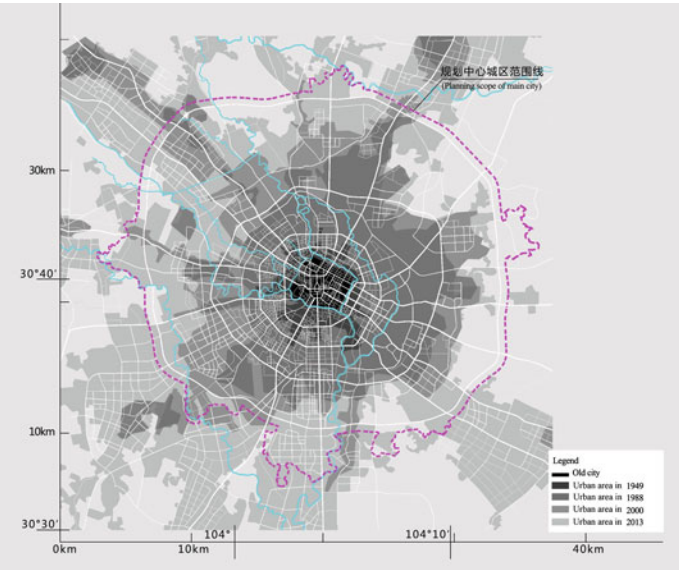

Fig. 10 Footprint of Chengdu (1949–2013)

of nature, to meet the functional requirements of the city and adapt to local environments.

These historical urban forms became complicated after a long evolution, and seemed to be inheritable and continuous. Historical urban forms have their origin in the functions and aims of the city, but are more stable and durable than these functions and aims (Mumford 1961). Moreover they had influenced the following development of the city. For example, the modern Chengdu kept the two rivers surrounding the old city, and formed a cross axis according to the north-south oriented axis, which expanded (Fig. 10). They are interweaved with, or overlapped under the modern city. Therefore their historical forms and values tend to be recessive and can hardly be perceived by people directly.

The Underground ruins tend to be highly stable; by comparison, the historical blocks and buildings are less stable. They all represented local cultures and people's values. They existed independently in the modern city, with distinct area. Therefore their images tend to be obviously different from modern forms and can be identified easily by people.

4.2 *Determinants of Historical Characteristics of Chengdu*

The analysis of the evolution of urban forms represents that the historical characteristics of Chengdu had their origin in various requirements of the city, such as the defense, water supply, transportation and flood control; the demand of land for the increasing economy and population; the spatial norm of power and different cultures. The analysis also indicates the dominant influence of environments to urban forms, such as the periphery mountain range, the adequate water and rivers nearby; the characteristics of the topography (higher in the North and West, lower in the South and East), and the sunshine and wind.

Contributions of these factors are comprehensive and dynamic. Influences of natural environments are stable, only partially changed. While functions of the city changed obviously in different periods. People's values and their activities to change the environment, according to laws of nature, to met the functional requirements of the city.

4.3 Local Experience and Lessons

The analysis of the evolution of urban form indicates that the respectful and matter-of-fact attitude toward nature; the experience to adapt to nature; and the overall arrangements to make good use of nature were the inner vitality which brought up the enduring and distinctive characteristics of local urban form. Meanwhile, there are bitter lessons that some valuable historical urban forms vanished because of the indifferent attitude, the poor maintenance, and the ignorance of historic values.

For instance, in ancient times, people kept exploring laws of nature, gained water from the Dujiangyan, and changed the river line nearby to surround the city. The two rivers had comprehensive functions, such as defense, water supply, transportation, flood control, maintenance of ecosystem; moreover, they improved landscape of the city significantly. However, at some time in the past, the change did not work well because of water shortage and poor maintenance. In 1970s, Dujiangyan cut off water flows, so the water flows of the two rivers shrank; because of the constructions, the watercourses were encroached and became narrower than before; the natural sloping riversides were replaced with steep cement masonry embankments; and for a time the two rivers were polluted seriously, like stinking sewers, with poor landscape, and were nearly filled.

Recognizing the severe consequence of environments pollution, at 1993, the government of Chengdu invested 2700 million Yuan to launch the "comprehensive improvement project of the Funan River". The project was a system comprising of flood control, environment protection, and infrastructure and settlement improvement. The Funan River was revived primarily, and the following flood control will spread to the Dujiangyan in the upper reaches and Leshan in the lower reaches. It prevented the pollution in the upper reaches of the Min River and the Yangtze River, brought significant influence to the development of sustainable city. Its' concept and arrangement were approved and praised widely (Xia and Liu 2001).

The ups and downs of the two rivers in history and their present successful revival indicate that present construction can learn from historical experience and lessons, and that people's values are crucial.

5 Discussion

The analysis indicates that the "historical structure" of Chengdu had its origin in various functional requirements of the city, but was far more enduring. The structure often inherits from the former urban form and developed complicated after long evolution. It adapted to the environment excellently, which indicate human being's eternal wisdom to work with and make good use of nature. This structure reflected the characteristics of the local environments, cultures, and urban forms. It has a high historic value, and influences the future development of the city.

This research can help urban planning and design to keep Cultural Continuity. The "historical structure" keeps the memory of a city, which is an important part of the characteristics of urban forms. Exploring the composition and features can help to improve the cognition of the urban conservation area and the value of historical urban forms; thereby the various values of historical forms can be preserved and expressed in the present city.

For example, the project of the Funan River represents the respect and development of traditional forms. The two rivers have revived and express the historical characteristics of Chengdu. At present, obvious historical urban forms, such as historic blocks and buildings, are preserved and can be easily distinguished; while some implicit historical urban forms, such as historical streets and rivers, are covered by modern appearance and cannot be recognized plainly. These implicit elements also comprise the memory of the city. Recognizing their values, then exploring proper approaches to convey these values can help to express the local historical characteristics of the city.

Grasping the local historical characteristics and principles of the urban form can help to explore the local characteristics of a city. Considering the determinants of urban forms, the present natural environments are constant with little change; while the functions, cultures and customs, and ability to reform the world changed greatly. Therefore the present urban forms should not constrained to traditional forms or imitate the foreign forms. Urban planning and design should explore the characteristic of local environments, respect and learn and eternal wisdom from the traditions, and apply relevant theories and technologies to create urban forms that adapt to the local environment and satisfy the modern functions, cultures and values.

6 Conclusion

Taking Chengdu as an example, this paper collects satellite data, historical literatures and maps, integrates history investigation, geographic information and morphologic analysis to study the evolution of historical urban forms. The expanded data resources and comprehensive analysis can help to judge the geographical location of historical urban form, thereby bridge the comparison of urban forms in different periods and connect to the present city to reveal determinants that cannot be found by site observation directly. These approaches can be used to study other regional urban forms including their characteristics, evolution and determinants, help to explore Chinese culture from various regional parts and provide fundamental theories for present urban planning and design.

Acknowledgments This study was supported by the Natural Science Foundation of China (51208530); the Fundamental Research Funds for the Central Universities (CDJZR12190008; 106112013CDJZR190001).

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The China Paradox of Migrant Labor Shortage Amidst Surplus Rural Laborers: An Alternative View

Chen Chen

1 Introduction

The China paradox of the simultaneous existence of a migrant labor shortage (*min gong huang*) and surplus rural laborers has attracted public interest and scholarly debate (hereafter referred to as the China paradox) (Cai 2010; Chan 2010; Kwan 2009; Golley and Meng 2011; Knight et al. 2011). On the one hand, China's migrant labor shortage, first appearing along its southeastern coast in 2004, has since persisted for ten years and expanded to a broader area, despite provincial efforts to raise wage standards for the lowest paid positions in urban areas (Cai 2010). On the other hand, extant research has also revealed that remaining laborers still exist in rural areas that could potentially migrate to urban sectors for higher wages, but instead have chosen to stay in rural communities (Chan 2010; Kwan 2009). Moreover, similar to their counterparts in other developing countries, China's migrant workers are also comparatively young and typically migrate as individuals while their families remain in rural areas (Fan 2011). This asymmetrical rural-to-urban migration further complicates the China paradox as the mismatch between labor surplus and workforce shortage cannot be resolved by drawing from the broader labor pool, particularly as wages within these industries continue to rise, presumably making them more attractive to laborers.

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_2

Understanding the logic of this paradox is important because promoting urbanization has become China's national strategy for stimulating a consumption-driven economic growth model; this model is meant to substitute the previous export-oriented economic growth model, which has become encumbered by rising domestic labor costs, the global financial crisis and frequent international trade conflicts. To achieve this goal, China's new national urbanization plan has set up a blueprint to reach an urbanization rate of 60 % by 2020 and grant urban *hukou* status to 100 million rural migrant workers (CCCPC and SCPRC 2014). However, aside from urging local authorities to grant urban *hukou* entitlement to rural migrant workers, new measures to implement this blueprint remain limited (Chan 2014).

Extant studies have tried to explain the China's migrant labor shortage as the arrival of the Lewis Turning Point (hereafter refers to LTP), a point of time when the expectations of tightening workforce supply from rural areas and rising wages in urban labor markets will occur in the Lewis Model (Cai 2010; Chan 2010; Golley and Meng 2011; Knight et al. 2011). In a seminal article, Lewis (1954) framed the economic structure of developing countries as a dualist rural-urban economy, in which the flow of workers between economies will go from rural to urban as laborers in the marginal agricultural economy seek the higher wages offered by the industrial economy. The point in time when the surplus agricultural workforce has been absorbed by the industrial economy and the institutional wage rate of urban sector will rise is referred to as the Lewis Turning Point.

Understanding the propositions by the Lewis Model is important because most studies on this paradox have adopted the Lewis Model as a theoretical platform, yet whether China's migrant labor shortage can be explained by LTP is contentious (Cai 2010; Golley and Meng 2011; Minami and Ma 2010). As a result, propositions in historical-structural perspectives including the diminishing demographic dividend, institutional barriers (for example, *hukou system*), and a segmented urban labor market, have dominated the current conversation (Cai 2010; Minami and Ma 2010; Chan 2010). However, the agency of individual actors, namely current migrants and remaining rural laborers and their dynamic roles in shaping the pool of rural-urban migrants has been overlooked. Therefore, this research aims to add an alternative view that looks at the efforts of individuals and households to overcome structural development constraints as embodied in their choice to stay at home, out-migrate, or settle down in destination cities.

Given that China's migrant labor shortage originated from the established major internal migration flow from Central and Western China to Eastern China, this research departs from the Lewis two-sector framework to an alternative approach: a push-pull model that looks at the migration dynamics at both ends of China's internal migration. Using nationwide survey data, this research aims to add to the present scholarship by testing two theoretical arguments: first, while extant research has explained China's LTP and labor surplus with risk-sharing income-generating behaviors among household members proposed by new economics of labor migration (NELM) (Liu et al. 2013), this research argues that risk-sharing income-generating behaviors is just one part of the household livelihood diversification strategy. This more comprehensive explanation takes into account the place-based intervening factors in both migrant-sending and –receiving areas. Second, while the extant research highlights the preference of an export-oriented economic model for young migrants as an explanation to the age selectivity of rural migrant workers (Chan 2010), this research argues that it could be possible that migration behavior varies across one's life course migration (Kley 2011)—People in different age cohorts respond differently to place-based factors at origins and destinations as in a push-pull model.

In the remainder of this article, Sect. 2 provides a literature review on the China paradox of a migrant labor shortage and surplus rural laborers, and the empirical findings on migration and settlement intentions of Chinese rural-to-urban migrants. Section 3 describes the research design, including explanations of data sources and analysis methods. The empirical model results and interpretations are reported and discussed in Sect. 4. Section 5 draws a conclusion.

2 Literature Review

2.1 *The China Paradox of Migrant Labor Shortage Amidst Surplus Rural Laborers*

Most of the extant research on this paradoxical phenomenon has adopted the Lewis Model as the basic analyzing platform, despite the controversy on the arrival of China's LTP. This approach has led to four major historical-structural perspectives: the detached rural-urban dual governance institutions (for example, *hukou* system[1]) (Cai 2010; Chan 2010; Golley and Meng 2011; Knight et al. 2011), segmented labor markets in urban areas (Knight et al. 2011; Golley and Meng 2011; Minami and Ma 2010), the deficiency of the demand for labor in urban industries (Minami and Ma 2010), and the age selectivity of migrant workers by China's export industrialization and cycles in the global economy (Chan 2010). However, while the aforementioned arguments are valid,the role of rural migrant workers as actors interacting with the above structural development constraints to form the China paradox is far less conclusive in previous researches.

To highlight the human agency of rural migrant workers in shaping the China paradox, this research departs from the Lewis two-sector framework and offers an alternative approach: the push-pull model that looks at the migration dynamics at both ends of China's unique interregional rural-to-urban migration from which the migrant labor shortage originates. In fact, the theoretical argument of laborer transfer from the rural to the urban sector, as proposed by the Lewis Model, manifests as a long-distance translocation process when applied to the China case. Previous research has revealed the distinctive spatial concentration of China's

[1]Migrant workers are excluded from the social amenities in almost every aspect of urban life, including medicare, housing, endowment insurance, child-rearing amenities, etc.

interregional rural-to-urban migration, which began in the early 1990s as surplus laborers migrated from the rural areas of Central and Western China to the urban areas of Eastern China and established the major flow patterns still typical today[2] (Fan 2005; Zhu 2007). Therefore, this research argues that both the push and pull factors are indeed shaping the volume and age structure of the rural migrant workers in two ways: the remaining laborers' migration intention, especially in rural migrant-sending areas and current migrants' settlement intention, especially in urban migrant-receiving areas.

The intent of this research, to study rural migrant workers as actors within the push-pull migration framework, follows in two lines of existing research; this existing research takes similar approaches but hasn't been applied to the rural migrant workers' migration and settlement intentions. One branch of the literature acknowledges that individuals respond to environmental opportunities and constraints in different ways, depending on their position in their life course—Specifically, that human life constitutes an age-related sequence of stages (pre-adulthood, early adulthood, middle adulthood, and late adulthood) with different developmental tasks (Levinson 1986). This argument provides an alternative to the current explanation on age selectivity of migrants (i.e. younger people are more likely to migrate than older people) can be attributed to their higher risk-taking ability, earnings potential, or higher human capital (Liu et al. 2013; Knight et al. 2011; Golley and Meng 2011). Another admits migration could be recognized as a household strategy (Fan 2011; Zhu 2007; Démurger and Li 2013). Following this line, Liu et al. (2013) introduces NELM's propositions to the Lewis Model, and frames the coexistence of China's LTP and rural surplus laborers as a result of risk aversion and risk sharing income-generating behaviors among family members. Based on their arguments, certain household members will stay in rural areas because they are risk averse, even where the urban working income is significantly higher than that of the farming income. Alternatively, this research refers to a more comprehensive strategy as proposed by household livelihood diversification (Ellis 1998), which not only accounts for risk-sharing income generating behaviors, market constraints, and relative deprivation (Stark and Bloom 1985), but also takes into consideration family members' (selective) access to assets, perceptions of opportunities, and aspirations of actors (Ellis 1998; De Haas 2010).

Therefore, this research comes up with two propositions that could be contributing to the China paradox: (1) Age selectivity in China's massive internal migration is attributed to one's position in his or her life course, rather than a manifestation of one's migration ability. (2) The allocation of family members in

[2]Specifically, out-migration flows originate from the Hunan, Anhui, Jiangxi, Henan, Hubei, Chongqing and Sichuan provinces, most of which are located in Central China or its adjacent areas characterized by large populations and lagging economic development. In-migration flows terminate in the Shanghai, Beijing, Tianjin Guangdong, Zhejiang and Jiangsu provinces. Located along the eastern coast of China, these provinces are in the most developed region of the country and rely heavily upon a foreign-direct investment (FDI) model.

rural households is due to a livelihood diversification strategy rather than the mere risk-sharing income-generating behaviors or the risk aversion of some family members.

2.2 *Migration and Settlement Intentions in China's Unique Interregional Rural-to-Urban Migration*

This research hereby briefly reviews the empirical findings of previous research on migration and settlement intentions. In accordance with the internal migration patterns, it is not surprising that studies on migration intention tend to focus on the "push" factors of the migrant-sending provinces (Liu et al. 2014; Chen and Korinek 2010; Yan et al. 2014; Démurger and Li 2013; Yang 2000) and research on settlement intention has tended to focus on the "pull" factors of the major migrant-receiving provinces (Fan 2011; Zhu and Chen 2010; Yue et al. 2010). From the supply side, it has been said that "migrants are positively selected" rather than a random sample of the rural population (Wang and Fan 2006). Studies have revealed that migration intention is associated with demographics and human capital at individual level and allocation of family laborers at the household level, as well as place-based intervening factors like housing and rural land ownership, etc. To elaborate, with a few exceptions, young, unmarried, male individuals were more likely to out-migrate for work, as were those with higher levels of educational attainment and past migration experience, and skilled workers (Liu et al. 2014). The number of migrants in the family, and other migrants' remittance amounts to the family are negatively related to migration intention (Démurger and Li 2013; Yang 2000). Research has also shown that migration decisions vary significantly with respect to local economic structure and rural institutional arrangements, including land-related factors, availability of local off-farm work, and types of available off-farm work. For example, the area of cultivated land owned by an individual will significantly restrict his migration intention (Yan et al. 2014). Local off-farm work is not only an alternative to migration, but has also been shown to be a preferred occupational choice by return migrants (Liu et al. 2014; Wang and yang 2013; Chen and Korinek 2010; Wang et al. 2011).

From the demand side, empirical findings have also investigated the roles of factors at the individual-level andhousehold-level, and at place-based intervening factors, however, compared to the empirical findings on migration decisions, the empirical evidence is less conclusive regarding determinants of settlement intention and outcomes (Fan 2011; Liu and Wang 2014). Although many believe that the accessibility of non-agricultural *hukou* status influences one's settlement intention positively, Zhu (2007) showed that non-agricultural *hukou* status is actually not as strong of a pull factor as we imagine. He argues that settlement intention is actually a process that involves multi-faceted factors. At the individual level, many believe that females, higher levels of educational attainment, and more sophisticated social networks may contribute to the settlement intention (Fan 2011). The effect of marriage is mixed, and the variance by age is non-linear or with generational differences (Yue et al. 2010). At the household level, Fan (2011) found that household characteristics, especially spousal separation or having children left-behind at rural homes, negatively contribute to one's settlement intention. As for place-based intervening factors, other studies stress the role of income level, occupational category, social capital, the cultivated land and housing at rural homes, longer duration of residence in local city, migrant housing conditions, etc. (Fan 2011; Liu and Wang 2014).

Although plenty of empirical efforts have been devoted to exploring the determinants of migration or settlement intentions, this research will add to present scholarship by testing how these determinants of migration and settlement intentions work through human agency in different age cohorts, when variables at individual, household, and place-based levels are accounted for. Policy implications will be discussed accordingly.

3 Research Design

3.1 Data Collection

Data used to model migration and settlement intentions were mainly collected from the Chinese Household Income Project Series administered in 2009 (hereafter refer to as CHIPS2009),[3] which became publically accessible in 2014. This sample data includes all family members in 5000 migrant households, 5000 urban households, and 8000 rural households in the nine-largest provinces[4] sending and receiving migrants. Within these observations, the characteristics of 12,495 rural residents from 35 counties/cities in the major migrant-sending areas (Sichuan, Chongqing, Hunan, Hubei, and Anhui) were used to model the migration intention of potential migrant workers, representing the supply side of available laborers. These rural migrant workers were selected with three conditions: had ages between 15 and 64, held local agricultural *hukous* and had lived in the rural household for over a half year in 2008. The characteristics of 4179 rural migrant workers holding non-local agricultural *hukous* from 8 counties/cities in the major migrant-receiving areas (Jiangsu, Zhejiang, Shanghai and Guangdong) were used to model settlement intentions (as shown in Fig. 1).

[3]CHIPS data in 2009 is coded as CHIP2008 or RUMiC2009. CHIPS has five rounds of national level survey data administered in 1988, 1995, 2003, 2008 and 2009. They're conducted by Beijing Normal University, National Bureau of Statistic of PRC, etc.

[4]These provinces are: Shanghai, Jiangsu, Zhejiang, Hubei, Sichuan, Guangdong, Henan, Anhui and Sichuan.

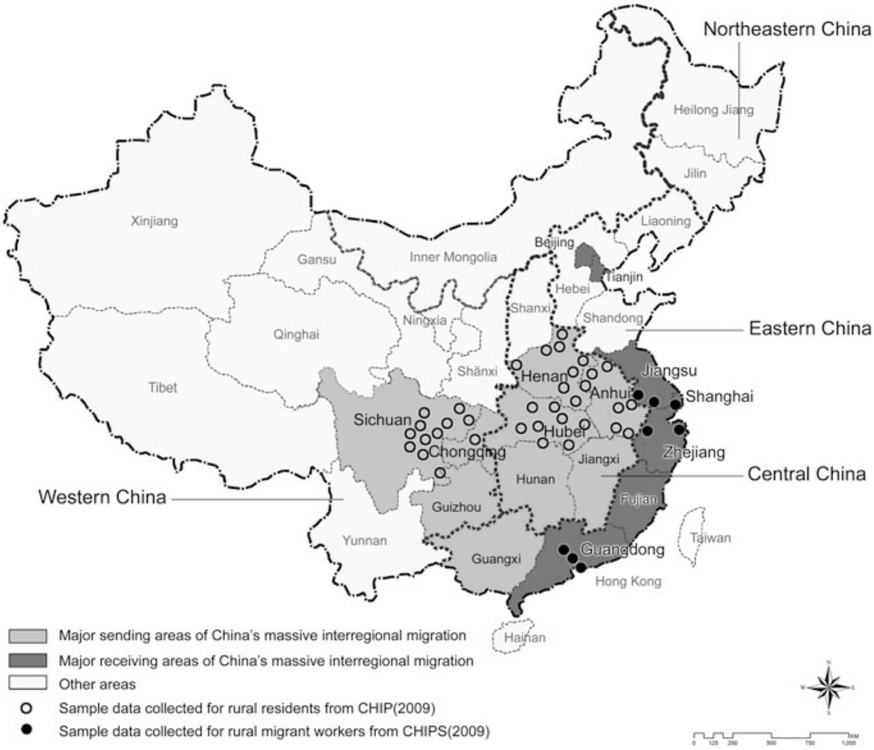

Fig. 1 Spatial concentration of rural-urban migrations and the sample-data location

The CHIPS2009 sample data is ideal for this research. First, since it was specifically designed to investigate the rural-urban migrants, the questionnaire includes explicit questions about both rural residents' migration intentions and the rural migrant workers' settlement intentions. Second, the comprehensiveness of the variables not only allows us to control for individual- and household-level attributes but also to include place-based intervening factors. Third, the geographical coverage of the sample data is representative, and the sample size as aforementioned is adequate for fitting multivariate regression models.

In addition to CHIPS2009, an earlier round of sample data in the same survey series administered in 2003 (CHIPS2003), and the newly initiated China Labor-force Dynamics Survey administered in 2012 (CLDS2012)[5] are also used to estimate the development trends of place-based intervening factors between 2003 and 2012. CHIPS2003 covers 2000 rural-urban migrant households, 6835 urban households, and 9200 rural households. The CLDS2012 dataset includes 1026

[5]CLDS2012 sample data is conducted by Center for Social Survey at Sun Yat-sen University.

rural-urban migrant households, 4051 urban households, and 5533 rural households. All data were collected through a series of cross-sectional questionnaire-based interviews conducted in both rural and urban areas.

3.2 Modeling Migration and Settlement Intention

Probit, binomial, multinomial, and ordinal logistic models are the most widely used models to test migration and settlement intentions (Zhu and Chen 2010; Knight et al. 2011; Fan 2011; Kley 2011). The dependent variables in this dataset are able to capture the ordinal nature of their decision making factors, therefore this research uses ordinal logistic regression model to predict the migration/settlement intentions. For model A (migration intention), this research takes on values 1 = yes, 2 = not decided, 3 = no, while in model B (settlement intention), this research takes on values 1 = stay forever, 2 = not sure, 3 = plan to leave.

To test the first proposition on life-course perspective, this research studies the cohort differentiation of the individuals when household-level factors and place-based intervening factors are accounted for. A preliminary test was run to look at the age groups of rural residents and rural-urban migrants in the sample data (Fig. 2). The descriptive results corroborate previous research findings that migrants in their 20's dominate the social group. Therefore, 25, 30, and 40, as proposed by Zhu and Chen (2010)'s work, provide appropriate cut-off points for migrants' age cohorts. However, it's not surprising to find a significant proportion of working-age rural laborers between 40 and 65. To achieve consistency between the two models, this research adds 50 as an additional threshold. Therefore, this research covers a full spectrum of five age cohorts in both rural residents and

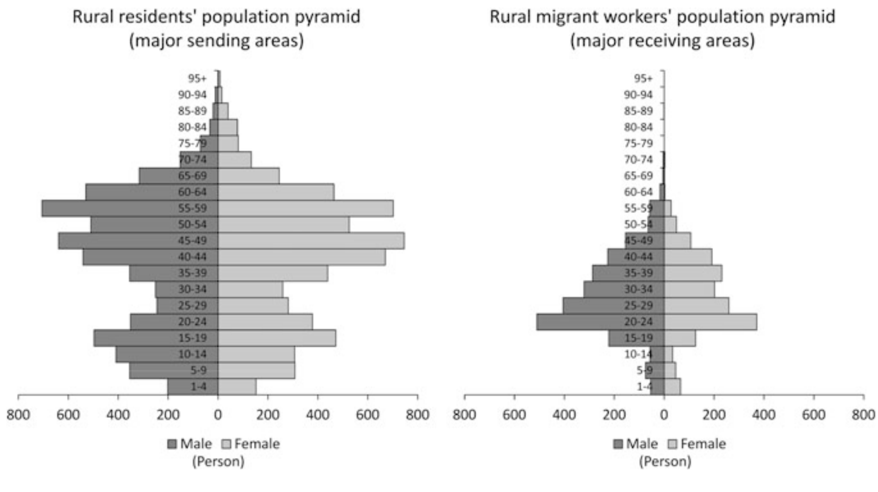

Fig. 2 Population pyramids of rural residents and rural migrant workers (CHIPS2009)

migrants, specifically 16–24, 25–29, 30–39, 40–49 and 50–64 (or over 50 for rural migrants).

To test the second proposition on household livelihood diversification, this research includes place-based intervening factors with a particular focus on income-generating activities and assets (for instance, the occupational category and location of off-farm work, cultivated land and housing at rural home, the occupation and the housing conditions in local city, etc.) in addition to individual level characteristics (demography, income, human capital, etc.) and household-level attributes (household arrangement, income, etc.).

Table 1 lists all the variables specified in the model. Although restricted by data availability, the detailed specification of the independent variables incorporates the findings of previous empirical research whenever appropriate. For example, the classification of off-farm work location incorporates the findings of Liu et al. (2014)'s work and the occupational category of off-farm work and the household arrangement in destination city incorporates the results of Wang and Yang (2013), Wang et al. (2011) and Fan (2011).

Table 1 Model specifications

	Model A (migration intention)	Model B (settlement intention)
Dependent variable	Q: Do you plan to migrate out for work? *1 = yes* (*including migrate within one month, half year, or one year*), *2 = not decided, 3 = no*	Q: How long would you like to stay in the city? *1 = stay forever; 2 = not sure; 3 = plan to leave* (*including planned stay for 1 year, 1–3 years and over 3 years*)
Cohort division	16–24, 25–29, 30–39, 40–49, 50–64	16–24, 25–29, 30–39, 40–49, ≥ 50
Individual-level factors	I1_Gender (*Male/Female*)	i1_Gender (*Male/Female*)
	I2_Marital status (*Married/Unmarried*)	–
	I3_Education attainment (*Junior high and below/Senior high and above*)	i2_Education attainment (*Junior high and below/Senior high and above*)
	I4_Migration experience (*Yes/No*)	i3_Migrant duration (*Years*)
Household-level factors	H1_Per capita monthly income (*10,000 CNY*)	h1_Per capita monthly income (*10,000 CNY*)
	H2_The share of migrants in the household (%)	h2_Remittance to rural home? (*Yes/No*)
	H3_Left behind children in the household (*Yes/No*)	h3_Household composition in destination city[a] [*Single; Sole; Couple* (*with or without their parents*)*; Couple with children* (*with or without their parents*)*; Other families*]

(continued)

Table 1 (continued)

	Model A (migration intention)	Model B (settlement intention)
Place-based intervening factors	P1_Occupational category of off-farm work (*Self-employed; Wage worker; Full-time agricultural worker; Unemployed or Non-economic population*)	p1_Occupational category in destination city (*Private business owner or managers; Professionals and clerks; Self-employed; Manufacturing and construction workers; Service and sales workers; Unemployed or Non-economic population*)
	P2_Monthly income of off-farm work (*10,000 CNY*)	p2_Monthly income in destination city (*including major and part-time job, 10,000 CNY*)
	P3_Location of off-farm work (*with hometown, other townships within home county, other counties within home province, and other provinces*)	p3_Housing conditions in destination city (*The self-owned house; Sharing housing with someone; Rent housing independently; Dormitory or construction sites provided by employer*)
	–	p4_Endowment insurance Coverage (*Yes/No*)
	–	p5_Unemployment insurance coverage (*Yes/No*)
	P4_Estimated value of rural housing (*10,000 CNY*)	p6_Own housing at rural home (*Yes/No*)
	P5_Area of cultivated land at rural home (*mu*)	p7_Area of cultivated land at rural home (*mu*)

[a]As a slightly revised version of the household types based on Fan (2011)'s proposition, we define "Couple" as those who live with their spouse with or without their parents, and "Couple with children" as those who live with their spouse and children with or without their parents

4 Results

4.1 Migration Intention in Migrant-Sending Areas

Overall, the models are reasonably well fitted, with the parameter estimates presented in Table 2. First, household-level factors and place-based intervening factors emerge as the most significant variables in predicting the older age cohorts' migration intentions. This indicates that household-level and place-based factors are driving the older migrants' decisions to return home. On one hand, the higher share of migrants in a household and being in a household with left behind children impair the probability of migration intention, but this is valid only in the age group of 50–64. It corroborates the proposition by NELM and previous findings that older family members' responsibility to the family (De Haas 2010; Golley and Meng 2011) is most significant for those aged 50 and older. The positive contribution of

Table 2 The migration intention of the remaining laborers in rural communities of migrant-sending provinces (CHIPS2009)

Parameter estimates	16–24	25–29	30–39	40–49	50–64
Intercept: *Yes*	−1.391***	−0.697	−1.781***	−2.799***	−2.553***
Intercept: *Not decided*	−0.071	0.476	−0.519	−1.411**	−1.457**
Gender: *male* (*ref = female*)	0.099	0.376**	0.300**	0.307***	0.197(*)
Marital status: *married* (*ref = unmarried*)	−0.276*	0.003	−0.092	−0.095	−0.221
Educational attainment: *senior high or above* (*ref = junior or below*)	0.270*	0.195	−0.033	−0.348	0.588*
Migration experience: *yes* (*ref = no*)	0.606***	0.637***	0.759***	0.853***	1.014***
Per capita household income	0.839	1.593	−1.196	−2.768	−0.443
The share of migrants in the household	0.186	−0.340	0.263	−0.156	−1.118(*)
Left behind children in the household: *Yes* (*ref = no*)	−0.205(*)	0.092	0.225*	0.273***	−0.181(*)
Occupational category of off-farm work (*ref = full-time agricultural worker*)					
Self-employed	−0.027	1.280*	−1.107***	−0.360	−0.679
Wage workers	0.104	0.330	−0.416(*)	0.883**	0.508
Unemployed or non-economic population	−0.500	−0.774(*)	0.471(*)	0.009	0.358
Monthly income of off-farm work	−0.172	−0.323(*)	0.120	0.116	0.287
Location of off-farm work (*ref = other provinces*)					
Within hometown	−0.527*	−1.088**	−0.523*	−0.677**	−0.283
Other townships within home county	0.515	1.183*	1.672***	−0.067	−0.388
Other counties within home province	0.756**	0.174	0.695**	0.621**	0.891**
Estimated value of rural housing	−0.012	−0.015	0.027(*)	−0.034*	0.009

(continued)

Table 2 (continued)

Parameter estimates	16–24	25–29	30–39	40–49	50–64
Area of cultivated land at rural home	−0.009	−0.031	−0.034	−0.062**	0.004
Generalized R^2	0.273	0.285	0.298	0.289	0.188
Misclassification	0.295	0.283	0.187	0.105	0.053
Observations	631	400	1107	2313	3161

(*)p < 0.01, *p < 0.05, **p < 0.01, ***p < 0.001

left behind children on the migration intention suggests that family members younger than 50 may be even more motivated to improve livelihood through migration rather than being restrained by child-rearing responsibilities. On the other hand, the results confirm the household livelihood diversification hypothesis and previous evidence that the estimated value of rural housing and area of cultivated land at the rural home negatively contribute to one's migration intention (Yan et al. 2014; Ellis 1998). Those aged 40–49 are most likely to be bounded by assets at the rural home, suggesting that the assets, in addition to the proposed risk aversion, are also driving return migration when one reaches 40 years old.

Second, some of the variables have persistently influenced rural laborers' migration intention across all (or most) of the age groups, and therefore, impede or promote further rural-to-urban migration in general as opposed to causing age selectivity. These variables include the individual variables of gender and migration experience, and place-based intervening factors of local off-farm work. The results support previous research that male laborers with previous migration experiences are more likely to out-migrate (with the exception of the 16–24 age category). In addition, although the contribution of occupational categories of off-farm work to rural laborers is inconsistent in each group between 25 and 49, the location of off-farm work on one's migration intention is consistent in all age groups between 16 and 49. Compared to inter-provincial off-farm work, individuals having a local off-farm job (within the hometown) are significantly less likely to out-migrate. Therefore, contrary to Knight et al. (2011)'s proposition that local off-farm work is a reluctant choice for returned older migrants compared to their inferior position in the urban labor market, this research argues that local off-farm work is actually a competing occupational choice to migrant work among migrant workers in all age cohorts, given that the negative contribution of local off-farm work on migration intention was found among all the age groups of 16–24, 25–29, 30–39, and 40–49. Individuals with off-farm jobs in other townships or counties within the home province are more likely to out-migrate for work than individuals who work outside their home provinces. Therefore, even if the remaining rural laborers are not absorbed by local non-agricultural labor markets, it is more likely that they will migrate within their home province. This trend implies that as off-farm jobs become available closer to the hometown, longer migration distances have deterred

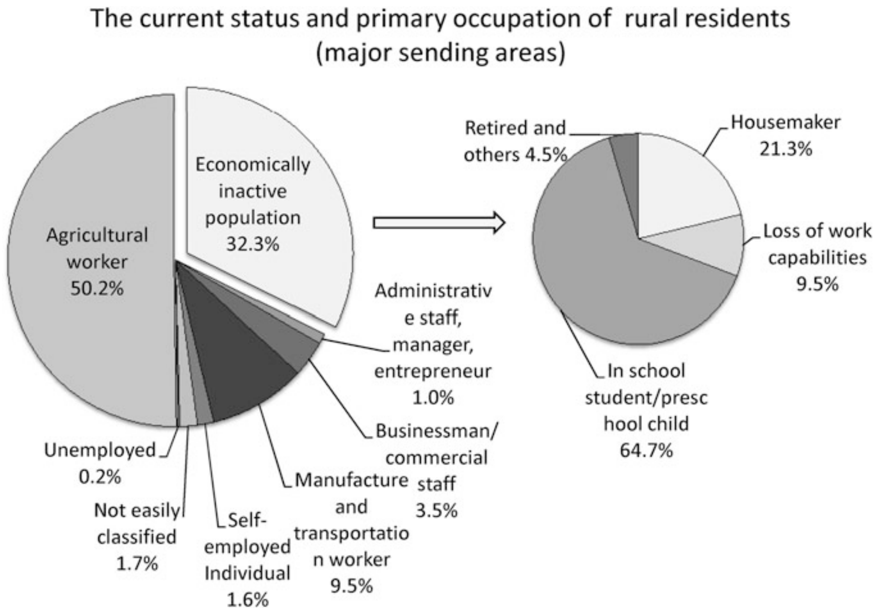

Fig. 3 The status and primary occupation of rural residents in major sending areas. *Note* The survey has a screening process to identify only the ones with over 3-month off-farm work as non-agricultural workers

individuals from out-migrating to the traditional migrant-receiving provinces, diminishing China's unique interregional rural-to-urban migration.

Third, responding to Liu et al. (2013)'s proposition that the risk-sharing income-generating behaviors between family members are causing more "surplus laborers" to enjoy leisure time, this research further looks into the primary occupations and the current status of all the remaining rural laborers (including the ones younger than 16 and older than 64). The results reveal another scenario which aligns with the propositions by household livelihood diversification strategies: the current status and primary occupation of the rural residents are characterized by low levels of unemployment, high levels of labor participation and diversified income generating activities (Fig. 3). On one hand, it turns out only 0.2 % of the remaining rural laborers are unemployed, and more importantly, the economically inactive population only represents 32.3 % of the rural population, which is even lower than the national share of the economically inactive population (43.2 % in 2009). A further breakdown shows 64.5 % of all the economically inactive people are in-school students or pre-school children, and home-makers occupy another 21.3 %. While full-time agricultural workers represent 50 % of the total population, the other 17.3 % works in non-agricultural sectors with a half (9.5 %) in the manufacturing and transportation industry. This implies that the process of "rural industrialization", rather than the service sector, is absorbing rural laborers. Thus it is safe to conclude that the existence of potential migrant laborers choosing not to migrate does not necessarily imply that these laborers are "surplus" in the sense of "zero" marginal productivity.

4.2 Settlement Intention in Migrant-Receiving Areas

The parameter estimates from the decision-making model in migrant-receiving areas are presented in Table 3. The model results confirm the findings of previous research that settlement intention is not as predictive as migration intention (Fan 2011; Liu and Wang 2014). When age cohort is accounted for, the differences in gender, educational attainment, per capita income, household income, medical insurance, unemployment insurance do not seem to affect one's settlement intention. However, an increasing generalized R squared and declining misclassification rates could be observed as the age group moves up, suggesting the complexity and diversity in the determinants of young migrants' settlement intention.

First, some of the variables are only valid in several particular age cohorts and therefore are probably contributing to the age selectivity of migration behaviors. These variables include the individual-level factor of migration duration, the household-level factors of remittance to rural home and household arrangement, as well as the place-based intervening factors of housing ownership and area of cultivated land at the rural home. Specifically, (1) the findings corroborate Fan (2011)'s argument that, compared to couples, the solely resided migrants are less likely to settle down and couples with children are more likely to settle down. In addition, the results further demonstrate that these propositions are confined to migrants older than 40. (2) This research also finds that remittance to the rural home represents a stronger attachment to the rural home and less likelihood to settle down, but these propositions are only valid when the migrants are 50 or older. (3) Housing ownership and area of cultivated land at the rural home are found to be negatively related to the settlement intention of individuals between 40 and 49. This is consistent with the previous finding on the remaining rural laborers' migration models in the previous section. The assets of rural migrant workers at their rural home are tied to their agricultural *hukou*, and the relinquishment of a rural peasantry identity suggests the abandonment of the right to lease rural land, as well as the household's loss of its homestead and income stream from collective land dividends. (4) The coverage of endowment insurance and unemployment insurance, which presumably function as counter-risk measures that work to extend the migrants' duration of stay, turn out to be ineffective on migrants older than 40. Therefore, this research argues that the older migrants' (over 40) reluctance to settle down in local cities are related to the individual's position in the family, in one's life course, and one's assets, but not necessarily attributed to risk aversion, as represented by insurance coverage.

Second, the occupational category and housing conditions in the destination city, as in place-based intervening factors, are found to be significantly associated with

Table 3 The settlement intention of the rural migrant workers in urban communities of migrant-receiving provinces (CHIPS2009)

Parameter estimates	16–24	25–29	30–39	40–49	50+
Intercept*: stay forever*	0.341	1.184**	0.948**	0.358	−0.638
Intercept*: not sure*	1.777***	2.670***	2.338***	1.972***	1.189
Gender: *male* (*ref = female*)	−0.010	−0.035	−0.032	−0.060	0.191
Educational attainment: *senior high or above* (*ref = junior or below*)	−0.017	0.098	0.067	0.018	0.044
Migrant duration	0.026	−0.002	0.021(*)	0.041***	0.027
Per capita household income	1.784	1.913	−0.508	0.932	−1.327
Remittance to rural home*: yes* (*ref = no*)	0.048	0.087	−0.024	0.057	−0.627***
Household type in destination city (*ref = couple*)					
Single	−0.121	−0.254	0.049	0.554	−0.830(*)
Sole	−0.186	−0.226	−0.303*	−0.426*	−0.711*
Couples with children	0.187	−0.028	0.376*	0.033	0.514
Other family	0.151	0.774*	−0.032	0.047	0.934*
Occupational category in destination city (*ref = service and sales workers*)					
Private business owner or managers	−0.150	−0.014	0.891**	0.155	1.003
Professionals and clerks	−0.162	0.134	0.341	0.331	0.580
Self-employed	0.591*	1.405***	0.035	0.571*	−0.318
Manufacturing and construction workers	0.078	−0.367 (*)	−0.449**	−0.208	−1.067**
Non-economic person or unemployed	−0.587 (*)	−0.986*	−0.633*	−0.977**	0.508
Monthly income in destination city	−1.462	−1.182 (*)	−0.061	0.717	6.271*
Unemployment insurance coverage: *yes* (*ref = no*)	0.305**	−0.078	−0.197 (*)	−0.131	−0.017
Endowment insurance coverage: *yes* (*ref = no*)	−0.125	0.096	0.162(*)	0.145	−0.328
Housing conditions in destination city (*ref = rent housing independently*)					
The self-owned house	1.464(*)	1.615*	0.991*	0.492	−1.610
Sharing housing with someone	−0.480	−0.358	−0.046	0.574*	0.850(*)

(continued)

Table 3 (continued)

Dormitory or construction sites provided by employer	−0.677*	−0.820**	−0.600**	−0.760***	0.509
Own housing at rural home*: yes* (*ref* = *no*)	−0.019	0.052	−0.066	−0.235(*)	−0.474*
Area of cultivated land at rural home	−0.008	−0.018	0.004	−0.054*	−0.033
Generalized R^2	0.042	0.103	0.091	0.167	0.297
Misclassification Rate	0.523	0.403	0.365	0.390	0.435
Observations	1107	633	1087	559	209

Source Calculated by author using sample data of non-local rural migrants in receiving areas
(*)p < 0.01, *p < 0.05, **p < 0.01, ***p < 0.001

the settlement intention of all age groups, therefore, the local labor market and housing tenure are also important players in curbing further rural-to-urban migration. Compared to service and sales workers, manufacturing and construction workers, unemployed, and economically inactive populations are less likely to settle down, while self-employed and private business owners are more likely to settle down. Since occupational category is representative of one's economic class, these results corroborate previous findings by Liu et al. (2013) that settlement intention is much more related to one's long term economic gain rather than the current income level, given that neither per capita income nor household income seems to be a significant contributor. It's of note that current income level does not play a significant role in shaping one's migration intention either, therefore, the results support Todaro's (1969) argument that migration decisions are more related to expected income (pull factor). It's also possible that the reluctance of manufacturing and construction workers' willingness to settle down, as opposed to service and sales workers, is due to the financial crisis triggered in 2008, as proposed by Chan (2010).

The results also support Liu and Wang (2014)'s argument that housing condition is a significant contributor to one's settlement intention, but we're able to further disclose the differentiation among different age cohorts and detailed housing conditions. More specifically, compared to the rural migrant workers who rent housing independently, individuals living in self-owned houses are more likely to settle down, and individuals living in dormitories or construction sites provided by employers are less likely to settle down. These results are consistent in all age groups of migrants younger than 40. Further descriptive analysis was run to compare the existing pattern of housing conditions between local urban residents and rural migrant workers in major migrant-receiving areas (Fig. 4). After years of working and living in cities, individuals who own their housing in local cities represent a mere 2.8 % of the total sample, in contrast to the 93.2 % of urbanites who own their housing. The major sources for migrant housing are actually

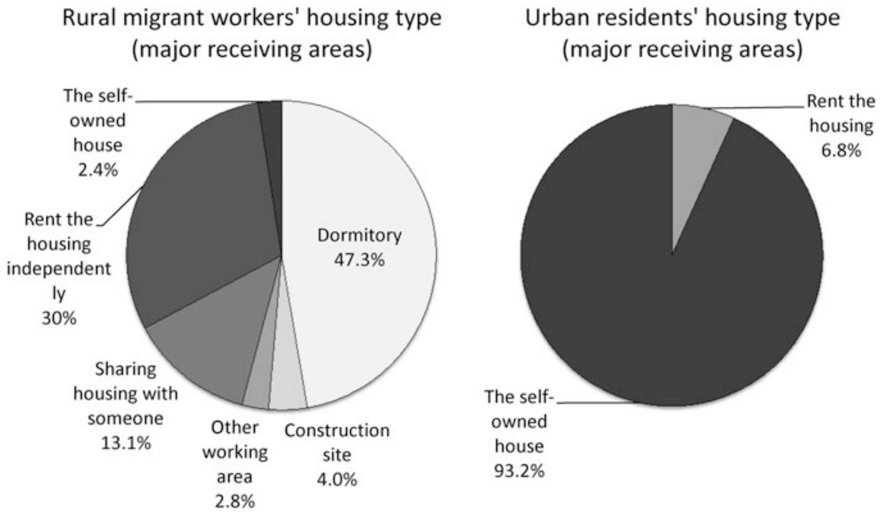

Fig. 4 The housing patterns of rural migrant workers and urban residents in major migrant-receiving areas (CHIPS2009)

dormitories provided by an employer (47.3 %), independent rentals (30 %), and sharing housing with someone (13.1 %). Therefore, in line with Chen et al. (2011)'s argument that migrants are not considered as a part of the urban housing provision system by housing policy makers, this research argues that the reluctance or inability of the coastal provinces to accommodate the rural migrant workers could be diverting their settlement intentions.

5 Conclusion and Discussion

This research argues that China's migrant labor shortage signifies an established equilibrium in the unique interregional rural-to-urban migration, which not only originates from the regional socio-economic development pattern, but has also been shaped by the agency of rural-urban migrants. Departing from Lewis' two-sector model, this research adopted an alternative approach: the push-pull model to test the pro and con factors at the origins and destinations of China's unique interregional rural-to-urban migration. Based on propositions by household livelihood diversification, and life-course perspective, two major findings are formulated to address the status quo of the China paradox. First, the persistence of a young migrant labor pool is not only related to the household arrangement, but also related to assets at the rural home and labor market characteristics in local urban communities, especially in those aged 40–49. This suggests that age selectivity is related to household strategies and one's position in their life course. Second, local off-farm work and housing conditions are both significant contributors (positive and negative, respectively) to rural-urban migration across most of the age cohorts, implying that place-based intervening factors in both migrant-sending and receiving areas are also key factors in shaping the China paradox. Further, the investigation on the development trends of place-based intervening factors suggests that the negative contribution of local off-farm work and housing conditions on rural-urban migration may persist. Therefore, while the findings support Knight et al. (2011)'s argument that the coexistence of China's migrant labor shortage and abundance rural labors will probably be a long-term scenario, this research has added to the current scholarship on this topic by illustrating the interplay of individual factors, household factors and place-based intervening factors.

Theoretically speaking, this research argues that the China paradox can be better explained by the household livelihood diversification than by NELM. The dynamics of rural households' livelihood diversification manifest in two ways. First, the household strategy of allocating family members is similar to the farm economic household model (Ellis 1993). Recognized as part of the livelihood approach, the farm economic household model treats the household as a single decision-making unit that maximizes its welfare subject to a range of income earning opportunities, and a set of resource constraints. The household will allocate its labor time so that the marginal returns per unit of labor are the same across different activities, whether on-farm, off-farm, or non-farm (Ellis 1998). In this case, prime laborers in a household, including young workers, will often seek jobs in cities, while less competitive laborers tend to remain in their rural locales and participate in agricultural work or local off-farm work. By taking a translocation work-life pattern, the rural household diversifies its income sources, maximizes its net income, and doesn't have to bear the full cost of urban life for the whole family. Second, the rural household is prone to optimizing the value of household assets, while minimizing financial stress (Zhao and Chen 2013). Often, the impeding factor of migrating from rural to urban areas is considered one-sided—owing to a lack of urban *hukou*, migrant workers are excluded from social welfare benefits. However, migrants face = additional friction factors if they relinquish their rural *hukou*. Vacating rural *hukou* means to abandon the household's share of collective assets, as well as the dividend income that would accrue to the household. Thus, many rural households chose to retain rural *hukou*, electing to become temporary rural-urban migrants to maximize both household income and household assets. Even when an entire household decides to migrate to an urban area, they frequently retain rural *hukou* and, by extension, de jure rights to collective rural assets, as a strategy for minimizing financial stress.

Therefore, to the extent that policymakers wish to achieve a more integrated economy rather than a dualistic one, opening urban *hukou* entitlement to rural migrant workers is just a first step. Despite the New-type Urbanization Plan to achieve "citizenization" of migrant workers, opening urban *hukou* entitlement may not be able to promote further rural-to-urban migration per se. The negative contribution of place-based intervening factors would need to be reversed and a more coordinated rural-urban development mode be achieved to change the current migrants, remaining rural laborers and their dynamic roles in shaping the simultaneous existence of migrant labor shortage and surplus rural laborers.

Acknowledgments This work was supported by Chinese Scholarship Council under Grant <No. 201206260001> and Tongji Architectural Design (TJAD). I would like to thank Professor Min Zhao (Tongji University), Theodore C. Lim (University of Pennsylvania), and Professor Bo Qin (Ren Min University) and the anonymous reviewers for their constructive comments on an early draft of this article. Any remaining error is the responsibility of the author.

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From Polysemous Affect to City Integration: The Definition Thinking and Frontier Method to Radiation Realm of City Rail Transit Station

Dongzhu Chu and Shuxiang Wei

1 Introduction: Why Is Redefinition Needed?

The upgrade and change of transit tools and travel modes affect two aspects i.e. urban macro spatial pattern and micro living state. As one of the effective approaches to mitigate the current urban public transport and environment problems, rail transit is ameliorating the current urban spatial pattern greatly. As the rail transit route (and stations along the route) are being implanted gradually into the existing urban environment, and are merging and developing with existing urban space, a series of new phenomena, new rules.

The spatial range radiated by a station of urban rail transit is a physical representation of its influential power, while the range definition is, to some extent, quantification of the said power. The influential power or influenced range has great value of reference and steering function on urban management, operation, and its spatial optimization.

Scholars from various disciplines all over the world have conducted research on defining radiation range. In terms of transfer modes, there are two types of passengers who take rail transit; one is to enter the rail transit system directly by walking, while the other is to enter the rail transit system by other travel means (e.g. buses, cars, bicycles, etc.) in addition to walking. In the study, the spatial range radiated by the stations of rail transit is primarily on the basis of the first transfer mode, because the ultimate manner is walking definitely no matter what manner is taken by the passenger to transfer to rail transit (Fig. 1).

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_3

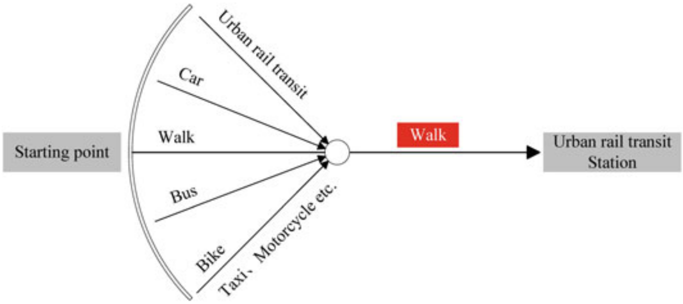

Fig. 1 The transfer process from starting point to urban rail transit station

Hyungun Sung found that a rail transit service coverage boundary of 500 m provides the best fit for estimating rail transit ridership levels, and that with regard to land use, density is positively related to rail transit ridership within a 750 m radius of each station (Sung et al. 2014). Heungsoon Kim and Jaehyeong Nam also found that the average distance of an SIA (station influence area) is identified as 462 m and the average walking distance is identified as 376 m from the survey of rail transit users of seven stations in Seoul (Kim and Nam 2013). Kim and Nam also found that the moving time required from stations to destinations was identified between 7 and 10 min. Sungyop Kim etc. found that the average distance of 0.76 km (Kim et al. 2007) is greater than that of light-rail transit (LRT) riders in the study of O'Sullivan and Morrall (1996) and close to the maximum distance 805 m of the guidelines that exist in the US. Robert Cervero analyzed the ratio of railway service users by distance to stations and found that the inflection points of the slopes were at 1000 feet (approximately 300 m) and 3000 feet (approximately 900 m) (Cervero 1994).

It can be found in further collation that thoughts of definition is relatively macro in the studies that the radiation range of the stations are discussed in terms of 300, 750 and 900 m, which is "almost defined as the average distance from the center of a station to users' destinations". This literature, which tends to focus more on the impacts of transit-oriented development (TOD), pays more attention to the structure of road systems, comprehensive utilization of land, population density, and development accessibility by walking within a certain scope around the station. On the other hand, the walking time that can be accepted by the people is taken into comprehensive consideration in the studies that the radiation range is defined in terms of time of 7, 10 min, etc. These studies reflect the concern of the researchers about subjective sensation of pedestrians. Such definition of radiation range characterized by concentric rings can generally be proper for analysis of utilization and management of urban space at macro level, while the requirement on the technical conditions of the definition is not so high. However, with the rapid process of urbanization, more dedicated development of urban space and satisfaction of

Fig. 2 The scope of radiation in a concentric expression for Zengjiayan Station of Chongqing Rail Transit Line 2 in China

people's micro demands are the important aspects faced by many cities. The way of definition of concentric rings can no longer reflect the actual spatial characteristics of a city and the elements in the system actually and comprehensively. Taking Zengjiayan Station of Chongqing Rail Transit Line 2 as example, it is easy to find that the way of definition of concentric rings is not accurate enough even if a ring of 50 m radius is defined (Fig. 2). So, how can the radiation range be defined properly when pieces of background information become available in the era of big data?

2 Thought of Definition and Generation of Concept

In view of the particular event that stations of rail transit are implanted into the existing urban space, this paper brings forward new thought for studying the spatial range radiated by a station on the basis of investigating the new phenomena, new laws, new problems and new space generated by the implantation (Fig. 3).

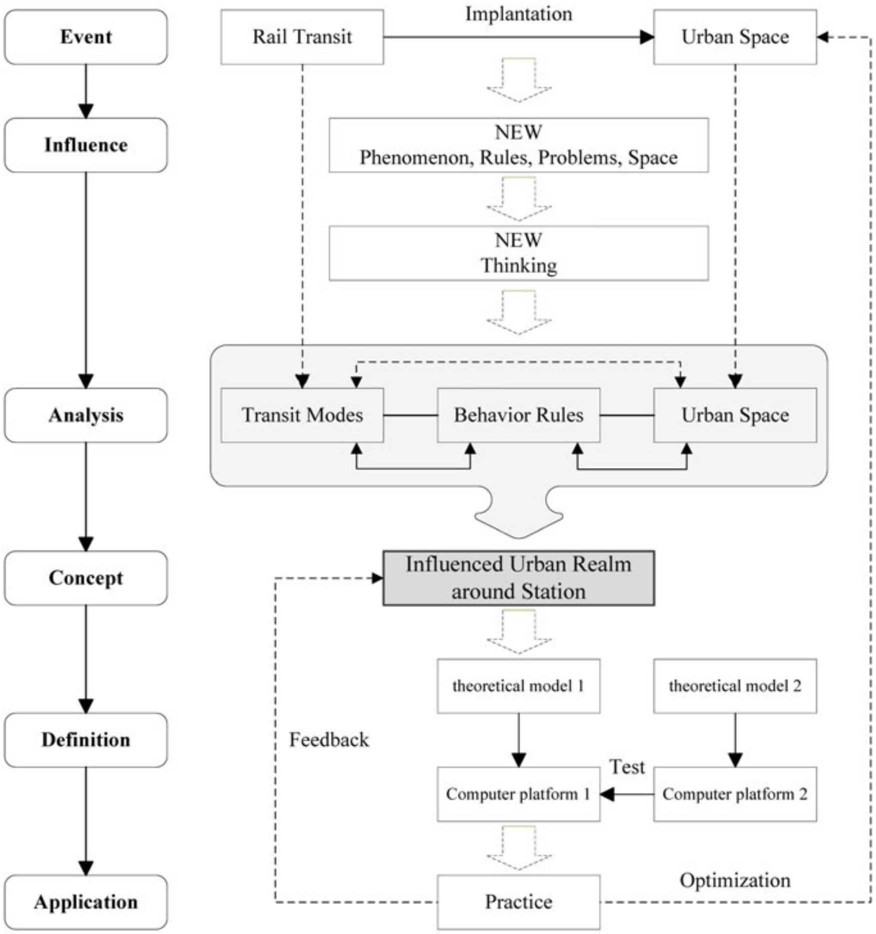

Fig. 3 New concept for studying the spatial range radiated by a station

2.1 Influence of Multiple Significances: Influences and Influence Set

It is found hat the urban space within a certain range around the rail transit station presents complexity of functions, diversity of behaviors, sensitiveness of ecology, complicacy of technologies, centrality of structure and other characteristics. These characteristics are generated due to the implantation of rail transit station into the urban space. Such influence is bi-directional (i.e. the rail transit station affects the urban space, and vice versa).

After the event that the station is implanted into the existing urban space happens, as to the underground stations, change of the urban surface is not only

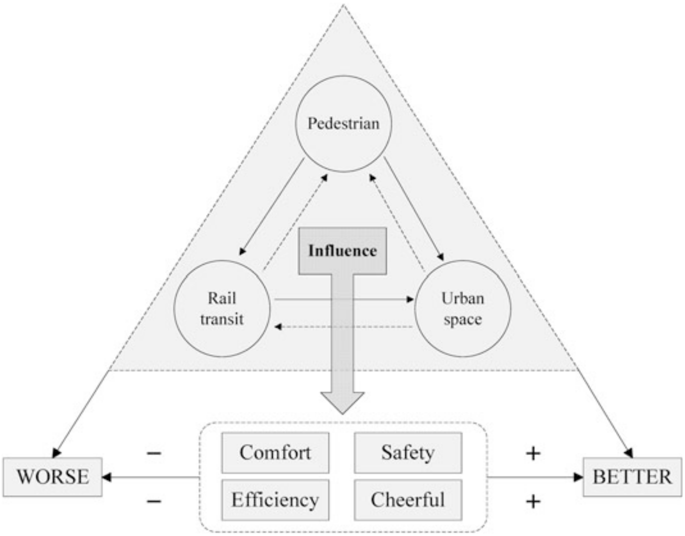

Fig. 4 Polysemous effects among people, city and traffic

expressed by more openings which streams of people come into and out of, but also expressed by the influences of multiple significances, between rail transit, population and city that are related to the implantation (Fig. 4). These influences are multi-dimensional, multi-faceted, and have interactivity, property of time and superposition. A set of scientific relations between travel modes, behavioral pattern and urban space can be abstracted by collating relations of these influences, and a set of influence within the space radiated from the station can be constructed. Whether each set of influence relation is treated properly or not affects directly the trend of development of the whole city.

2.2 Integration of Systems: The System and Subsystems

The city is a complicated system as a whole. The level of its sustainable efficiency is associated closely to the matching degree of the subsystems, and actual operating efficiency of rail transit system must be dependent on participation and cooperation of other subsystems related to it. In terms of station, the urban space within a certain range around the rail transit station is also a complicated system. In terms of general radiation direction from the station to the gate by centering on the station, the urban space consists of rail transit station system and comprehensive access system, and the efficiency of the comprehensive access systems is critical to integration of the systems.

The comprehensive access system of stations is the spatial carrier of comprehensive access. It is a series of behavior pattern of continual transit within a certain urban space, centering on a station. The behavior pattern includes not only the transfer between two transit tools, but also the mutual transfer between walking and rail transit. Comprehensive access system of higher efficiency is not only the key that determines if rail transit is capable of becoming the principal mode of passenger transit and attracts more people travelling by means of rail transit, but also one of the important bases to realize the integrated development of the urban systems. Moreover, the comprehensive access system consists of multiple subsystems, including the road subsystem, public space subsystem, pedestrian subsystem, etc., and each subsystem can be divided further. Taking the subsystems into integrated consideration is an important aspect to define the radiation space of the station.

2.3 Space-Time Correlation: Time and Space

Time and space are two basic dimensions of operation and development of a city. From the point of process of development and operation of stations of whole rail transit, the radiation space of station changes remarkably before and after the rail transit is put into operation, especially the change of travel mode of people. From the point of daily operation of rail transit, the utilization rate of the radiation space of station changes with various time ranges, such as rush hours and work period. The space is so jam-packed that it is difficult to pass through during rush hours in the morning and evening, while the utilization rate of the space is relatively low during work period.

The radiation space for a station is not homogeneous. Changes in elevation, road features, and the layout of buildings can pose problems for the traditional method of using distance as a way to determine radiation space. The destinations at which the people arrive in the same time are not quite the same. Time is an important factor that affects if people choose rail transit for travel, especially in the city that makes a feature of mountainous region. Therefore, when defining a radiation space influenced by a rail transit station, the time and space shall be taken into consideration correlatively.

2.4 Generation of Concept: Influence and Influence Realm

It is mentioned above that there will be influence of multiple significances after the stations of rail transit is implanted into the existing urban space. In addition to the physical effect based on the scientific relations of “travel modes, behavioral pattern and urban space”, there will also be significant influence at political and economic aspects, typically, the influence on the value of real estate. This paper collates the critical problems in the radiation space of station again on the basis of investigation of previous researchers on the influence degree at different aspects, as well as the concepts brought forward by them, such as the attractive zones and extent of attraction in the ring centering on the station, the radiation area of streams of passengers, final one kilometer, the area influenced by the station, and the accessible range by walking.

From the current status that during the development of rail transit, the stations affect the micro spatial pattern of city and the micro living state of people, three key factors, i.e. urban rail transit stations, urban space, and people can be abstracted by means of analysis and conclusion. Relation between the three key factors is Influences, not just Radiation. Compared with Range, Realm gives emphasis to that the space influenced by a station is taken into consideration as a whole system. Realm is concerned about not only its space and boundary, but also the core element in the system: human behavior. As a result, the concept that influenced urban realm around station is generated naturally. The influenced urban realm around station is an urban space within a certain range centering on a station, in which the station affects human behaviors. It shall be pointed out that this concept is neither a denial of the concepts of previous researchers, nor a new space type. It is an innovation of view point in studying the existing urban space on the basis of previous concepts. As a key node that rail transit is implanted into urban space, such urban space system is the basic link in study of the integration of rail transit and urban space. Its definition in new research background becomes naturally a basis of development of further research.

3 Method to Define the Influenced Urban Realm Around Station

3.1 Theoretical Basis

The influenced urban realm around station is not a new type of space. It is brought forward to facilitate the micro deconstruction of specific regional space from the macro urban view. The theoretical basis to define the influenced urban realm around station, in which SF model and PESASP model are used as its prototype, is established preliminarily by integrating the thoughts to define the influence of multiple significances, integration of systems and time-space correlation, and by discovering deeply advanced theories, such as the transit and transportation science, urban planning science, architecture, geography, sociology, which are closely correlated with the scientific relation of travel modes, behavioral rules and urban space.

Human is the activity entity of the influenced urban realm around station. If viewed from micro level, passengers in the influenced realm around station exhibit various characteristics of walking, e.g. a variety of walking velocity, free walking direction, random walking routine, undefined walking regulation; therefore, complicated and jumbled phenomena are apt to take place. The parameters of social force model by German physical scientist Helbing and Molnar, are most similar to the actual condition of actions of pedestrians, and can describe veraciously the operating rules in the influenced urban realm around station (Helbing and Molnar 1995). Therefore, taking behavior characteristics, space environment and influence mechanism comprehensively into consideration, the social force model becomes the best model to study the influenced urban realm around station with micro perspective.

After the stations of rail transit are implanted into urban space, the influenced urban realm around station becomes, to some extent, an urban development zone under restricted condition of the station. If viewed from micro level, the path of human behavior also exhibits certain centrality because of the influence of the station, which fits basically the path characteristics expressed by DPPA in Program Evaluating the Set of Alternative Sample Paths model (PESASP) developed by Lenntorp (2006). The influenced urban realm of station is the time-space expression of DPPA in city, and the calculation model of the time-space expression of influence of the influenced urban realm of station on the station can also be found in PNA and PPS (Kwan 1999).

3.2 Technical Basis

It is planned to utilize the Pedestrian Microscopic Simulation technology to define preliminarily the influenced urban realm of station, then use Geographic Information System (GIS) technology to correct the result. By taking the conceptual characteristics of the influenced urban realm of station as well as the advantages and disadvantages of different technical platform into consideration, and choosing comprehensively the PMS and GIS technologies, on the basis of SF model and PESASP model.

The influenced urban realm of station is a complex space system, while the mutual influence mechanism among the three entities, i.e. city, human and transit becomes the basis to define the influenced urban realm of station. Pedestrian Microscopic Simulation technology evaluates the influence power of the station by constructing the virtual relation between space and behavior (Liao et al. 2010) (Fig. 5). Technical platforms that are used usually include STEPS, Legion, Vissim, SimWalk, NOMAD, Anylogic, etc. Among them, Anylogic is capable of reflecting truly various factors of walking behavior of pedestrians and mutual influence between pedestrians, so it is the only one commercial simulation software that is able to support the systematic description of the mixing state of continual and discrete behaviors (Chu and Lin 2015). In defining the influenced urban realm of station, Anylogic can simulate comprehensively the diversity and complexity of human behaviors of pedestrians within the influenced urban realm of station, and

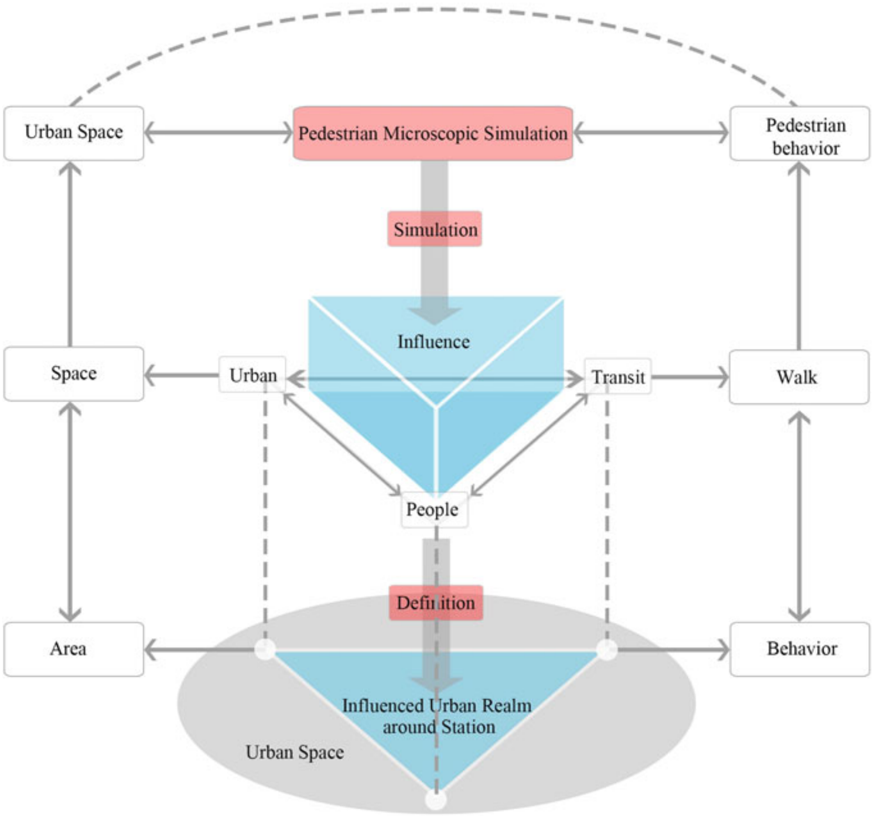

Fig. 5 The definition thought of influenced realm around rail transit station based on Pedestrian Microscopic Simulation (PMS)

can re-organize the modules in accordance with the mode of formation of activity chain of pedestrians and construct the interactive dynamic simulation rapidly within the complicated zone.

The ArcGIS 10, A GIS software platform, released by ESRI, USA, integrates comprehensively the database, software engineering and network technology, and provides users with a completed all-around solution based on GIS system. With continual improvement of geographic information and data, it is possible for ArcGIS to be used in refined micro space analysis at urban design level (Tang and Yang 2012). With the aid of ArcMap software of ArcGIS desktop platform, the user can carry out various analysis at three-dimensional level in accordance with urban space data, such as slope analysis, shortest path, transit cost calculation, etc., while these analysis results are all important factors to define the influenced urban realm around station.

3.3 Definition of Influenced Urban Realm of Station Based on Platform Anylogic and ArcGIS

First, on the basis of Anylogic software platform, taking the influenced urban realm around Zengjiayan Station of Chongqing Rail Transit Line 2 (in China) as an example, the influenced urban realm is defined preliminarily. Basic procedure of the definition includes information acquisition and collation, information input, calculation and simulation, analysis of result, etc. Secondly, the definition shall be inspected and corrected on the basis of ArcGIS platform.

3.3.1 Information Management

Information acquisition is mainly to collect the information of space, pedestrians and transit. With respect to space, field survey is carried out within the influenced urban realm around station to identify the layout of architectures, streets and various facilities. The field survey result is combined with the urban surveying map to determine accurately the urban physical space relation, which is used as the space basis of calculation and simulation. With respect to pedestrians, streams of people coming into and out of the station in unit time is measured in rush hours, off-peak hours, holidays and working days respectively, including the pedestrian flow volume, velocity, path and composition of the pedestrians, etc., which are used as the important behavior parameters in simulation process. With respect to transit, the speed and flow volume of vehicles around the station, as well as the layout of the station shall also be measured, in addition to train departure frequency, quantity and location of entrances and exits of the station, which correlate with the rail transit.

The influenced urban realm of Zengjiayan Station locates on the bank of Jialing River in Yuzhong District, Chongqing (Fig. 6). Residential zones, governmental and commercial offices, architectures of protection of historical and cultural heritage dominate in the influenced realm. There are three exits (entrances) in Zengjiayan Station, which are arranged linearly. Exit A is adjacent to the People's Great Hall of Chongqing, Chongqing People's Square, Chongqing Municipal Government, etc. and also serves for various residential zones and accessorial facilities. There is large flow volume of people and complicated transit condition. Residential zones and sites of cultural relic dominate in the area around Exit C, where the flow volume of people is low, compared with that of Exit A. Exit B has lesser flow volume of people because it is close to Expressway along Jialing River (Figs. 7 and 8).

3.3.2 Information Input

Since the Anylogic pedestrian database is relatively complete, its modeling process becomes more clear. The modeling process consists of the definition of simulation environment and definition of behavior of pedestrians, among which the simulation

Fig. 6 The location of Zengjiayan Station

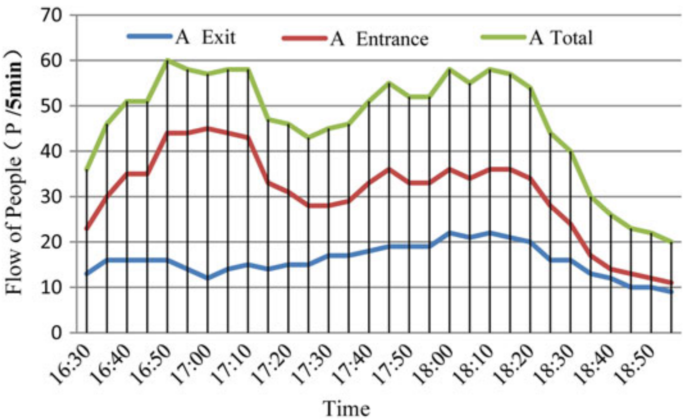

Fig. 7 The flow of people to and from Exit A

environment includes the information of space and transit in last step. Therefore, the information of urban space, behavior rules, transit mode, etc., collected in last step can be input into the software platform (Fig. 9). After the flow volume, velocity, destination of pedestrians and other key data and information are input, a virtual urban space can be constructed on the platform, so that the walking behavior of the pedestrians in virtual space is authentic relatively (Fig. 10).

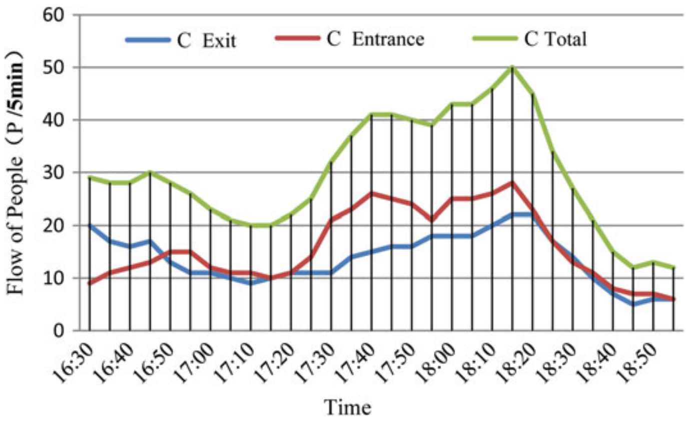

Fig. 8 The flow of people to and from Exit C

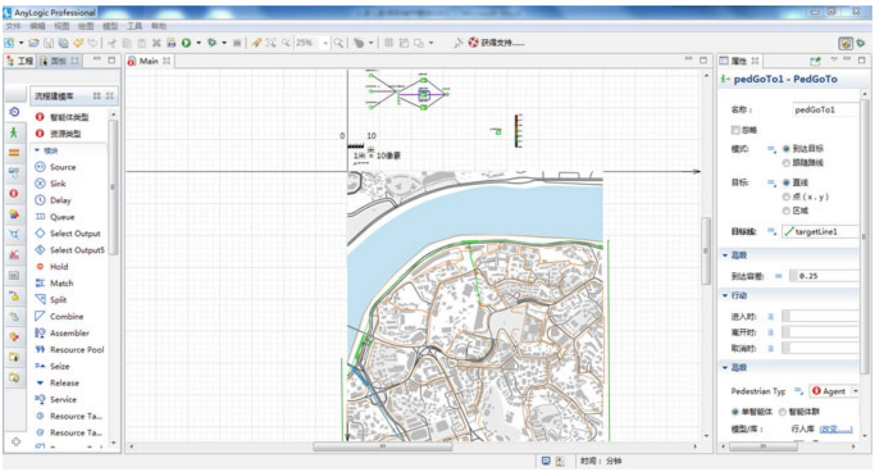

Fig. 9 The operation interface of Anylogic

3.3.3 Calculation and Simulation

After the information is input, the simulation can begin. During the operation, potential path area of the pedestrians at various times, i.e. the accessible urban space, could be observed on the basis of time of walking. Because of the limitation of simulation program, the simulation of gated community or of mechanism is somewhat deficient in authenticity (Fig. 11). Difference between the simulation result and actual state shall be reduced as much as possible by correcting the simulation result according to the actual state of functional layout within the

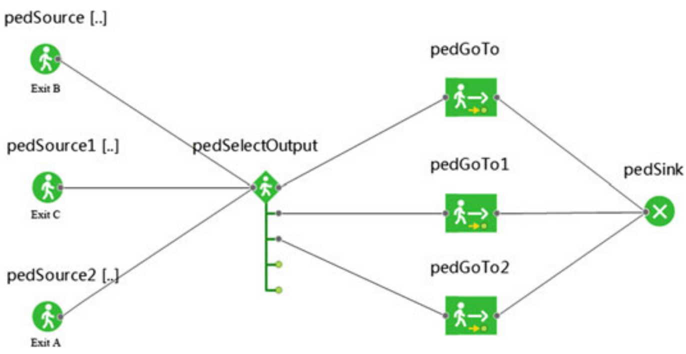

Fig. 10 The virtual simulation frame of walking behavior in Anylogic

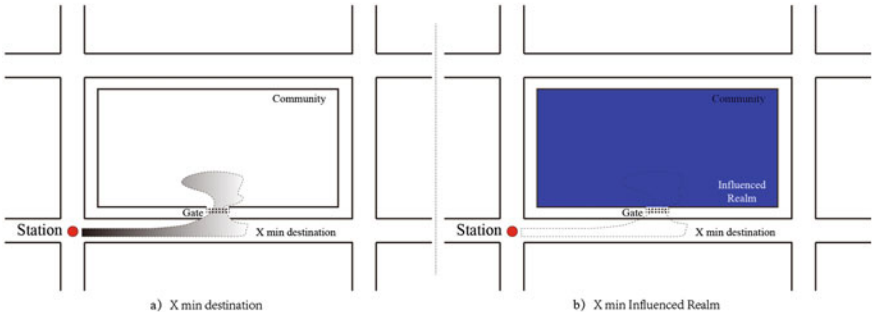

Fig. 11 The correction principle of Anylogic's simulation results

influenced urban realm around station and characteristics of human behavior psychology. The final Anylogic simulation result is shown in the diagram (Fig. 12).

3.3.4 Dimension-Changing Inspection

In order to further improve the accuracy of influenced urban realm around the station, second platform verification is carried out to the Anylogic definition result based on ArcGis platform (Fig. 13). First, ArcMap and ArcCatalog are used to establish the basic geographic database, including buildings, roads, landforms, rail routes and stations that contain vector information, as well as data information of terrain that is exhibited in form of grid. Second, the slope analysis tool in ArcMap space analysis module is used to transfer the dem terrain data into slope grid plan, and Photoshop is used to create the grid plan of spatial information that includes the information of buildings and streets (Fig. 14). Third, on the basis of the walking velocity that is determined in investigation, the zones of various slopes are assigned with corresponding moving cost value (i.e. the time that is spent on passing a unit

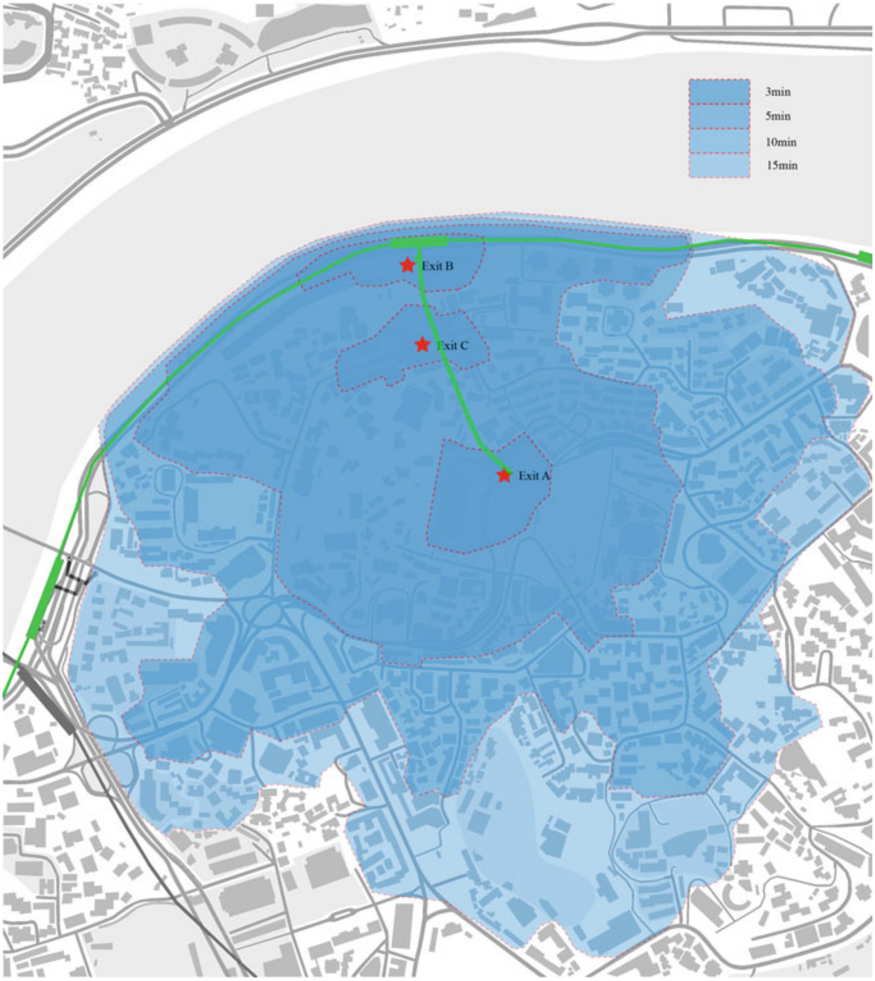

Fig. 12 The simulation results in Anylogic

distance). Similarly, the grid plan of space information is re-categorized, then the re-categorized slope grid plan and space information grid plan are assigned with weight and overlaid, thus to obtain the moving cost grid plan. Finally, a distance cost calculation tool is used to obtain the accumulated cost grid plan on the basis of cost distance grid plan. The accumulated cost grid plan can be visualized further so that it is presented in steps, and the corrected reference diagram of the influenced urban realm around the station is obtained (Fig. 15).

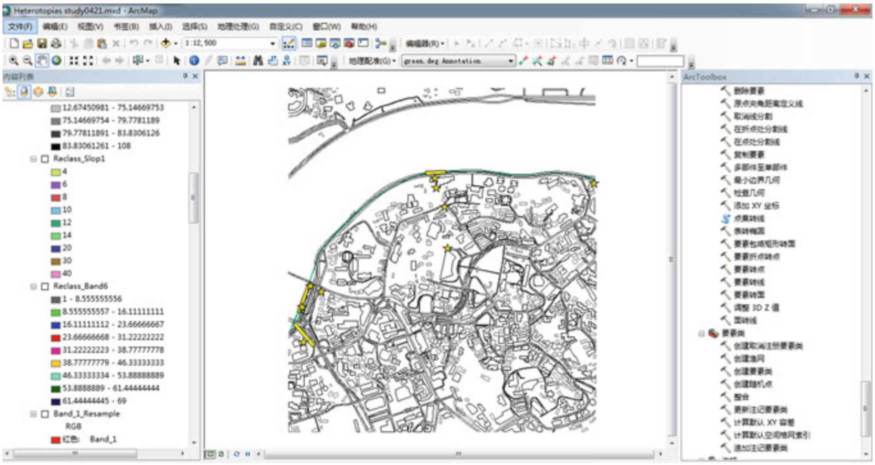

Fig. 13 The operation interface of ArcGIS

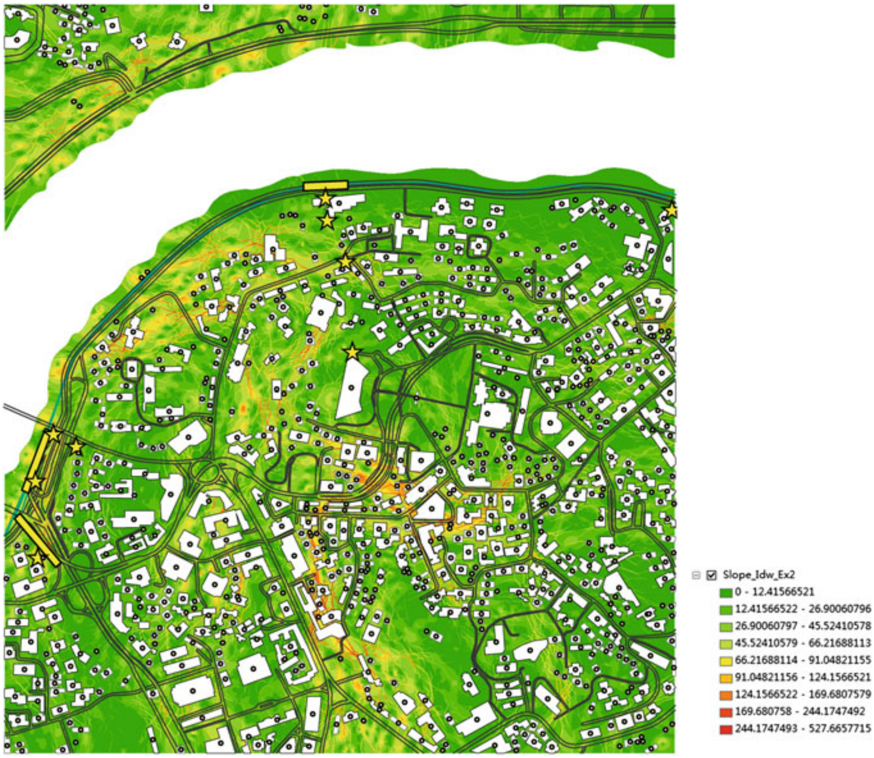

Fig. 14 The slope grid plan

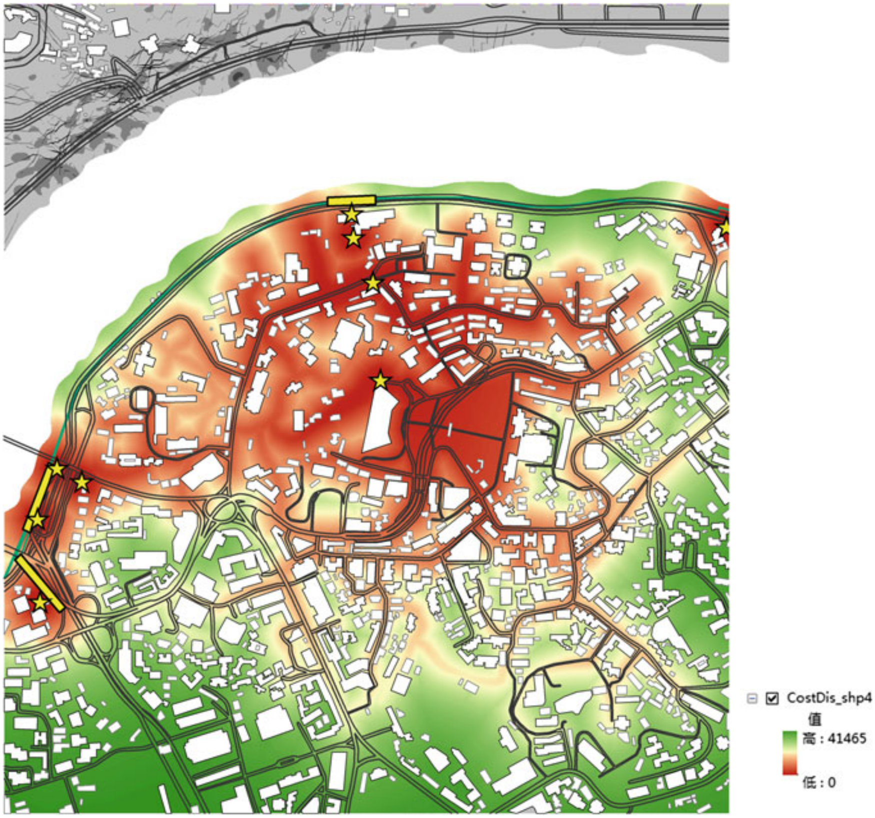

Fig. 15 The corrected reference diagram of the influenced urban realm around the station in ArcGIS

3.3.5 Comprehensive Correction

A city is an integral system even though each rail transit station has its own influence. In order to define the influenced urban realm around station more authentically, the influence generated by adjacent station of the rail transit should also be taken comprehensively into consideration. Therefore, it is largely necessary and more scientific to use the influence power of station represented by ArcGis under angle of view in time geography to correct the influenced urban realm around station defined by Anylogic under micro angle of view. As a result, Fig. 12 is overlaid with Fig. 15 in the study, to take the realm influenced by adjacent stations comprehensively into consideration, to generate the final influenced urban realm around station (Fig. 16). It shall be clarified that the influenced realm cannot be represented by isochronous zones in unit of *min* anyway, it shall be represented in Level 1–Level 4 in unit of m^2.

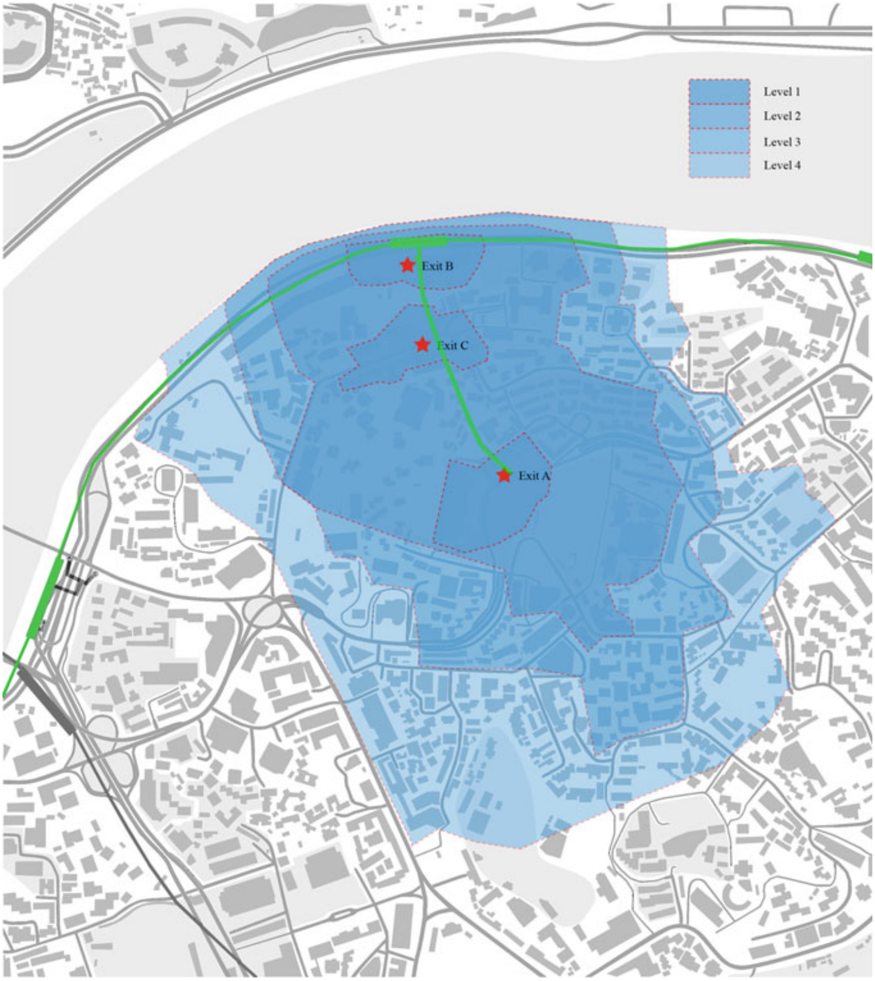

Fig. 16 The influenced urban realm around Zengjiayan station

4 Conclusion

This study summarized the current condition and development background in terms of the definition of radiation range of rail transit station, analyzes the influence of multiple significances, integration of systems, time-space correlation and other characteristics of the zonal space, and brings forward a concept of influenced urban realm around station. Next, the study defined the influenced urban realm around station with the aid of Anylogic platform on the basis of SF model and PESASP model, corrects the defined range based on ArcGis platform, and finally proposes a

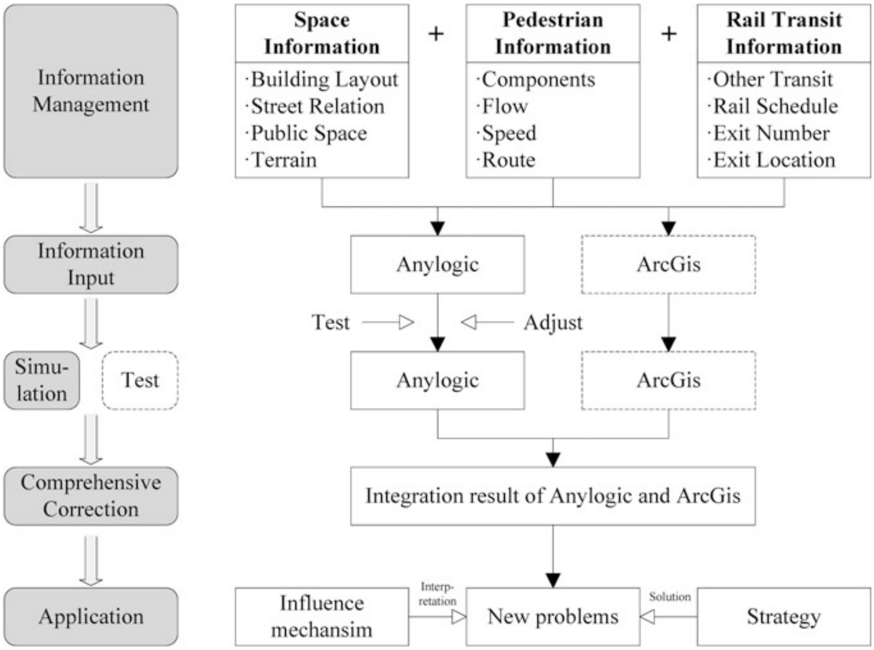

Fig. 17 The theoretical model to define the influenced urban realm around rail transit station on the basis of Anylogic and ArcGis platforms

theoretical model to define the influenced urban realm around rail transit station on the basis of Anylogic and ArcGis platforms (Fig. 17).

The number of stations in China with rail transit access increased by an average of 60 every year since 2000 With rapid construction speed of urban rail transits and increase of stations in many cities, issues caused by the influenced urban realm around station are being highlighted in operation management, transit planning, urban design, traveler behavior, support degree of infrastructures and other aspects. Solving the influenced urban realm around station has become a key to the integrated development of transit and city. The core research output of the study, namely the theoretical model of influenced urban realm around station of urban rail transit is greatly significant and useful to the study of new problem, new phenomena and new laws above-mentioned within the influenced urban realm around station.

Acknowledgments This research was supported by National Natural Science Foundation of China (Project No. 51478055), Foundation and Frontier Research Project of Chongqing (Grant No. cstc2015jcyjA00047) and Chongqing Graduate Student Research Innovation Project (Project No. CYB14016).

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The Optimizing Strategies of Three-Dimensional Walking System in Mountainous Cities: Take Chongqing Yuzhong District for Example

Xiyue Li and Ling Huang

1 Introduction

As the most common mode of transportation, walking bears significant meaning in the daily life, and as an activity it involves other important aspects such as transportation, entertainment, communication, vision and psychology. Therefore, walking space is a rather a complex zone integrating transportation, landscape, and activities, rather than a simple one only for transportation.

In mountainous cities, walking is more convenient than taking cars due to the special terrain, so that people there are more likely to walk for moving around compared with those who live in non-mountainous cities. Provided a social context of improving ecosystem, an increasing number of people nowadays prefer to walk in pursuit of an environment-friendly and low-carbon lifestyle. The terrain in a mountainous city varies sharply with multi-layered landscapes, which suggests a flexible walking space. However, under the city's renovation projects, while motorways and other transportation facilities are greatly improved, the traditional walking space is seriously shrunk as streets and alleys are eroded, a situation which has degraded walking experience. In recent years, this issue draws the attention from the government that has intensified their efforts in improving the walking condition. For example, in Chongqing, the Yuzhong District has built the "Shancheng Trail (the trial in the City of Mountain)," which has become not only

"Twelfth Five Year" National Science and technology support program (2013BAJ10B07).

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_4

the important path for local residents but also an attraction for foreign tourists. Accordingly, studying the three-dimensional walking space in mountainous city can contribute to the optimization of urban transportation system and to a better walking condition for citizens; at the same time, it is also an important component of living environment study.

2 Definitions

2.1 Mountainous City

A mountainous city refers to a city the most part of which is mountainous terrain. As to mountainous terrain, geographically it includes mountains, hills and rugged plateau.

After an extensive study on mountainous cities, Huang (2006) points out that this sort of city can be categorized into two types. One is the city which,despite the elevation, “is built on the bumpy slope whose grades is above 50-degree” (Huang 2006), which has totally different space configuration and natural environment compared with plain cities. And the other type is more generalized, which refers to the “city that, although built on the plain terrain, is considerably affected in terms of urban layout, developmental model and ecological environment by the varied terrain and the natural surroundings” (Huang 2006).

According to Huang (2006), Chongqing is a typical mountainous city with rolling mountains and rugged terrain, and the city has been long renowned as “the City of Mountains”. As a representative of these cities for its distinct geographical condition, Chongqing boasts its own charm and characteristics. And the study on how to exploit these features is gaining currency.

2.2 Walking System

Walking system is a part of transportation system, means all the ways or roads people can use by foot form a system.

Refer to the study about walking system, Wang (2013) said it can be summed up as four aspects: ① research and conclusion about walking system in foreign countries, such as in Germany and in the U.S. city of Minneapolis; ② walking transportation and space; ③ walking space in urban special zone, such as in a commercial district; and ④ walking system planning and design (Wang 2013). According to the study, most literature are talking about plain city, such as Guangzhou, Shenzhen, Xiamen, lacking the walking system in mountainous city, which differ from the plain city. Thus, research the walking system in mountainous city is unique and essential.

2.3 Transportation in the Mountainous City

Compared with the grid structure of the plain city, which features straight lines and a clear direction, the mountainous city has a more complicated network structure which is more three-dimensional. As to the roads, curved lines are the most common due to the limitation imposed by the terrain. For the elevation difference, the city builds more mountain roads along the ridge, which increases the distance between two spots. From the aspect of the road network, it is difficult for the roads in the mountainous city to be integrated as a grid network because of a combination of terrain, large amount of cul-de-sacs, poor inter-connection and few switching points, which also leads to a longer travelling distance.

Besides the complicated network, the transportation in a mountainous city is also more varied and three-dimensional due to its distinct terrain. In terms of the means of transportation, for adapting itself to the geographical division by mountains and rivers, this sort of city has developed some non-conventional means of transportation (i.e., the out-door grand escalator, cable car and cableway, etc.) While in the central area with dense population, walking is always the preference rather than taking cars because of the twisted roads. In Chongqing, for example, three major means of transportation remain the car, the bus, and walking since 2007; walking is still the most dominating means while percentage of car and bus trips remains changed (Chongqing City Comprehensive Traffic Planning Office 2003).

2.4 Three-Dimensional Walking System

Lei (2011) found the three-dimensional walking system is a pedestrian network system which can organize different kinds of pedestrian traffic to different vertical plane, and then use the vertical tool to connect each other, it will not produce interference and increase the traffic capacity (Lei 2011).

2.4.1 Three-Dimensional Urban Zone

The traditional city is laid out on a two-dimensional surface, while this layout now goes against the better using of land resource as well as the realization of urban function since today's cities have a more complicated system of function and have less lands.

It is essential to utilize the urban zone as a whole at various levels in order to exploit the space resource and to establish the innovative three-dimensional structure by means of, for example, enabling the comprehensive switch between means of transportation within the urban system, integrating the transportation routes into a whole network, lifting or sinking urban squares for improving the underground and high-altitude environment, and vertically layering the facilities of construction, transportation and infrastructure.

Due to the terrain, the mountainous city has developed the natural utilization of the three-dimensional space, such as the layered space that is demonstrated in certain architectural forms including "diaojiao" and "xuantiao" (both refer to the wooden house projecting over the water). For a better use of the space resource, it is necessary to optimize the three-dimensional transportation routes.

2.4.2 Three-Dimensional Walking Space

Due to the urban space that is rather vertical and the limitation found in a mountainous region, the walking space is consequently adapted into a three-dimensional one instead of a common plain surface. The three-dimensional walking space refers not only to the pavements stretching upward or mountain roads, but also, more importantly, to the overpasses, mountain paths, and other common pedestrian roads which jointly form an integrated transportation system with diversified means. Combined with the architectures, open spaces and ecological landscapes, the walking space of multi-elements upgrades the psychological experience of the citizens who are walking within the whole system.

3 Analysis on Three-Dimensional Walking System in Mountainous Cities

3.1 Components of Walking System in Mountainous Cities

3.1.1 The Pavements

The pavements refer to the roads on the both sides or one side of motorways and separated by curbs or rails for pedestrians only, which are usually decorated by trees and other plants, and furnished with the infrastructure including dustbins and road lamps. The function of the pavements is designed for a smooth passage, while lack of consideration in terms of comfort and aesthetics.

The pavements in mountainous cities meander along the urban roads, which is commonly flanked by ever-green or deciduous trees such as ficus virenses, ficus microcarpas, gingkoes,cinnamomum camphoras and chinars. Those sidewalk trees which is more liable to be curved form a distinctive landscape to that in plain cities where the tresses are planted in straight lines.

3.1.2 The Pedestrian Zones

The pedestrian zones refer to the pedestrian-dedicated streets in the central area with traffic concentration, as well as to the walking area in the business centers. By design, those zones exclude motor vehicles for prioritizing pedestrians, while setting up the parking lots on periphery. Like the pedestrian zones of Jiefangbei in Chongqing, of Chunxi Road in Chengdu and of Xiajiubu in Guangzhou, those zones are usually the combination of business, entertainment and tourism.

In the past, the pedestrian zones in mountainous cities are plain, while the ones built in recent years are adapted to the terrain and retain the elevation difference. These new zones, like the pedestrian zone of Datidao in Panzhihua, and the Riyueguang Shopping Mall in Chongqing, have broaden the walking experience through making use of the terrain.

3.1.3 The Pedestrian Crossing Facilities

The facilities mainly include overpasses, underpasses and crosswalks in order to keep vehicles and pedestrians on their designated trails.

3.1.4 The Outdoor Escalators

In the area of long slope with high elevation difference and great stream of people, besides the stairs, the outdoor escalators are built as transportation facilities, and the transition terraces are set up at the entrances and exits of the escalators.

3.1.5 The Recreational Trails

The recreational trails generally refer to the urban roads for walking, entertainment, workout and resting. Those trails are commonly decorated by various trees, shrubs and grasslands, and dotted with benches and landscape pieces, which brings beauty and comfort. In mountainous cities, thanks to the natural terrain, the recreational trails can be diversified to a large extent because they can be built into the three-dimensional walking space with varied space configurations and unique characteristics by making good use of the elevation difference. And this sort of walking space is what this thesis studies. Chongqing's Shancheng Trail, for example, is one of the recreational trails in the walking system (Fig. 1).

3.2 The Richness of Three-Dimensional Walking System in Mountainous City

3.2.1 Hierarchy

Hierarchy refers to the pedestrian system break away from the shackle of terrain, transfer disadvantage to advantage, make use of the limited mountainous city space

Fig. 1 Different kinds of trails (*Source* Photograph by author)

in a three-dimensional way. A frequently-used method is arranging different pedestrian flow in a space with diverse height. For example, in commercial area, we use air corridors and distribute the entrance and exit in different layer to connect all the customers. It disperses the stream of people through the space corridor, guide the customers to each entrance-exit in the buildings and the streets, not only ease the traffic pressure on the ground, also increase the shopping mall possible visitors. On one hand, from the visual effect, a space corridor adds to the abundant landscape view. On the other hand, entrance-exit in different layer taking advantage of the height difference and contribute to customer increasing.

3.2.2 Life Feature

The long tortuous street carries the history of a city and shows the daily life of the residents. It is familiar to the mountain cities and its' residents. On both sides of long steps is the residents' homes and shops, if you walk through them, you will meet the dribs and drabs of citizens' life. Hurried pedestrians and residents' life are intertwined, the inadvertently stay may led one to participate in the residents' daily contacts. The ordinary street traffic attribute overlaps the life characteristics, formed a complex space with the milk of human kindness. This is how the life feature in three-dimensional walking system expressed (Fig. 2).

3.2.3 Landscape Values

Most mountain cities possess favorable natural environment, mountains, rivers, canyons all become part of the urban environment. The landscape values of mountainous city walking system is divided into two aspects. On the one hand, the

Fig. 2 Life feature in three-dimensional walking system (*Source* Photograph by author)

pedestrian walkways which near the rivers and mountains can bring about the pleasant feeling, make the pedestrian feel like walking in nature and forget the fatigue. On the other hand, the road over the mountain with natural elevation changes make pedestrians get various points of view and sight. Walking on the road, overlooking the surrounding landscape, finding the trees and mountains sometimes form barriers, sometimes show the distant scenery, at the same time, the ups and downs of the sight lines bringing the variety of landscape experiences. This is how the landscape values in three-dimensional walking system landscape expressed.

3.2.4 Systematisms

Walking occupies a larger proportion of trip mode in mountain cities, the pedestrian system planning has the prominent status. Pedestrian system planning is not simply focused on a single area or business center, nor a simple traffic technical specification, also not only refer to walking road design. It means coordinate regional pedestrian network and environment, combine the public transport system, such as rail system, then carry out the integrated pedestrian system planning. Paying

Table 1 Hierarchy of three-dimensional walking system (*Source* The author draw according to the related information)

Hierarchy	Theoretical support	Elements
First (city)	Urban transportation planning theory, Theory of land use, traffic demand forecast model	The pedestrian system, traffic patterns, searching available mountain, walking route system plan
Second (cluster)	Theory of urban design, landscape ecology, road plan, mountainous city planning principles	In-depth study in each group, relation of walkways and the surrounding space, design of important node of pedestrian system, trails vertical design
Third (joint, centre)	Urban design theory, the landscape planning theory, environmental psychology, theory of public space	Walking system design of public space, Walkways combine with environment and life, the scale and interface control of road parts
Fourth (street)	The theory of landscape design, Street scale theory, community planning theory	Psychological effects of pedestrian system, Guide the residents' green travel

attention to the terrain changing and multi-type traffic intersection is the characteristics of mountainous city three-dimensional walking system. Utilizing this system to give an overall consideration to the whole area traffic function and integrate the pedestrian and cars.

On the basis of scale, three-dimensional walking systematisms could be divided into three hierarchy (Table 1).

4 Inspiration from Case Study and Field Research—Central Hong Kong and the Mountain Trails

4.1 Similar Background

4.1.1 Topographic Condition

Hong Kong is located in Lingnan (South of the Five Ridges) foothill zone, the continuous rolling mountains occupied the entire region, only a small amount of land for urban land.[1] Chongqing has various changing terrain and obvious layered landform. The main landscape of Chongqing is mountains and hills which is similar to Hong Kong's terrain.

[1]Surveying and Mapping Lands Department: Hong Kong's geographical information.

4.1.2 Density

Hong Kong's population density increased every year, according to the official data, it points out that in 2011, Hong Kong's population density ranked third in the world. Until mid-2014, Hong Kong's population is about 7234,800, increased 47,300 compare to same period in 2013. Furthermore, compared with the mid 2004, it increased 451,300.[2] Most Hong Kong people live in tall buildings during recent decades. The residential buildings reach 30 to 40 layers above, part of them even up to 70 layers, and commercial building can reach about 100 layers. Moreover, the space which a ordinary family of four normally live or own is from 400 to 400 square feet (about 37.2 to 74.3 m^2). Thus, Hong Kong with high population density still remains largely untapped land at the same time.

Statistics (2015) suggest that Chongqing's total urban and rural population within the municipal boundary is 28,846,200, ranked 1st among cities in China.[3] Yuzhong District has the highest density compare with the other districts. Therefore, experience from Hong Kong is constructive.

4.2 Three-Dimensional Walking System of Central Hong Kong

4.2.1 Overview

Due to the Hong Kong's high density of population, and the limited land resources in central region, such as Central Hong Kong, This current situation makes the promotion of the pedestrian traffic become inevitable in Central.

Three-dimensional trails became part of the urban public space in Hong Kong, it is formed by space corridor outside building, underground walkways, ground streets and public channel inside the building. Furthermore, "a tile covered" three-dimensional trail system connects residential district, office, business area, shopping mall, recreation facilities and so on. Therefore, citizen can reach every corner of the city without weather interference and live a convenient life.

The Hong Kong Central walking system present stacked layers, which includes pedestrian streets, sidewalks, Bridges, underground walkways, pocket park, garden platform, shared lobby in building, roof garden, etc. All these factors connected and superposed to build the three dimensional network (Guo and Hou 2011). The network's most distinct character is highly cascading, which involves bridge, corridor, lobby, roof garden, rooftop square. The other character is the complete barrier-free facilities and walkers for the disabled and baby stroller. In addition, the

[2]Population Numbers in 2014 years. The census and statistics department. On August 12, 2014.
[3]National Bureau of Statistics of China. January, 2015 (Fig. 3).

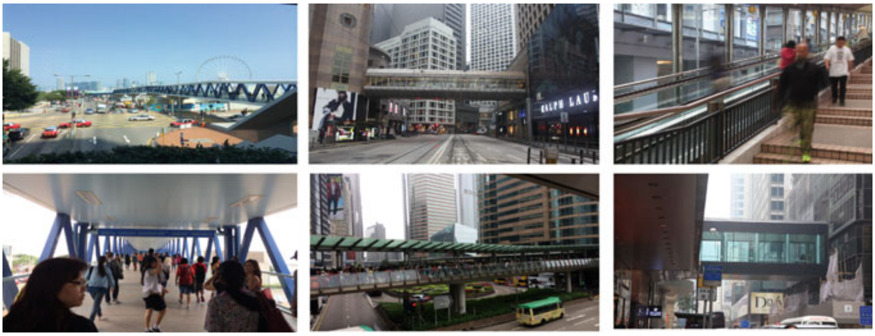


Fig. 3 Different types of the Hong Kong central walking system (*Source* Photograph by author)

network shows a strong public openness, allows all social hierarchy gather on the bridge or other place for leisure activities or rallies (Fig. 3).

4.2.2 Significance

The Central Hong Kong walking system is highly networked, connected, reachable, multilayer, sheltered, humanized, it also meets the requirement of delightful living, However, the deficiency is the huge-scale walking system has negative impact on urban landscape. The Central owns the advantages of mountain and water surrounded, however, the huge-scale three-dimensional traffic facilities cut the trails which originally linked to the harbor, make the natural geographic advantages buried. Therefore, city planners should aim to make better use of the local geographical characteristics in other mountainous cities' walking system planning.

4.3 Field Research of the Mountain Trails Zangjiahuayuan Part

4.3.1 Overview

The field research object is the Third Mountain Trail, which located in Yuzhong District of Chongqing. It begins from the Jialing River's riverside road, by way of the Daxigou light rail station, Renhe Street, Pipa Mountain, Yanzi Cliff, then arrive the back door of the Coral Park. This trail is 3.9 km long, 2–5 m wide, built around the mountains' ups and downs, the altitude difference is more than 170 m. Among this trail, the Zhangjiahuayuan Part is about 100 m long, 3–4 m wide, the elevation difference is about 20 m. Along the both sides of Zhangjiahuayuan Part is residential area, present strong traffic function and life feature (Fig. 4).

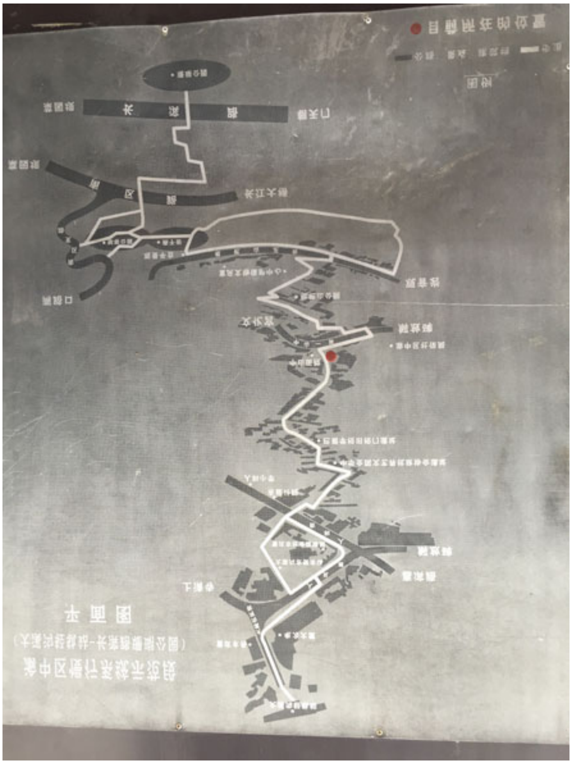


Fig. 4 The guide map of research object (*Source* Photograph by author)

4.3.2 Activity Analysis

The activity types on this trail can be summarized to: get through, chat, fitness, leisure and recreation, dining. The activity time distribution are different according to the different sort of activities. In the afternoon and evening, activity types change based on time of day in part because the age of the users changes. The crowd's favorite place are space near the building wall, space under the tree and the corner space.

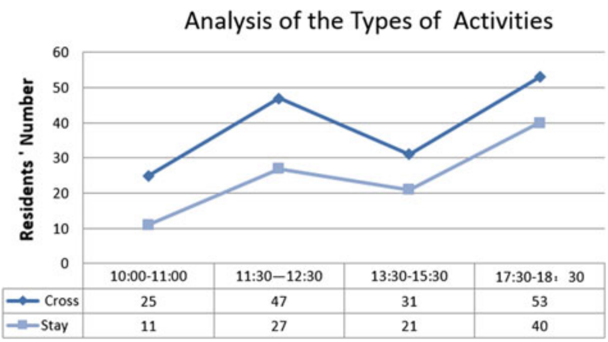


Table 2 Residents' activity types and numbers during different time (*Source* Draw by author)

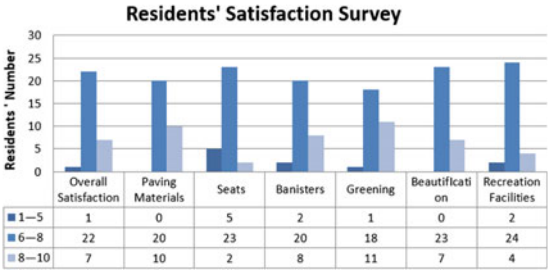


Table 3 Residents' satisfaction survey about the facilities (*Source* Draw by author)

Time	Activity types	Number	Activity types	People types	Number
10.00–11:00	Get through	25	Chat, walk the dog	The elderly	11
11:30–12.30	Get through	47	Dinning, chat	The elderly, the young and middle-aged	27
13:30–15:30	Get through	31	Chat, exercise, reading	The elderly	21
17:30–18:30	Get through	53	Walk the dog, dinning	The elderly, the kids, the young and middle-aged	40

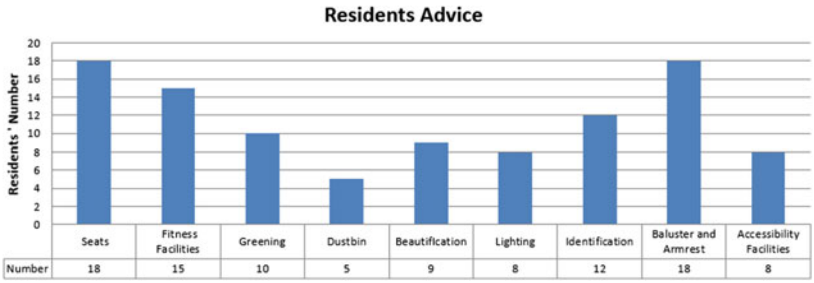
4.3.3 Satisfaction Survey

Through the observation and interview,the findings suggest the primary users of the trail are the surrounding residents. The majority number of permeants are young and middle-aged workers, while the majority who stay at this trail are is elderly, followed by the children. When it comes to the satisfaction, the overall is above the average, but for the satisfaction of different aspects, such as facilities, landscaping, styles, came out various. On the basis of questionnaire research, grade can be concluded that the pavement, green have the highest satisfaction, the seats get the lowest satisfaction (Tables 2, 3 and 4).

4.3.4 Significance

People in different areas and times showed various interests even in the same trail, we should take the citizen's willing into account.

Table 4 Residents' advice about the facilities (*Source* Draw by author)



The most essential city furniture is the seat and baluster, suggest the demand of safety and rest area. For greening, people may not show enough concerns as the designers used to think.

4.4 Inspiration

From the Center Hong Kong case and Zhangjiahuayuan Part field research, it can be concluded that the main propose of walking system design is to satisfy the different needs of various citizens. To reach this goal, multiple expression of walking system and humanization design are necessary.

5 The Optimizing Strategies for Design: Take Chongqing Yuzhong District Mountain Trails for Example

5.1 Strengthen the Three-Dimensional Walking System Network Construction

5.1.1 Effective Connectivity

The precondition of walking system's space efficiency is the high connectivity. First of all, it solves the whole area's walking road connectivity. Secondly, it solves the connection between building's different elevation layer and ground. Take Yuzhong district for example, the streets system has a long history which own the rich traditional space element. After years of development, these streets adapted to Chongqing's terrain changes and become shortcuts which connect the up-down platform. However, due to the vehicles increasing and the rapid development of vehicular road, the streets were intercepted, occupied, even disappeared. Now we have to restore and strengthen its connectivity through the way adding the pedestrian overcrossing, underground crossing trails.

The Yuzhong district mountain trails aiming to complete walking 12 routes in the north-south corridors, 5 routes in the east-west corridors, and one riverside road circuit, make it a comprehensive walking network which connect the whole district. When making the walking system planning, it should be considered that the walking trails may link to bridges and rails, so people can transfer though these trails and stations. It means the plans for walking trails should make a whole arrangement about the main traffic conversion nodes to link the city, not only form in internal network in each area.

5.1.2 Urban Functions Correspond with Walking System

Once the mountain trail was the historical records of citizen life. In the current situation, under the background of urban high density development and mixed land use, the diversity of the urban function is increasingly obvious. The piece in the walking system should be able to meet the diverse needs of pedestrians. Make trails, bridges, parks and squares highly connected, and tight the public space and commercial building together to create a three-dimensional network with multiple functions. For example, the Third Mountain Trail connects the Coral Park, South Park and Pipashan Park. The trail meets the needs of transportation, recreation, business, while the three parks add color to this trail.

5.1.3 Unite the Rail Transit and Pedestrian Traffic

Trails as an essential part of three-dimensional transportation, also should be considered its integration with other methods of transportation. At present, Chongqing is constructing the rail transit on a large scale. If the rail and the trail are combined and are connected to the public life, it can reduce car demand to a certain extent, then provide a low carbon, green pedestrian network. Furthermore, from the aspect of users, walking on Mountain Trails is feeling the city on feet, experiencing the three-dimensional space, taking rail transit is overlooking the mountainous city, feeling the changing space. The combination of these two means of transportation can form the abundant spatial experience with changing rhythm.

5.2 Strengthen the Identifiability of Three-Dimensional Walking System

5.2.1 Combine with Regional Culture

Urban space is the carrier of regional culture. As for Chongqing, the three-dimensional walking system is the prominent manifestation of local culture.

Fig. 5 Embossment along mountain trail (*Source* Photograph by author)

Therefore, excavating the cultural elements and exhibiting them is the significant part of optimizing strategy. It is also important for city planners to pay attention to the historical landmark along the trail or show some historical stories only reflect the regional culture superficially, while focus on the three-dimensional walking space combined with the continuation inheritance of residents traditional life make a profound expression of regional culture (Fig. 5).

The cliff walkway, stairway, and eaves gallery are apparent manifestation of the three-dimensional walking space. Inserting some sculptures and landscape walls to express the historical events is a common way to reappear the culture. Using the traditional local paving type and pattern are also appropriate to perform the details.

5.2.2 Ecology Landscape Unite with Pedestrian Space

Chongqing is a mountainous and waterish city where the residents live and walk in encircled landscape. There are two main aspects of how to strengthen the trails' conjunction with landscape. On the one hand, using of mountains, rivers, streams, and beaches to connect with important ecological corridor, and set the trails in them simultaneously. On the other hand, set more observation decks at the vertices, let the pedestrian able to overlook mountains, rivers and lush green landscapes by the up or down sightlines. In addition, the buildings and vegetation on both sides of walkways, should have the sense of rhythm, which means the pedestrian can feel the changes of plants. Meanwhile, let the pedestrian experience suddenly expanse and dramatic psychological change in the corner can create an entertaining atmosphere (Fig. 6).

Fig. 6 Overlook on the mountain trail (*Source* Photograph by author)

5.2.3 Improve the Sign System Construction

Strong identifiability can make people gain a sense of place when they walk in the complicated winding streets in Yuzhong District, and it also help to clearly distinguish the difference of public area and private area. So as to define a clear code of conduct and suggest safe walking environment, it should include several identifiable elements, such as entrance marks, recognizable material that lay the ground, unified modelling of lamps and colors, and consolidated urban furniture, etc. On this basis, the sign system should be regular maintained, inspected and managed. Currently there is no unified style in Yuzhong District, where the performance is unclear because the entrance logo and signs are damaged (Fig. 7).

Fig. 7 Some signs were destroyed in mountain trial (*Source* Photograph by author)

5.3 Humanization Design

Humanization design refers to the consideration of the user, the people, before providing the design service and facilities. It should be fully considered that the demand of human nature, the difference of the human weakness, and human naturally self-protection consciousness. Then it can led to a satisfied, comfortable and dignified user experience (Xie 2001).

5.3.1 Communication Combine with Environment

Life feature of trails embodied in the complicated interpersonal communication. A building's attractive stopping points which suitable for people to stay, can help to improve the residents' contact possibility and add vitality. In order to attract people, planning professionals should be familiar with the citizens' activities of time, type, and preferences. Hence one can see that the quality of trail space is not connected with the number of people who cross the place, but is determined by the duration of stay behavior.

5.3.2 Barrier-Free Design

Planners should consider barrier-free design as a way to better accommodate an aging population. Especially for a complicated terrain and elevation difference city like Chongqing, it need to take barrier-free facilities design into account during the construction of trails, such as the kerb ramp, wheelchair ramps, double rails railing, vertical elevator, etc.

5.3.3 The Urban Furniture—Public Facilities

A humanized space should be people-oriented, meet the need of pedestrian safety, comfort, convenience. First, the appearance of public facilities (e.g., lighting facilities, trash cans, chairs, etc.) should have a consistent color and style. Second, combine the specific site conditions to make appropriate changes about these facilities. Based on the survey, the residents' age, occupation distribution, transportation method, activity preference in different regional show diversities, it comes out that the attraction gap in different sections is obvious. Third, carrying out the in accordance with the average number is dull, blind and wasteful. Thus, it is essential to make the facility plan meet the needs of the public it intends to serve.

6 Conclusion

The unique topography landforms and rich spatial structure determine the significant position and the advantage of walking in the mountainous city. After years of evolution, the topography formed a unique street space with strong connectivity. In the years of rapid development, the built environment has been planned around the automobile. Thus, we should reconstruct the street system to reflect the regional characteristic, and create a mountainous city three-dimensional walking system which contains multilevel, life feature, systemic network, and delightful landscape, to make the city more humanization. After studying the walking system in highly developed city—Hong Kong, which own the similar geographic conditions with Chongqing, we propose the optimization design strategy of the walking system. In addition, the filed research has been conducted to investigate the Chongqing Yuzhong District. After that, it is concluded that the key point of building the three-dimensional walking system is the systematisms, accessibility, identification, humanization, and create the diverse, affluent, pleasant, convenient, cultural three-dimensional walking system with local characteristics.

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A Study on Urban Spatial Structure in the Context of the Jobs-Housing Balance: A Case of Suzhou, China

Zhenlong Zhang

1 Introduction

Reducing the number of trips and the length of travel is an important objective in the movement towards sustainable development—an important subject in urban planning. In the pursuit of less travel and shorter travel distance, local governments try to achieve a jobs-housing balance (Cervero 1991). After the World War II, Western countries entered a high-speed development period. The economy and population developed rapidly in many large cities, which brought many problems to the environment, management and other aspects of city life. This idea grew to have a significant impact on city planning. In North America, the discussion and practice of the job-housing balance has persisted in urban planning. After the 1980s, traffic congestion problems caused by suburbanization in the United States has become increasingly serious; the jobs housing balance was introduced into developing policies as an important way to solve urban traffic problems (Meng et al. 2009). From planning theory and practice, policy makers and scholars have triggered a heated discussion from different perspectives.

With the market-oriented reform, the built area of Chinese cities expanded rapidly in the last 20 years. Nowadays many big cities are facing similar problems such as the separation of employment and living space and increasing traffic congestion and air pollution. The research on job-housing balance in China started at the beginning of the 20th century and mainly focuses on the large cities such as Beijing, Shanghai, Guangzhou, and Wuhan, etc. Some scholars have studied its impact on residents' travel and the spatial structure of population and employment (Zhou and Yan 2006; Sun et al. 2012). Some scholars have analyzed the influence of a job-housing balance on commuters such as using the jobs-housing balance index and statistical methods to

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_5

examine the major factors of commute efficiency (Sun et al. 2008; Zhou et al. 2013). Some scholars examine the separation of jobs and housing by analyzing the jobs-housing spatial organization in commuting characteristics, the spatial match of jobs and housing, job-housing distance, employment accessibility, (Liu et al. 2009) and exploring the differences caused by the social and economic attributes of residents, community types and other impact factors (Meng 2009). There are also scholars who study the difference and the complexity of residents commuting behavior at the individual level (Chai et al. 2013). Other scholars use Geographic Information System (GIS) technology and a large number of survey data to propose the idea of city spatial development characteristics and optimization of the urban spatial structure on the perspective of the job-housing balance (Hu et al. 2013). Since the majority of cities in China do not have conventional commuting investigations, research is mostly based on survey data in individual cities. It is quite difficult to compare the results of different cities.

This paper studies the spatial structure of the job-housing balance in Suzhou City, in order to provide a reference for urban planning and urban spatial optimization in this city.

2 Methods and Data

2.1 Spatial Unit of Measure

The issues of the job-housing balance should be analyzed at a certain geographical scale. Different results can be obtained due to different scales. Thus, the geographic scale is an important factor of measurement. Generally speaking, the bigger the geographical scale is, the higher the balance of job housing should be, vice versa. Some scholars classify these geographical scales into three different levels: macro, middle and micro (Peng 1997). The macro level refers to the larger administrative unit. At this level, the quality of balance is generally higher. However, because of the geographical range, even though jobs and housing keep in relative balance, the actual commuting distance may be very far. Therefore, macro analysis results have great limitations for planning policy. Most of the research concentrates on the middle or micro level. Middle level usually refers to the scope of street/town level. In China, the street is the lowest and smallest unit of administrative management. In addition, the statistical data at this level is complete and available, so it is convenient for the comparative study of different regions and cities. However there is also a downside to the study of this level. In most cities, there are large differences between the streets in downtown and the fringe in both population and area, which may impact the results. The micro level refers to the community, census area, or traffic statistical area. On this level, the better balance of jobs and housing can reduce commuting distance to a great extent, but sometimes even the commuting distance across an administrative range is not very far. What's more, the dynamic range is also commonly used at this scale, which is defined as an area including a given residence or employment center and the area in a reasonable commuting radius around it. The range of "reasonable" is a subjective judgment. Based on research in a different city, some scholars have summarized different reasonable radii, and other scholars have considered the average commuting distance as a reasonable commuting distance. In fact, population density, employment density and average commuting distance in different streets of the city are quite different. Therefore, reasonable commuting distance can be different according to varied locations in a city.

2.2 Measure Indicators

1. Balance index.

At a certain spatial scale, the degree of job-housing balance can be measured by the relevant index. The most common index is the ratio of the number of employment and family, which is the ratio of jobs and families in a geographic unit (Sun et al. 2008). However, the index has an assumption: there is only one employed person per household in a study area. When the jobs housing ratio is equal to 1, the region is at an absolute balance. If the ratios are above 1 or below 1, it means that the region is in a state of imbalance. Since absolute balance does not exist, Cervero (1991) thought that the ratio between 0.8–1.2 is considered at a balanced state. In practice, the employment structures in Chinese urban families have changed–there are more dual earner households, which have a great impact on the jobs-housing ratio. In this research we use the ratio of total employment and the employed population as the balance index, as follows:

$$\mathrm{WRi} = \mathrm{Wi}/\mathrm{Ri} \tag{1}$$

Wi refers to the number of jobs in region *i*, while *Ri* refers to the number of the employed population in this region. In theory, when this ratio is close to 1, it shows that residence and employment are in relative balance. When the ratio is more than 1 or less than 1, it shows that jobs and housing are at an imbalance. According to the related literature, when the index ratio is more than 1.2, the area is employment-oriented. When the index is less than 0.8, it is residential-oriented. If the index is between 0.8 and 1.2, it is a relatively balanced region. In addition, there is also research that puts balance boundaries between 1.25 and 0.75.

2. Independent index

The advantage of the job-housing ratio is its simplicity in practice. It is easy to acquire data, and control the implementation of the policy. However, when the ratio closes to 1, it only shows that there is a possibility of balance between job and housing in this area. The possibility is determined by the proportion of local residents working in this unit (Deakin 1989). Even if the number indicates employment and living are balanced, it cannot guarantee that the employees in a geographical unit live inside this unit. Therefore, the job-housing balance usually includes a further Independent index measurement. The Independent index refers to the degree of the balance between housing and employment in a spatial unit However, when the residents' jobs are not in the same administrative area, it does not necessarily mean that the jobs are far away from the home. It is very common that the home and workplace are adjacent different administrative boundaries. Conversely, when residents and jobs are in the same district, it also does not mean that the distance between them is short. Therefore it is common to choose the elastic travel radius as the spatial measure unit. The independent index is defined as the ratio of the employed population whose commuter distance is lower than the average total employed population in a geographical unit (Hu et al. 2013):

$$\mathrm{XRi} = \mathrm{Xi}/\mathrm{Ri} \tag{2}$$

Xi refers to the population whose commuter distance is lower than the average in unit *i*, while *Ri* refers to the total employment population within unit *i*–the higher the index, the better the balance between housing and employment in the unit *i*.

2.2.1 Average Commuting Distance And Commuting Time

The fundamental objective of the jobs-housing balance is to pursue shorter commuting distance and less commuting time. Therefore, on the basis of the two job housing balance indices above, we add commuting distance and the commuting time to measure the job-housing balance.

2.3 *Study Area and Data*

2.3.1 Study Area

Suzhou was listed into the first group of the national famous historical and cultural cities. It is also one of the most important central cities of the Yangtze River Delta. There are 6 districts within the city boundary. The total area of the city is 8488, 2743 km^2 of which is the urban area is (including the Wujiang District 1176 km^2). By the end of 2012, the population of the urban area was 5.45 million. In 2012, the city's GDP was 1.2 trillion yuan; total economic output was ranked sixth in the country, and was second only to Shanghai in the Yangtze River Delta. What's more, its total industrial output value is 3.45 trillion yuan, second only to Shanghai, and ranks second across the country (shown in Fig. 1).

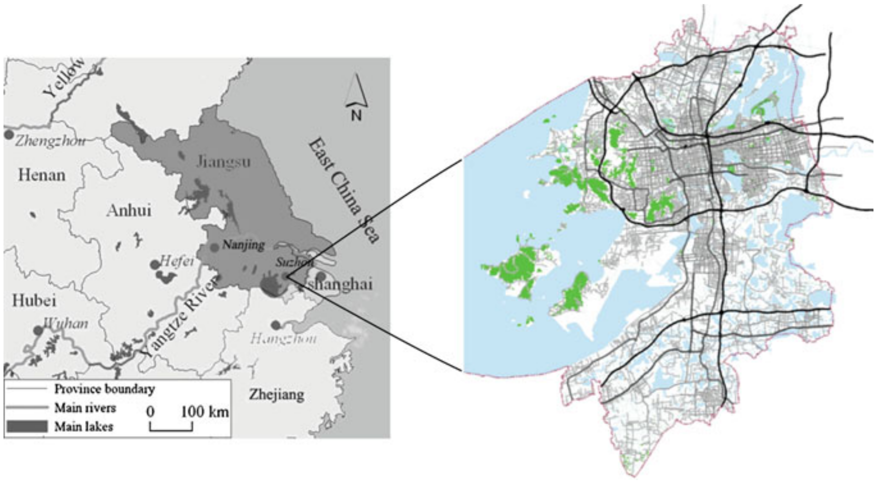

Fig. 1 The site of Suzhou city

This study analyzes the spatial characteristics of the jobs-housing balance in different spatial scales in Suzhou city. The spatial scale is divided into the district scale and the street scale. In the district scale, Suzhou is divided into six administrative units, including the Gusu District, Wuzhong District, Xiangcheng District, Suzhou New District (Gaoxinqu, SND), Suzhou Industrial Park (Gongyeyuanqu, SIP) and Wujiang District. Job-housing self-sufficiency is measured by the dynamic spatial unit, consisting of a radius of the average commuting distance in a certain unit.

2.3.2 Study Data

The study data includes two pieces: the statistical data and the survey data. Statistical data includes the working-age population in "the sixth national Census" data (20–59 years) and the number of jobs in the second economic census data for each street. We try to use these statistics to measure the balance between jobs and housing. The survey data is from the resident trip survey done in Suzhou City in June 2012. We use this data to analyze the balance index, self-sufficiency, commuting distance and commuting time. The questionnaire covered the 6 districts in Suzhou city. We issued 2000 questionnaires, and 1925 questionnaires were returned, of which 1740 questionnaires are valid, with an effective response rate of 87 %. In order to meet the needs of the study, we exclude the commuting behavior of students, the unemployed, retired, leisure and other samples. This left 746 effective samples.

3 The Job and Housing Spatial Characteristics at the District Level

3.1 General Spatial Characteristics of Job Housing Balance

According to the data from the second economic census of Suzhou in 2008, there are 27.83 million jobs in Suzhou city in 2008. The working age population is 3.70 million, according to "the national sixth Census" in 2010. The overall urban jobs-housing ratio in Suzhou is 0.75, and the independence index is 0.63. The average commuting distance is 9.6 km and the average commuting time is 26 min. Compared to other cities, Suzhou is lower than Beijing and Shanghai whose average commuting times are 52 and 47 min, respectively, and higher than Wuhan whose average commuting distance is 6.3 km and commuting time is 25.9 min. According to the analysis of distribution of the employment commuting time in all districts, there are about 32 % of the residents whose commuting distances are more than the average number.

3.1.1 Job Housing Space Characteristics

On the district level, the spatial difference of jobs and housing is obvious. The spatial layout of imbalance in Suzhou may aggravate the increase of commuting time and distance, and reduce the spatial performance of the city.

Balance index. On the district level, the highest job-housing ratio index is 1.26 in the SIP, which is much higher than the average value of 0.75 in Suzhou. SIP represents an employment-oriented district. SND and the Wujiang District are 0.94 and 0.75, respectively, representing job-housing balanced districts. The balance index of Gusu District, Wuzhong District and Xiangcheng District are 0.55, 0.59 and 0.67, which are lower than the average values, representing a residential-oriented district.

3.1.2 Commuting Distance and Commuting Time

In regards to commuting distance, the commuting distances of SIP and SND is longer than other districts, being 12 and 13.4 km, respectively. Since the two districts are located on the East and West sides of Suzhou City, respectively, the main commuting direction in Suzhou is neither east nor west. The average commuting distance in the Wuzhong District is 10.5 km. The commuting distances of the above three districts are higher than the average value of 9.6 km in Suzhou City. The commuting distance of SND, Xiangcheng District and Wujiang District, are 8.4, 9 and 7.8 km respectively, which are lower than the average level. With respect to city spatial structure, Wujiang District is independent from the main area of Suzhou. In the Wujiang district, most of the traffic commuting is inside the district,

Table 1 Jobs housing balance indexes in districts of Suzhou City

Space division	Jobs (ten thousand)	Employment (ten thousand)	Balance index	Average commuting distance (km)	Average commuting time (min)
Gusu district	35.85	64.77	0.55	8.4	25.1
Wuzhong district	48.98	83.24	0.59	10.5	24.7
Xiangcheng district	33.42	49.63	0.67	9.0	28.1
Suzhou Industrial Park (SIP)	56.18	44.56	1.26	12.0	29.1
Suzhou New District (SND)	37.91	40.19	0.94	13.4	27.5
Wujiang district	65.97	88.08	0.75	7.8	19.9

so the distance is the shortest. The employment-oriented districts will have a longer commuting distance, while the living oriented districts will have a relatively short commuting distance (Table 1).

With regards to commuting time, there is a relatively longer commuting time in SIP, Xiangcheng District and SND, which are 29.1, 28.1 and 27.5 min, respectively, whereas the commuting time in Gusu District and Wuzhong District is 25.1 and 24.7 min, respectively. The commuting time in Xiangcheng District is relatively longer, although there is a shorter commuting distance. This illustrates that the commuting efficiency in this district still needs to be improved. In Wujiang District, the commuting time is the shortest, which is 19.9 min, but the commuting *distance* is not the shortest, which shows the relative independence of urban structure.

4 The Jobs-Housing Spatial Characteristics at the Street Level

At the street level, the spatial difference of employment and living in Suzhou is more obvious. The job-housing layout in Suzhou does not keep in balance.

4.1 Balance Index

According to the balance index, the streets are divided into five types: residential streets, residential oriented streets, job-housing balanced streets, employment-oriented streets, and employed streets. The highest balance index is 2.43 in the Shuangta street, Gusu district. The second-highest is Shishan Street in SND at 1.77. Guanqian Street in Gusu District, the Xiangcheng Development Zone, and Loufeng Street in SIP also have relatively high balance indices, and have become the employment center as they are employment-oriented streets. The relatively balanced streets are Youxin street, Sujin street, Fengmen street, and Loumen street in the Gusu District—they have lower balance indices, which form denser residential areas, and are called residential streets. Canglang Street, Pingjiang Street, and SuYuan Street in the Gusu District, Fengqiao Street in SND, the Wujiang Economic and Technological Development Zone, Tongli Town, FenHu Town, Pingwang Town in the Wujiang District and the Huangqiao Street in the Xiangcheng District are job-housing balanced streets. The remaining streets are the other two types, which are employed streets and residential-oriented streets (Fig. 2a).

4.2 *Independent Index*

With the independent index, the spatial distribution forms a circular structure, namely the streets in the city center have a higher index, and successively reduce outwards. It is quite different from the balance index in urban areas. Because of the isolation of the downtown of Suzhou, the independence index of the Wujiang District is obviously independently distributed (Fig. 2b). Xujiang Street, North Street, Youxin Street, Changqiao Street are a little higher in the self-sufficiency index, which means employment is relatively close to residential. In addition,

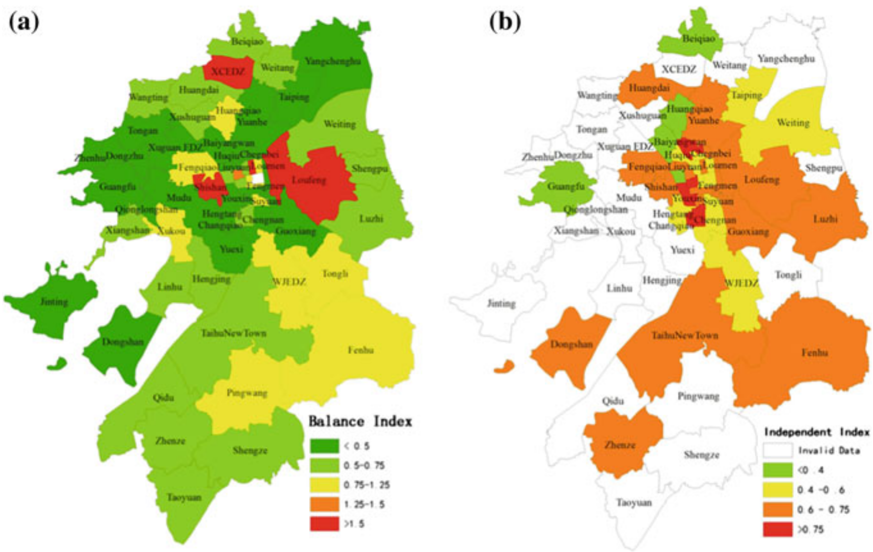

Fig. 2 Balance index (**a**) and independent index (**b**) at the street level

another street in the Gusu District, SIP, the street near the center of SND and the parts of Wuzhong District and Xiangcheng District are in the better self-sufficiency level. However, in the districts far away from the city center such as Beiqiao Street, Huangqiao Street, Baiyangwang Street, Guangfu Town and other outer districts, the Independent index is the lowest. It shows that the job and housing are obviously imbalanced in outer city areas.

5 Commuting Distance and Commuting Time

Measuring the commuting distance of all the streets in Suzhou, apart from the certain independent spatial structure in the Wujiang District, shows circular characteristics: the commuting distance increases from the city center to the periphery of city (Fig. 3). Firstly, the streets whose commuting distances are less than 5 km include Hengtang Street, Shilu Street, Huangqiao Street, Taihu metro, and Tongli town, accounting for 9.6 % of the streets involved in the statistical analysis. Then, there are 18 streets whose commuting distances are 5–10 km, accounting for 34.6 % of the streets involved in the statistical analysis. There are 12 streets in Gusu District, which account for 23.1 % of the streets involved in the statistical analysis. There are 12 streets whose commuting distances are 10–15 km, accounting for 23.1 % of the street involved in the statistical. Last but not least, there are also 5 streets whose commuting distances are more than 15 km and all these streets are in the outside town. From a statistical point of view, the towns whose commuting

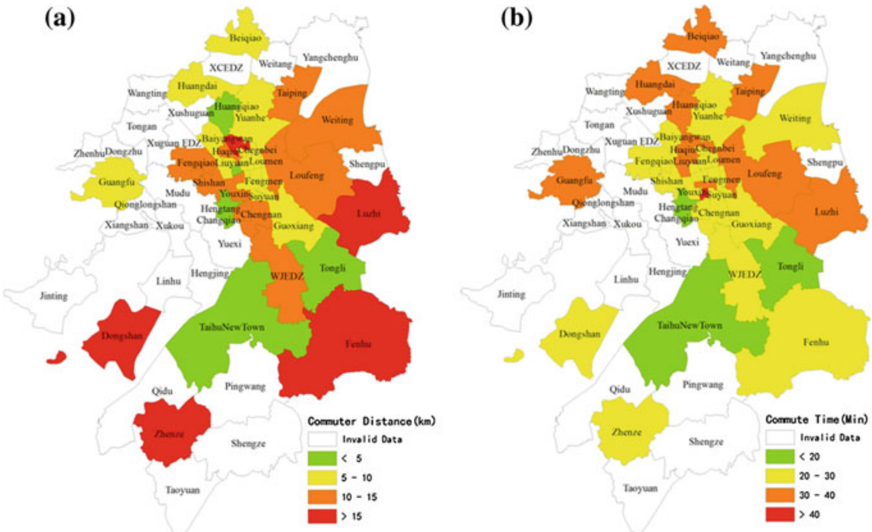

Fig. 3 Commuting distance (**a**) and time (**b**) distribution at the street level

distances are less than 5 km or have relatively independent functions, apart from Shilu Street, all have more balanced job-housing ratios. In the majority of streets, the commuting distances are 5–10 km and most of these towns are located in the center of the city, especially in the Gusu District. The commuting distance in the city periphery is longer.

6 Conclusions and Policy Recommendations

6.1 Job-Housing Balance Is in a Reasonable Range

According to this research, the average commuting time is 26 min and the average commuting distance is 9.6 km in Suzhou. It is commonly accepted that the commuting time range people can tolerate is 30–45 min. Referencing the latest domestic related research results, compared with the domestic cities such as Beijing, Shanghai, Guangzhou and other big cities, the average commuting time in Suzhou is relatively short. In addition, current studies about cities of equal size of Suzhou are quite few, and also lack the direct comparison between cities. Levinson (1989) has put forward a reasonable commuting distance of 9.7–12.9 km Deakin (1989) has put forward a reasonable commuting distance standard of 4.8–16.1 km. In this context, the commuting distance and time in Suzhou are at a reasonable level, which shows that the relative rationality of urban spatial structure in Suzhou City. But, due to the difference of economic development level, city form, and traffic conditions in the cities, there is not any uniform standard for reasonable commuting distance and time in different cities. There are great differences between domestic and foreign large cities and the comparability between them is not obvious.

6.1.1 Job-Housing Spatial Difference Is Obvious in Suzhou City

The job-housing spatial distribution is obviously different in Suzhou. The Gusu District in the ancient area of Suzhou is still a residential area. Apart from the commercial center, most streets in Gusu District are residentially-oriented streets; the SND and SIP are obvious employment-orientation areas and are the new centralized employment centers. Urban growth of Suzhou is extended from the old city to the development zone on the east and west sides of the city, as well as development in the north and south of the Wuzhong District and Xiangcheng District, which form a spatial structure with four corners. However, as the last district joined the city, Wujiang has certain independence in residence and employment, which shows a relatively balanced ratio and relatively low commuting distance and time. According to the job-housing balance rate and independent index, it has obvious differences in districts, and has great relationships with its urban function districts. The c areas are both higher than those of the central city district.

6.2 Rapid Spatial Reorganization in Job-Housing Structure

Suzhou is shifting from decentralized development to integrated development. All the partitions are in the process of continuous integration. The main employment centers are located in the commercial center in Gusu District and the central area in both SND and SIP; the employment sub-centers are forming, and the employment area has begun to spread to the outer space of the city, especially the Wujiang Economic Development Zone and the Xiangcheng Development Zone. This shows that the Development Zone construction plays a significant role for the employment concentration effect. However, the Ecological Town (Shengtaicheng) in SND and Taihu New Town (Taihuxincheng), which have been constructed in recent years, have no significance on the guidance of employment. With the further development of Suzhou's economy, the job-housing balance will gradually achieve a more reasonable extent in Suzhou city.

6.3 Policy Recommendation

When purchasing a house, the majority of residents are willing to live close to their employment to minimize their commuting costs. However, the reality often does not align with hope–people cannot find suitable residences in the vicinity of employment or suitable jobs near their residence, leading to the situation in which the job-housing balance deviates from the optimal state. Therefore, it still needs to be the consideration of urban planning, transportation and other development policies to keep the job-housing balance.

6.4 Urban Planning Policy

The job housing balance is an important measure to reduce commuting. Currently, the urban planning policies in Suzhou should pay more attention to the job-housing balance. Master plans ought to strengthen the relationship between the industrial layout and residential land to achieve an overall job housing balance. In regulatory detailed planning, it is necessary to measure the job-housing balance to reach equilibrium between employment and residence in an area. Residential development, especially large residential area development in the outskirts, ought to pay attention to the analysis of living population, the characteristics and features of different occupational groups, as well as their relationship with the surrounding employment space. It should avoid imbalance between residence and employment and long distance commuting in suburbs.

6.5 Urban Transport Policy

Attention should be paid to major transportation infrastructure, particularly non-motorized transportation that is able to guide urban residence and employment equilibrium. People should be encouraged to use low carbon trip modes such as public transport, cycling and walking. It is an important measure to reduce commuting in order to form a convergence between these trip modes. These trip modes will reduce the commuting distance tolerable, so that it will urge people to live near employment or work near residential, and optimize the combination of job and housing. In addition, a moderate use of private cars can not only reduce urban congestion and environmental pollution, but also reduce long-distance commuting.

6.6 Housing Policy

In the current stage of the housing market, the government's most important obligations are mainly housing policy guidance and housing security in lower class. It cannot be avoided that in a certain period, the lower class cannot afford the housing prices near employment centers, choose to purchase residences in suburbs, and are forced to choose a relatively long commuting distance. However, solutions can be sought from the supply of affordable housing and optimized layout of housing structure, for example increasing the supply of affordable housing and coveraging groups in the downtown to resolve the living problem of low income employees in the central areas. In addition, it is also an important measure to balance employment and residence in old cities, improve the living conditions and municipal facilities. which will prompt residents to move back to the old city. In the current employment context, renters have more flexibility to choose housing and employees change their job frequently. It is necessary to increase the supply of rental housing and develop the rental market.

Acknowledgments This work was funded by the National Science Foundation of China (51208330) and the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD).

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Analysis on the Spatial Impact Factors of Poverty and Its Planning Suggestions: A Case Study of Guizhou Counties

Zhengxu Zhou and Wenning Zhao

Poverty is one of the ‘3P’ issues (Poverty, Population, Pollution) worldwide. In 2000, the UN Millennium Summit set ‘to eradicate extreme poverty and hunger’ as the first priority of the Millennium Development Goals (MDGs). In 2012, China proposed ‘to build moderately prosperous society in all respects’ in the Report to the 18th National Congress of the Communist Party, of which a centerpiece is to greatly reduce poverty. Hence, there’re still a large number of people living in poverty in China. According to the poverty standard of 2300 RMB defined officially in 2011, there are a large number of 122 million persons still under the poverty line now. Poverty tends to gather in space, which raises an important question of whether there’s a correlation between the generation of poverty and spacial factors. This paper takes the poorest province in China as an example, analyzing the spatial characteristics of poverty and then constructing a ‘poverty–space’ correlation model, using data from 75 counties in Guizhou Province.

1 Review of Research on Poverty

In the Encyclopedia of China, poverty is defined as “the status that people can’t have enough income to keep the basic standard of living according to physiological requirement, social culture and general consensus under certain circumstances for a long time”. The World Bank defines poverty as “lacking the ability to maintain lowermost life level” in 1990, and then expanded its meaning to “the vulnerability

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_6

facing risk of poverty and the incapacity to express their own needs" in 2011. Poverty has long been one of top topics concerning researchers. There are multiple interpretations of the essence of poverty and the reason of its generation, which form two main research paradigms: "poverty structure" and "poverty culture".

Researchers of "poverty structure" paradigm are from a broad range of subject areas, such as economics, sociology, and politics. They believe the reason of poverty lies in the inequality of the possession of natural, economic and social resources, the inequality of capital possession, and the inequality of social policy. Similarly, deprivation theory believes that poverty results from the deprivation of capacity and right for historical, social and institutional reasons, and considers it the outcome of the structural inequality of economy, society and politics due to different social divisions of labor. These make income inequality, poor social rights and the deprivation of development opportunity become social norms. The "poverty culture" paradigm was proposed in 1950s, represented by Lewis (1959), Banfield (1958), Moynihan et al. (1967), etc. Chinese researchers such as Xiaoqiang et al. (1986) are also deeply influenced. According to this paradigm, people in a certain area or of a certain group share general characteristics such as low individual ability, information occlusion, unambitious mentality, exclusion to new things, fear of challenges and not willing to make efforts; This forms the subculture of poverty that is isolated from the society as a whole. People affected by the subculture are vulnerable in social competition, which may anchor them in poverty and increase poverty by intergenerational transmission.

Recently, researchers tend to observe and explain poverty from some other angles, of which "space" is an important perspective. Based on the fact that poverty presents particular spatial characteristics to a large extent, their studies started with the description and explanation of the spatial characteristics of poverty, and then tried to establish the framework of the influencing mechanism of spatial factors on poverty. Since 1997, Jalan and Ravallion (1997, 2002) from the World Bank Development Research Group proposed the concept of "Spatial Poverty Traps" and "Geography Poverty Traps" through empirical study in Bangladesh, arguing that geographic capital composed of a series of spatial factors had a significant impact on farmers' poverty (World Bank 2007). They believed geographic capital is as important as physical capital and social capital, which has made a pioneering contribution to the study of "space poverty". Since then, "space poverty" has become an important issue in the study of poverty by researchers from World Bank, the Food and Agriculture Organization of the United Nations and so on. With further study of poverty in Bolivia, Bulgaria, Cambodia and the Yunnan Province in China, researchers summarize the four basic characteristics of space poverty: (1) remote distance; (2) poor agricultural ecology and climate conditions; (3) the fragile economic integration; and (4) the lack of preferential policies. These four characteristics correspond to the aspects of location, ecology, economy and policy. Meanwhile, the evaluation index of road infrastructure, education infrastructure, land, rainfall, and reign manner is also set up. After over ten years of development, the theory of "space poverty" and "spatial capital (or geography capital)" has established a method consisting of the spatial gathering phenomenon of poverty, analyzing its spatial factors and mechanism of action, and then looking for spatial ways to tackle poverty.

Overall, there has been a comprehensive study of poverty and its resolvable measures from the perspectives of society, economy and culture, while study from the spatial perspective has just become a hot topic in recent years. Therefore, more in-depth study of poverty and space based on different regions is required to achieve further development of the extensiveness, depth and explanatory power of the theory. Meanwhile, the spatial study of poverty lacks a feasible and comprehensive framework, which results in two trends: some studies can't distinguish spatial factors from economic, social and cultural factors, thus weakening the effects of space, while other studies only discusses spatial factors apart from economic, social and cultural factors. This makes it impossible to achieve comprehensive understanding. Spatial factors have direct influences on the formation of poverty, and work as material carrier of the economic, social and cultural activity, affecting poverty all together. Therefore, further study needs to establish an analytical framework, which should be able to highlight the role of space and also cover its direct and indirect influences. Sciences of Human Settlements (Wu 2001) can provide the foundation for the framework's establishment.

2 Spatial Characteristics of Poverty in Guizhou Province

Guizhou Province is located in the southwest of China with the most poverty-stricken population, largest impoverished region and most serious degree of poverty, which makes it the province where it is "most difficult to build moderately prosperous society in all respects". Impoverished regions gather in most cities and counties in the eastern, southern and western part of Guizhou Province, usually suffering from tensions between human and land, stunted county economy, low urbanization level, and lack of infrastructures and public service simultaneously.

2.1 Concentrated Distribution of Poverty

A large portion of the poor population in Guizhou lives in the counties. Among 75 counties in Guizhou, 50 are key counties for national poverty alleviation and development, and 65 are national concentrated poverty areas. In 2011, the number of people in poverty in the 75 counties was 10.814 million, accounting for 94.1 % of total 11.49 million poor people in Guizhou Province.

Figure 1 shows the poverty incidence of 75 counties in 2011, which demonstrates that most of the counties with a high poverty incidence are located at the edge of the province. All of the 48 counties with a higher poverty incidence than the provincial average are located in the west, east and south of the province. In the southwest and southeast, poverty incidences of Qinglong (56.2 %), Ceheng (54.8), Wangmo (50.8 %), Pingtang (50.2 %) and Sandu (50.1 %) are over 50 %, which is extremely serious.

2.2 Tension Between Man and Land

Guizhou is the only mountainous province in China that has no plain. According to the “Measurement Research on Information Data of Surface Configuration in Guizhou Province”, mountains and hills cover 92.5 % of the province. Landscape barriers are common cases in the counties because of multiple rivers, different elevations, and dissected rolling topography. Flat land in counties usually lies in the inter-mountainous basin (Bazi) and has a small area and a scattered distribution. Additionally, most areas suffer from serious stony desertification. As much as 33,000 km^2 areas have at least mild stony desertification, making up 18.8 % of the provincial land area. Meanwhile, Guizhou has a relatively high population density, which puts great pressure on its poor ecological capacity. According to county annals, people living in the counties have suffered from food shortage frequently before, which has been eased recently. Representing a direct spatial factor, tension between man and land has significantly affected poverty in counties for a long time.

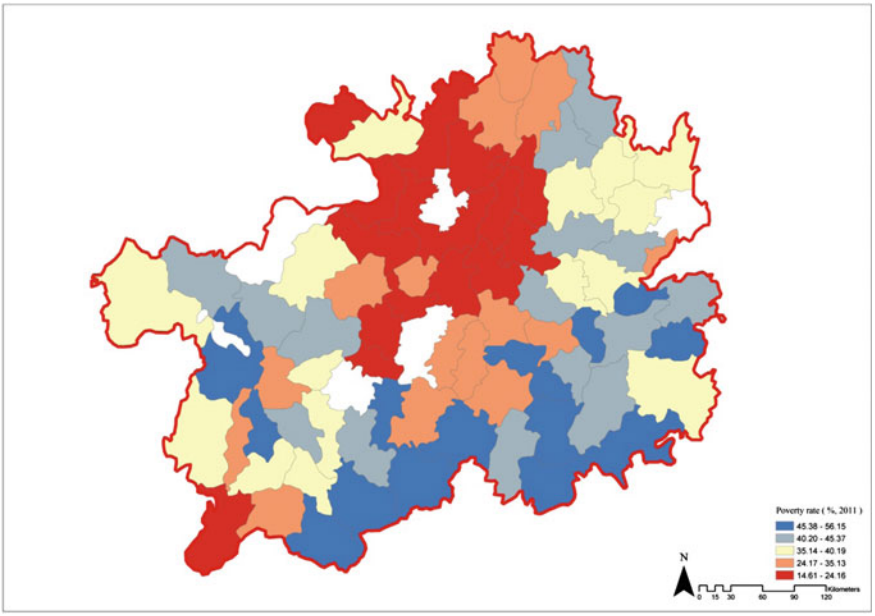

Fig. 1 Poverty rate of Guizhou counties, 2011 (GBS 2012)

2.3 Uneven Spatial Distribution of Economic Activity and Underdevelopment of the County Economy

Economic development in Guizhou has extremely uneven spatial distribution with most economic activities concentrating in major cities such as Guiyang, Zunyi, Liupanshui, etc. the per capita GDP of most counties in Guizhou is lower than the national average, which indicates their backward economic development. These counties usually locate in the northeast, southeast, south and northwest of the province, and are generally the same as those counties with a high poverty incidence. Uneven distribution of economic activity has a negative impact on farmers' income.

2.4 Low Urbanization Level in the County

Due to geographical and historical reasons, economic and urban development in counties in Guizhou is prevalently lagging, reflecting low urbanization rates and town densities as well as poor development of the center towns. According to the Sixth National Population Census, the urban population in Guizhou Province is 11.7478 million, accounting for 33.81 % of the total 34.7465 million person permanent population. This means its urbanization rate is the second lowest for all provinces in China. Only Kaili's urbanization rate (57.4 %) is over the national average, while the urbanization rates of all the other 74 counties are lower than the national average (ranging from 10 to 40 %). A prominent expression of the low urbanization level in Guizhou is the scattered distribution and small size of towns in the counties. According to data from the Housing and Construction Department of Guizhou Province, the density of designated towns in Guizhou Province is only 0.35 per hundred square kilometer, the average built-up area (except the county town) is 127.25 ha, and the average population is 6.5 thousand. Due to the low density and small scale of counties and towns, it's difficult to form agglomeration and radiation effects.

2.5 Weak Support of the Infrastructure

With the low density of roads as well as the low capacity of external and internal transport facilities, the backward transportation system has become a bottleneck for economic development of the counties and income growth of the people in Guizhou Province. According to the Second National Agriculture Census in 2006, many indexes of the transportation system in Guizhou Province are lower than the national average. For example, of all the counties in Guizhou Province, only 8.6 %

have a railway station, compared to the national average of 9.6 %; only 18.6 % have accessibility to second-class roads, which is lower than the national average of 46.2 % and much lower than the average in central and eastern China. Overall, Guizhou Province suffers from its poor rural infrastructure and public services and has disadvantages over other provinces on main indicators such as telecommunication, power, education, hospital, environment, health, tourism, business and trade.

3 "Space-Poverty" Correlation Model

Based on the Sciences of Human Settlements, this paper establishes a correlation model of spatial factors and poverty to comprehensively study the influence of spatial factors on the formation of poverty. The Sciences of Human Settlements studies the interrelation and laws of development of human settlements and their environment, including counties, towns, cities and regions, in order to achieve ordered space and a livable environment. The five systems of human settlements—nature, humans, society, residence and support systems—expand the simple concept of space study, which is suitable for the comprehensive problem-oriented study on the Complex Giant System (CGS) of space. This paper tries to establish a framework of space study based on the Sciences of Human Settlements and explores the influences of complex and diverse spatial factors on poverty.

Specifically at the county level, this research divides spatial factors into nature, human, economy and society, city and town, and infrastructure systems. Here, the natural system is the material basis of human survival and development, which affects poverty by terrain and resource constraints. Being a key issue of poverty, the spatial characteristics of the human system, such as the spatial distribution and spatial mobility of the population, have a direct effect on poverty. Economic and social systems have a close relationship with poverty, and the spatial distribution and evolution of economic and social activity are both important factors affecting poverty. The city and town system refers to not only microscopic entities such as housing quality, but also macroscopic settlement forms such as the layout and scale of towns and cities, which play a more and more important role in rural poverty by functioning as material space for human survival and development. Infrastructure systems provide solid support to economic and social activities, especially in the fields of transportation accessibility and infrastructure. All five of these systems have close relationships with poverty, as either direct factors or carriers of economic and social activities affecting poverty generation.

Based on the Science of Human Settlements, this paper establishes the following correlation model of spatial factors and poverty in counties (Fig. 2).

Each of the five systems contains several spatial factors, composing of the overall human settlement in the county, which is closely related to the generation of poverty. In this paper, per capita net income of farmers and rural poverty incidence in the counties are used to measure poverty as two main indicators.

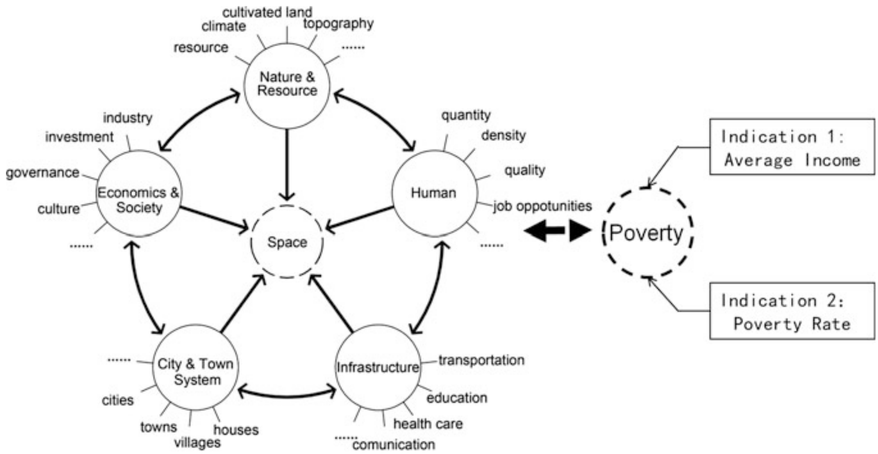

Fig. 2 Correlation model for spatial factors and poverty

4 Impact Analysis of Spatial Factors Based on PLS Regression Method

Partial least-squares (PLS) regression method is applied in this paper to verify the correlation between spatial factors and poverty in the counties, using relevant historical data of counties in Guizhou Province.

4.1 Introduction of PLS Regression Method

Regression analysis is a kind of statistical analytical tool to reveal correlations between multiple factors, widely used in engineering and social sciences (Hulland 1999; Martens and Martens 2000). Usually the least square method (OLS) is used in multivariate linear regression analysis, but it has certain limitations. Based on the selection of variables, ridge regression and principal components, S. Wold et al. proposed the partial least-squares (PLS) method in 1983. The PLS method can overcome multicollinearity and solve problems that couldn't be solved by ordinary multiple linear regression. The PLS method acheieves a relatively accurate estimation of regression coefficients, even in the case of small samples. Thus, it's called the second generation multiple regression analysis method and is widely used.

The basic idea of PLS is to extract several feature matrices from the independent variable matrix and dependent variable matrix respectively, that are the best representatives and have the closest relationships with each other. The regression coefficient is then derived from the feature matrix. The level of influence of the independent variable on the dependent variable is expressed by VIP (The specific calculation method for PLS regression is omitted. If you are interested in it, please contact the author).

4.2 Data Selection

This paper assesses 75 counties in Guizhou Province, taking rural poverty incidence and per capita net income of farmer as the dependent variables, while 15 spatial indicators based on the five systems of the Science of Human Settlements as the explanatory variables. The majority of the data is from 2010.

There are 4 key indicators from the natural system: (1) The proportion of plain land to total area. The slope of plain land is less than 6°, making it suitable for industrial and urban construction and large-scale farming practice. This proportion indicates how much land can support the economic development of the county. (2) The proportion of gentle slopes to total area. This slope is less than 15°, making it suitable for agricultural cultivation. This proportion indicates how much land can support agricultural production. (3) The proportion of steep slopes to total area. With over a 25° slope, the land is unsuitable for any industrial, urban or agricultural usage, and may suffer from soil erosion and landslides. Therefore, this proportion indicates the degree of land constraints in the county. (4) The per capita cultivated land (mu per capita). This proportion is calculated as the area of cultivated land in the county divided by its permanent population, indicating the natural support for agricultural production currently.

There are two key indicators from the human system: (1) Population density. This is the permanent population divided by the land area of the county, indicating the tension between man and land. (2) The proportion of migration to total population. This proportion is estimated by taking the difference between the registered population and the permanent population dividing it by the registered population. Considering that many farmers in Guizhou Province go out to work, this proportion indicates the cross-regional flow of population and the rural surplus labor of the county.

There are four key indicators from the economic and social system: (1) GDP of the primary industry calculated in accordance with the land, (2) GDP of the second industry calculated in accordance with the land, (3) GDP of the third industry calculated in accordance with the land, and (4) Fixed investment calculated in accordance with the land. These indicators are the GDP of industry and fixed investment per square kilometers of land, representing the spatial distribution of economic and social activities.

There are three key indicators from the city and town system. (1) Urbanization rate, which is the proportion of the urban permanent population to the total population of the county at the end of 2010, (2) Density of towns, which is the number of designated towns and towns at higher levels per hundred square kilometers of land, and (3) The proportion of the permanent population of the county town to the total permanent population. This proportion indicates the attraction and agglomeration function of the county town.

There are two key indicators from the infrastructure system. (1) Road density, which is the length of available roads divided by land area in 2003; and (2) Density of middle schools, which is the number of middle schools per square kilometer of land in 2003. In consideration of the delayed effects of a support system on economic and social development, these two indicators use data from an earlier time.

The data sources used were the Guizhou Statistical Yearbook, the Guizhou Yearbook, the Measurement Research on Information Data of Surface Configuration in Guizhou Province, the Urban Construction Statistics of Guizhou Province, Report on the Work of Government of the counties, etc. When the data was missing, we used linear interpolation to get an estimation based on data for other years. Table 1 shows the descriptive statistics of the variables, which have all been standardized before calculation.

Table 1 Descriptive statistics

		N	Min.	Max.	Mean	SD
Poverty	Y_1 poverty rate	75	0.0526	0.1966	0.1302	0.0398
	Y_2 average income	75	2586	5463	3564.3467	713.3597
Nature and resource	X_1 proportion of land with slope <6°	75	0.0196	0.3715	0.1324	0.0649
	X_2 proportion of land with slope 6°–15°	75	0.0687	0.7735	0.393976	0.1718
	X_3 proportion of land with slope >25°	75	0.0405	0.6778	0.216523	0.1357
	X_4 cultivated land per capita	75	0.5338	1.3165	0.777378	0.1532
Human	X_5 population density	75	71.0678	420.8837	218.8997	81.8039
	X_6 proportion of migrant population	75	−0.3902	−0.0287	−0.2262	0.0688
Economics and society	X_7 GDP of 1st industry/km^2	75	13.7903	73.5130	38.2031	15.5076
	X_8 GDP of 2nd industry/km^2	75	3.6926	702.6560	85.4575	107.8598
	X_9 GDP of 3rd industry/km^2	75	20.9922	352.3266	77.4836	65.5895
	X_{10} Fixed Assets Investment/km^2	75	12.1492	535.1669	112.9543	110.3282
City and town system	X_{11} Urbanism rate	75	0.1680	0.5950	0.3104	0.0837
	X_{12} Density of cities and towns	75	0.0279	0.7752	0.3920	0.1455
	X_{13} proportion of county-town living population	75	0.0872	0.5915	0.2357	0.0996
Infrastructure	X_{14} Density of road	75	0.2029	1.4893	0.6027	0.2791
	X_{15} Density of middle school	75	0.4325	2.9240	1.2548	0.5506

Resource GBS (2011)

4.3 Regression Result

This paper uses a PLS regression analysis of the data through the statistical package R. We built linear regression models between the independent variable and the dependent variable with two PLS components respectively, and then ran a final multiple linear regression model after conversion.

Overall, the interpretation validity of the Y value (R2Y) is 0.706, and its cross validity is 0.656, which shows high accuracy for a multi-variable regression model with cross-section data. The figure below shows the comparison between the actual and predicted values of poverty incidence and farmers' per capita net income in 75 counties in Guizhou Province. Their good agreement with each other indicates that the model can provide an accurate explanation of the influential factors on rural poverty incidence and famers' per capita net income (Figs. 3 and 4).

Table 2 shows the standardized regression coefficient of this model, indicating the effect of varying independent variables (after standardization) on the dependent variable (also after standardization). 90, 95 and 99 % confidence intervals of standardized coefficient are given through Jack-Knifing method, and Table 2 shows the 90 % confidence interval.

As shown in the Table 2, there is a positive correlation between rural poverty incidence and the proportion of steep slopes (X3) and population density (X_5), which indicates that the higher the proportion of steep slopes and population density, the higher the rural poverty incidence is. Other independent variables have a negative impact on rural poverty incidence. Thus the lower the proportion of plain land, the proportion of gentle slopes, proportion of migration, GDP of the third industry, fixed investment calculated in accordance with land, urbanization rate, urban density, proportion of population in county town, road density and school density, the higher rural poverty incidence is. Upon testing, all the 90 % confidence intervals of the independent variables are located on the same side of the zero point,

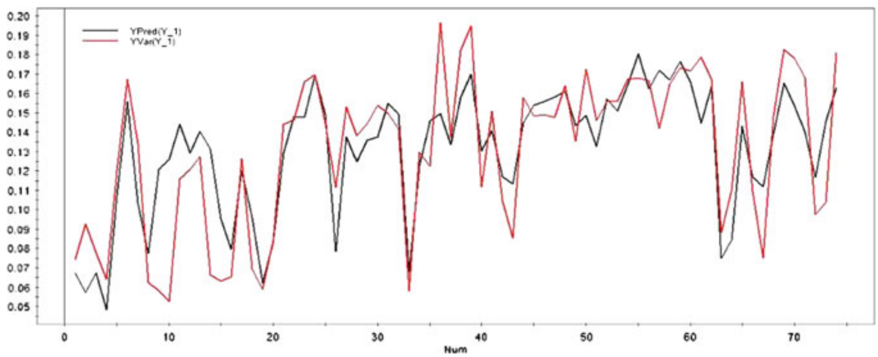

Fig. 3 Comparison between the actual and predicted values for poverty rate (*Red line* for actual value, *black line* for predicted value)

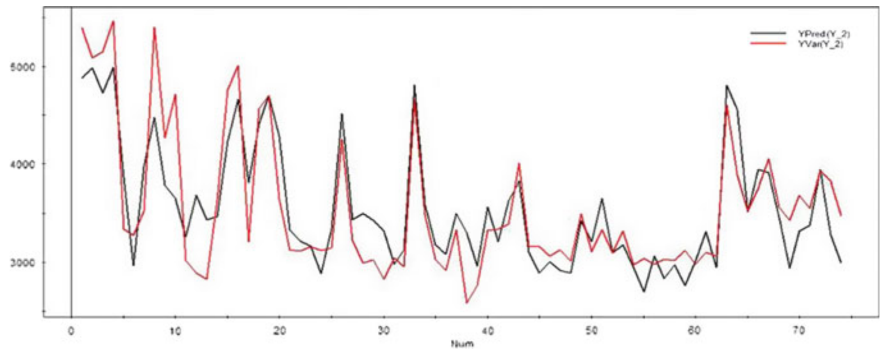

Fig. 4 Comparison between the actual and predicted values for income (*Red line* for actual value, *black line* for predicted value)

Table 2 Model results (standardized coefficients)

		Y_1 poverty rate		Y_2 average income	
		Standardized regression coefficient	90 % confidence interval	Standardized regression coefficient	90 % confidence interval
Cons.		3.284	–	4.971	–
Nature and resource	X_1	−0.061	[−0.100,−0.021]	0.049	[−0.020,0.118]
	X_2	−0.043	[−0.069,−0.015]	0.020	[−0.027,0.068]
	X_3	0.043	[0.078,0.009]	−0.022	[−0.071,0.027]
	X_4	−0.130	[−0.231,−0.029]	0.180	[0.050,0.312]
Human	X_5	0.052	[0.012,0.093]	−0.114	[−0.159,−0.068]
	X_6	−0.095	[−0.133,−0.055]	0.117	[0.068,0.167]
Economics and society	X_7	−0.078	[−0.122,−0.033]	0.070	[0.003,0.139]
	X_8	−0.061	[−0.099,−0.023]	0.050	[0.010,0.092]
	X_9	−0.096	[−0.153,−0.037]	0.095	[0.028,0.164]
	X_{10}	−0.143	[−0.173,−0.112]	0.166	[0.130,0.202]
City and town system	X_{11}	−0.235	[−0.290,−0.179]	0.305	[0.239,0.372]
	X_{12}	−0.063	[−0.112,−0.013]	0.061	[−0.006,0.130]
	X_{13}	−0.121	[−0.164,−0.078]	0.164	[0.089,0.241]
Infrastructure	X_{14}	−0.096	[−0.151,−0.040]	0.102	[0.028,0.179]
	X_{15}	−0.054	[−0.087,−0.019]	0.035	[−0.011,0.083]

$N = 74$, $R^2X = 0.586$, $R^2Y = 0.706$, $Q^2 = 0.656$

as well as most of their 95 and 99 % confidence intervals, proving a high stability of estimation (at least in the respect of positive or negative impacts on the dependent variables).

In contrast with rural poverty incidence, per capita net income of farmers has a negative correlation with the proportion of steep slopes (X_3) and population density

(X_5)—the higher the proportion of steep slopes and population density, the lower the per capita income of farmers. Other independent variables have a positive impact on the per capita net income of farmers. The lower the proportion of plain land, proportion of gentle slopes, proportion of migration, GDP of the third industry and fixed investment calculated in accordance with land, urbanization rate, urban density, proportion of population in county town, road density and school density, the lower the per capita net income of farmers is. Upon testing, most of 90 % confidence intervals of independent variables are located on the same side of the zero point, which also demonstrates the high stability of the estimation.

4.4 Analysis of Variable Important in Projection

Variable Important in Projection (VIP) is the indicator that shows the effect of how one independent variable changes over the dependent variable, thus it's the measurement of the marginal contribution of the independent variable. It can be assumed that when VIP > 1, the influence of the independent variable on the dependent variable is very significant, when 1 > VIP > 0.8, the influence is significant, and when VIP < 0.8, the influence is not significant. The figure below shows the VIP of independent variables in this model (Fig. 5).

First, the VIP of all 12 independent variables based on the five systems are over 0.8, indicating that these factors play an important role in the explanation of poverty generation, which confirms the basic hypothesis of this paper: spatial factors have wide impact on poverty.

Second, the VIP of urbanization rate (X_{11}) is 1.56, ranking first among all the 15 variables. Demonstrated by the regression result, the process of urbanization has a significant effect on reducing poverty incidence and improving net income of farmers.

Third, four indicators of social and economic system generally have a great influence on poverty. VIP of fixed investment (X_{10}), GDP of the third industry (X_9), and GDP of the first industry (X_7) rank second, third and fifth among the 15 variables. Combined with the regression result, we can say that fixed investment

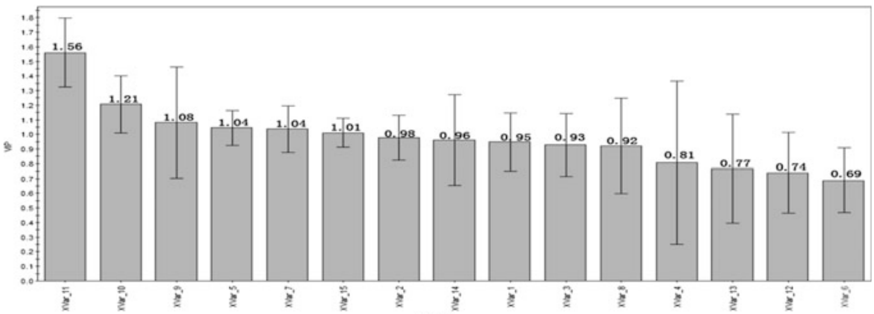

Fig. 5 Variable Important Plot (VIP) of the independent variable

and development of the third industry can greatly help the local economy and reduce poverty.

Fourth, the VIP of population density (X_5) is 1.04, ranking fourth, indicating that population density has a great impact on poverty. Additionally, four indicators of the natural system have a stable influence over poverty generation. The VIP of the proportion of gentle slopes (X_2), proportion of plain land (X_1), proportion of steep slopes (X_3) and per capita cultivated land are all over 0.8, ranking 7th, 9th, 10th and 12th. Based on the regression result of the human system together with the natural system, the contradiction between population and natural resources plays an important role in poverty generation.

Fifth, the VIP of school density (X_{15}) and road density (X_{14}) are both about 1–ranking sixth and eighth respectively—indicating that whether the spatial support system is solid can also greatly impact poverty generation.

5 Conclusions and Recommendations

Poverty is the consequence of many interacting factors. Space is the basic requirement for economic, social and political factors to take effect, and has direct and indirect influences on poverty generation itself. Five systems of space—the natural system, human system, socio-economic system, urban system and support system—all have close relationships with poverty generation. In the counties of Guizhou Province, the prominent contradiction between human and land, the backward economic development and urbanization level, and weak infrastructure such as the transportation system form the mechanism between space and poverty generation. Based on the above analysis, this research argues that we can explore the possibilities of poverty management from the following aspects.

First, based on the current situation where poverty is distributed mainly in rural county areas, the county should function as the unit of governance. Using the foundation of strengthening the county power, establishing the governance platform at the county level can advance the poverty governance.

Second, strengthen the economy and promote urbanization in the county. Establish the "center + network + hinterland" spatial pattern and improve the distribution of man and land in the county. Explore an urbanization path that balances urban and rural development, taking county town as the key point to promote overall development in the rural areas, facilitate a reasonable distribution of population, and remit the contradiction between man and land.

Third, improve the infrastructure and public services of the counties, and establish a "basic life circle" to raise the level of production and living standards in the rural areas. Improve external transportation links of rural areas in the counties and enhance their communication of people, objects and information with urban areas in and out of the counties. Meanwhile, improve the public service, focusing on county town and central towns to establish the educational, medical and cultural center of rural areas.

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Research for Increasing FCD Map Matching Accuracy Based on Feature Extraction of Continuous Traffic Flow and Interrupted Traffic Flow

Zhiping Zhang and Hangfei Lin

1 Background

Traffic flow statistics and forecasting is the basis of transportation planning work. Using traffic flow information, people can analyze traffic flow features, estimate volume of traffic flow, and assess the reasonability of road network layouts.

In an ITS system, people get traffic flow information based on FCD (floating car device) data acquisition and processing technology. In China, almost all taxis have GPS or BEIDOU devices for the purpose of monitoring. In most big cities, such as Beijing and Shanghai, the total number of taxis is more than 40,000 and we have enough courage area on main roads that taxis have an advantage over other vehicles when using FCDs.

Real-time information was obtained from BEIDOU or GPS devices installed on vehicles, which send vehicle position, direction and speed to an information processing center through the GPS receiver and wireless communication system, after which the processing center does map matching and path deriving and information fusing, finally resulting in road traffic information (Brakatsouls et al. 2005). Although the dynamic traffic information processing system is advanced in concept and technology for FCDs, a lot of basic research is still needed with regard to positional accuracy to meet the needs of the system in terms of accuracy requirements of

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_7

information processing, due to the complex road network structure (Li and Wu 2009). Taking the road structure of Shanghai city as an example, the expressways and trunk roads use a parallel structure of elevated/ground roads, and the existing GPS positioning is very difficult to accurately match to the elevated road or ground road. In such cases, system will get the wrong path results, leading to inaccurate results when estimating the traffic information. Since the elevated roads and ground roads are very important in the road network of the city, accurate identification of the FCD route has become an important research topic in the processing of dynamic traffic information.

Traffic flow is divided into continuous traffic flow and interrupted traffic flow based on the operational status. In general, vehicles running on the elevated roads reflect the continuous flow features, and those running on the ground road reflect the features of interrupted flow. For convenience, this paper uses elevated roads to approximate continuous flow, and ground roads to approximate interrupted flow.

– Continuous flow: vehicles will not stop because of external interferences. From the definition of continuous traffic flow, vehicles on the road are continuously arriving, and continue to leave. If all arriving vehicles can leave in a timely manner, there will not be any vehicle queuing on the road section. If the number of vehicles arriving is greater than those leaving, vehicles will have to collect or queue in the bottleneck of the road section.
– Interrupted flow: vehicles stop because of outside fixed factors such as intersection signs or signals. Interrupted traffic flow is caused by periodic intermittent fixed factors. Fixed factors causing traffic interruptions include traffic signals, traffic signs, and other types of control equipment. No matter the traffic volume, these devices will cause traffic to periodically stop or decelerate significantly.

Feature extraction of continuous and interrupted traffic flow is very useful for path deriving in a complex road network with elevated road and ground road structure. Because elevated and ground road are almost entirely coincident, vehicle location information received from GPS alone has been unable to differentiate between an elevated or ground road. Reliance on traditional speed clustering methods can only provide limited accuracy, which will reduce greatly during peak hours or accidents caused by the elevated road congestion situation.

Grey relational analysis theory and fuzzy pattern recognition theory are useful for uncertain problems. Since vehicles running on the elevated or ground road is uncertain based solely on positioning data, we have selected grey relational analysis theory and fuzzy pattern recognition theory as the research basis.

This article describes a method of forecasting travel features for continuous and interrupted flow based on deep analysis of different period travel speeds. We use feature extraction to determine continuous and interrupted traffic flow and use grey relational analysis theory and fuzzy pattern recognition theory, which greatly improve the accuracy of discrimination of vehicles on the elevated road or ground road, thereby greatly improving the accuracy of real-time traffic conditions and travel time.

2 Grey Relational Factor Analysis Based on GPS Data

We can get latitude and longitude, instantaneous speed, azimuth angle and distance information from a GPS floating car acquisition system. For deriving the paths of elevated and ground road trips, features of vehicles running on different roads can be obtained by analyzing three factors: GPS instantaneous speed, azimuth angle, GPS matching distance. Table 1 shows the feature differences of the three factors for the parallel road network.

However, because the influence of different factors is also different, there is a need to determine the factors affecting the running path of each vehicle through the correlation analysis method, and to determine the influence of each factor for forecasting vehicle speed. The method of grey correlation analysis is an important part of grey system theory, and is an effective method for mining internal rules of data. It is a method of factor comparison and analysis, a method of correlating the degree between things and factors through the comparison of statistical series' geometric relationships of the system to analyze the degree of relevance for multiple factors of the system (i.e., to determine the degree of relevance according to the data sequence's geometrical relations or the degree similarity of curve geometry for things and factors).

Algorithms using the GPS instantaneous speed, azimuth, and GPS matching distance as x_0 for vehicles running on elevated roads, with the data sequence of these three factors for the vehicles running on the corresponding ground road as x_i(based on the grey balanced adjacent degree correlation analysis theory), can use the following calculation steps to determine the major influence factors and degrees of vehicle running features for continuous and interrupted flow (Liu 2007).

(1) For the original data sequence $\{x_i(j)\}$ $(i = 1, \ldots, l; j = 1, \ldots, n)$, l is the number of the sub-sequence, n is the length of the sub-sequence. Determine the

Table 1 The feature differences of the three factors for the parallel road network

Items	Elevated roads	Ground roads
Cluster analysis of high speed, to judge whether there is continuous high speed	Special feature	
Cluster analysis of low speed, to judge whether there is continuous "0" speed	Continuous "0" speed is rare	Special feature of ground roads because of signals
The stability of speed change	Average vehicle speed and mean GPS speed have a strong correlation	Average vehicle speed and mean GPS speed have weak correlation
The overall average matching distance of path	Minimum or less	Minimum or less
GPS angle changes of vehicle running	Fit the road section better	Irregular changes

factor sequence x_0 of elevated roads and the factor sequence x_i of ground roads and calculate the difference for each time point $\Delta_i(j) = |x_0(j) - x_i(j)|$. The maximum and minimum values of $\Delta_i(j)$ are called as $\Delta_{\max}$, $\Delta_{\min}$.

(2) Calculate the grey relational coefficient for each time point of sequence x_0 and x_i:

$$r_i(j) = (\Delta_{\min} + \Delta_{\max})/(\Delta_i(j) + \Delta_{\max})$$

(3) Calculate the distribution map of the grey relational coefficient for the sequence:

$$p_i(j) = r_i(j)/\sum_{j=1}^{n} r_i(j)$$

In the formula, $r_i(j)$ is the grey relational coefficient and n is the length of the sequence.

(4) Calculate the relational coefficient entropy for each item i inside the relational coefficient sequence $R_i = \{r_i(j)\}$:

$$H_{\otimes}(R_i) = -\sum_{j=1}^{n} p_i \ln p_i(j)$$

In the formula, $p_i(j)$ is the distribution map of the grey relational coefficients and n is the length of the sequence. The value of relational coefficient entropy reflects the equilibrium degree of grey correlation coefficients.

(5) Calculate the equilibrium degree of grey correlation coefficients sequence R_i:

$$B_i = H_{\otimes}(R_i)/H_{\max}(R_i)$$

In the formula, $H_{\max}(R_i) = \ln n$, and is the maximum entropy value of R_i.

(6) Get the balanced adjacent degree from the grey correlation degree and equilibrium degree:

$$B_a(i) = B_i \gamma_{0i}$$

In the formula, γ_{0i} is the grey correlation degree, and $\gamma_{0i} = \frac{1}{n}\sum_{j=1}^{n} r_i(j)$.

We do sorting for all the calculated equilibrium proximity. The correlation degree of the factors is stronger for the ground roads and for the corresponding elevated roads when balanced adjacent degree is bigger. Otherwise the correlation degree is weak.

A large number of experiments and practical application results show that the degree of correlation of GPS instantaneous speed factors between elevated and ground road is the weakest. That is, through the extraction of feature difference for

GPS instantaneous speed between elevated roads and ground roads, we can identify the FCD travel path to the greatest extent.

3 Fuzzy Pattern Recognition for Continuous Flow and Interrupted Flow

Based on the above analysis, choosing the GPS instantaneous speed as major factor, we can get the features of continuous and interrupted flow and classify the path of parallel road networks through analyzing "displacement-speed" curves obtained by GPS instantaneous speed within a period of time by a GIS analysis tool.

Using a GIS data analysis tool, the FCD trajectory features of different road grades are visually displayed and analyzed, effectively helping us to identify the running path of parallel road networks via GPS data.

However, using GPS instantaneous speed as the analyzing data, we can only obtain the "displacement-speed" curve; there is no other information available. The fuzzy information processing technique of fuzzy set theory has been developed as a new method in modern information processing, and has allowed great progress in many fields. In this paper, we use the method of fuzzy recognition as feature extraction method for vehicle running path recognition and classification of parallel road networks.

In this section, we first describe the process of vehicle speed feature recognition for continuous flow and interrupted flow and then do feature extraction of vehicle speed through the obtained "displacement-speed" curve after analyzing GPS speed data. Then the method of establishing the subordinate function of each feature is given, and finally we give the method of path recognition for parallel road networks using feature extraction and matching classification.

3.1 Vehicle Speed Feature Recognition Steps for Continuous Flow and Interrupted Flow

Guo (1993) has given the procedure of feature recognition of fuzzy pattern systems. Correspondingly, we set up the procedure of vehicle speed feature recognition for continuous flow and interrupted flow as follow:

(1) Obtain GPS instantaneous speed information by floating-car processing system;
(2) Preprocessing of abnormal data;
(3) Feature extraction from the "displacement-speed" curve;
(4) Establish subordinate function for each feature curve;
(5) Fuzzy recognition;
(6) Obtain result of path recognition.

3.2 Feature Extraction and Subordinate Function Establishment

We selected the Shanghai inner-ring elevated road and the Zhongshan North Road (Chifeng road to the North Tibet Road) as the sample data (including the evening peak and peace peak period) since the selected road has typical overlapping features for both elevated roads and ground roads.

The GIS data analysis and traffic processing tool is shown in Fig. 1.

Through the running features' analysis of vehicles run on elevated and ground roads, we drew the "displacement-speed" curve, and analyzed the different features individually (Figs. 2, 3 and 4).

From the above curve, we can see that the "displacement-speed" curve is different for the vehicles running on different road grades and at different time periods. Because each curve can be split into independent "smooth", "slow", and "jam" conditions, we can extract features according to the three different traffic conditions through deep analysis of the curve, as shown below:

Feature 1 (T1): Mean speed of different road conditions
Feature 2 (T2): Speed variance of different road conditions
Feature 3 (T3): The existence of continuous highspeed
Feature 4 (T4): The existence of continuous "0" speed
Feature 5 (T5): Whether we can cluster the data set or not.

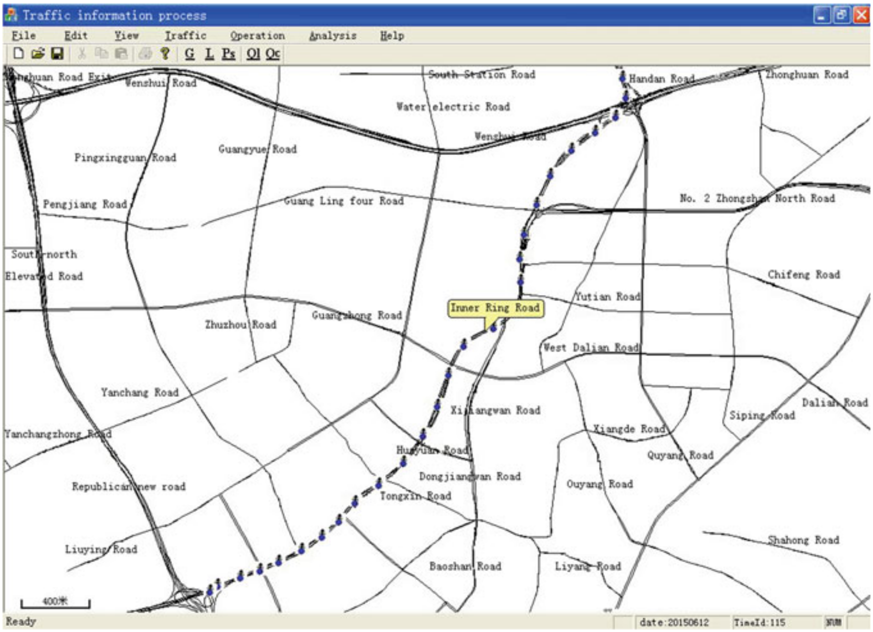

Fig. 1 GIS data analysis and traffic processing tool

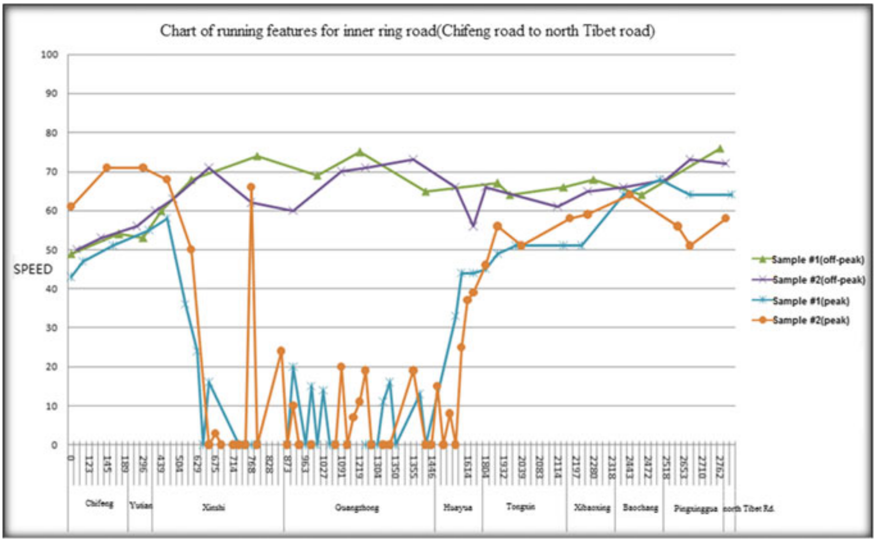

Fig. 2 Running speed features chart for elevated roads

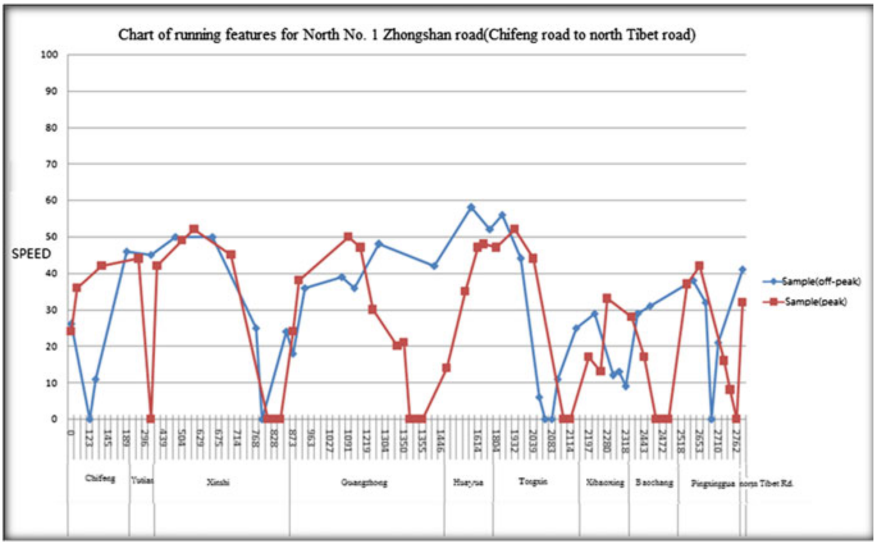

Fig. 3 Running speed features chart for ground roads

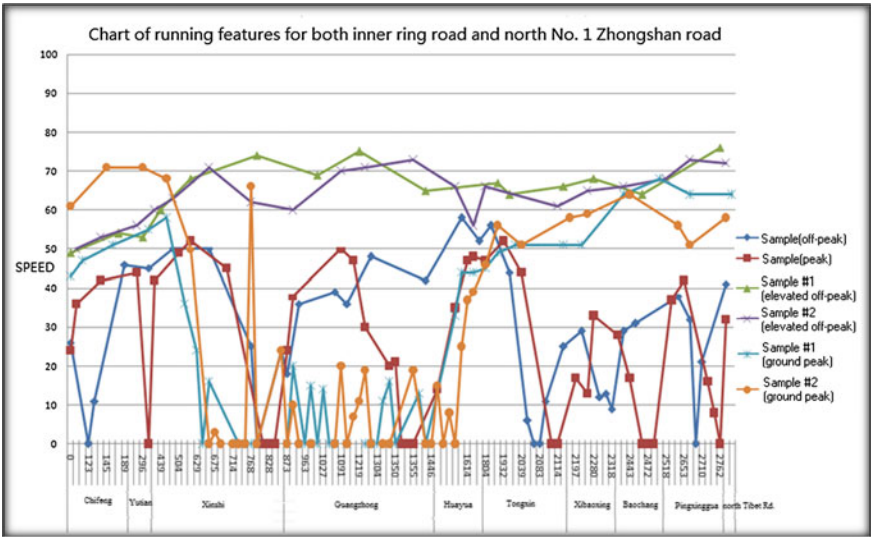

Fig. 4 Comparison chart of running speed features for elevated and ground roads

Among them:

T1: in the “smooth”, “slow”, and “jam” traffic conditions, the GPS instantaneous speed of mean value can be described as: “high” or “low”.
T2: in the “smooth”, “slow”, and “jam” traffic conditions, the GPS instantaneous speed of variance can be described as: “big” or “small”.
T3: “smooth” condition GPS instantaneous speed sequence existence in the continuous high speed can be described as: “yes” or “no”.
T4: “slow” or “jam” condition GPS instantaneous speed sequence existence in the continuous 0 km/h can be described as: “yes” or “no”.
T5: whether curves along the axis of the displacement GPS instantaneous velocity data sets show obvious clustering can be described as: “yes” or “no”.

For the feature difference of different traffic conditions for continuous flow and interrupted flow, please see Table 2.

We use the triangular description method of subordinate function to describe the speed feature because the speed feature of continuous and interrupted flow is determined in a certain range, and at the junction with the other types of traffic flow is fuzzy. The triangle description method can exactly express the characteristic that is determined in a certain range and is fuzzy at the edge.

Table 2 Feature difference of different traffic conditions for continuous flow and interrupted flow

	Continuous flow (elevated)	Interrupted flow (ground)
Smooth	The speed is high, very small changes	Affected by signal lamp; generally a vehicle can pass the intersection by waiting one time
Slow	The speed is low, but almost no absolute stop	Affected by signal lamp, and waiting time becomes longer; generally a vehicle can pass the intersection by waiting one time
Jam	Has the feature of "move-stop-move-stop"	Affected by signal lamp, and waiting time becomes longer; generally vehicles cannot pass the intersection until waiting more than one time

3.3 Feature Selection and Matching Classification

We use the feature separation method of fuzzy pattern recognition to identify the speed of continuous flow and interrupted flow as shown in Fig. 5.

(1) *Feature selection*

The uniqueness of the fuzzy pattern recognition method of feature recognition lies in the "feature separation". For the path identification of parallel road networks, we use a feature separation method to find out the class feature of each kind according to the characteristics of the two kinds of paths, and only this set of features can describe the class's attribute.

The feature here is described by the variables of concept hierarchy after summarizing characteristics about the "displacement-speed" curve. Fuzzy sets are used as a way to express features when features are selected.

According to the path recognition of the sequence of GPS instantaneous speed, we use different combinations of features to calculate the sample's subordination degree, and use the maximum subordination principle for classification. The following are lists of the combinations of the two features for continuous and interrupted traffic flow.

Continuous flow:

Among the five features, speed mean, speed variance, continuous high speed and whether the data can be clustered are the main features of continuous flow, and there is almost no continuous 0 speed. Variables to describe the features are: T1 (higher); T2 (smaller); T3 (exist); T5 (yes).

Feature expression is: $T1 \wedge T2 \wedge T3 \wedge T5$.

Interrupted flow:

Variables to describe the features are: T1 (lower); T2 (higher); T4 (exist).
Feature expression is: $T1 \wedge T2 \wedge T4$.

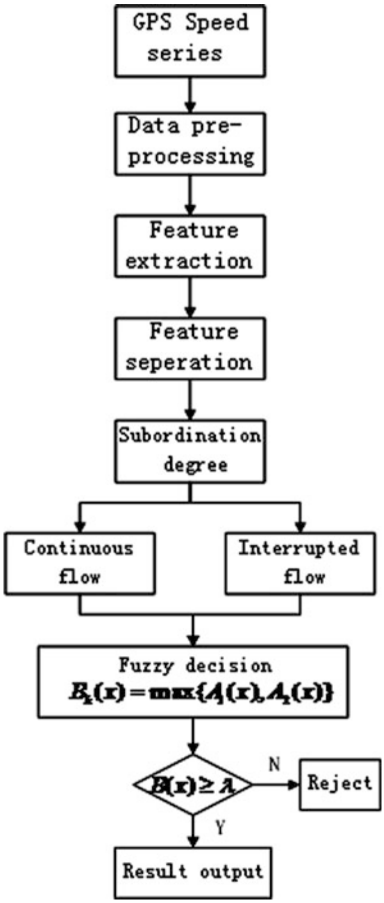

Fig. 5 Flow chart of feature recognition for continuous flow and interrupted flow. *Note* In the above graph, A is degree of subordination, x is sample of path recognition, λ is the threshold

(2) *Matching classification*

In the real application, we used the listed subordinate function to describe the i feature of the k path pattern:

$$D_i^k(x) = \frac{1}{1 + \alpha|x_i - x_i^k|}$$

We define the sample as $x = (x_1, x_2, \cdots, x_n)$. Fuzzy recognition inference steps are as follows:

(a) Calculate the subordination degree ($D_i^k(x)$) of the subordinate function (D_i^k) for each relative factor (T_i) of path pattern (A_k).

(b) Calculate the subordination degree for each path pattern A_k: $A_k(x) = \bigwedge_{i=1}^{i=5} D_i^k(x)$.

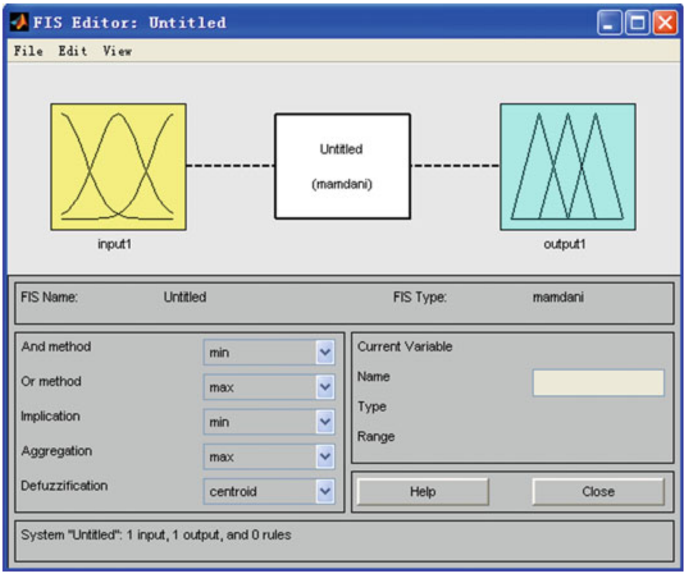

Fig. 6 MATLAB FIS

(c) Calculate the max subordination degree for each pattern of each path: $B_k(x) = \max A_k(x)$.
(d) Calculate the max subordination degree for all paths: $B(x) = B_j(x)$.
(e) For a preset threshold λ, if $B(x) < \lambda$, we determine that the path cannot be judged (no similarity between the two path patterns). If $B(x) \geq \lambda$, we determine the path to be the one that has the max value of subordination degrees.

The MATLAB toolbox of fuzzy inference system (FIS) provides the above fuzzy recognition processing function. MATLAB-FIS has a high degree of integration, is rich in content, is powerful, and is easy to use. Using MATLAB FIS, we can easily get the results we need, see Fig. 6.

3.4 Result Verification

In a practical application of floating-car processing, we set up an extraction method using speed features of continuous flow and interrupted flow and found a good solution for path recognition under the parallel road-network.

We selected 86 road sections which have parallel elevated and ground roads in Shanghai, and used traditional speed clustering and our new method to do the path matching. The result are as follows:

Table 3 Comparison between before-improvement and after-improvement

	Before improve	After improve
Fixed rate of accuracy	7 % (6/86)	94.2 % (81/86)
Error rate	About 50 %	5.8 % (5/86)

(1) Before improvement

The system can correctly identify 6 sample paths; the paths of the remaining 80 samples cannot be effectively distinguished. The fix rate of accuracy is about 7 %. After post-processing using speed clustering method, the fixed rate of accuracy is about 50 %.

(2) After improvement

The system can correctly identify 81 samples' path, the remaining 5 samples are judged error. The fixed rate of accuracy is up to 94.2 % (Table 3).

4 Conclusion

The feature extraction method for the continuous flow and interrupted flow-based GPS data can effectively solve the existing problem of map matching and path recognition under the parallel road-network. In this paper, we used the fuzzy pattern recognition method based on feature separation, fully considered the characteristics of continuous flow and interrupted flow, and set up a series of features for each traffic flow type. At the same time, we used a fuzzy subset as the feature expression, which has very high tolerance of external interference. In a practical application, we found that the human brain is able to accurately identify the path through GPS location, but computers cannot do this. Using the fuzzy pattern recognition method makes better use of the human brain recognition experience and put the experience of people into the inference rules for reasoning, replacing computing, to complete the identification process. As a result, the accuracy of recognition rate increased greatly, to more than 90 %.

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Visual Impact Analysis and Control Method of Building Height for Landscape Preservation of the Traditional Gardens: A Case Study on the Suizenji Jōjuen in Kumamoto City

Li Lin, Riken Homma and Kazuhisa Iki

1 Introduction

In recent decades, with the progress of urbanization, urban renewal and redevelopment, many large cities have shown a trend of high-density land. It is indicated by an increasing number of denser and taller buildings and skyscrapers through various urban renewals and redevelopment projects. The urban environment which has a great quantity of high-rise buildings not only causes a visual impact on residents negatively, but also leads to the destruction of the pleasant urban forms (Asgarzadeh et al. 2012).

To ameliorate these problems, building height restriction started to be adopted as a common practice in urban planning and management in many countries all over the world. Preliminary attempts emerged in Chicago and New York with a flat limitation on the entire city (Weiss 1992). Then, based on aesthetic considerations, different height limitations by districts were implemented in some larger cities, such as Washington, DC, Boston and Beijing (Yu et al. 2010). In European countries, different approaches of building height restrictions were also used for city's historic preservation districts, such as Strategic Views within London (Wang 2006), Fuseaux de Protection within Paris (Su and Nie 2007) and so on. However, these

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_8

existing approaches usually realize building height control on 2D drawings by zoning or dividing levels according to landscape category. For example, in Paris, there were 45 landscape protection points designated in 1999. Almost the whole sky of Paris was covered with different kinds and different levels of control line on drawings. Although, constructers just need to calculate the building height limitation of this district by referring to drawings, it was not convenient to obtain effective data with so many lines crisscrossing together. Therefore, this study tried to present a quantitative and more practical method of building height restriction, based on simulating the virtual vision of people by 3D analyst tool in GIS.

As a representative of historic preservation districts which have been mentioned before, traditional gardens, especially those who located in inner city, their scenery is unavoidably influenced by high-rise buildings bordering them. Additionally, traditional gardens often utilized “borrowed scenery” as a design strategy, which means take natural features outside the garden (like mountains, trees, sky, etc.) as garden landscape (Arifin and Masuda 1997). Thus, the natural landscape outside of garden is also an essential ingredient of garden itself. And appropriate protection of the landscape in the background of the garden is as important as the inner landscape for the view from within the garden (Shinobe 2012). Therefore, it is significant to research this problem and put forward an approach to control building height surrounding traditional gardens.

This paper selected Suizenji Jōjuen, a traditional garden as a case study to estimate the degree of landscape destruction caused by high-rise buildings using collected data sets, and presented a quantitative approach for control the height of buildings by GIS. In the following sections, case study area and data sets which were used will be described firstly. Then, the methods how a 3D urban model was constructed and how to calculate the oppressiveness of high-rise buildings based on the height of buildings and the distance from observation points to buildings will be expounded in detail. Thirdly, we will analyze the current situation viewing from observation points, and evaluate the degree of landscape destruction by angle of elevation analysis. Next, a quantitative control method of building height will be put forward based on a virtual vision plane. In the last section, we will summarize the research productions and obtain some conclusions.

2 Study Area and Data Collection

Suizenji Jōjuen is a traditional Japanese strolling garden in Japan, located within Suizen-ji Park in Kumamoto City (Fig. 1). The garden has been declared as a historic site of scenic beauty in 1929 by the national government. According to a field survey in 1970 (Kitano et al. 1978), this garden covers an area of 59,500 m^2, and the ground slopes down from northeast to southwest. A spring pond was sited in the centre of the garden which was surrounded by elegant garden path, and many

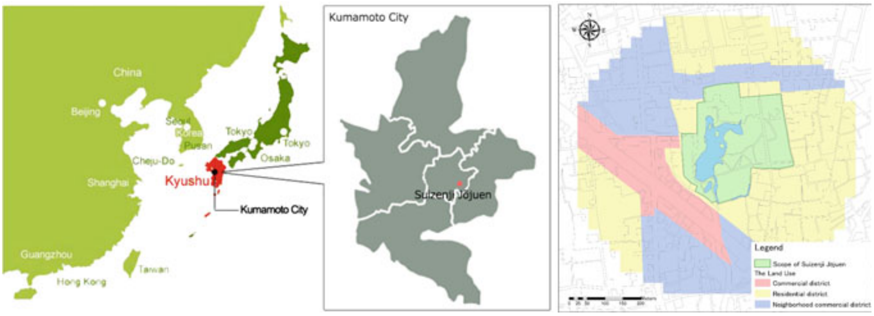

Fig. 1 The location of Suizenji Jōjuen and the land use surrounding Jōjuen

Fig. 2 Destruction of the scenery in Suizenji Jōjuen

artificial hills were built in the east of the pond. There is a tea-house standing in the west of the pond. It is a historical building, which was used by Prince Yūsai Hosokawa, a former feudal lord of Kumamoto, for teaching his brother the “Collection of Japanese Poems of Ancient and Modern Times”. It is said that viewing from the perspective of this building, the best scenery of garden could be enjoyed.

In the past, the garden was surrounded by farmland, and it could borrow scenery easily from surrounding landscape, like Mount Aso, Mount Tatuda and so on. Hence, a large quantity of tourists was attracted, and the amount of tourists was up to 1,800,000 one year approximately in the golden age. However, in recent years, the number has been decreasing continually and becomes less than 400,000 persons every year.

One of the main causes is that rapid development of region leads to garden scenery’s damage. Specifically, the garden is situated along the main street of city with convenient traffic, where has stations of the streetcar and JR nearby. Moreover, the western and southern areas outside the garden are respectively declared as a commercial district and two neighborhood commercial districts (Fig. 1). Under this condition, this region have been developing quickly, and more and more high-rise apartments have been lined around neighboring and been visible from inner of garden (Fig. 2).

The data sets included three parts, a digital elevation model (DEM) with elevation data of 5 m mesh measured by the Geospatial Information Authority of Japan (GSI), a basic survey data of Kumamoto City Planning provided by city hall in 2012 and a field survey data collected by my groups.

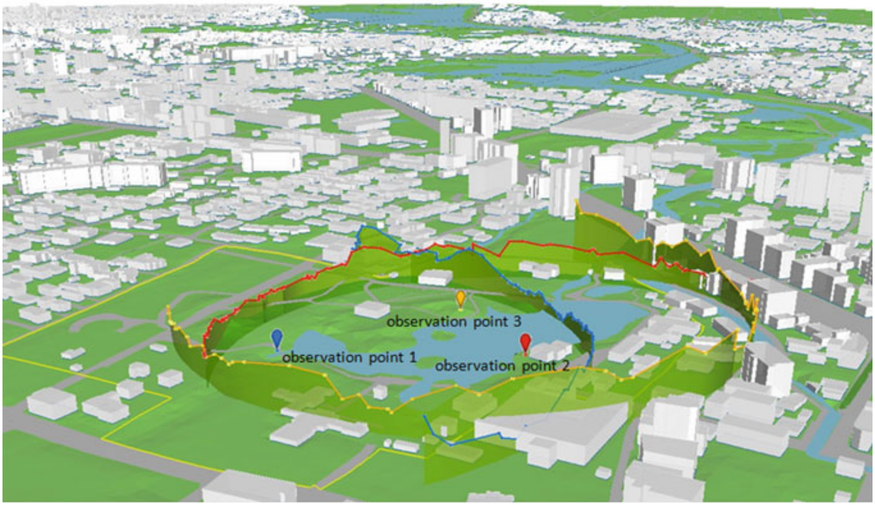

Fig. 3 The 3D urban model surrounding Suizenji Jōjuen

According to the digital elevation model (DEM) with elevation data of 5 m mesh, the terrain surface around garden was reconstructed really. Normally, triangulated irregular network (TIN) or regular grid (GRID) is used to depict the terrain surface generally. A TIN model consists of a series of nonintersecting triangles based on a certain number of elevations, and can be used to describe complex terrain frequently (Wang et al. 2008). Therefore, a TIN model was chosen to build the terrain surface of nearby district of Suizenji.

In addition, on the basis of the metadata, a 3D urban model (Fig. 3) was built by GIS, including terrain, rivers, road network, buildings with height and storey. It should be emphasized that all the analysis in this study was based on the 3D urban model. Then, in order to simulate real vision of observers in the 3D model, three main view points (displayed in Fig. 4) were selected as observation points, through a field survey of the place where tourists usually stop and spend long time to enjoy the scenery relatively.

Also, with the field survey, the contours of trees around the garden from each observation point were described (Fig. 3). It should be noted that, due to the quantity, latitude and longitude of trees, and the size of crowns were difficult to measure directly, so another method was adopted to compute the contours of trees in this research. The method was used by measuring the horizontal angle and vertical angle of some characteristic points which could represent ups and downs of the crowns from each observation point. This process made use of the Leica DISTO ™ D5, a laser distance measuring device.

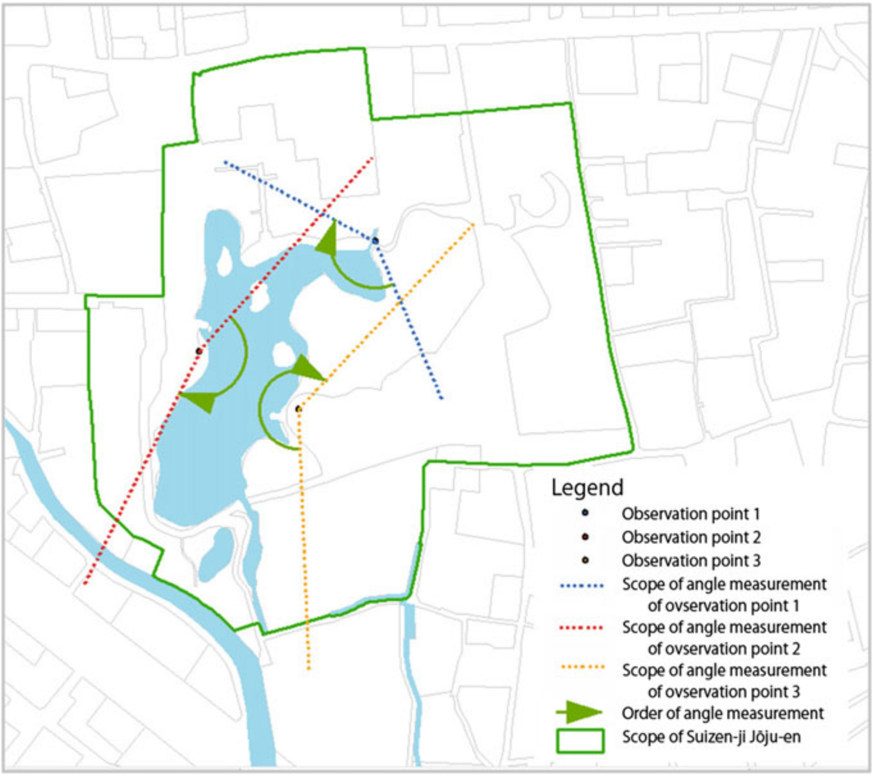

Fig. 4 The location of observation points and the scope of angle measurement

3 Methods

3.1 Extraction of the Visible Buildings

In order to extract the visible buildings when viewing from the garden, we used two kinds of methods. One method was Skyline Analysis. It was a 3D Analyst tool in GIS which could generate a 3D polyline representing the contour line of the neighboring highest features in the view from each observation point, such as a big tree in the garden or a high-rise building nearby.

Nevertheless, a visible building would not be extracted if it was located in front of the highest building with lower height and narrower volume from the perspective of sight line. Therefore, another method was used, and it generated a 3D polygon by TIN Triangle, which was composed of a series of extension lines connecting viewpoint to contour line of trees. The 3D polygon was defined as the boundary surface of visible and invisible, because it could extract all of visible buildings whether they could be seen from observation points or not at present.

Combined with these two methods above, when the 3D intersect relationship was found in the Select by Location in GIS, all of the visible buildings which could be seen from three observation points were extracted completely.

3.2 Analysis of Angle of Elevation

Angle of elevation (AE) is an index to estimate a sense of oppressiveness by the height and position of the buildings. We use this index for the sake of understanding the current situation that the landscape of garden was confused by the visible buildings.

As a calculation method of AE, the height of the buildings was computed based on this formula, and the position of the buildings was indicated by the distance from the center point of the spring pond of the garden to the buildings (Fig. 5). The measurement range was set as under approximately 800 m, which is the greatest distance that could see the visible buildings viewing from three viewpoints in the garden. Then, we got the degrees of the elevation angle through calculating.

Especially, we adopted Shinohara’s evaluation standard in this study, which had been verified in the study of landscape destruction caused by tall buildings in 5 Japanese gardens in Tokyo (Shinji et al. 1989). This standard is that when the AE is greater than 5°, it makes the person produce a sense of obstacle. Meanwhile, when the AE is greater than 11°, it makes the person produce a sense of oppressiveness.

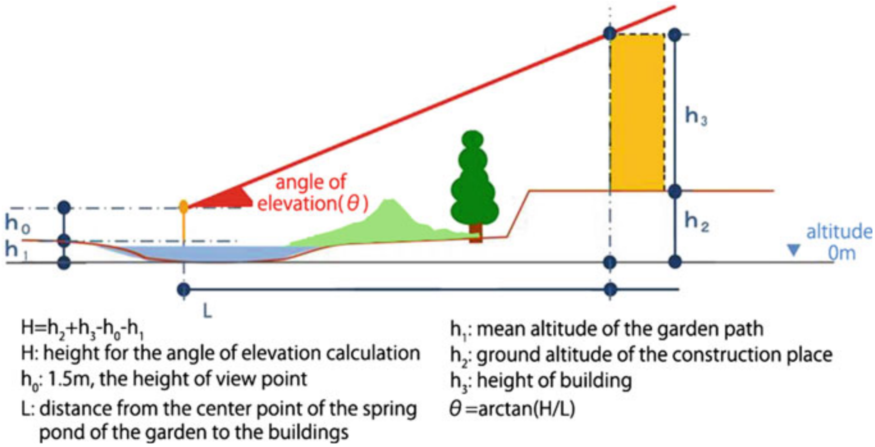

Fig. 5 The calculation method of angle of elevation

3.3 Creation Method of Building Height Restrictions

In terms of the boundary surfaces of visible and invisible which were introduced in the previous section, we came up with a quantitative method to restrict building height by GIS.

Firstly, create a fishnet of 30 m $\times$ 30 m rectangular cells (mesh) in a 2000 m radius around the garden. The elevation values of three boundary surfaces were interpolated into each mesh. Secondly, the intersecting parts of each boundary surface were extracted, and the lowest elevation value in the same mesh was assigned to the mesh. Next, these parts merged with the parts which did not intersect, and then produced a completed surface of building elevation restrictions. Finally, by subtracting the elevation value of terrain surface from this surface, we created the layer of building height restrictions.

4 Results and Discussions

4.1 Current Situation of Landscape Destruction

Integrate the visible buildings extracting from three view points, eliminate the repeated buildings, and then get the distribution map of the visible buildings (Fig. 6), which shows the current situation viewing from the garden.

As a result, there were 36 visible buildings distributed within an 800 m radius extending from the garden, whereas most of the visible buildings were located within the scope of circle whose radius of less than 400 m. They were concentrated along the north-south road in west side of the garden and along the main street with streetcar tracks obviously.

In addition, there were 14 high-rise buildings more than ten floors around the garden, which occupied almost half of amount. For the building type, apartment house occupies the largest proportion, while the number of commercial facilities and lodging facilities were also not in the minority.

4.2 Evaluation of the Degree of Landscape Destruction

According to the analysis of the angle of elevation from three observation points, we made an assessment on the degree of landscape destruction caused by the visible buildings. The results were displayed in the form of some frequency histograms (Fig. 7).

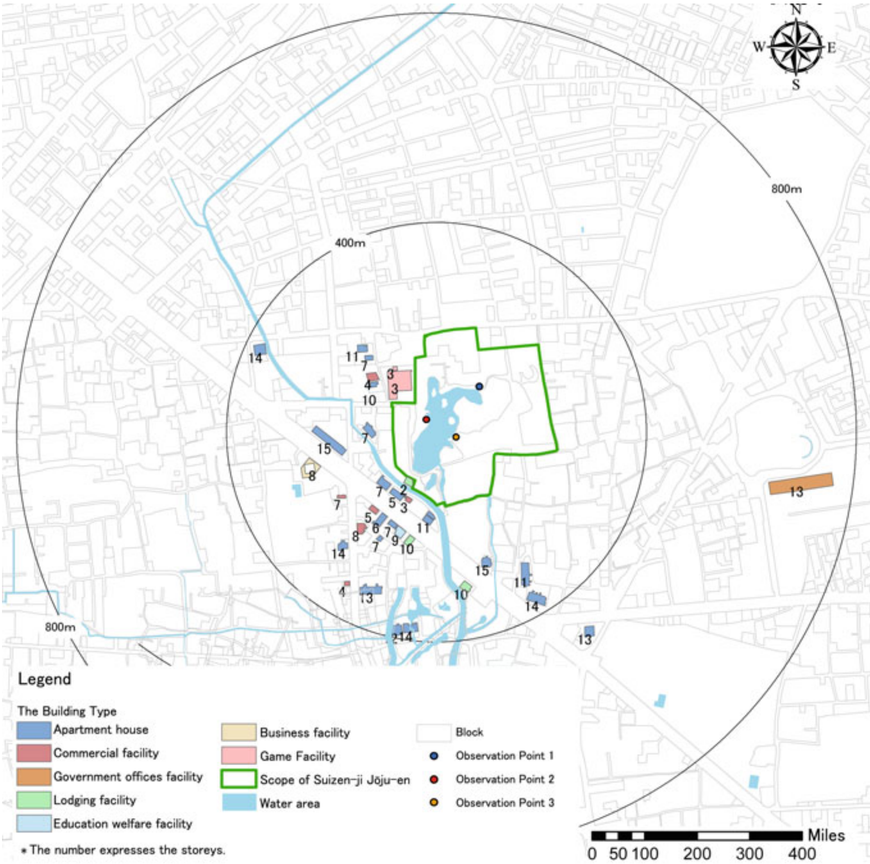

Fig. 6 Distribution of the visible buildings surrounding Suizenji Jōjuen

From the analyzing results, at every observation points, the visible buildings whose AE were greater than 5° account for a larger proportion, and the visible buildings whose AE was greater than 11° exist and can be seen from every observation points. In particular, in the position of the observation point 3, all of the visual buildings owned an AE above 5°; and in the position of the observation point 1, the AE within one of the visual buildings reached to 14.10°, which was towering, and gave rise to a strong sense of pressure. It means that the landscape in the background of garden has been destroyed, and it is necessary to put forward a more effective program of height restriction for these visual buildings.

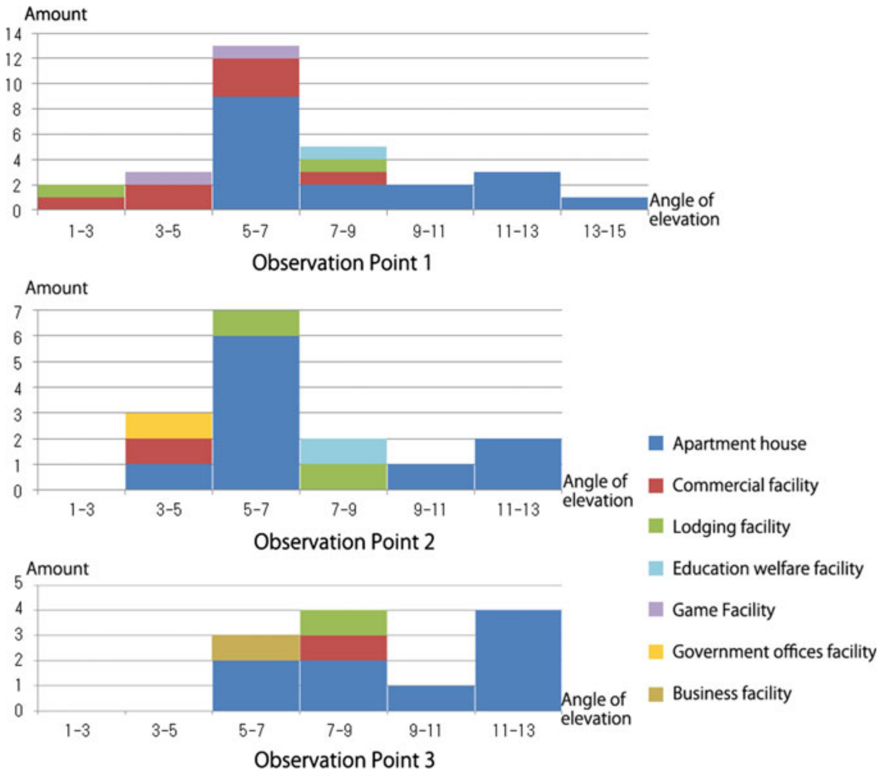

Fig. 7 The results of analysis of angle of elevation

4.3 *Quantitative Method of Building Height Restrictions*

As mentioned in 3.3, a layer of building height restrictions was created by GIS (Fig. 8). In this figure, all the meshes are displayed by different colors based on their height value from 1.5 to 120 m, and each mesh corresponded to some plots. It also showed that height of the region in the southwest of garden should be the most stringently regulated. Furthermore, the region in an 800 m radius around east of garden and the region in a 400 m radius around northwest of garden should have also been strongly restricted.

Based on the height value of mesh, not only the height of visible buildings can be restricted, but also the height of plot where buildings have been built or will be built can be restricted. Hence, it is recommended that the method could be a quantitative method of building height restrictions for landscape preservation of the Suizenji Jōjuen.

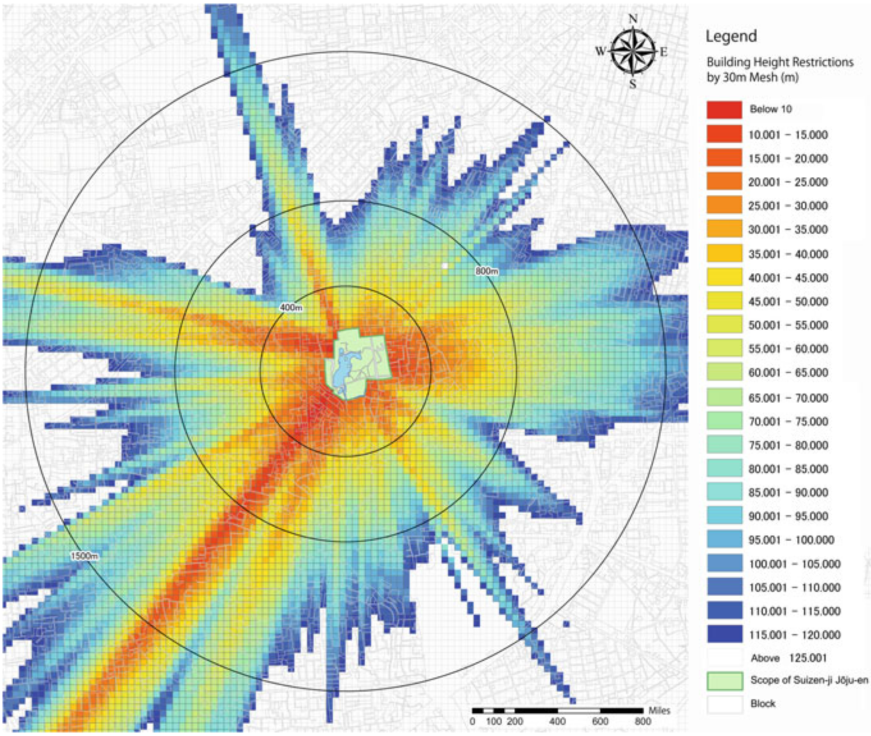

Fig. 8 Building height restrictions by 30 m mesh

5 Conclusions

The purpose of this research was to present a quantitative method to analyze the visual impact of visible buildings on people and control the height of buildings for preserving landscape of the traditional gardens. The output of this research included three parts. First, build a 3D model by using GIS, and made it possible to visualize the problems of landscape destruction viewing from garden. Second, computed and estimated the degree of visual impact caused by the visible buildings by angle of elevation analysis. Third, provide a quantitative method of building height restrictions by making use of some boundary surfaces of visible and invisible.

In this study, this method was based on small mesh. It could regulate building height on small plot for conserving the view of scenery from the garden. Simultaneously, it did not hinder regional construction on the area where the buildings were invisible from garden. That is, this method could preserve garden landscape while making the most effective use of the land surrounding garden. Thus, it could be a better quantitative approach, compared with the solution proposed on other gardens, such as dividing some concentric zones from the garden and restricting the maximum building height in each zone. If it is possible, this method could not only make contribution to landscape preservation of the Suizenji Jōjuen, but also could be used as a quantitative approach for controlling the height of buildings which can provide reference for the traditional gardens in other cities.

However, there are still many problems should be included in the further research. For instance, all of the 3D analysis depended on the selected three observation points and the measured data of horizontal angle and vertical angle of some characteristic points which could describe the contours of trees. In fact, it is certain that the more the number of observation points is selected, the results of data analysis will be more accurate. Therefore, whether needed to increase some effective observation points or not, it should be considered in the future research.

In addition, this study only analyzed the current situation of landscape destruction. However, for landscape preservation of the historic traditional garden, it should be possible to analyze the secular variation of landscape destruction, for grasping the seriousness of the problem completely and accurately, and putting forward more relevant suggestions.

Moreover, although the quantitative method of building height restrictions as a proposed research production can benefit architects or planners to draw up a construction planning conveniently, but the method was presented based on 30 m mesh with height values. Whether it is reasonable or not, the precision of restriction that takes 30 m as a unit still remains to be further discussed and studied.

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Satisfaction Level of Elderly People's Life in Urban Communities Based on the Status of Internet Usage—A Survey Covering Different Types of Communities in Xi'an

Liuchangyue Li, Xin Dong and Jing Zhu

1 Introduction

With the accelerating pace of population aging and ever-growing aging population, China is now experiencing the largest and fastest aging process in the world history. Statistics show that as of February 2014, the number of people over age 60 has exceeded 200 million in China, accounting for 14.9 % of the total population; and it is expected that China will enter the peak of aging over the next 20 years. Nowadays, there are severe aging problem in China. With the economic and social development, people are in pursuit of higher quality in material life while having increasing quality requirements for spiritual life, which raises higher requirements for meeting the elderly people's demands. Meanwhile, with the popularization of the Internet, more and more people have enjoyed the convenience and fastness of information world. In the network era and "smart city", people not only live in physical space, but also in the internet-based virtual space. People's quality of life depends not only on activities in physical space, but also on their usage of internet and related activities. In the process towards aging society, not only young people do activities such as social networking, entertainment and shopping via the network, more and more elderly people also get more life convenience, and enrich their material and spiritual life through the "Internet". "Internet support for elderly people" will come into view as a new form of support for elderly people.

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_9

In the current situation of prevalent shortage of elderly support facilities in Chinese communities, which will continue for a long period of time, "How is the status of network facility in different urban communities? What are the population, proportion and demographic characteristics of elderly internet users among community residents? What is the elderly people's network usage status? How are the elderly people's living conditions in the "virtual space"? Whether the use of Internet improves the quality of life of elderly people? Does the use of network facilities effectively supplement the lack of other elderly support facilities in communities? Is there any correlation between internet usage status and elderly life satisfaction degree for elderly people?" The above issues are the focus of this research. Based on these, the author conducted a random sampling survey on internet usage status of elderly people in different communities of Xi'an. Our study show that there was a quite significant correlation between "whether use Internet or not" and the level of elderly life satisfaction in many communities, and this trend became increasingly significant with decreasing age of samples.

2 Methods

The cope of this study was some residential area within the Second Ring Road and outside the Ming Dynasty City Wall in Xi'an. In the selection of survey sites, 50 residential communities with household fixed broadband penetration over 70 % were screened firstly. Then, unit communities, commercial housing communities and affordable housing communities were sampled by stratified sampling combined with random number table, in order to ensure the validity of various types of samples. On this basis, stratified random sampling was used to randomly select 30 elderly people in each community, totaling 1500 elderly people, as well as 30 middle-aged people in each community, totaling 1500 middle-aged people as the respondents. A total of 3000 questionnaires were distributed in this survey, and 2826 questionnaires were valid, with a return rate of 94.2 %. Afterwards, field visit surveys and questionnaire surveys were conducted to obtain information on the status of living & recreational facilities, and statuses quo of network facilities and elderly support in different types of communities. On the basis of grasping the basic conditions of network infrastructure in different communities and their differences, internet usage behavior of different groups of elderly people, as well as spatial-temporal & typological characteristics of network life and their differences, "SPSS" software was used to perform Logistic Regression Analysis on the correlation between Internet usage status and degree of elderly life satisfaction in elderly people. And comprehensive evaluation and comparison were made between "intra-network" and "extra-network" elderly activities by Likert scale and AHP.

3 Analysis and Results

3.1 Dependent Status on "Internet" for Elderly Life

The survey found that the internet usage status of elderly people was inversely proportional to age. The ages of internet users were mostly concentrated between 60 and 74 years, and the older the internet users, the higher their education levels. Elderly Internet users over 80 years of age generally had high education levels, all of whom had received high school or university education. Elderly people used the Internet mainly for entertainment, chatting, learning, watching movies, listening to music and shopping. Most elderly Internet users used traditional networking products like desktop computers, while having low acceptance of new networking products such as mobile phones and television. The type of network elderly people use was also mainly wired network, and few of them use WIFI. Elderly people were a quite special group, limited by their age, the main obstacle in using internet was health issues. Elderly people generally did not have very high proficiency in using the internet, and only about one-third of them were moderately proficient and highly proficient in using the internet (Fig. 1).

Different communities had different elderly support facilities. Generally, elderly people in communities with relatively complete elderly support & network facilities, such as ordinary mixed communities and new commercial housing communities, had lower daily frequency of Internet usage, and shorter length of time on the internet; whereas those in communities with inadequate elderly support & network facilities, such as unit communities and affordable housing communities, had higher daily frequency of internet usage, and longer length of time on the Internet. It can thus be seen that the completeness of elderly support and network facilities were closely related to the internet usage status of elderly people, and inadequate urban infrastructure had led the elderly people to improve their quality of life by using the network (Figs. 2 and 3).

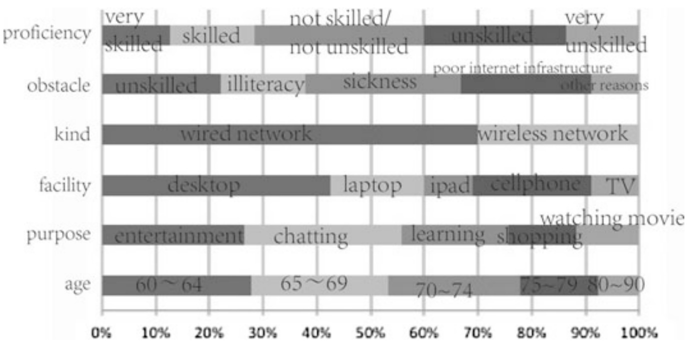

Fig. 1 Internet usage status

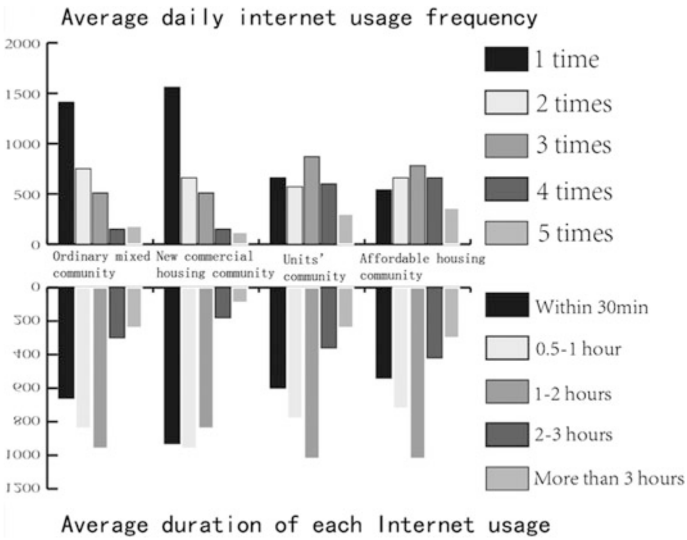

Fig. 2 Average daily internet usage status

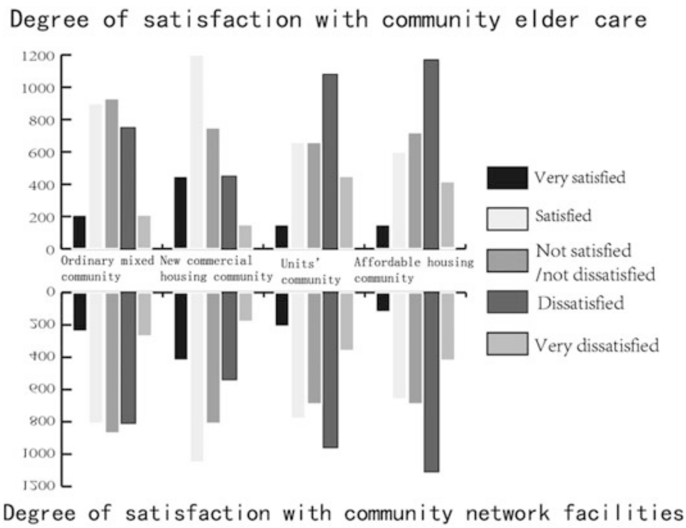

Fig. 3 Degree of satisfaction

3.2 Dependency on the "Internet" Become an Increasing Trend for Elderly People

Most elderly people did not use the internet for very long every time, and the duration was mostly concentrated within three periods: less than 30 min, 0.5–1 and 1–2 h. In comparison, middle-aged people generally spent longer time on internet than the elderly people. 3/4 of the middle-aged people had an average duration of each internet use of 1–3 h. Elderly people also had a low frequency of internet use, 50 % of elderly internet users access the internet about once a day, and about 1/4 of them access the internet about twice a day. Middle-aged people had a higher frequency of internet use than the elderly people as well, which was mostly 3–5 times a day. Comprehensive analysis of the two charts showed that the middle-aged people use the internet more frequently than the elderly people. Elderly and middle-aged people who use the internet generally had a high level of satisfaction with their life, while only a few were not very satisfied. This indicated that the use of internet was somewhat helpful in improving the quality of life for elderly people (Fig. 4).

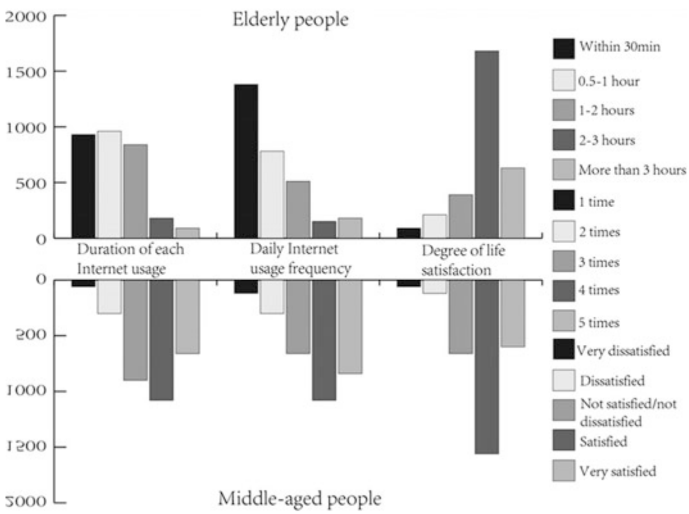

Fig. 4 Internet usage statement of different people

3.3 Correlation Between "Internet" Usage Status and Life Satisfaction Level

After statistically processing the returned valid questionnaire data of "Survey on Network Usage Status and Elderly Life Satisfaction of Elderly People in Urban Communities", the data was analyzed by multivariate logistic regression using "SPSS" software with daily frequency of Internet use, duration of each Internet use and proficiency in Internet use as the independent variables, and degree of life satisfaction as the dependent variable. Then, the correlation between Internet usage status and life satisfaction degree in elderly and middle-aged people was analyzed. The results showed that the "Internet" penetration was not very high among elderly people, and the correlation between Internet usage status and elderly life satisfaction degree was only 45.2 %. The fact that elderly people did not had very high acceptance of Internet and that the correlation between Internet and elderly life satisfaction was not very high suggested that the improvement of quality of life via network just began among elderly group at present. The survey also showed that the Internet penetration had already been high among the middle-aged group; and the correlation between their Internet usage status and life satisfaction degree was 95.7 %. In middle-aged people's life, almost everyone would spend part of their time on the Internet. Most middle-aged questionnaire respondents agreed that the impact of network on their life was positive. Therefore, enhancement of life satisfaction by using the Internet has become an inevitable choice in modern society (Table 1).

Table 1 Model fitting information

Model fitting information				
Model	Fitting criterion	Likelihood ratio test		
	−2 Log likelihood	χ^2	df	Sigf
Intercept only	147.435	52.561	52	0.452
Final	94.874			
Model fitting information				
Model	Fitting criterion	Likelihood ratio test		
	−2 Log likelihood	χ^2	df	Sigf
Intercept only	71.959	19.671	32	0.957
Final	52.288			

Analysis of correlation between Internet usage status and elderly life satisfaction for elderly people
Analysis of correlation between Internet usage status and life satisfaction degree for middle-aged people

3.4 Differences in Satisfaction and Convenience Degrees Between "Intra-Network" and "Extra-Network" Life

Differences in satisfaction degree between "intra-network" and "extra-network" elderly life were evaluated by AHP. From two aspects of elderly life demand and Internet use, evaluation index system was constructed, which consisted of three primary indices and seven secondary indices. The weight of each index was determined by expert scoring (Table 2).

Five grades were set up for each evaluation index, including totally agree, agree, not agree/not disagree, disagree and totally disagree, which were scored 5, 4, 3, 2 and 1 point(s) based on Likert scale. Questionnaires were statistically analyzed to construct the satisfaction degree matrix. Comprehensive evaluation results of this survey were obtained by multiplying the weights of indices by the corresponding fuzzy matrices, which showed that the degree of satisfaction with "intra-network" elderly life was 3.25, while that of "extra-network" elderly life was 3.64 (Table 3).

It can be seen from the research results that the degree of satisfaction with "intra-network" elderly life is slightly lower than that of the "extra-network" elderly life. However, the results of secondary index evaluation showed that the degree of "intra-network" elderly life satisfaction was higher than the "extra-network" elderly life satisfaction in three areas: mental health, spiritual happiness and self-fulfillment; while in aspects like material security, life convenience and sense of belonging, "extra-network" elderly life still had comparative advantages, especially in the aspect of physical health. On this basis, five-point analysis was performed, which found that some daily life needs of elderly people were not correlated with the Internet, such as dropping off and picking up children, looking after children and strolling; while some must rely on Internet, such as WeChat and online games. Nevertheless, most daily activity needs can be met both in the

Table 2 AHP analysis

Primary index	Weight	Secondary index	Weight
Physical and mental health	0.4	Physical health	0.2
		Mental health	0.2
Material satisfaction	0.4	Material security	0.15
		Life convenience	0.15
Spiritual satisfaction	0.3	Spiritual happiness	0.1
		Sense of belonging	0.1
		Self-fulfillment	0.1

Table 3 Satisfaction with intra-network and extra-network

Secondary index	Physical health	Mental health	Material security	Life convenience	Spiritual happiness	Sense of belonging	Self-fulfillment
Virtual	2.3	3.3	2.6	2.8	3.4	3.1	3.9
Physical	3.7	3.2	3.5	3.3	3.0	3.4	2.7
Primary index	Physical and mental health		Material satisfaction		Spiritual satisfaction		
Virtual	2.8		2.7		3.5		
Physical	3.45		3.4		3.0		

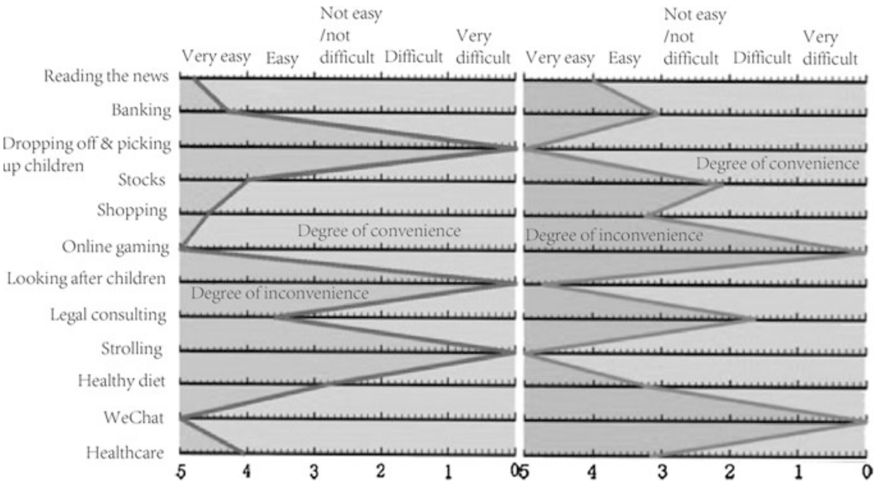

Fig. 5 Difficulty of daily activity needs fulfillment via "intra-network" and "extra-network" for elderly people

"intra-network" and "extra-network". As can be from the figure in the left, the majority of life needs can be more easily fulfilled through the Internet, and the overall convenience of "intra-network" elderly life is higher than the "extra-network" one.

Ways of implementing daily activities: "Intra-network" "Extra-network" (Fig. 5).

It is clear that the "intra-network" elderly life has formed a useful supplement to the "extra-network" elderly life. Although "Internet" is not omnipotent in enhancing the quality of later life due to restrictions of network infrastructure conditions and elderly people's own usage conditions, in the context of increasing "Internet" penetration and usage, it has comparative advantages in many aspects, and still possesses great potential in improving the quality of life of elderly people. Therefore, acceleration of community Internet infrastructure construction and promotion of elderly people's better Internet use should be the key directions for promoting the development of elderly support (Fig. 6).

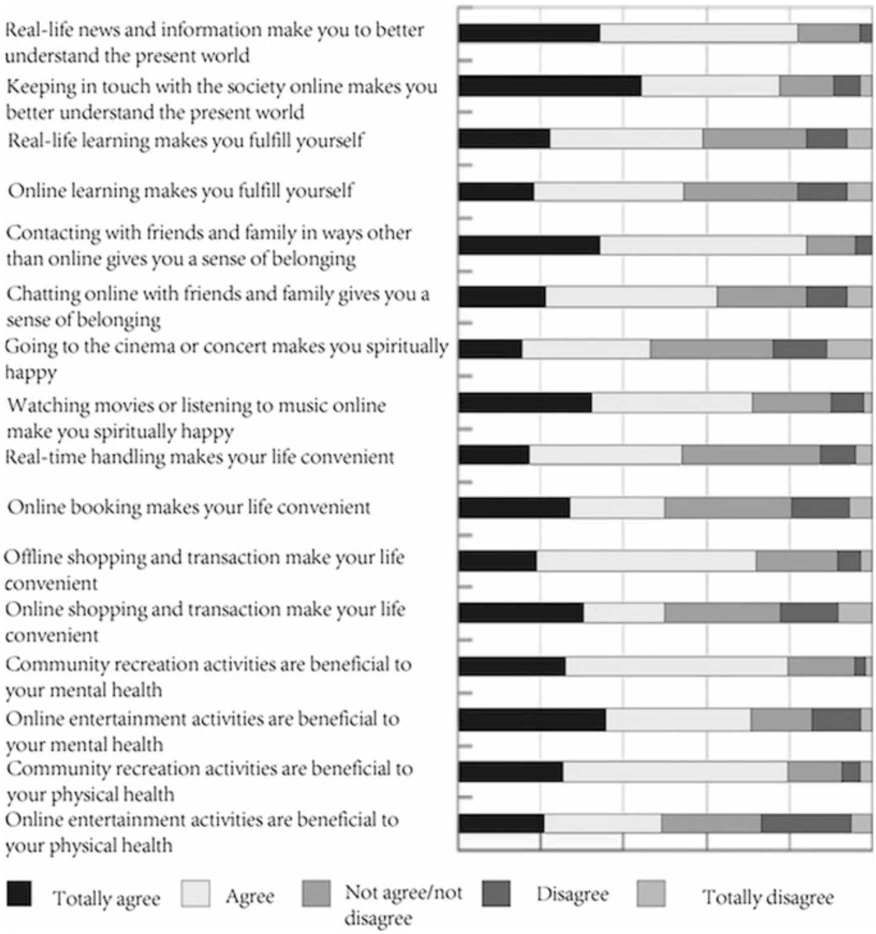

Fig. 6 Comparison of online and real life

4 Conclusion and Outlook

Through the research, we draw the following conclusions, Firstly, age and elderly life satisfaction level have an inverse relation, and the linear correlation of elderly people's dependence and proficiency in internet with elderly life satisfaction degree is relatively low, but this feature presents an increasing trend with decreasing age. Secondly, abundant leisure time, lack of community elderly support facilities, physical inconvenience and widespread "empty nester" phenomenon have given elderly people some difficulties in meeting their spiritual needs, and the use of internet has played a positive role in addressing these issues. Although a considerable number of elderly people do not often use the "Internet", and think that the "Internet" is mysterious and difficult, they all believe that the internet has a positive

Table 4 Role of Internet usage in improving the quality of daily life of elderly people

Lack of elderly support	Physiological needs	Safety needs	Sense of love and belonging	Esteem needs	Self-fulfillment
Role of Internet	Health (e.g. online appointment registration); supply of daily necessities (e.g. online shopping)	Life safety (e.g. calling for help); property safety (e.g. binding account to a mobile phone)	Kinship (e.g. family VoIP); friendship (e.g. using online social networking platform to interact with old friends and make new friends)	Affiliation (e.g. joining online community); internal esteem (e.g. online games); external esteem (e.g. online chess and other competitive activities)	Individual capacities (e.g. online creation, publication); enhancing creativity (e.g. learning new knowledge, acquiring new information online)

impact on society; with the advancement of "gray hair tide", "eldercare e-age" will come eventually (Table. 4).

In the next period of time, research on individual and social activity patterns of elderly people from "virtual space" aspect will open a new research perspective for related sociological, demographic, human geographic and urban planning studies. Inclusion of "virtual space" in urban and rural community eldercare system as a public resource will also open a breakthrough point for policy innovations in urban and rural area public service facilities. Incorporation of "network infrastructure" into the research system of Chinese urban and rural planning, and the focuses on elderly life activities and spatial characteristics in virtual space, and planning & design requirements on public facilities are the innovative points of this study. Our study shows that the "Internet elderly life" can effectively remedy the current prevailing problem of insufficient community eldercare service facilities. Elderly support by means of "Internet" is an inevitable development trend of modern society. In the research of urban and rural planning, the importance of "Internet" in the fields of "community elderly support" and "public service facilities" must be stressed, and more intensive study should be carried out.

Study on Characteristics and Policy Recommendations of Small Towns in View of Regional Development Strategy in the Coastal Area of Jiangsu Province, China

Shuping Cui and Wei Fu

1 Introduction

As important parts of an urban system, small towns influence the conditions of cities and countries (Fei 1996). In the past 30 years, urbanisation in China has attracted attention from the world for its high speed and quality. However, compared with the development of central cities and metropolises, that of small towns lags behind, thereby lessening the appeal of small towns. According to a survey in the rural area of Jiangsu in 2012 (Zhou et al. 2012), only 10.70 % of rural respondents were willing to live in small towns, and only 5.43 % of them wished their children to live in small towns in the future. In recent years, discussions on the mode and path to accelerate the development of small towns have drawn considerable attention, not only from academic circles (Li 2012; Xu and Zhang 1990) but also from the government of China. The New Urbanisation Plan (2014–2020) indicates that focus should be given to developing key small towns, combined with the decentralisation of large cities, the activation of characteristic industries, and the improvement of services in rural areas. However, in practice, the paths and strategies of development for key small towns still require deeper exploration.

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_10

2 Study Area and Methodology

2.1 Study Area

The study area is located in the coastal land in the eastern Jiangsu Province, which includes the domains of Lianyungang, Yancheng and Nantong cities, with a land area of 32,500 km^2 and a total population of 20.81 million. This study area has good environment and industrial base. The sea area with a water depth of less than 30 m is 70,000 km^2, with a coastline of 1000 km. The area features prominently in regional development. The Development Plan for the Coastal Area of Jiangsu was promoted as one of the national strategies in early 2009. In the process of regional development, the issue of small towns is emphasised by the local government. The incubation of coastal cities and towns is included as one of the Six Action Plans for the development of coastal areas. This study selected 26[1] towns listed in the action plan as samples (see Fig. 1) to evaluate and to guide the further development of small towns.

2.2 Methods

The capability and potential for development are often equivalent to the sustainability of a city/town. According to the United Nations Centre for Human Settlements Sustainable Cities Programme, the concept of sustainability integrates social, economic, and physical development [United Nations Human Settlements Programme (UN-Habitat) 2002]. Likewise, a sustainable city is defined as including economic, social, and environmental achievements in the Habitat Agenda of the United Nations (1996). To sum up, the concept of sustainability involves economic, physical, environmental, and social aspects. Thus, this study used the framework of the four pillars mentioned above to analyse the status of key small towns. In the analysis of specific issues, the strengths, weaknesses, opportunities, and threats (SWOT) model was applied to identify the advantages and disadvantages of towns in a particular aspect under the framework. The opportunities and challenges should also be predicted in the macro environment.

[1]According to The Six Action Plans for the Development of Coastal Areas and the Key Points for the Work of 2014 [S. Z. F (2014) No. 62], 27 towns are on the list of coastal towns. Considering that the new town of Lianyungang is considered a built-up area of the city, this study analysed 26 small towns, and excluded the new town of Lianyungang.

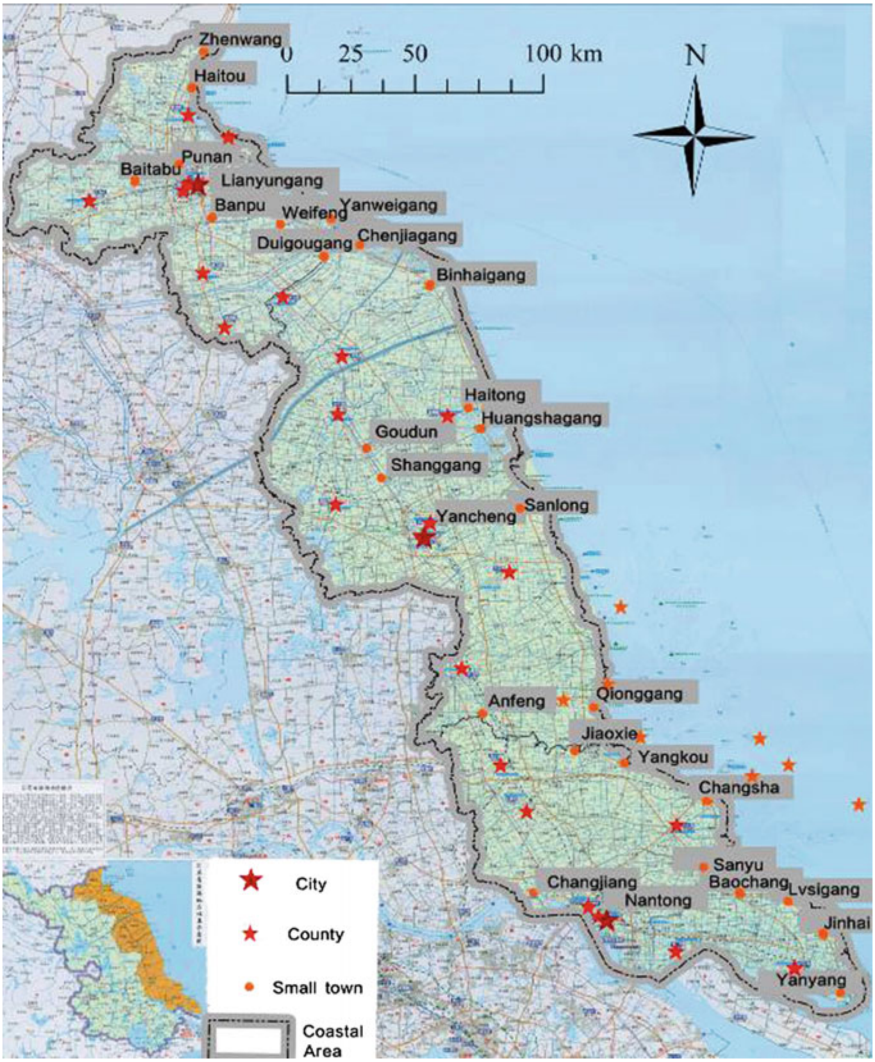

Fig. 1 Distribution of the key coastal towns

3 Results

3.1 Status of Towns

3.1.1 Industrial Economy

The strategic deployment and support of policies from the government, the construction of the fast track between Jiangsu and Shanghai, the rapid development of harbours, the swift expansion of large-scale regional infrastructure, and the completion of a series of large projects for the past five years have resulted in the accelerated progress of socio-economic development and urbanisation in coastal areas. In 2013, the gross domestic product (GDP) of coastal areas surpassed the threshold of 1 trillion RMB to an unprecedented 1.03 trillion, representing a 12 % growth compared with the previous year, which was 2.4 % higher than the average of all the towns in the province. The gross regional product per person was 54,401 RMB, which was an 11.8 % improvement, 2.5 % greater than the provincial average. The added value of industrial enterprises experienced an increase of 13.8 %, which was 2.3 % greater than the average of Jiangsu Province. The income of the public finance budget was 108.6 billion, which was a 15.3 % increase, 3.2 % greater than the average level for the province. All prefectures of Nantong City, Dongtai City, Dafeng City, Jianhu County and Yandu District of Yancheng reached the indices of the province for a moderately prosperous society. The coastal area has been considered one of the regions with the fastest growth, greatest growing capability, and highest potential in the past few years. With the increasing development of the area, the key small towns also exhibited good performances in urbanisation, population growth, and employment. Data showed that the average growth rates in developed land area, population, and employment for the key small coastal towns in 2013 were 1.55, 1.34 and 1.07 times higher than those of all the small towns in the Jiangsu Province, respectively (Fig. 2).

Given that the coastal area is almost entirely muddy land, continuous sedimentation from the sea has led to the expansion of the coastline. As a result, the small coastal towns are located beside neither the city nor the harbour (see Fig. 3). The small coastal towns consequently had weakened capacity for expansion. Compared with the urbanisation of the land, the urbanisation of the population, the integration of industries, and the expansion effects on the region still require further

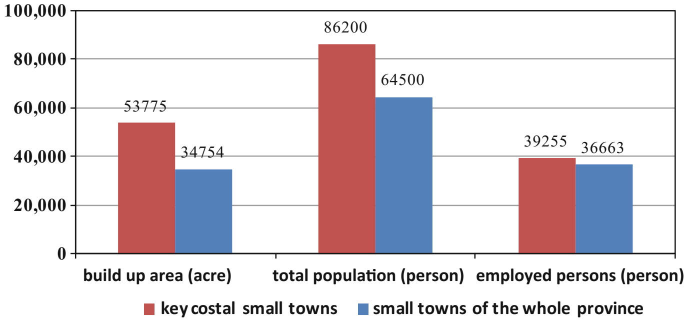

Fig. 2 Comparison of economic and social indicators between key coastal towns and small towns of the entire province (*Data source* Statistic Yearbook of Jiangsu 2014, Annual Report and Statistics of Towns and Villages in Jiangsu 2014)

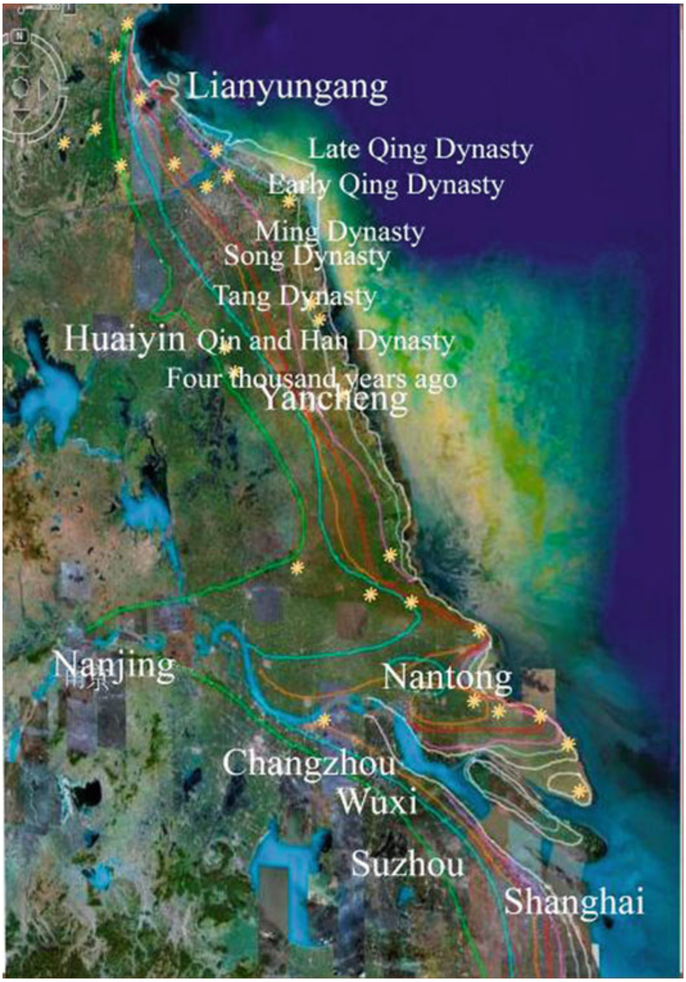

Fig. 3 Location of key coastal towns and the coast

improvement. The industry of small coastal towns was composed mainly of primary and secondary industries. The majority of enterprises could be classified as labour-intensive with low technical content. The core business of companies focused on the processing of foods, machinery, chemistry, textiles, and building materials (see Fig. 4). However, the development of modern producer services and the commercial industry lagged behind the industrial system. Industrial structure sustainability remained a serious problem. Facilities supporting industrial development were also lacking. New companies and high-level talents rarely settled in coastal areas.

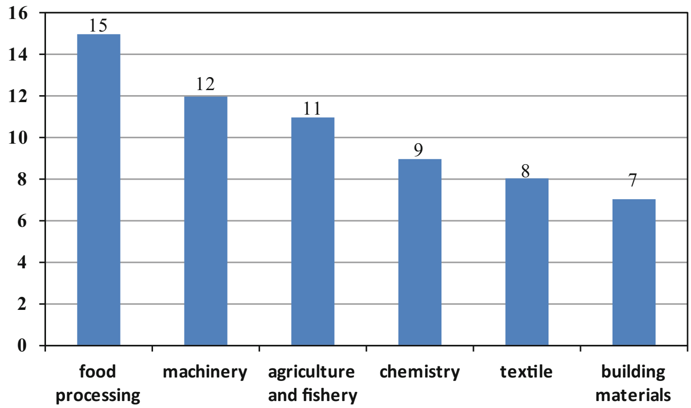

Fig. 4 Number of key coastal towns featuring different industries. *Data source* Field survey

3.1.2 Physical Space

The key small coastal towns have shown significant improvements in planning and construction during the past years. By 2013, all towns had completed their general planning; some of the local governments invited top planning institutions in China to design and create plans for towns. With the guidance of planning, the level of public utilities and services increased. In some towns, the living environment was significantly improved. For example, the coverage ratio of the water supply of Huangshagang and four other towns reached 100 %, the ratio of non-hazardous disposal of municipal solid waste in Duigougang and six other towns reached 100 %, the disposal rate of sewage water in Lysigang reached 95.63 %, and the greening rate of Jiaoxie in built-up areas reached 30.46 %.

Although physical space is improving in different aspects, this achievement could not resolve problems such as the lack of coordination between planning and economic development and between the time and method of construction. As for planning, the master, land use, and development plans had not been integrated. The issue of homogeneous competition and waste of resources also existed because of the unclear orientation of towns, developed zones, and harbour areas. As for construction, the 'project-oriented' idea was generally carried out, thereby causing staggered land use. Furthermore, the area has had insufficient supply of public services and comprehensive capacity for limited investment from public financing for a long time. The indices all fell below the average for the province, including the water supply rate, greening rate of built-up areas, and non-hazardous disposal rate of garbage (see Fig. 5).

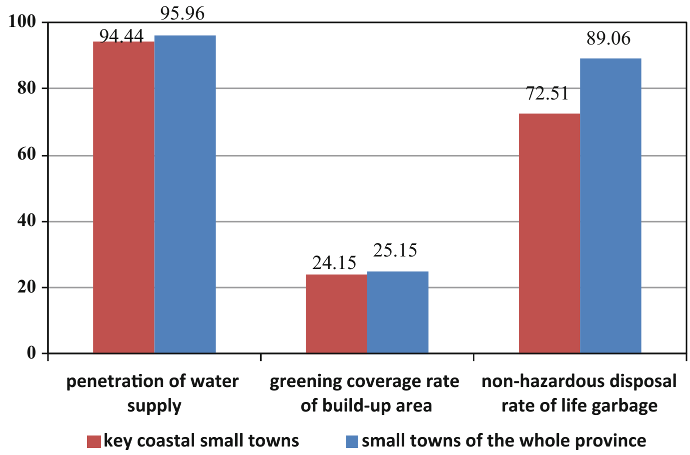

Fig. 5 Comparison of construction indices between key coastal towns and towns of the entire province. *Data source* Annual Report and Statistics of Towns and Villages in Jiangsu 2014

3.1.3 Ecological Environment

The coastal area was listed as a core protection zone of the ecosystem and wildlife for its superior ecological environment. The area has a high-level ecosystem service, i.e. the seaside wetland regulates the microclimate, eases the damage from storm surges, and purifies the atmosphere. The area also has abundant natural resources, such as wind energy, plentiful land, fishery resources, and rich species. The land area and agricultural acreage were 1.26 and 1.44 times greater, respectively, than those of the average of towns in the province. The Lyusi Fishery Ground in Lyusigang is one of the most important fishery grounds in China. The town of Sanlong is located near the national natural reserve for rare birds.

The relationship between development and environmental protection remained a problem. According to the survey, of the 26 coastal towns, 11 (42.31 % of the total) featured polluting industries, such as the chemical industry and silica products. Some of the small companies in the towns still applied lagging, coarse production and non-standard operational procedures, which posed barriers to the protection and improvement of the environment. Pollutants from the industry cannot be neglected in environmental management.

3.1.4 Social Administration

As ‘the head of the country and the tail of the city,’ towns played important roles in urbanisation and urban–rural development. However, the government of towns took on huge responsibilities but actually had limited power, weak functions, and low efficiencies. They could be qualified in organisation, operation, and allocation during the integration of urban and rural areas.

The coastal areas of Jiangsu have recently made institutional innovations, such as 'strengthening the towns and increasing the power of the governments.' For example, since 2013, Nantong has propelled the integration of districts and counties. In this way, the party working committee of the industrial park, the management committee, and the communist party were placed in a co-working environment, which provided institutional guarantees for the general coordination and planning of the coastal area. This innovation helped coordinate resource allocation between the harbour area and towns, increase interest of coastal towns, improve the functions of cities, and facilitate interactive development.

3.2 Situation of Towns

3.2.1 Opportunities

In 2013, the Decision of the Central Committee of the Communist Party of China (CPC) on Some Major Issues Concerning Comprehensively Deepening the Reform was passed on the Third Plenary Session of the 18th Central Committee of the CPC. The Decision made it clear that

> We should adhere to the new road to urbanisation with Chinese characteristics, as well as promote human-centred urbanisation and coordinated development of large, medium and small cities and small towns. Towns should attract much population with economic strength. We should also establish and perfect coordination mechanisms for regional urban development.

The relevant ministries of the State Council have issued a series of policies and advices in recent years. They aimed to clear the barriers for people to settle in small towns. The pilot project of 'strengthening the towns and broadening their authorities' was also carried out to reiterate the important roles that small towns play in the new-type urbanisation. After the conference for promoting the development of the coastal area, the Jiangsu Provincial Committee and the Provincial Government issued a new decision concerning coastal development and deployment. The official document proposed 'six actions' as a breakthrough to promote scientific development and upgrade the economy and society of the coastal area. Later, the Jiangsu Provincial Government announced the 'six action plans for coastal development.' The document placed the cultivation of coastal towns in the regional plan. Specifically, the improvement of the functions, features, and charms of the towns was emphasised in the development strategies. The promulgation and implementation of such policies provided considerable opportunities for the development of small towns along the coastline.

Table 1 Level of economy and urbanisation of the three coastal cities

City	GDP of 2013 (100 million RMB)	PGDP of 2013 (RMB)	Urbanisation rate of 2013 (%)
Lianyungang	1785.42	40318.41	55.7
Yancheng	3475.50	48138.45	57.2
Nantong	5038.89	69047.65	59.9
Average of the five cities in southern Jiangsu	7277.71	106153.5	72.1

Data source Statistic Year Book of Jiangsu 2014

3.2.2 Challenges

However, four barriers were found to constrain the further development of towns.

(1) The expansion of the central city is limited. The three coastal cities and their counties presented low levels of urbanisation and economic and social development. They were still in the middle and late stages of industrialisation, making it difficult to attract resources, capital, and labour from external markets. Having a significant spill-over effect and expansion to the small towns around them also proved difficult. The GDP, PGDP, and rate of urbanisation of the three coastal cities in 2013 were all much lower than those of the five cities in southern Jiangsu Province, which are located in the most developed region (see Table 1). As the first batch of coastal cities chosen for opening up, Nantong and Lianyungang still ranked in the middle or lagged behind in terms of GDP, compared with other opened cities in 2013 (see Fig. 6).

(2) The development of towns, small cities, and harbour areas was divided. Emphasis was given to the development of harbour areas. As a result, preferential policies for land and other resources often gave priority to large cities, developed zones, and harbour areas, thereby leading to weakness in the development of small cities and towns.

(3) Towns lacked investments in construction. On the one hand, towns had low populations and development levels across the province; on the other hand, the government of towns had no independent financial rights in the existing financial allocation system, in which most of the taxes from towns were turned

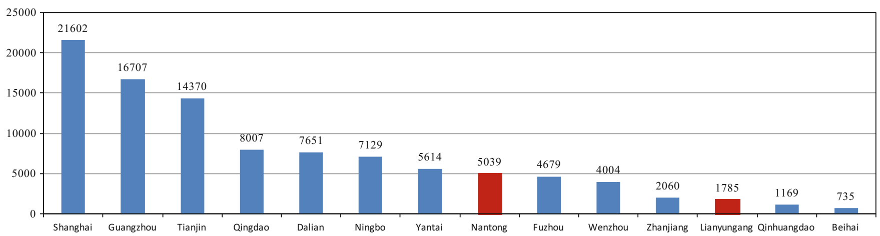

Fig. 6 Comparison of the GDP of the first batch of opening up cities in 2013 (100 million RMB)
Data source The website of the city

over to higher levels of government and the funds returned to small towns were matched with the authorities. Issues such as the scarcity of financing funds and the unitary subject of investment increased dependence on the financial allocation and resulted in a shortage of construction funds.

(4) The development of towns was not planned and implemented systematically. Some cities had insufficient awareness of the importance of the development of small cities and towns. Some counties did not focus on the key small coastal towns and did not give priority to their cultivation. For example, the towns of Punan, Sanlong, Jiaoxie, Goudun, Sanyu, and Jinhai were not listed in the catalogue of the national or provincial centre towns. Great changes often took place in the goals and directions of the development because of the adjustment of the county–rural layout planning and the frequently changing leadership of the town.

4 Discussion

With the rapid development motivated by regional strategies, towns in the coastal area of Jiangsu Province were also confronted with a series of problems and challenges. Under favourable policies for towns, the cultivation of towns still required further innovations and reform. Cultivation should start from a reform of the administrative system and the running mechanism to create an environment beneficial to the scientific development of small towns, including transforming the roles, functions, and ways of working. The development of small towns should be boosted by following the principles of different developments and fully upgraded based on the conditions, scales, and potential of towns. The systematic philosophy of regional planning should be established to promote synergic development of industries and towns by coordinating the different demands of areas, cities, and towns. The principle of ecological priority and sustainability could not be disregarded in the development of the coastal area. Arrangements should be made for further development of towns in terms of planning, industry, characteristics, capacity, governance, and so on.

4.1 Innovation in Urban and Rural Planning

The reform and innovation for planning should be vigorously advanced by introducing the idea of regional planning and increasing the integration of planning in order to accelerate the development of towns. The towns listed in ‘the cultivation action plan of the coastal towns’ should work together and formulate their specific function orientations, development priorities, and industrial distributions depending on their differentiation. A planning system of towns should also be formed, with the general plan as the leader and the short-term construction, project, and regulatory plans as supplements. In the system, the compilation and implementation of district, regulatory, rural, construction, and subject plans should be emphasised. Based on the current development situation and conditions, the current revision of the general plan should be undertaken by promoting plans that blend with one another to provide a guide for the scientific development of towns.

4.2 Transformation and Upgrading of Industry

The principle promoting the integration of industry and city and the interaction between ports and towns should be promoted to make towns more liveable, ecological, and appropriate for work. The choice of industries for small towns should meet the demands of the adjustment for urban industrial structure. Therefore, industrial policies should be created, rather than promoting only low-level industrial diffusion. The ecological environment should also be preserved by making full use of local resources, but controlling the sensible exploitation and use of resources. Technological progress and lower technical barriers should be set up to attract considerable numbers of low-quality workers. Small towns should learn from city industries but avoid the deterioration of demand and supply of the market caused by duplicated construction. Hence, the development of non-agricultural industries in small towns should be promoted while maintaining their relationship with agriculture.

Amongst the different industries, tertiary industries may be a good choice for industrial structure adjustment for small towns. The tertiary industry has broad prospects for its pollution-free and labour-absorptive capacity. With the industrialisation of agriculture, the modern service industry related to agricultural production would undergo steady development. Therefore, the internal structure of the tertiary industry in towns should be optimised and upgraded. The service industry should be transformed from the traditional low-level retailing and dining services into services for the people's production and living. Several coastal towns could also develop tourism and recreational agriculture depending on whether their conditions will allow it.

Towns should improve the urban scale and quality to serve the development of industry. Industrial performance would promote the concentration of population. Cooperation with other cities should be strengthened at a large scale, such as occurs in the Yangtze River Delta area. The opportunities for industrial transformation from the developed areas of Shanghai and Suzhou-Wuxi-Changzhou should be seized. However, the industry to be established should be beneficial to the industrial cluster and amenable to upgrading. The behaviours in pursuing economic growth with high input, emissions, and pollution should be avoided.

4.3 Identification and Manifestation of Characteristics

Policies should focus on the mining and moulding characteristics of towns. The advantages of towns in the marine and coastal wetland landscape should be manifested. Local art, folk customs, traditional crafts, and other intangible cultural heritage should be fully exploited and perceived as precious cultural resources to develop the leisure and tourism industry in the region. Architectural culture should be enhanced and developed by protecting historical relics and through the careful planning and design of new buildings. The pleasant scale and style should be considered in the plan or design of new districts, streets, and public spaces. Traditional elements should be applied discreetly and creatively to satisfy the needs of people. Land resources saving should not be neglected. Large squares, large lawns, broad roads and inappropriate 'European-style' buildings should be avoided.

4.4 Improvement of Comprehensive Capacity

The development of infrastructure and public facilities should be promoted to enhance the overall carrying capacity of small towns along the coastline. Based on the Action Plans, efforts should be made in the following areas: green coverage and green areas in parks should be increased to build a garden town; full coverage of sewage-processing facilities and water supplies should be achieved in urban and rural-integrated regions; rates of water quality of the concentrated drinking water sources should reach the 95 % level; concentrated recycling rates of garbage should be improved to 90 % or above; commercial networks should be prepared to promote the business, dining, tourism, and other consumption service industries; and public service system should be optimised and improved, especially in medical treatment, social security, employment service, and so on.

4.5 Systematic Reform and Innovation in Governance

According to the spirit of the Third Plenary Session of the 18th Central Committee of the CPC, social funds should be fully mobilised for investment into the construction of towns. The methods of government-led and market-domain investing and financing mechanisms should be explored and established. The mode of Public-Private-Partnership should also be considered and applied. Following the requirements of the Notice on Improving the Assessment of Achievements of Local Party and Government Leading Bodies and Cadres, the old GDP-oriented government assessment mechanism should be reformed. Assessment should focus on the quality and benefit of sustainable economic development, improvement of livelihood and social economic harmony, cultivation of ecological civilisation, and the building of the party. The weight of factors like resource consumption, environmental protection, security, and stabilisation should be increased, thereby emphasising the importance of technological innovation, education, culture, employment, income, social security, and public health. Policies on household registration should also be reformed to create conditions for the settlement of migrant workers from rural areas. The land and taxation systems should be transformed to allow for breakthroughs in certain areas, such as ‘transforming the towns into cities’ and ‘integrating districts with towns.’ Related projects should gain support from the comprehensive reform of the coordinated development of land and sea.

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Space Design of Slow Mode Transportation System of Mountainous City

Yong Huang, Jie Feng and Dan Wan

1 Introduction

In the background of new-type urbanization, slow mode transportation is the hot topic in the field of Green Traffic. Some scholars summarize five types of urban transportation patterns and point out that the Automobile-oriented Transportation could not be implemented in China where in the status of high population density, scarce land resources, low per capita energy and serious environmental pollution. Meanwhile they confirm that the *Bus and Urban Train Oriented Transportation* and *Cycling and Pedestrian Oriented Transportation* is the best choice for metropolis, and the Cycling and Pedestrian Oriented Transportation is also the development direction of small and medium-sized cities.

However, the lack of research in the stage of traffic design and the lack of attention in the stage of traffic management of slow mode transportation is common phenomenon in most cities of China, among which only a few developed plain cities have planned or researched on it. Due to the special topography conditions and underdeveloped socio-economic status, the mountainous cities have lesser research on slow mode transportation. Mountainous or hilly terrain comprises of

Science and technology innovation project of Chongqing social undertakings and the people's livelihood security:Technology and Engineering demonstration of Drainage network planning of Mountain town (cstc2016shmszx0504).

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_11

66 % of the total territory of China. Therefore, how to organize the slow mode transportation of mountainous cities effectively is an important content of sustainable development.

Slow transportation space is the form element of slow mode transportation system which provides material support for its efficient operation. This paper studies on the space design of slow mode transportation system of mountainous cities, hoping to provide theoretical basis for the development of mountainous cities' slow mode transportation.

2 An Overview of Slow Mode Transportation in Mountains Cities

2.1 The Meaning of Slow Mode Transportation

The concept of slow mode transportation in China originated in the *Shanghai Metropolitan Transport White Paper*, afterward scholars have developed different definitions. Some of them emphasize non-motorized "traffic mode", which is to take walk and bike as the main body of the non-motorized transportation system and is called "non-motorized traffic" or "pedestrian and bicycle system". Some others emphases on the "traffic speed" of slow mode transportation, whose speed is no more than 15 km/h and is called "slow travelling traffic". Someone scholars also believe that the concept of slow mode transportation should be enlarged to all to slow mode value orientation "transportation organization mode", whose counterpart is traditional transportation organization that take fast and efficiency priority as the principles and is called "slow mode transportation".

Compared to plain cities, the transportation mode in mountain cities faces many restrictions. Thus, this paper adopts the definition of "slow transportation organization mode", deeming that slow mode transportation is a kind of urban transportation organization mode. Its core is to take "slow" mode transportation as the value orientation, committed to improve the slow mode transportation travel proportion by optimizing cities' slow transportation space system.

2.2 The Meaning of Slow Transportation Space

Slow transportation space refers to the physical space in the city providing basic support for slow transportation behaviors. Slow transportation space together with slow transportation body and slow transportation behavior constitute the three elements of slow mode transportation.

Slow transportation space includes both traffic slow transportation space and non-traffic slow transportation space; the former is mainly passing through facilities, while the latter refers to spaces for leisure and commerce.

2.3 The Acting Factors of Slow Transportation Space Design in Mountains Cities

2.3.1 Rugged Terrain

Mountain cities usually have rugged terrain, which poses many traffic barriers. On the one hand, the motor vehicle travel range cannot cover every place of a city area, so the use of motor vehicle is quite limited. Thus, walking is more convenient in small cramped space or large terrain gap areas, leading the situation that slow mode travel covers larger range of urban area. On the other hand, according to several surveys results, the mean travel distance is less than 2 km in plain cities, while in mountain cities the average travel distance is about 3–4 km, thus the residents there usually have the habit of climbing when traveling. As a result, residents live in mountain cities require more in slow transportation space safety and comfort due to larger travel range and longer travel distance.

2.3.2 Ultra High Urban Density

The terrain of mountain cities is usually cramped and, as a result, there's relatively less land available for development. Moreover, their population density and building density are much higher than other developed cities in China. The ultra high urban density has already caused many problems, such as the unbalanced development of urban roads and the cramped condition of motor vehicle lane and slow transportation space. At the same time, the function efficiency and safety of slow transportation space are threatened because there a large number city activities gathered in relatively cramped space.

2.3.3 Intensive and Composite City Function

Compact structure and multi-function (i.e., high density, high capacity) land exploit mode is the traditional strategy used by mountain cities which faced with limited land resources and building economic conditions. Intensive urban functions lead the arrangement of slow transportation space cannot exist in isolation. Based on the certain terrain, slow transportation space must be laid with green space, square and buildings, which put forward higher requirements for space design.

2.3.4 Limited Transport Facilities

Bicycle transportation is usually a challenge in mountainous cities due to the challenges posed by the steep, uneven terrain. As a result, mountain cities form a kind of slow transportation mode that relies mainly on walking while takes mechanization transport tools such as moped, escalators, vertical elevator, ropeway, river crane as auxiliary travel methods.

2.3.5 Relatively High Road Network Travel Speed

Subject to terrain conditions and land layout, the interval of arterial roads intersections in mountain cities in southwest China is relatively large. Thus, there is smaller interference by non-motorized vehicles and the traffic condition for motor vehicles is quite good. So the average travel speed of motor vehicles in mountain cities is relatively high. However, this phenomenon increases the potential safety hazard of slow mode transportation travelers.

2.3.6 Various City Landscape

Mountain cities usually have beautiful landscapes. Slow transportation space with proper landscape design can enrich the visual experience of travelers effectively and prolong travel time significantly, which is a huge advantage over plain terrain cities.

2.4 The Definition of Study Area

From the perspective of urban planning, slow transportation space can be divided into three levels: macro level, meso level and micro level. When considering the macro level of the whole city, slow mode transportation system is an important part of city transportation, so the planning and coordination of slow transportation space should be raised to the level of city development model; when considering the meso level of the city zoning, it is crucial to research the structure system of slow transportation space within certain zone, analyzing the relationship between slow transportation space and driving system, green space system, mountain terrain; when considering the micro level of part of the city area, it is important to analyze the space design, facilities arrangement, traffic connection and technical support of slow transportation space.

This paper mainly studies the space design method of slow transportation space from a micro level and provides suggestions for slow transportation space's construction and improvement.

3 Design of Slow Transportation Space

The micro level of slow transportation space can be divided into 3 basic elements: Unit, Corridor and Node. Unit is the relatively complete area with systematic condition of slow mode transportation; corridor is a linear element connecting slow space; and node is the conversion and distribution space.

On the basis of domestic and foreign research and characteristics of mountainous city, this paper define crossing facilities as "slow node", the non-motorized road as "slow corridor" and relatively independent slow transportation space as "slow unit".

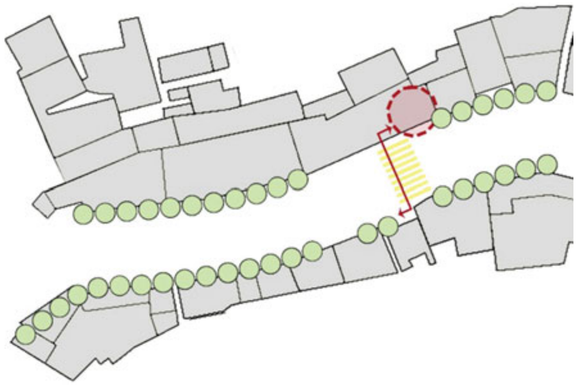
3.1 Slow Node Design of Mountainous Cities

3.1.1 Plane Crossing Facilities

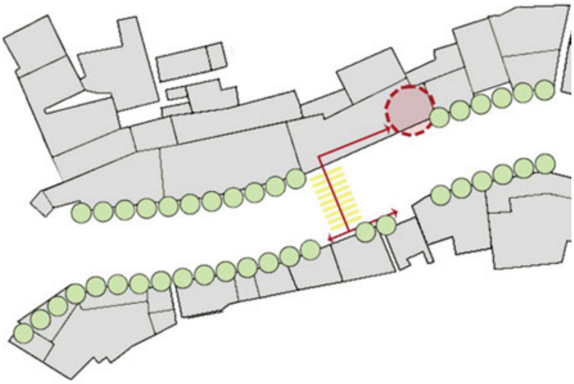
The roads of mountainous cities are generally narrow and plane crossing facilities have the feature of low cost, high operational efficiency and convenience which have a wide range of use. The design of plane crossing facilities has 3 basic principles: convenience, legibility, and security. Pedestrians have the habit of taking a shortcut; therefore, plane crossing facilities should be set up in crowd gathering point with high security to avoid detouring of pedestrian and enhance traffic efficiency (Pictures 1 and 2).

Plane crossing facilities should be noticeable both by driver and pedestrian, thus some color zebra or pattern zebra can be set especially in schools, kindergartens or where there is long separation distance between two facilities (Picture 3).

To improve the security of slow mode transportation, the plane crossing facilities should not set directly in the entrance of schools and kindergartens and if it has done, identification system and safety barrier must be established. On the other hand, reducing the speed of vehicles can increase the security. Plane crossing



Picture 1 Crossing facilities with poor convenience



Picture 2 Crossing facilities with good convenience

Picture 3 The sketch map of Color Zebra

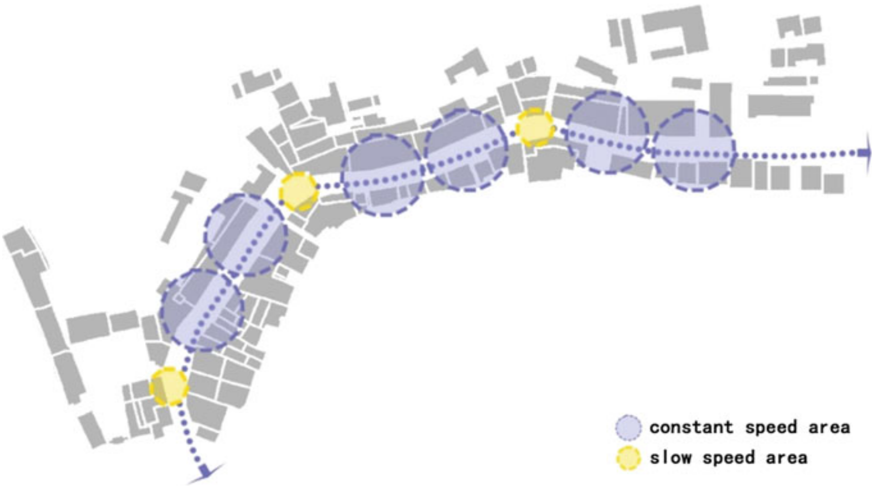
facilities can set appropriate elevation (Picture 4); in the crowed city branch with great crossing demand, the vehicle lane can be constructed slightly curved combined with terrain (Picture 5), which can remind the driver and increase the number of slow speed zone.

3.1.2 Spatial Crossing Facilities

Spatial crossing facilities can be divided into overpass and underpass from the perspective of form. Additionally, these facilities can be divided into independent-facilities and integrated-facilities from the perspective of function. Independent-facilities only play a role of crossing and some independent underpasses have low use rate because of poor sanitary condition and security risk. Combined with architecture, footpath or bus hub, integrated-facilities have higher use rate.

Some city center and sub-center in mountains cities are evolved from traffic node which have intensive traffic flow, thus spatial crossing facilities can be integrated with construction in these specific area. The construction of three-dimensional slow

Picture 4 The sketch map of Elevated Zebra

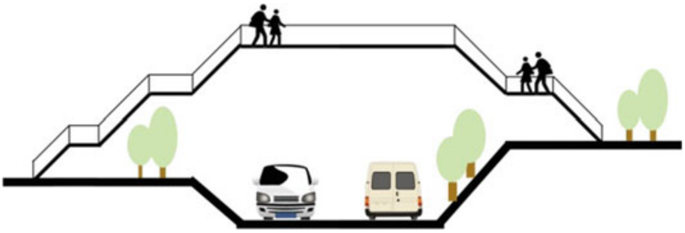


Picture 5 Slightly curved road increasing slow speed area

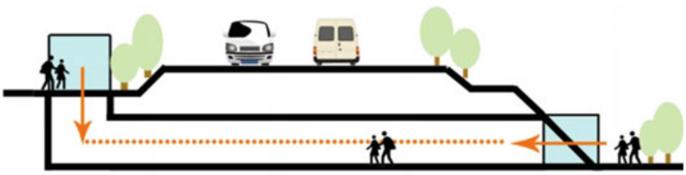
mode transportation system can provide safe walking environment and increase business value and commercial viability as well. For example, Hong Kong established the central pedestrian system in 1980s. This system integrates building, traffic hub and other activity places together (Picture 6).

The setting of spatial crossing facilities should be combined with mountainous terrain so that it can achieve the maximum economic benefit, environment benefit and crossing efficiency (Pictures 7 and 8).

Picture 6 Hong Kong central pedestrian system



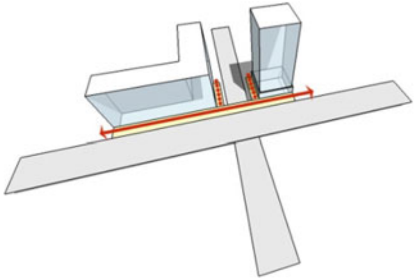
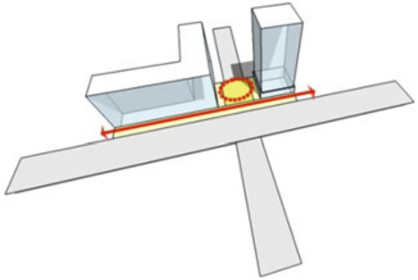
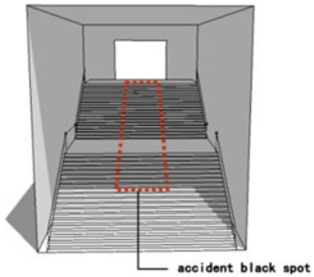
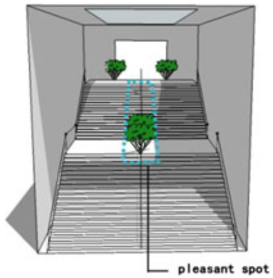
Picture 7 Overpass adapting to Terrain



Picture 8 Underpass adapting to Terrain

In this paper, the methods of humanization design can be summarized as node space setting and humanity environment shaping (Table 1). The setting of node space can enhance pedestrian's feeling and increase communication and participation. The shaping of environment include lighting, handrail, plants and so on, and all of these method could bring pedestrian with pleasantness. The handrail in the centre of city stairs, for instance, could avoid crowded stampede and ensure security.

Table 1 Humanity design method

Humanity design method	Before	After
Node space setting		
	Lower participation	Higher participation and commercial activity
Humanity environment shaping		
	Dull environment, unsafe stairs, bad feeling	Bright environment, safe stairs, good feeling

3.2 Slow Corridor Design of Mountainous Cities

3.2.1 The Space Separation of Pedestrian and Vehicle

The space separation of pedestrian and vehicle is important to safety and comfort of slow mode transportation. It can be divided in two ways as plane separation and spatial separation.

Plane separation includes ground pavement division, height division, structure division, plants division and terrain division, and terrain division is the important method to separate space in mountainous cities (Table 2).

Spatial separation includes parallel division and complete division, both of which are the wide use separation method in mountainous cities (Table 3).

3.2.2 Building Space Integration

The integration of building and slow corridor can improve the viability of road and continuity. The slow corridor usually integrates with public buildings such as basement, roof and the main building (Pictures 9, 10 and 11). These integrations adapt to the terrain and install mechanical transport to make pedestrian more convenient and labor saving.

3.2.3 Humanity Design

Pedestrians in mountainous cities, which must conquer great elevation and walk farther distances, often result in exhaustion far quicker than pedestrians in plain terrain cities covering a similar distance. Therefore, the design of slow corridor should make a more comfortable environment.

On one hand, because of the undulating terrain, the slow corridor can set platforms, barrier-free structures, seats and plants to create pleasant and humanized space.

On the other hand, some corridor can be set vertical to the contour. Conforming to the contour of mountain, the corridor would have a longer distance. Optimization of vertical transportation could shorten the walking distance and escalators and other mechanical transport can be used in the steep slope places (Pictures 12 and 13).

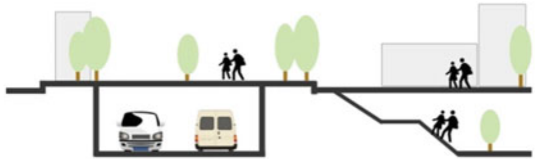
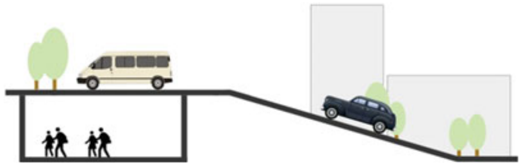
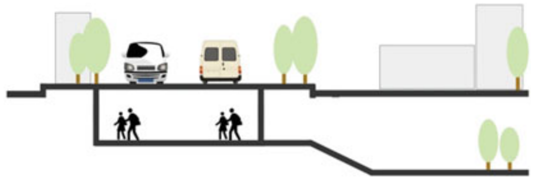
3.3 Slow Unit Design of Mountainous Cities

A mountainous city can be divided into several slow units according land use, road network and other factors. In the middle of the slow unit, slow mode transportation

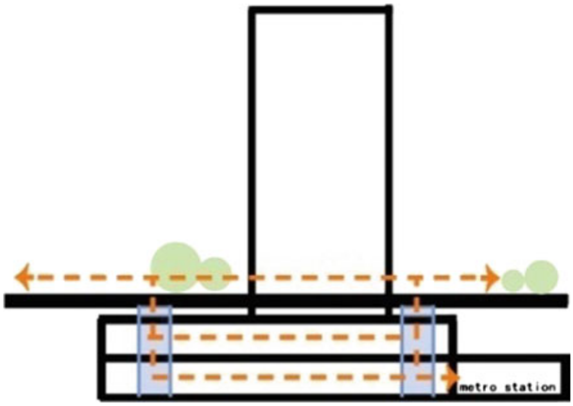
Table 2 Plane separation methods

Separation methods	Strengths	Weakness	Graphical representation
Ground pavement division	Wide and unrestricted use, low cost	Weak field sense, easy confusion	
Height and structure division	Strong field sense, efficient	Low usage of some space	
Plants division	Strong field sense, nice environment, pleasant feeling	Passing space waste	
Terrain division	Strong field sense, suited to terrain	Security risks	

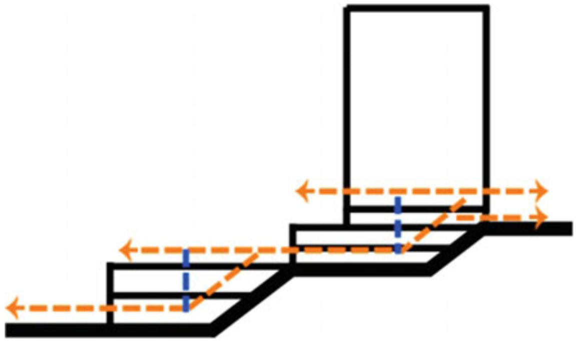
Table 3 Spatial separation methods

Separation methods	Strengths	Weakness	Image
Parallel division	Suited to terrain, low cost	Security risks, poor continuity	
Complete division	Higher security, good continuity, multi spatial levels	Poor accessibility, high cost, poor way finding	 Vehicle road below
			 Vertical vehicle road above
			 Parallel vehicle road above

Picture 9 Building basement integration

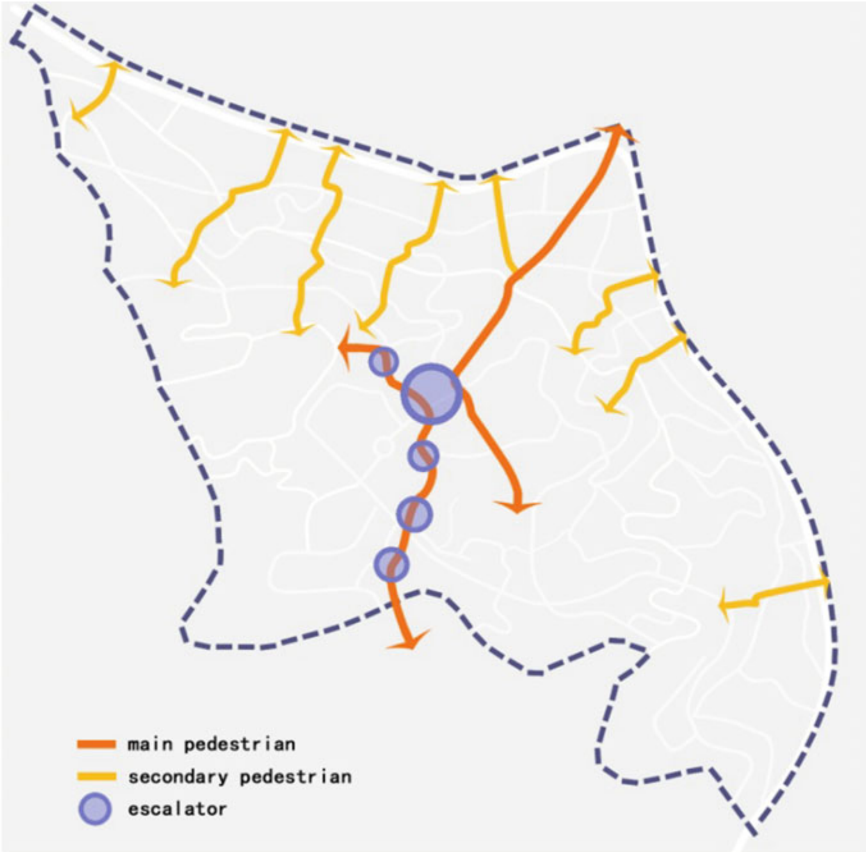


Picture 10 Building roof integration

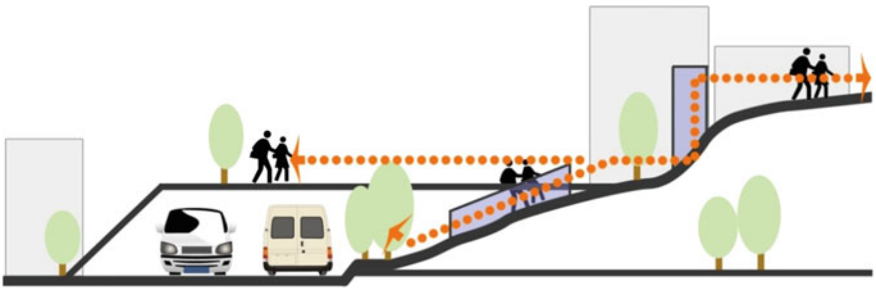


Picture 11 Main building integration

should be given priority; between the slow units, they can be connected mainly by bus and urban train accompanying private cars. For example, Bijie, a city located in the Guizhou province, divides the central city into 5 units as life unit, leisure unit, production unit, activity unit and traditional style unit.



Picture 12 Mechanical transport distribution map in Jiangnan District, Fuling, Chongqing



Picture 13 The integration of mechanical transport and walking

4 Slow Mode Transportation and Fast Mode Transportation Transfer Design

Transportation modes with a "slow" value orientation are all slow mode transportations, hence the integrated transfer design for slow mode transportation and fast mode transportation is conducive to the importance and efficiency of slow mode transportation. In this section, we focus on the transfer design of slow mode transportation and bus as well as rail transit in mountain city

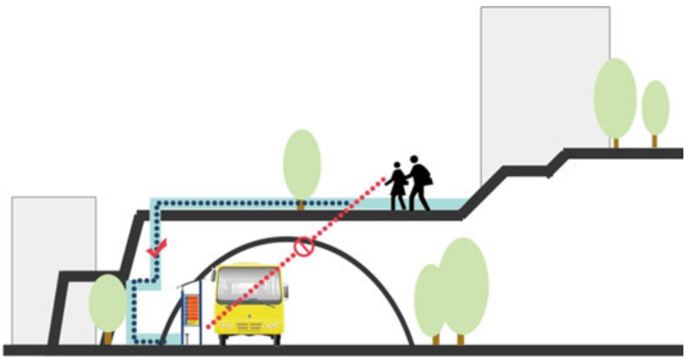
4.1 Slow Mode Transportation and Bus Transfer Design

4.1.1 Accessibility

Because of the steep terrain and narrow roads, in mountain cities pedestrian entrances (or exits) and bus stations may be blocked. Sometimes the distance between these facilities can be very far. Thus the transfer accessibility is severely weakened. Therefore, when designing the transfer space, corridors should be set to ensure the implementation of transfer (Picture 14).

4.1.2 Convenience

The convenience of slow mode transportation and bus transfer determines the utilization ratio and efficiency of slow mode transportation. To ensure the fast and barrier free connection between pedestrian entrances (or exits) and bus stations, the distance between these facilities should be shorten when designing the transfer space.



Picture 14 Set corridors to ensure accessibility

4.1.3 Legibility

The spatial level of mountain cities is usually complicated, which triggers serious problems for slow transportation travelers in way finding. Hence the legibility of bus stations should be enhanced: on the one hand, the identification system should be well arranged; on the other hand, the bus stations, taxi stations and rail transit stations should be integrated laid properly to improve the legibility of the area.

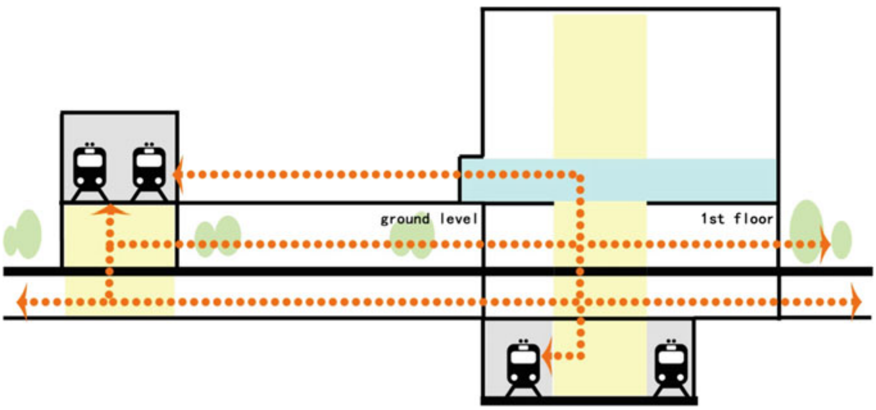
4.2 Slow Mode Transportation and Rail Transit Transfer Design

4.2.1 Building Integration

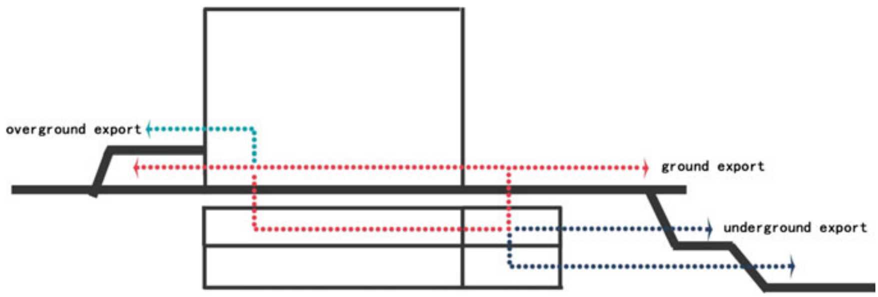
To integrate rail transit into buildings, the rising and sinking streamlines can be interpenetrated and make walking system and rail transit system as a whole. In this way, we can improve the effectiveness of rail transit utilization and promote the use frequency of public buildings to increase commercial activity (Picture 15).

4.2.2 Slow Transportation Corridor Integration

Slow transportation corridors should be integrated into rail transit system, including plane and stereoscopic walking facilities. This can not only save construction cost, but also realize seamless connection.



Picture 15 The integration of buildings and rail transit



Picture 16 The three levels walking exits

4.2.3 Coverage Expansion

Based on the location and surrounding city elements, rail transit should set three levels walking passage, including air, ground, and underground levels to expand its coverage. For example, the Xujiahui railway station in Shanghai has 19 entrances and exits, and the Mong Kok railway station in Hong Kong set up accesses in 7 main directions (Picture 16).

5 Conclusion

Slow mode transportation is an important method and tool to realize cities' sustainable development in the background of new-type urbanization. However, there are just a few studies focus on slow mode transportation planning or management in domestic academic circle. Moreover, the literature on slow mode transportation in mountain cities is limited. It is important and useful to research mountain cities' slow mode transportation system, because it can not only conduce to the transportation system improvement and urban development of individual city, but also contribute to our mountainous motherland. Based on a summary of the theories of slow mode transportation and slow transportation space as well as the acting factors of slow transportation space design in mountains cities, this paper studying the slow transportation space design in mountain city slow mode transportation system from the perspective of form design. More specifically, this paper analyzed the design method of slow transportation space elements including slow mode node, slow mode corridor and slow mode unit, and studies slow mode transportation and fast mode transportation transfer design. Hence this paper provides a relatively comprehensive discussion and summary of slow transportation space form design theory. The researchers hope that the study findings can offer some beneficial reference to develop and improve mountain cities' slow mode transportation system in our country, and make contribution to the optimization of city transportation system and city development mode.

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Combined Commuting Mode for Residents in Big Cities by Public Health—A Case Study of Xi'an

Zirui Lyu, Jing Zhu and Xin Dong

1 Relationship Between Commuting mode and Public Health

It has seriously affected the sustainable development of cities that long-distance travel manifolds, commuting distance extends, level of motorization travel constantly enhances and automotive vehicle amount greatly increases year by year by urbanization. The high mobility transportation has gradually replaced walking and bikes etc., which has made our life rely on travel with motor vehicles more and far away from health.

For individuals, walking is a healthy travel mode. Researches have shown that the travel proportion of slow-moving traffic is highly related to the proportion of obesity. The data analysis from various countries in America and Europe indicates that countries with high travel proportion of slow-moving traffic are usually with low proportion of obesity. Meanwhile, in the slow-moving traffic, the cost of walking is zero and the increase investment of bikes is almost zero except the low initial investment.

For society, walking is a green and environmental friendly travel mode. As the urban traffic transfer is mainly conducted depending on humans (little power assistance), compared with other traffic mode, it barely generates crude consumption and carbon emission, thereby, vicious cycle of environmental contamination

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_12

also decreases; meanwhile, it is quite convenient to connect with motorization of medium and long distance travel, since it is an independently short-distance travel mode. Its relation with public traffic is complementary and cooperative.

1.1 Prior Research

With the proceedings of urbanization in China, automotive vehicles play an important role in modern traffic, which increases people's attention on healthy problems in commuting brought by automotive vehicles. Overall, countries all over the world start their research from different respects and have made numerous achievements.

1.1.1 The Commuting Environmental Perspective

A. Air pollution

Karanasiou et al. (2014) in Spain studied the impact of air pollution to commuters by cars, cycling and walking. Their study is about the assessment of personal exposure to particulate air pollution during commuting in European cities. Their studies show that studies on personal exposure to air pollutants during car commuting are more numerous than those dealing with other types of transport, and typically conclude by emphasizing that traveling by car involves exposure to relatively high particulate matter, PM exposure concentrations. Thus, compared to other transport methods, traveling by car has been shown to involve exposure both to higher PM and BC as compared with cycling. Widespread dependence on private car transport has produced a significant daily health threat to the urban commuter (Karanasiou et al. 2014).

B. Noise pollution

The Urban Traffic and Health written by Dora et al. (2012) mentions that about the assessment about environmental burden of disease caused by noise assessment, pointing out that in Western Europe countries, traffic noise caused more than a total of one million healthy time loss, including illness, disability and premature death each years. The burden include irritability, sleep disorders, a heart attack, learning disabilities, and tinnitus (the WHO regional office for Europe 2011) Dora et al. (2012).

1.1.2 The Medical Perspective

Domestic and overseas relevant scholars quantitatively research relations between various different commuting mode and health on healthy problems from the medical perspective. Foreign scholar Cohen et al. (2014) unite a number of organizations from European countries to conduct a long-term investigation on the relation between teenagers' health and different traffic mode they adopt for school. Data is collected, which proves that Active Travel is more beneficial for their muscle growth and physical development and their health status is obvious better than those of the teenagers who go to school relying on automotive vehicles (Cohen et al. 2014). Polish scholar Tomasz Zdrojewski et al. normatively measure the weight, height, waist girth, blood pressure, fasting plasma glucose, triglyceride, high-density lipoprotein (in term of NCEP-ATP III and IDF Standardized Approach) through random interview questionnaire on more than 6000 individuals in Poland. The research also finds that the augment of commuting exercise amount probably largely influence prevalence rate blocked by metabolism reduction (Kwasniewska et al. 2014). British scholar Flint et al. (2014) with the result of multivariate linear regression analysis indicating compared with application of private transportation. The model is completely adjusted. The BMI scores of males through public or active mode commuting are 1.10 (95 % CI 0.53 − 1.67) and 0.53 (0.40 − 1.55), which are separately lower than those of private transportation users. The BMI scores of females through public or active mode commuting are 0.72 (0.06 − 1.37) and 0.06 (0.36 − 0.87), which are separately lower than those of private transportation users. The conclusion is that both male and female BMI and body fat percentage applying public and active mode commuting are obviously lower than those of private transportation users (Flint et al. 2014). British scholar David K. Humphreys et al. conduct a sampling track questionnaire lasting a week in a lot of places in Britain and discuss the relations between ages, genders, commuting mode, leisure, working & physical activities, mental as well as physical health scores with regression analysis method, which draw the conclusion that higher level physical health is related to longer time active commuting. Except the other daily activities, the most beneficial practice for an healthy individual is to adopt at least 45-min active commuting constantly every day (Humphreys et al. 2013). Two long-term studies have found that in Copenhagen and Shanghai, the annual mortality rate of bike commuters compared with people without activity travel or regular exercise had a 30 % lower (Anderson 2000; Matthews 2007). Systematic review also found that walking can reduce cardiovascular disease (Boone Heinonen et al. 2009), physical activity can improve many other aspects of health (Table 1) (Wan and Zhang 2010).

There are some overseas researches in the Table 2.

1.1.3 The Slow-Moving Traffic of Urban Planning Perspective

The Urban Traffic and Health written by Dr. Carlose Dora et al. mentions that it will lead urban residents exercise insufficiency and their health will be further effected with long-term auto-oriented travel mode. It also conducts a relevant assessment (HEAT) on economic benefit brought by mortality reduction due to the increasing physical activities by walking and riding bikes, where countries such as Dutch and New Zealand etc. have actually applied and a comparatively

Table 1 Healthy influences related to physical activities

Lower death rate[a]	Reducing coronary heart disease[a]
Reducing high blood pressure[a]	Reducing stroke[a]
Reducing Type 2 diabetes[a]	Reducing metabolic syndrome[a]
Reducing colon cancer[a]	Reducing breast cancer[a]
Reducing depression[a]	Better body shape[a]
Better BMI and body composition[a]	Beneficial for preventing cardiovascular diseases[a]
Healthier physical function for seniors[a]	Keeping bones healthy[a]
Reducing falling risk for seniors[a]	Better sleep quality[b]
Better cognitive function[a]	Better life quality[b]

Note [a]Powerful evidence; [b]Certain evidence from: United States Department of Health and Human Service (2008)

Table 2 Summary sheet of some researches (part)

Year	Author	Country	Research aspect	Research achievements
2011	Winer et al. 2011	United States	Environmental health	Various travel modes are compared through comparing examination of commuting nature and discussion of diversified possible health results, including direct and indirect effects
2012	Yang et al. 2012	United States	Preventive medicine	It is found that among the respondent weekly healthy status (in terms of MVPA) of females adopting active commuting is relatively better through mathematical approach
2013	Laverty et al. 2013	Britain	Preventive medicine	For individuals adopting active travel tools, the possibility to catch cardiovascular diseases is lower
2014	Cohen et al. 2013	Britain	Medicine	Researches indicate that Active Travel is more beneficial for teenagers' muscle growth and physical development and their health status is obvious better than those of the teenagers who go to school relying on automotive vehicles
2014	Martin et al. 2014	Britain	Preventive medicine	Except the potential benefits on health, searching for active travel is more beneficial for positive mental health Martin et al. 2014

consummate bike traffic system has been developed. Walking and bike commuting become possible (Dora et al. 2012).

1.1.4 The Commuting Effects to Health

Domestic scholars, Jing Zhu et al., adopt metabolic equivalent as an index for modal characterization value measuring health effects of different commuting behaviors, and its results show that walking occupies fist bus and subway come second, private car is far below others (Fig. 1) (Zhu et al. 2014).

1.1.5 Brief Sum-up

To sum up, a great number of domestic and overseas scholars from different fields proceed from their professional aspects, aiming at commuting healthy problems and peripheral theories, expand a series of researches.

From the perspective of environmental pollution, its shows different transportations get different degree of the health effects about exposure to air pollution, and noise pollution. In medicine, the influences between commuting mode and psychology, body and relevant diseases; in planning transportation, social environment is provided by the rapid development of green travel and slow-moving traffic.

But the study did not consider to the present status of the cities in China under the limits of this completely activity travel commuting in the short term, and in

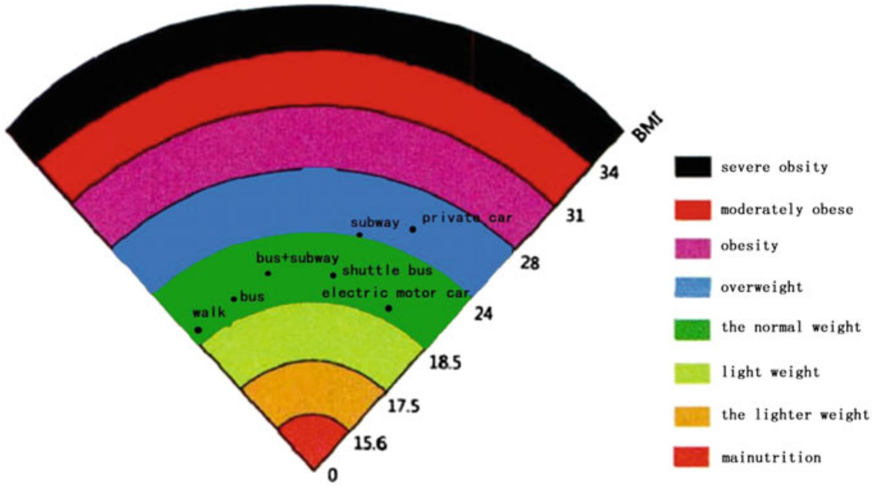

Fig. 1 The distribution of the 7 commuting modes in the circle diagram of physical-levels*. *Note* *Fig. 1 from: Zhu et al. (2014)

commuting ways, ignored the commute demand for traffic mobility, and the necessity and urgency of reasonable commuting combination mode of activity and public travel, and the health effect evaluation, in which scholars only in BMI for standards, is not comprehensive and objective. According to the above two points, this article will conduct a series of investigation and study to this problem are discussed.

1.2 Active Commuting Related to the Positive Feedback

1.2.1 Environment

Research has shown that the degree of different commuting ways is exposed to the air pollution is different, the health effects of different. However, the commuting mode will also cause varying degrees of pollution to air, the active commuting, such as walking and biking, is almost zero emissions, public transport emissions per capital is low. Therefore, the adoption of more active commuting can reduce air pollution, which in turn reduces exposure to air pollution health damage, forming a virtuous cycle.

1.2.2 Road Traffic Safety

Speed is the main risk factors of traffic injuries—kinetic energy is the damage of incentives (Peden et al. 2004). Kinetic energy is the combination of quality and speed, motor vehicle usually in these two aspects greater than walking and biking. However, different ways suffer with different degree, different number of traffic injury, and also has a certain traffic injuries, as well as the active commuting mode generated by the low traffic injuries. At the same time, increasing the number of pedestrians and cyclists may make "more people, more safety" effect, because the higher the proportion of walking and cycling, the lower the risk of their per capital (Jacobsen 2003). To improve road traffic safety could encourage more walking and cycling, forming a virtuous cycle (Dora et al. 2012).

1.2.3 Slow Traffic System

After long-term urban motorized expansion brings many problems, build the development direction of urban slow traffic system is more and more countries urban identity and practice, it must also be inevitable way for urban transportation system in future. Encouraging and guiding residents adopt active commuting will produce more the demand of the slow traffic system, and push further improving urban slow traffic (Karanasiou et al. 2014).

Table 3 Parameter table of urban main traffic mode at normal speed

	The index parameter of City's main transportation way at normal speed				
Transportation way	Velocity (km/h)	Dynamic roadway taking-up area (m^2)	Dynamic roadway taking-up area (individual)	Passengers per capital encroachments space (m^2)	User cost (RMB)
Walk	3–5	1.0	1.0	1.0	0.0
Bicycle	10–15	8.0	1.0	8.0	0.3
Motorcycle	15–40	40.0	1.2	33.3	4.0
Car	20–50	120.0	1.5	80.0	18.0
Bus	16–25	50.0	50.0	1.6	1.5

Note Table from U*rban Traffic*

1.2.4 Other

Healthy combined modes of commuting mode leading the residents to transfer from travel with private car to public traffic mode and active mode such as "walking +bus" and "bike +bus" etc., to fulfill healthy demand, contain urban resource waste, decrease car travel volumes, reduce car gas emission, remit urban traffic jams, improve resident travel efficiency and realize the traffic mode of seamless and effective connection of urban traffic "the last kilometer".

From Table 3, it is easily to recognize that under the same operating condition (normal speed), car occupants occupy the maximum space, motorcycle occupant occupants occupy less and walking, bike and bus occupants occupy least. Due to the space that cars take up in the urban environment, such a mode is not scalable as the city grows. Other modes, such as bicycling and walking, are key solutions to ameliorating congestion challenges. Analyzing from the perspective of resource consumption, the cost of car travel is the most, motorcycle is less and walking, riding bikes as well as taking buses is the least, which fully explains that it will effectively save resource and conform the requirement of urban low carbon environment protection and sustainable development to travel with walking, bikes as well as buses.

2 Empirical Analysis: The Current Situation of Resident Commuting in Xi'an, China

2.1 Data and Methods

2.1.1 Data

This paper is aimed to explore the relationship between residents' commuting mode and public health. Therefore, considering the comprehensiveness and reliability of the samples when selecting the sample, the author randomly selects several residential districts in Xi'an by land use. Questionnaire data were collected randomly distributed 250 questionnaires recovered 238 valid questionnaires, the effective rate of 95.2 %

2.1.2 Methods

In order to explore the health effects of diffrent commuting modes, the author in this paper, uses the analytic hierarchy process to quantitatively analyze the commuting modes to compare and analyze the efect of each commuting mode, and get a reliable analysis.

2.2 The Current Commuting Mode of Resident

The author obtained the following data through the questionnaire on Xi'an residents (Table 4).

Problems: In the questionnaire, it is noticed that residents seldom adopt commuting mode such as walking, riding bikes and taking automotive vehicles, only 5.6 %; and the purpose is not actively adopting this combination for health, but the bus stops is far away from the residence. They are forced to walk. Besides, the residents in the survey only adopt the commuting mode of walking and taking buses as well as subways, which is quite unitary.

2.3 Influencing Factors of Commuting Mode

To research reasonable commuting combining mode, factors influencing commuting mode option are supposed to consider firstly to obtain reasonable and feasible implementation scheme.

Table 4 The commuting mode Xi'an resident adopting

Distance (km)	Walk	Bicycle	Car	Bus	Subway	Electric Car	Varnish Company shuttle bus	Else	Total
Proportion (%)	16.0	3.4	20.2	44.5	5.0	9.2	1.7	0	100

Note Combination mode travel combination of walking with buses and subways

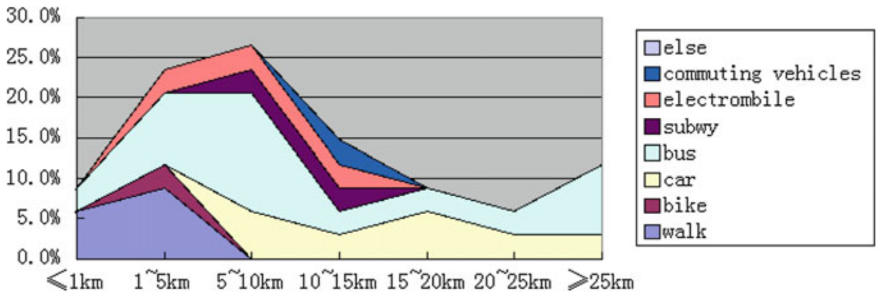

Fig. 2 Travel mode by commuting distance. *Note* This thesis takes Xi'an residents as the investigation object to conduct data analysis from 238 sample residents

2.3.1 Commuting Distance

Commuting distance is the fundamental factor influencing resident commuting mode options. When residents make difficult decisions on commuting mode options, they usually recognize all kinds of commuting mode by commuting distance and then compare the commuting time, cost, comfort and convenience between different commuting mode. The commuting mode are ordered with functions according to their time limit, budget constraint and utility. The commuting mode to realize the maximum own utility is chosen. Among this decision, the commuting distance between residence and working place is the main decision foundation and starting point. The data obtained from the investigation shows:

From Fig 2, it is seen that:

a. Xi'an is devoting to developing a bus city, which mode buses play a significant role in residents' daily commuting options. The commuting distance for residents choosing buses as the commuting mode is from less than 1 km to more than 25 km. The proportion of taking buses is different for different commuting distance. The commuting distance for taking buses is concentrating on less than 15 km and more than 20 km. As seen from the side, Xi'an's current bus system possesses certain advantage, which can be effective in commuting combining modes and taken into main consideration.
b. Cars occupy certain place in commuting mode. When commuting distance is more than 5 km, most residents owning cars probably choose this mode, which mode this group is the main aiming group and is the potential group that may change their commuting mode.
c. Residents taking walking and riding bikes as the commuting mode only distribute on the commuting distance less than 5 km and the amount is quite a few.

2.3.2 Commuting Time

Commuting time is the time spend on going to or getting off work. The commuting time duration influences residents' daily life and working schedule.

From Fig. 3, it is seen that:

a. The longer the commuting distance is, the longer the commuting time residents spend relatively. In other words, the acceptable commuting time consumption is longer.
b. The commuting time Residents spend always concentrate on some period for the same commuting distance range. But it is usually the time period that riding bikes and taking buses can reach. It provide data support for research of feasible commuting combining modes.

2.3.3 Other Influencing Factors

Commuting tools options not only influenced by distance and time but also influenced by other external factors, such as comfort and safety etc.

From Fig. 4, it is seen that:

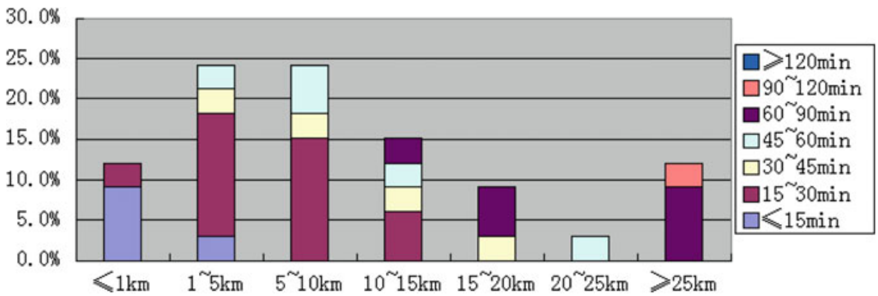

Fig. 3 Commuting time distribution under different commuting distance

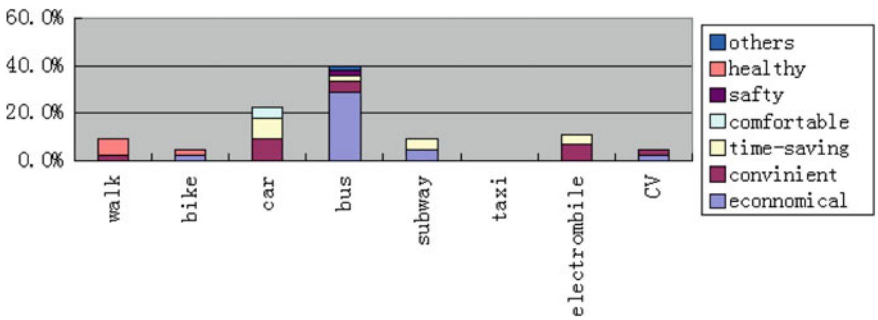

Fig. 4 Reasons for choosing different commuting tools. *Note* CV is shuttle bus

a. a few residents choose walking and riding bike for consideration of health.
b. Residents choose public transportation mode such as buses and subways for it is economical and practical and convenient as well as time-saving.
c. Most residents take economy, convenience and time-saving as the main influencing factors for commuting mode option. This phenomenon reminds us that combining modes of commuting are supposed to have relevant features, and health factor will be further enhance for feasibility of commuting modes.

2.4 Health Status Under the Current Commuting Mode in Xi'an

2.4.1 Self Healthy Evaluation of Different Commuting Mode

Urban residents choose different commuting mode for different limiting factors. For health, the comments of satisfying degree is made on their commuting mode and the following data is obtained.

From Fig. 5, it is seen that:

a. Self healthy comment of all residents choosing walking and riding bikes is good.
b. Most residents comment their healthy status well and wish to change the commuting mode. Quite a part of them comment their healthy status general and are eager to change the current commuting mode urgently. These data suggest the urgency, necessity and possibility to research this mode.
c. In the survey process the author found that xi 'an residents don't have adequate consciousness with health effects of exposure to the air pollution. It seems that the only standard they judge healthy or not is physical exercise.

Aiming at the above data analysis, one conclusion is drawn: most of Xi'an residents value their health and are not satisfied with the current commuting mode

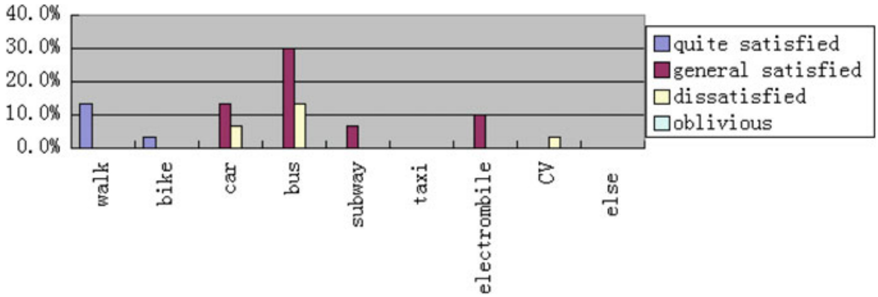

Fig. 5 The frequency of self healthy satisfaction rating of different commuting mode. *Note* CV mode is shuttle bus

Table 5 Self-ratings of physical health status

	Ways	5	4	3	2	1	Synthetical mark
Sole	Active Commuting	80.0 %	10.0 %	10.0 %	–	–	4.7
	Public transport	–	18.2 %	54.5 %	18.2 %	9.1 %	2.818
	General motor vehicle	4.5 %	–	40.9 %	36.4 %	18.2 %	2.382
	Else	–	–	100.0 %	–	–	3
Combination	Walk + car	–	100.0 %	–	–	–	4
	Bicycle + electric vehicles	–	100.0 %	–	–	–	4
	Walk + bicycle	100.0 %	–	–	–	–	5

Note Due to the less sample obtained under the combining mode in the practical survey, the comprehensive evaluation score doesn't not have university and representativeness

(for consideration of healthy perspective). They wish to change their commuting mode urgently and are zealous for healthy commuting mode, which is fully embodied on the high approval on the commuting combining modes we promote; meanwhile, for factors, such as commuting time and commuting cost etc. are the major influencing factors to determine resident commuting mode option.

2.4.2 Self-ratings of Physical Health Status

Statistical analysis was conducted through investigating the questionnaire data. Each commuting mode is classified and scored with the application of simple Fuzzy Comprehensive Evaluation. The following data is obtained (Table 5).

From the above table, it is seen that the score of residents on active commuting mode is commonly higher, that of public traffic is lower and that of automotive vehicles is the lowest.

3 Combining Modes for Commuting

3.1 Optimized Modes

According to the data analysis of Xi'an residents survey, it is obtained that combination of urban resident commuting mode is quite simple and the result of exercise is not reached. Most residents' commuting mode are influenced by external environment so that their commuting mode is unitary and demand for healthy commuting is higher. But it is supposed to meet the conditions such as economy and in the range of reasonable commuting time at the same time.

Based on the current social conditions, this thesis propose several commuting combining modes according to the reasonable real demands. Firstly, the theoretical precondition is that the most beneficial for normal person's health is to adopt active commuting continuously for 45 min except their daily activities proposed by British scholars David K. Humphreys et al. Secondly, the level of air quality is good, which mode the air is suitable for outdoor sports.

3.1.1 Publicbikes+Buses/Subways+Public Bike

The precondition of the setting of this mode is: serve the public bike service sites in the dwelling district, namely "serve to the door". It is different from the traditional public bike sites which only distribute the public areas out of the dwelling district. The sites are special under this mode, for it is serving for the internal part of the dwelling district. It is a good choice for residents' commuting in large dwelling district. It is the embarrassed distance far for walking and not economy for driving. Meanwhile, convenient public service facilities guide more residents to give up taking cars and choose this mode for commuting, which effectively remits urban traffic pressure and reduce urban traffic pollution while they are commuting healthily (Fig. 6).

Features:

(1) Set public bike service sites in the dwelling district, totally realizing the seamless transfer of "the last kilometer".

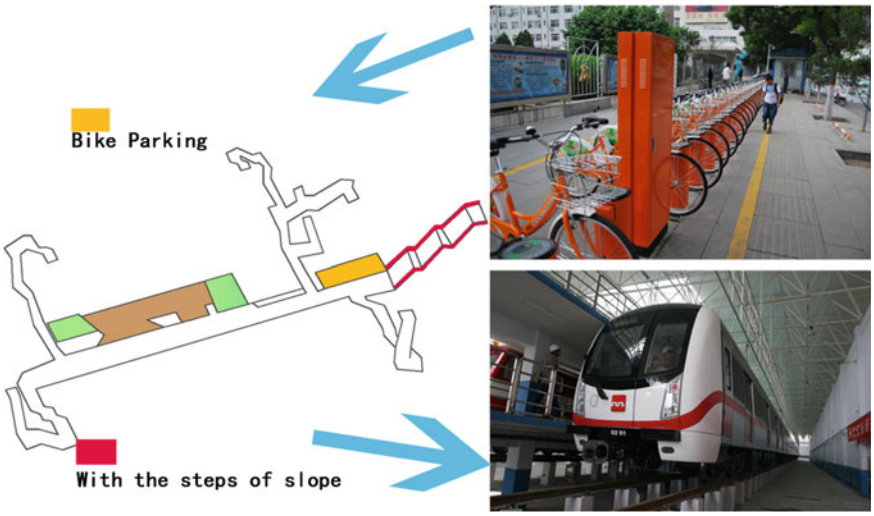

Fig. 6 Schematic diagram of public bikes +buses/subways +public bikes. *Note*: Picture is from internet

(2) The rapid efficiency of subway could bear commuting demands of most residents, meanwhile meet the requirements of commuting time as short as possible for medium and long distance commuting residents.
(3) Promote residents to apply public traffic to improve their healthy status in a greater degree.

3.1.2 Private Bikes +Buses/Subways(Portable Private Bikes) +Private Bikes

Advantages of this mode (Fig. 7):

(1) residents could choose the duration of various commuting mode application freely. They can flexibly change the duration of various tool application in terms of self healthy status and commuting demand or weather condition to satisfy the demand for convenience, freedom and health at the same time;
(2) The moving and real time connection of traffic operation mode are realized and the advantage of the two public traffic resource such as bikes and buses is utter mostly integrated;
(3) Bike parking lot and rental facility construction are reduced;
(4) The transfer efficiency between bikes and buses is improved limitedly;
(5) The investment of traffic infrastructure for the government is decreased greatly to enable feasibility enhanced;
(6) The moving connection between the two mode makes flexibility of bike exercise for residents increase.

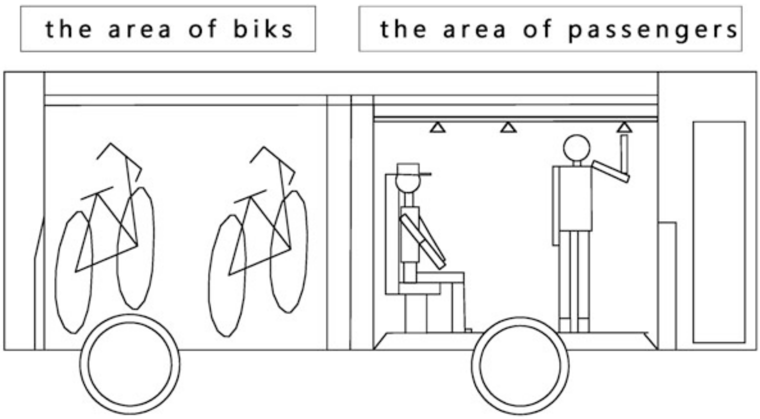

Fig. 7 Schematic diagram of private bikes capable of carrying

3.2 *Rationality Analysis of Commuting Combining Modes*

Reachability: Realization of urban community residents travel mode “the last kilometer” perfect cohesion, convenient residents’ daily life.
Realizability: Based on the reality of social conditions and economic feasibility, market demand into account, has strong operability.
Perspectiveness: These patterns from the dominant from car traffic model to the reasonable dominated by slow traffic transportation mode transition, conducive to the further development of urban slow traffic.

4 Health Evaluation of Different Commuting Mode

The Analytic Hierarchy Process (AHP for short) is a type of systematic analysis method proposed by American operational research expert Professor T1L1Saaty in the 1970s. The basic thought of AHP is to classify complicated matters into several orderly hierarchy and establish an internal independent hierarchy structure to describe the system function or characteristic (namely model tree). Then quantitative express is made on the relevant significance of each hierarchy according to the judgment on certain objective matter. The weight of relevant significant order of each element in each hierarchy is determined through maximum eigenvalue and of this matrix and the corresponding feature vector under the precondition of single test. Depending on analysis on each hierarchy, the analysis of the whole matter is derived, namely total order weight (Fig. 8).

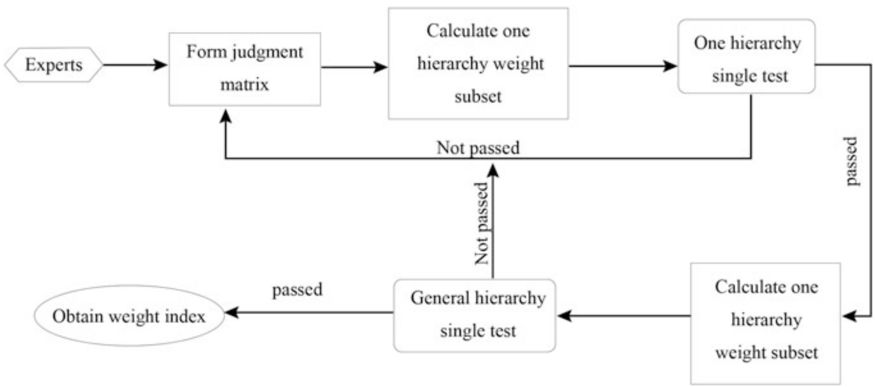

Fig. 8 Implementing process of AHP

4.1 Constructing Recursive Hierarchy Structure

4.1.1 Factors Influencing the Evaluation Index

There are a lot of factors which can affect health. With referencing and summarizing relevant literature, this paper tries to comprehensively evaluate the health effects of commute ways.

A. **Environment to commuters**

It is known that air pollution has a strong influence on health, for instance, long-term exposure to air pollution will suffer from allergic or non allergic respiratory disease, cardiovascular disease, cancer and even death. The Urban Traffic and Health written by Dr. Carlose Dora et al. mentions that about the assessment about environmental burden of disease caused by noise assessment, pointing out that in Western Europe countries, traffic noise caused more than a total of one million healthy time loss, including illness, disability and premature death each years. The burden include irritability, sleep disorders, a heart attack, learning disabilities, and tinnitus (the WHO regional office for Europe 2011) (Cohen et al. 2014).

Different commute ways are affected differently by air pollution and noise pollution.

B. **The physical exercise** (lack of physical activity, obesity and non-communicable diseases)

Lacking physical sport is the reason of more than three million deaths a year all over the world (WHO 2009a), the main risk factors of poor health, also a cause of death and disease in the world, such as cardiovascular disease, II diabetes and certain types of cancer. Different commute ways have different physical exercise, and different effects on health (Cohen et al. 2014).

C. **The safety of life (road traffic injuries)**

Road traffic safety damage led to the deaths of 1.3 million people worldwide each year (WHO 2008c), 50 million injured (Peden et al. 2004). The burden of road traffic injuries is increasing as the increase in mobile growth. Different ways of commute suffer with different safety risk.

D. **Psychological effects**

Different commute ways contacting outdoor air, sunshine, sounds, natural scenery urban landscape and so on, is different, then there is a difference to the person's psychology influence. In general, the more contacting with nature, the humanities environment outdoor will more helpful for spiritual pleasure.

4.1.2 Constructing Recursive Hierarchy Structure

In the problems of reasonable commuting mode option, it is wished that healthy degree is enabled to the highest through choosing and comparing different commuting mode, namely the target is "reasonable commuting mode enable healthy degree highest". To reach this target, four principles should be considered, namely physical stamina exercise, life safety, commuting environment and psychological relaxing. Assuming only these principle is considered, the following to determine is the possible schemes under the above principle hierarchy. According to the real situation, private cars, private bikes, buses, subways, commuting vehicles (CV is shuttle bus, which is provided by employers for their employees commuting, often has fixed time table, and comfortabe vehicle environment), private bikes +buses (private bikes capable of carrying), public bikes +subways are compared and it is obvious that these schemes are related to all the hierarchy.

Each hierarchy factor is located in terms of relations. Meanwhile, A, B, C are used to represent the different hierarchy in order to enable the latter quantitative express convenient. From left to right on the same hierarchy 1, 2, 3, 4… represent different factors. The recursive hierarchy structure formed is as the follow Table 6.

4.2 Constructing Judgment Matrix and Assignment and Single Hierarchical Arrangement (Calculating Weight Vector) and Test

Seeking for experts' opinion, with the air quality data of Xi'an for nearly a year, serving as a benchmark for commuter environment reference assignment, fill out the judgment matrix.

The weight vector obtained from above calculation and the result of the test is as follows.

From the Tables 7 and 8, it is seen that all the single hierarchical arrangement C.R. < 0.1, the uniformity of these judgment matrix is all acceptable.

Table 6 Diagram of recursive hierarchy structure

<table>
<tr><th>Targeted hierarchy</th><th>Index hierarchy</th><th>Scheme hierarchy</th></tr>
<tr><td rowspan="4">Reasonable commuting mode enables healthy status highest (A)</td><td>Physical activities (B1)</td><td rowspan="4">Private cars (C1)
Private bikes (C2)
Buses (C3)
Subways (C4)
Commuting vehicles (C5)
Private bikes +buses(private bikes capable of carrying) (C6)
Public bikes +subways (C7)</td></tr>
<tr><td>Life safety (B2)</td></tr>
<tr><td>Commuting environment (B3)</td></tr>
<tr><td>Psychological influences (B4)</td></tr>
</table>

Table 7 Calculating weight vector and testing result table on B hierarchy

A	Single (total) sort weights
B1	0.142
B2	0.527
B3	0.078
B4	0.253
λ	4.000111403
RI	0.9
CR	0.000025

Table 8 Calculating weight vector and testing result table on C hierarchy

B1	Single sort weights	B2	Single sort weights	B3	Single sort weights	B4	Single sort weights
C1	0.016	C1	0.180	C1	0.180	C1	0.025
C2	0.483	C2	0.058	C2	0.058	C2	0.366
C3	0.069	C3	0.158	C3	0.158	C3	0.067
C4	0.053	C4	0.197	C4	0.197	C4	0.067
C5	0.024	C5	0.189	C5	0.189	C5	0.153
C6	0.196	C6	0.109	C6	0.109	C6	0.157
C7	0.160	C7	0.109	C7	0.109	C7	0.166
λ	7.000027	λ	7.000026713	λ	7.000000029	λ	7.00084
RI	1.32	RI	1.32	RI	1.32	RI	1.32
CR	0.000000	CR	0.000000	CR	0.000000	CR	0.000000

4.3 Total Hierarchy Permutation and Check

Total hierarchy permutation, mode the relevant weight of each judgment matrix aiming at targeted hierarchy (the uppermost hierarchy). The calculation of this weight adopt the method from top to the bottom and compound hierarchy by hierarchy.

The weight of C1 on general targeted hierarchy is:

$$0.016 * 0.142 + 0.180 * 0.527 + 0.284 * 0.078 + 0.025 * 0.253 = 0.126.$$

With the same principle, obtaining the weight of C2, C3, C4, C5, C6, C7 to general targeted hierarchy is separately: 0.197; 0.117; 0.136; 0.160; 0.134; 0.131.

And

$$\begin{aligned} \text{CR} &= (0.00000 * 0.142 + (-0.00000) * 0.527 + (0.00000) * 0.078 + 0.00000 * 0.253)/1.32 \\ &= 0.000000 < 0.1 \end{aligned}$$

Thus, total hierarchy permutation pass the consistency check.

Table 9 The final weight value of commuting ways

Private car (C1)	Private bicycle (C2)	Bus (C3)	Subway (C4)	Company shuttle bus (C5)	Private bicycle + bus (which could carry private bikes) (C6)	Public bicycle + the subway (C7)
0.126	0.197	0.117	0.136	0.160	0.134	0.131

4.4 Results

The weight values from scheme hierarchy to general targeted hierarchy is shown in the Table 9.

From the Table 9, private bicycle on the right to re-target layer biggest, accounting for 0.197, followed by the commuter bus, accounting for 0.160, the lowest of which private cars and buses, respectively, accounted for 0.126, 0.117, a combination of two models in the middle position, accounting 0.134, 0.131.

Simply from the above table, private bikes and commuting vehicles are supposed to be the first choice as the commuting mode to improve our health. But it is found from the survey that the commuting distance of Xi'an residents concentrate on more than 5 km, 50 % of them is more than 10 kms. Taking the bike speed as 10 km/h, 50 % residents single commuting duration is over an hour; second, it shows that the current slow-moving traffic is not complete and the system is not formed and it is not feasible to adopt bike for long distance commuting. Secondly, with the separation of workplace and residence, it's hard to do large-scale use of commuter car. Bus and subway are good choices, but there is not a perfect cohesion "the last kilometer" commuting requirements, are less convenient. Taken together, we still recommend the use of commuter portfolio model proposed in this paper, to both health and reality.

At present, the weight of two kinds of combination modes are in the middle position, which weight significantly lower on the life safety and commute environment, but due to the positive feedback of the combination modes on commute environment and traffic safety (i.e., life safety), it means,with promoting the use of it as the commute combination patterns, its role in the health advantages will be more apparent.

5 Conclusions and Recommendations

5.1 Conclusions

In this study, we found there are many factors influencing commuter's health, such as air pollution, noise pollution, life safety and psychological influence.

Considering the influencing factors above and the consideration of people's choice of commuting mode by the survey, we proposed possible ideal commuting combination modes from the health view, "public bikes +buses/subways +public bikes" and "private bikes +buses/subways(portable private bikes) +private bikes". Furthermore, we built a evaluation index system, and evaluate the healthy effects on all the commuting ways, including the modes we proposed and people's current ones, by analytic hierarchy process. The result shows that the weight of the combination modes we proposed are in the middle level, this because they get a low weight on life safety and commuting environment aspects. The reasons why the weight is not highest are that the air quality in Xi'an is not good enough and life safety of the modes is low.

Based on studies all of above, we found that there is a positive effects between active commuting such as walking and biking, and people's health in life safety view, air quality view and exercise view. The more people commuting by walking and biking, the better the air quality will be. The better the air quality is, the better commuter's health will be by walking and cycling. With this positive feedback, we believe that commuter's health will be improved by the combination modes we proposed.

5.2 Recommendations

5.2.1 Improving Slow-Moving Traffic System

It is known that most residents hold that the current situation in Xi'an is not ideal for real healthy commuting for the infrastructure of walking and bike road is the maximal resistance factor. In China, the determined traffic development strategy is under the precondition of based on public traffic for large cities to improve the road of slow-moving traffic system such walking and riding bikes etc. the experience of various developed countries inform us that it is necessary for China's urban road traffic system development to strive to develop slow-moving traffic system and it is conformance to the developing demand for China's cities. Slow-moving traffic has the irreplaceable function on improving short distance travel efficiency, filling bus service blank, promoting traffic sustainable development and guaranteeing vulnerable groups' travel convenience etc. It compete and cooperate with private automotive traffic and public traffic, and co-forming the urban passenger traffic system is the necessity of China's development (Xiong et al. 2010).

5.2.2 Strengthen the Mixture of Land Utilization

Land utilization changes is one of the factors that have profound influence on traffic, meanwhile influences health indirectly. "Direct" means that compared with track traffic or bus lane, expanding road system frequently stimulates more energy intensive travel means and cause more air contamination and river contamination. “Indirect” means that road-oriented expansion development inside and outside cities as well as between cities strengthen the relying on cars so that healthy commuting is more hardly to implement. It is because cars individuals apply and the road they travel are intensive space consumers. Compared with active traffic or public traffic, road-oriented development increase the land area of cars travel and park, mainly in business districts, office buildings and dwelling districts. In turn, it makes walking, riding bikes even public traffic space small and efficiency low, meanwhile land for other use like green land is reduced. Through influencing these more extensive land use modes, traffic also influences various determined factors of health (WHO 2010). Road-oriented development more relies on the appearance of “vicious cycle”, leading inactive traffic, durable sitting posture and diseases this brings. On some level it shortens residents’ commuting distance and duration and lays foundation for the enablement of healthy commuting combining modes, meanwhile more residents could participate and better social atmosphere is formed, which is beneficial for virtuous cycle.

5.2.3 Smart Growth of Urban Space

The main content of smart growth is: to take full advantage of the current urban space, reduce blind expansion; to strengthen the reconstruction of the existing community, and to develop the wasted, polluted industrial land use, in order to saving the cost of infrastructure and public services; Urban construction is relatively concentrated, and encourage use of public transportation and walk; to protect open space and create a comfortable environment, by encouraging, limiting and protecting measures, and achieve the coordination of economic, environment and society.

Urban space development strategy is influenced by urban social and economical development strategy and space development strategy. The urban space structure and spatial form have a profound effect on urban traffic system. On one hand, it directly influences the total demand of urban road traffic and the distribution, density, constructing status, traffic structure as well as corresponding traffic policies of the whole traffic networks. On the other hand, it also indirectly influences urban land utilization planning and the travel mode of residents. Large plain cities like Xi’an are supposed to change the space development strategy of overspreading in the development. Through constructing compact cities, smart growth is realized and the share ratio of residents’ adopting bus travel is improved, meanwhile through controlling other traffic mode, active traffic is promoted and better conditions are provided for residents adopting beneficial commuting combining mode for health.

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Problem Analysis of Urban-Rural Industrial Land Use in Metropolitan Areas Under the New Urbanization Policy—A Case Study of Shanghai

Fan Yang

1 Background

With the advancement of urbanization in China, more and more people will live in towns. The rapid economic development in the past three decades promotes this process as well as the drastic changes in the form of urban and rural space. Various "parks or zones" and "new districts" located between urban and rural areas have become an important carrier of spatial growth in the city; At the same time, they affect the spatial structure of industrial, residential, public service and other functional areas, and influence the spatial distribution of local industrial structure and urban and rural labor and employment.

Since the "Twelfth Five Year", the main tone of development in several places is to make "structural adjustment"—innovation-driven and "transformational development" while maintaining economic growth. The Yangtze River Delta region has been the pioneer. Policy-makers in the Jiangsu and Zhejiang Provinces and Shanghai City have realized that land investment density and environmental carrying capacity are close to their peak, and that there is higher risk of regional development. In response, they all have lowered their target economic growth rate, stepped into the path of "low-speed" growth, and made efforts to adjust the industrial structure.

Foundation Key project of decision-making consultation research of the People's Government of Shanghai City (Approval No.: 2014-A-28-B).

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_13

The data released by the National Bureau of Statistics in January 2014 showed that by the end of 2013, the urbanization rate of the resident population was 53.7 %. Meanwhile, arable land decreased by one million acres, on average, every year in China, which is approaching to the red line of 300 million acres of arable land. Due to the size expansion, the problems of urban construction land have become increasingly highlighted. Lots of relevant policies of the national level have come out at that time, such as the “Central Work Conference on Urbanization” at the end of 2013 and “China’s New Urbanization Plan” at the beginning of 2014. This is a sign that we will adopt the development road of “steady growth, adjusting structure, promoting reform” for a long time henceforth. The new urbanization policy consists of six major tasks, including “control of population size of super-large city, no unreasonable expansion of construction land, less local finance depending on land resources, control of city development boundary to optimize the spatial structure and for the continuation of city culture”. These tasks require that the government “mainly reuse the inventory for urban construction land” and have “less industrial land use”, to reach the target of a more intensive degree of urban construction land through “strict size control, revitalizing the inventory, optimizing structure, and improving efficiency”. This fits with the current development dilemma quite well.

The newly published 2040 Master Plan of Shanghai City put forward a scheme of three “rigid control limits” and four “structural control limits”.[1] Structure optimization and control are the basic ideas of future space development, based on the idea of “total scale unchanged”. The new development paradigm represents a new normal, that is, the mode of structural adjustment replacing expansionary growth. The constraint mechanism of land use will compel the transformation of local economic and financial resources and industrial upgrading, changing the expansionary, predatory strategies to the endogenous, potential-tapping ones.

2 Review of Relevant Research on Industrial Land Renewal in China

Presently the regeneration, redevelopment and reuse of industrial lands and industrial space have become hot research subjects, and Chinese scholars of planning science, geography, economics and other disciplines have written studies over a long period of time and obtained a lot of achievements. Examples of these studies include.

[1]The three rigid control limits refers to the control line of basic farmland protection areas, the red line of ecological function protection, and the control line of specific protection zones. The four structural control limits refers to form optimization control, scale reduction control, development boundary under limited conditions, allowing construction areas.

2.1 Introduction of International Studies on Industrial Land Renewal

Theories and practices of urban regeneration have always been valued by western countries. These thoughts, theories and research have been an important basis for improving the city environment, providing more housing, and promoting inclusive growth in the urban and social economy (Roberts 2009).

Study of the behavior and space of industrial aggregation has provided a new perspective and theoretical method for industrial land renewal. Since the 1990's, new economic geography (NEG) scholars have studied the phenomenon of industrial aggregation by analyzing the temporal and spatial patterns of economic behaviors. They found that regional industrial gathering follows urbanization gathering, which is an important concept for explaining spatial evolution and city development drivers (Sheng and Wang 2011). Research on geographic clusters and knowledge spillover of industrial activities are usually used to test or construct the analytical theories of urban industrial space differentiation. The process of industrial aggregation will end with the formation of industrial zones, and industrial clusters are accelerated and highlighted by the construction of industrial zones.

2.2 Current Domestic Research and Their Development Trend

Early domestic study on industrial land renewal was based on theories of old city transformation, especially focusing on the dialectical relationship between protection and development during the process of "shifting from labor-intensive industry to service economy". Research based on the subsequent social practices discuss the decline of the inner city and the upgrading of traditional old manufacturing district.

Since the 1990's, domestic scholars have studied the new industrial space and its interaction with city space. Taking industrial suburbanization and the city fringe region as their starting point, they found that the city fringe region, due to its unique location and convenient traffic, has become the portal area for attract ing enterprises with advanced technology (Cui 2006; Gu 2000 etc.). With the appearance of development zones everywhere, the topic of economical and intensive use of lands has become more and more urgent, and people have become aware of the need to seek the optimal degree of intensity. Intensive utilization is the unification of economic, environmental and social benefits. Intensive land use and urbanization complement each other, and have different characteristics in different stages; they have also developed from labor and capital intensive to capital and technology intensive, then to structurally intensive, and finally ecologically intensive with the integration of urban and rural areas (Dong and Yuan 2000; Tang 2008; Qian 2011).

Based on this, there has been research on spatial optimization by using development zones as the inventory space. They hold the opinion that re-development of development zones is likely to be China's new smart growth space (Wang and Xu 2008), and may grow into the edge city (Yuan and Wang 2010). They consider that industrial optimization and upgrading, function transformation and upgrading, intensive use of space, renovation and reuse of buildings are effective ways to redevelop development zones (Yuan and Wang 2011). Then they can establish an index system to evaluate intensive use of construction lands (Tu and Wang 2012).

Since 2000, international theories on industrial clusters have received much attention in domestic academic circles—theyhave been used to analyze the social and economic causes of the phenomenon of industrial parks in China. Empirical and theoretical studies on the Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei and other large urban cluster areas, as well as the economic zones in provinces, have revealed the geographical phenomenon that industries gather in space, especially in the economically developed eastern cities. Industrial clusters have become one of the driving forces for regional economic growth and have had a significant impact on regional urbanization and city structure (Wang 2010; HE 2009). In the 2010's, scholars have made research on the underlying causes of industrial agglomeration. They have considered that it is partially the result of knowledge spillover (Wu 2007; Shi and Wang 2010), and that in an industrial cluster, better companies will merge with inferior ones, collecting resources to achieve industrial upgrading. When companies' demand for urban lands reduces, the utilization and intensive degree of urban land resource will be improved, after which a close relationship is formed between the spatial carrier of industrial agglomeration and the urban spatial structure.

The utilization benefit of industrial lands and their relationship with city space have gradually come into the scope of research. The marketing of industrial lands and industrial parks has a direct impact on the whole economic operation of the city, thereby affecting the structure of urban space. Excessive supply increments of industrial lands will lead to several problems, such as less arable lands, idle industrial lands and low use efficiency. Studies show that chaotic forms of development zones actually reflect that land marketing is declining, which is adverse to economical and intensive land use, economic structure adjustment and industrial upgrading, and creating job opportunities.

One empirical study uses GIS and other methods of spatial quantitative analysis to examine the impact of the spatial evolution of industrial parks on the overall spatial structure of the city using, but scholars have put forward the spatial analytic method of inventory and incremental land replacement (Yin et al. 2008).

Meanwhile, a study using the perspective of "space performance" has obtained preliminary progress. Urban planning specialists can research space forms using three indexes: the density index, gradient of density profile and daily travel mode. Accordingly, at the regional level, by building the evaluation model of land use performance based on the 4E (economy, efficiency, effectiveness, equity) framework, we can study the spatial distribution characteristics of land use performance and its spatial matching relationship with its industrialization and urbanization levels (Wu et al. 2009). At the urban level, the performance of urban spatial structure can be measured by four indexes, namely "performance density, performance spread, population gradient and performance OD ratio" (Wei and Zhao 2006). In addition, from the perspective of combining macro process (such as system, economy, social structure transformation) and local process (such as city development and construction of development zones), some studies have noticed differences in local land use with overall efficiency, phase difference of spatial distribution, the complexity of dual complementarity between functions, and the impacts of failure of both market and government. They advise studying the industrial land transformation at a wider scope of "growth, urban and land planning, spatial planning, urban and rural planning, old and new planning" (Yang 2010). More and more emphasis is put on industrial lands with internal and external integration and functional interaction (Zhou 2004; Zhou and Zhang 2009).

2.3 Characteristics of Existing Studies and Their Problems

Existing studies are based on the aggregation and evolution of urban industrial space. They analyze the mechanisms of use efficiency of industrial lands as they change with industry life-cycles and as they impact the optimization of spatial structure. But they also have some shortcomings.

Firstly, in theory, research on industrial land renewal has not included all industrial lands in urban and rural areas according to national conditions. A large number of industrial parks are the consequence of land finance behavior of local governments. Moreover, township industrial lands do not have total quantity control or coordinating spatial structure. The traditional industries in cities, industrial parks at the city edge, and industrial parks in rural areas should not be divided in studies; otherwise it is difficult to achieve the target of limiting and reducing the total quantity of industrial lands and optimizing urban-rural spatial structure.

Secondly, in method, studies on the evaluation of utilization performance of industrial lands are insufficient. Besides input-output evaluation from the economic aspect, there should be spatial performance evaluation from the view of spatial match efficiency.

Thirdly, in application, studies on the adaption of spatial optimization models of industrial lands to regional differences are insufficient. The overall cooperative relations among regional economic development, the city's industrial structure and the land use and spatial structures should gradually become the research focus.

3 Analysis of the Problems of Urban-Rural Industrial Land Use in Shanghai

3.1 Imbalance of the Scale Structure of Industrial Lands in General

Statistics shows that industrial lands in many cities account for too big of a proportion. It has affected people's lives in livable and ecological aspects and touched the red line of arable land protection. Moreover, their contribution to employment opportunity and economic growth is not optimistic, and they undermine the sustainable development of industrialization and urbanization. The proportion of industrial land in cities of China is often more than 20 % (Huang 2008). Middle and small-sized cities also have the problem of too high of an industrial land proportion and too rapid industrial land growth. For example, the industrial lands in Kunshan city increased by 210.92 hectares on average every year between 1990 and 2001, which accounts for 50 % of the average annual increase of total construction lands and 21.25 % of the average annual progressive increase (Cao 2006).

In addition to industrial lands in urban construction lands, there are township industrial lands located in rural places within the administrative jurisdiction of the city. If the aggregation scale is large enough, these lands will become the township industrial parks or industrial zones. They create taxation and employment opportunities for the countryside and support rural economic development, but on the other hand, they occupy a large number of collective construction lands and cause environmental pollution. These lands of industrial enterprises in the countryside are generally not included in urban construction lands, but their output and tax contribution is contained in the industrial structure and GDP statistical calculation per unit of the city's administrative areas. Therefore, the proportion of industrial lands in the total urban and rural construction lands, rather than in just urban construction lands, can reflect more accurately whether industrial lands are of reasonable size or structure (Fig. 1).

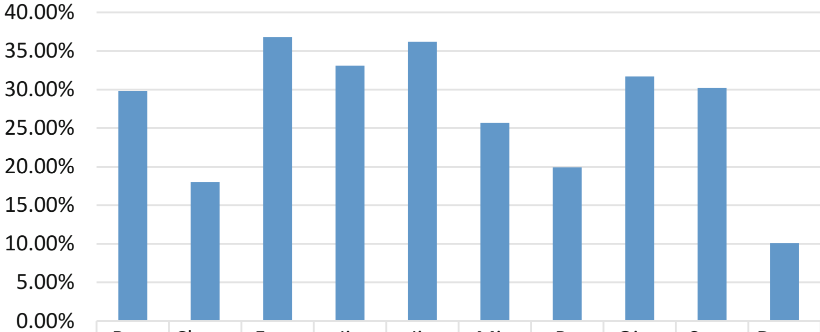
Taking Shanghai city as an example. Data by the end of 2011 shows that the existing industrial and warehouse lands in Shanghai make up 843 km^2, and account for about 26 % of its total construction lands; within this, industrial lands make up 752.4 km^2 and 23 % of its total construction lands. The eight downtown districts of Shanghai have the lowest industrial land proportion, but still make up 10.1 %, and they mainly consist of the areas surrounded by the outer ring road of Shanghai. The Fengxian District has the highest percentage of industrial land in urban-rural construction lands, up to 36.8 %. The percentage of other districts and counties are also around 30 %. Even in Pudong New Area that is considered by outsiders to have the most diversified industrial structure, the percentage of industrial land in urban and rural construction lands is also 20 %. On the whole, the percentage of industrial lands in construction lands exceeds the national standard of land use structure. It also does not help Shanghai achieve a higher level of city development goals.

Fig. 1 Administrative zoning map of all districts and counties of Shanghai City

From 1998 to 2010, Shanghai's gross value of industrial output has displayed an obvious increase. But as shown in Fig. 2, the industrial output value of average land goes up at a speed much lower than the gross value. A reasonable explanation is that the increase of Shanghai's gross value of industrial output still depends on the size expansion of industrial lands and on the quantity and the scale benefit of industrial enterprises. This is similar to second industry development driven by scale. The industrial transformation and the economic growth mode driven and relying on innovation have not yet been achieved. In many strategies for Shanghai's new round of development, industrial lands are regarded as the main object of the city's transformation and development and the revitalization of the lands in inventory; reducing the spatial scale of industrial lands will propel the industrial transformation. While Shanghai has launched various industrial policies and innovation promoting policy, the spatial shrink policy is also needed for support, otherwise it is difficult to effectively achieve true transformation (see Table 1, Figs. 2 and 3).

Based on the analysis of Shanghai's industrial land use, its total industrial output value, and the growth trend analysis, we find that when using various economic statistical data of a city, we tend to ignore the distribution of spatial carriers of the data. This is partially due to China's special territorial economic factors. If we observe statistics by construction lands in the administrative area rather than the state-owned land use right, it is easy to find that the use of industrial land, especially the structure of construction lands in the city's administrative area, is not optimistic.

Table 1 Proportion of industrial lands in construction lands for districts and counties of Shanghai in 2011



	Bao shan	Chong ming	Feng xian	Jia ding	Jin shan	Min hang	Pu dong	Qing pu	Song jiang	Down town
Percentage	29.80%	18.00%	36.80%	33.10%	36.20%	25.70%	19.90%	31.70%	30.20%	10.10%

Note The construction lands in the table refer to the urban-rural construction lands

Data source Statistical yearbook and annual reports at all levels

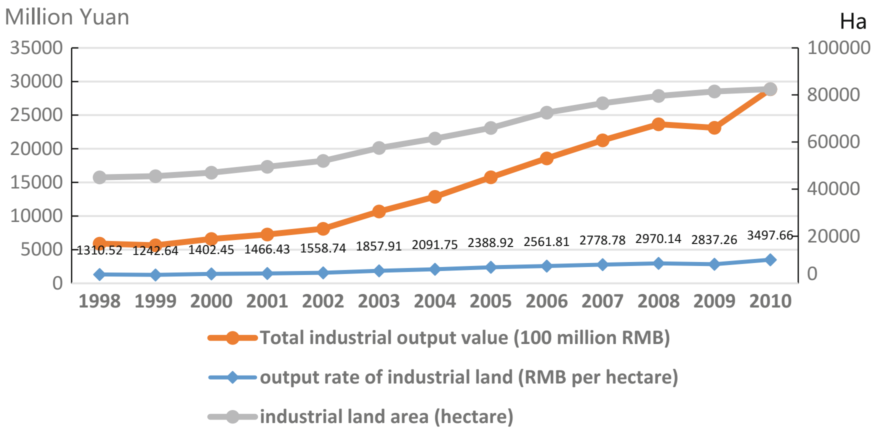


Fig. 2 Trend comparison of industrial land with Shanghai's total industrial output value in 1998–2010 (unit: million RMB). *Data sources* Data of the gross value of industrial output in 1998 are quoted from the "Statistical Bulletin of Shanghai National Economic and Social Development in 1998", the data of the other years from "Shanghai Statistical Yearbook". Data of industrial land size are quoted from "Theory and Practice of Land Use Planning of Super-large City during Transition Period", Feng (2013)

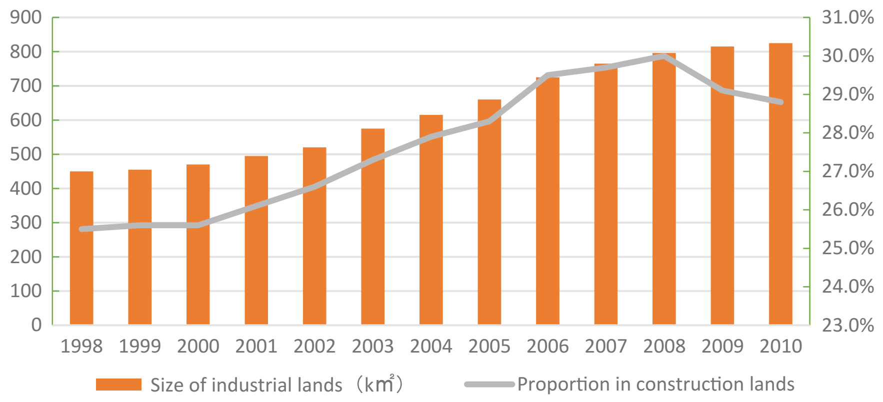


Fig. 3 Size of industrial lands and the trend of their proportion to construction lands in Shanghai between 1998–2010. *Data source* Feng (2013)

3.2 Spatial Structural Imbalance of Industrial Land

Industrial enterprises located in the city's central area is facing decline, pollution and traffic problems as the city develops. Under the effect of differential rent of the land market, the urban industrial land has now become the object of land functional replacement with its higher input-output ratio. Since the 1990s, the policy of shifting from labor-intensive industry to a service economy has promoted this renewal process. Large-scale renovation of old districts and population outflow have propelled the industries in the city to move to the outskirts of the city. Most of China's traditional industrial cities have witnessed this process, and Shanghai is no exception (Fig. 4).

Urban fringe and rural areas, with their low land price, are the preferred location of all kinds of parks and zones. Various industrial parks, development zones and new districts have become important spatial carriers of the city's out-extension. According to statistics, by the end of 2011, China had established 131 national economic and technological development zones, 88 national high-tech industrial development zones, 13 free trade zones, 8 comprehensive bonded zones, 56 export processing zones and 14 border economic cooperation zones.[2] In addition, there are thousands of county, urban or province development zones in China, and also a number of industrial zones built in accordance with various goals and government bodies. The construction of industrial parks and new districts has brought about a substantial expansion of the urban area and improved the city's ability to absorb labor. This has promoted the city's industrial development to some extent, and

[2]Refer to: Xu Kuangdi as the editor, Research on Development Strategies of China-featured New Urbanization (Integrated Volume) [M]. Beijing: China Construction Industry Press, 2013:237–238.

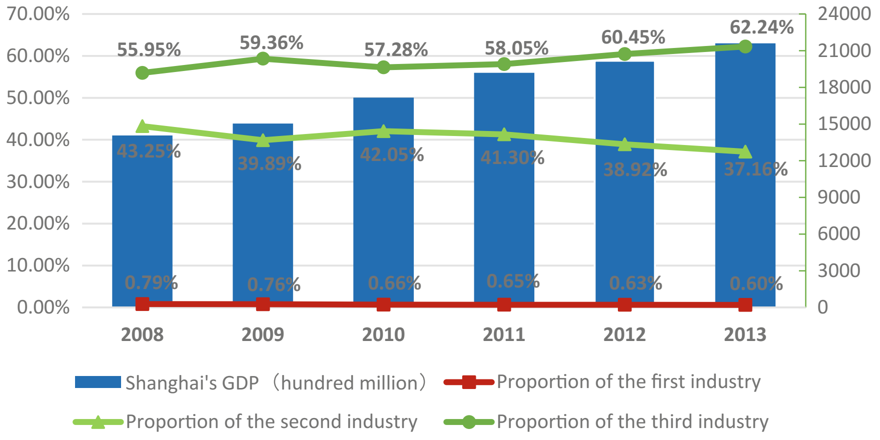


Fig. 4 Structural trend of the top three industries in Shanghai. *Data source* 2014 Shanghai Statistical Yearbook

propelled the change of urban industrial structure. However, the local government has held the goal of building industrial parks to promote real estate development and stimulate the growth of the GDP to obtain fiscal revenue. However, this results in a large number of lands in industrial parks staying idle even though they have construction approval. These industrial parks often occupy the best locations, resource conditions and development corridors, and their idle lands and inappropriate functional structure have had adverse effects on the city's spatial structure.

Moreover, there are a large number of industrial parks built on the collective construction lands in the urban fringe and rural areas in the city's administration jurisdiction. These parks do not have unified space management, so they have the same excessive size as previously mentioned, and their spatial distribution is mixed.

Taking Jiading District of Shanghai as an example. Its industrial lands in its rural area have such a bad spatial structure that they have problems with infrastructure support, industrial land use efficiency and environmental pollution (see Fig. 5).

After an investigation and analysis of industrial lands in the Jiading District, Pudong New Area, and the central eight districts of Shanghai, the author has found that, considering all the three natures of the lands (i.e. use, selling and ownership), industrial lands in Shanghai are located in following three types of "construction areas":

1. Specially designated industrial blocks within the intensive construction regions (The brown patch in Fig. 5).
2. Industrial blocks within the intensive construction regions, mixed with other types of construction lands and space. There are most likely three reasons for their appearance: first, the traditional industry existing in the city's built areas

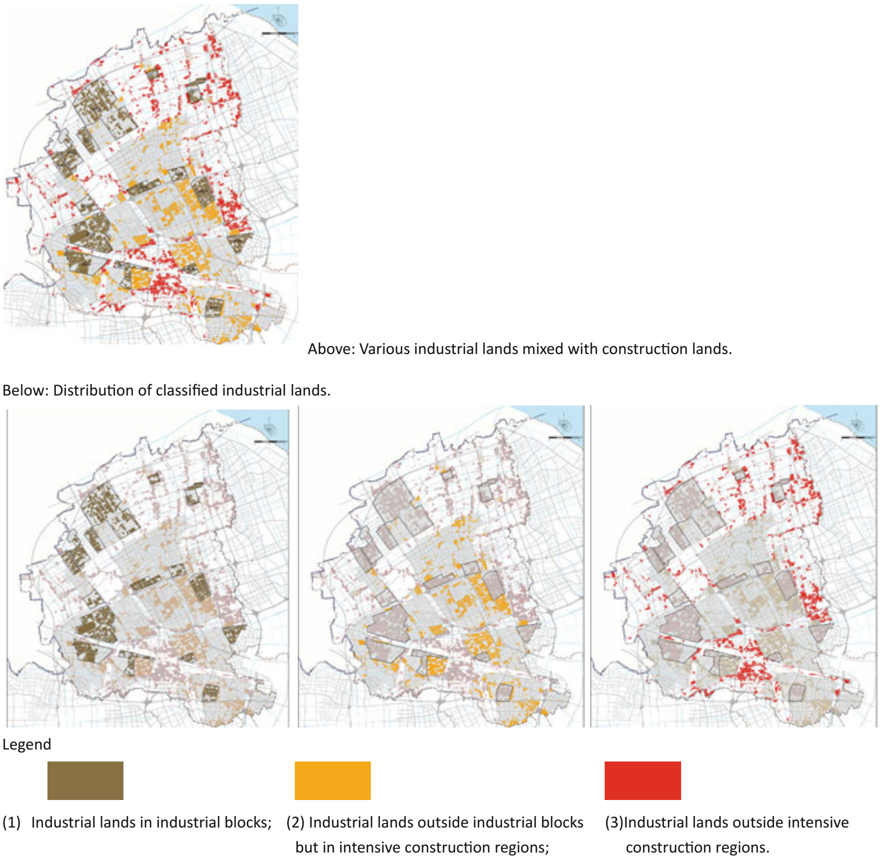


Fig. 5 The spatial distribution of industrial lands in the Jiading District of Shanghai (2011). *Data sources* Drawing by the author according to study data

has been "surrounded" gradually due to the expansion of the city; second, the street-level government.[3] In the city's built areas, in order to develop its economy and get fiscal revenue, has constructed industries through foreign investment or its own development; third, the merger of the original township industrial lands during the urban spatial expansion (The yellow patch in Fig. 5).

3. Rural areas within the city's administration jurisdiction, but outside the intensive construction regions. As mentioned before, these industrial lands have been subject to unified planning, but their products circulate on the market, and the industrial output value produced by them is calculated in the annual statistics of their administrative government. Most of the employees there are local citizens

[3]Shanghai applies the municipal system of "three levels of governments, management of three levels", and the sub-district authority is the lowest level of government management body.

or migrant workers, but the lands are of rural collective ownership; and most have the nature of agricultural lands. The central eight districts of Shanghai do not have this kind of industrial land (The red patch in Fig. 5).

Pudong New Area is another example. The "104" blocks have a total planned area of 168.05 km^2, but the industrial lands that are actually located in the blocks are just 44.14 km^2 and account for 26.26 % of the block land area. That means over 70 % of land in the blocks have not been utilized fully to build factory buildings. On the contrary, 71.97 km^2 of industrial land are located outside the blocks and far less than 124 km^2 of the unused lands that are located within the blocks. Why are these industrial lands scattered in urban and rural areas, rather than located together in the industrial blocks that have favorable facilities, service, locations and road conditions? This is a complex question that is caused by both historical and system factors (Tables 2 and 3).

From the two cases above, we can find some questions. The disordered location of industrial lands in the intensive construction regions has several adverse effects.

1. It will lead to chaotic functional space structure of the city, and make spatial management more difficult.
2. It will cause mutual interference between production traffic and people's daily travel, and bring pressure on the road network and supporting facilities.
3. The industrial production will bring along security and health risk to residents and offices nearby.
4. It will be an obstacle to reuse industrial lands. Enterprises can use the industrial lands for 50 years legally, and many failed enterprises do not consider transformation, transfer or re-development. Rather, they wait for government purchasing after the expiration of the lands in order to obtain a huge land price increment, resulting in idle lands increasing year by year.

Table 2 Industrial lands in industrial blocks of Pudong New Area

Classification		Quantity	Total area of industrial lands (hectare)	Proportion according to different location
Bulletin parks	National development zones	2	1410.14	
	Municipal development zones	7	1402.87	
Industrial bases		7	927.16	
Industrial blocks		5	673.64	
Total in "104" blocks			4413.81	38.0%
Outside "104" blocks within intensive construction regions			4703.21	40.5%
Outside intensive construction regions			2493.68	21.5%

Data sources: Measurement according to the drawings of "104" industrial blocks
Note: 1) The national development zones do not contain Lujiazui financial and trade zone and Zhangjiang R&D land
2) "104" block were planned for about 16593.27 hectare, but only 26.6% land resources were built for industry

Table 3 Gathering state of industrial land parks in Pudong New Area

	Area of industrial lands (hectare)	Proportion (%)
"104" blocks	4413.81	38.00
Outside "104" blocks within the intensive construction regions	4703.21	40.50
Outside intensive construction regions	2493.68	21.50
Total	11610.7	

Data sources Measurement according to the drawings of "The second time land survey"

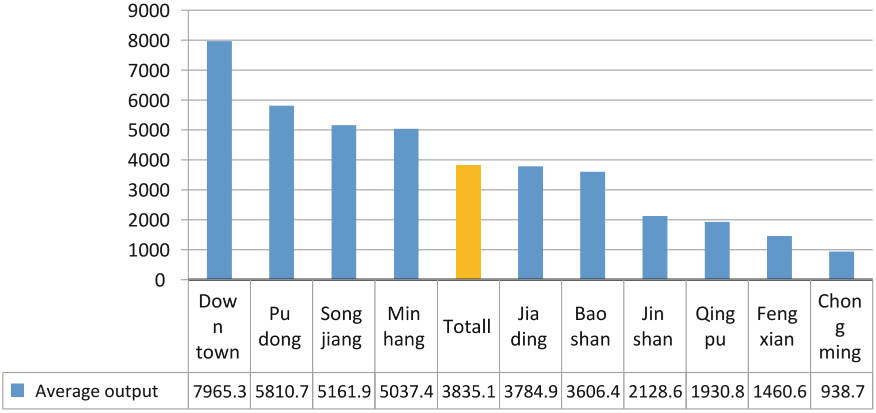
3.3 Serious Problems of "Industrial Lands in Inventory"

Industrial lands in urban and rural areas are beyond the reasonable proportion in scale structure, and also occupy a large amount of city growth space. The high location value in spatial structure results in a disordered spatial structure of the city. Moreover, inefficient use of urban and rural industrial lands is quite common. Some of this inefficiency is a low efficiency of the spatial structure—that is, the layout fails to reflect the location value of the lands. Some of the inefficiency is economic inefficiency—that is, low input and output efficiency of industrial lands. The others not gathered into industrial parks result in spatial fragmentation of the urban and rural construction lands, less land resources for urban and rural construction, and the industrial accumulation benefit cannot be achieved.

The reasons for both low economic performance and low spatial performance of lands include: first, the government body at the local level (referring to not only the township government, but also the rural autonomous body) has fiscal dependence on land renting. Second, besides land transfer, the local government body is able to attract a lot of companies by inviting foreign investment. The registered capital will also contribute to local GDP growth, and create fiscal revenue. Third, whether enterprises can bring about economic activity and job opportunities is not of the highest importance. Of course, if the company can produce good benefits of industrial gathering, then it will be the "gold owner" that the local government body will try to obtain at any cost. The reality is that all companies cannot settle there successfully due to the industrial life cycle and competition at home and abroad; nor can all companies produce profits, create job opportunities and grow continuously. Therefore, a number of industrial lands are approved but not used for construction, leaving lots of idle and neglected lands. This is the problem of "industrial lands in inventory" under the impact of China's rapid economic development and foreign investment policies (see Tables 4 and 5, Fig. 6).

Nearly all cities have used the indexes of input intensity and the efficiency of land use (the former mainly about average "input-output" of lands, and the latter about "average GDP growth rate of lands") to evaluate the land use performance of

Table 4 Output rate of industrial lands in districts and counties in Shanghai (2011) (unit: million RMB per hectare)



Data source Data in 2008–2013 "Shanghai Statistical Yearbook"

Table 5 Gathering proportion of industrial lands located in bulletin development zones in districts and counties of Shanghai

Districts and counties	Proportion of industrial lands located in bulletin parks (%)
Qingpu District	45.0
Songjiang District	43.7
Jinshan District	40.4
Jiading District	37.6
Pudong New Area	30.6
Minhang District	29.8
Fengxian District	25.6
Baoshan District	22.8
Chongming County	7.5
The central eight districts	13.0

Data sources Drawing of the author according to study data

industrial parks.[4] But after comprehensive comparison of data on the increase of industrial lands, three industrial structural changes, the increase of industrial output value, and the rise of industrial land use efficiency, it is not difficult to find that cities have neglected the comparison and evaluation of the huge gap between industrial land use efficiency of rural areas and that of bulletin development zones.

[4]Refer to: Feng Jingming as the editor, "Theory and Practice of Land Use Planning of Super-large City during Transition Period" [M]. Shanghai: Tongji University Press, 2013:225–227.

Fig. 6 Policy areas of spatial reconstruction of industrial lands in Shanghai (Jiading District as an example). *Notes* (1) Policy area of "104" industrial blocks (sometimes known as 107); intensive construction regions at all levels, optimize industrial blocks; (2) Policy area of "195" industrial transformation; industrial transformation and upgrading, land renewal; (3) Policy area of "198" quantity reduction of industrial lands; quantity reduction, adjust and gather into industrial blocks, residual reclamation. *Data sources* Drawing of the author according to research data

They also seldom evaluate the inefficient spatial structure of industrial lands while trying to avoid economic inefficiency.

Reuse of industrial lands in inventory is the most serious and special issue in the reuse of industrial lands. It shall include the following three kinds of updates: First, reuse of industrial lands from companies closed down or moved away due to industrial cyclical decline; Second, reuse of idle industrial lands approved but not built; And third, spatial structure optimization and industrial space reconstruction to solve structural imbalance of industrial land layout as both urban and rural areas promote rapid development of the economy. Renewal of industrial lands, especially industrial lands in inventory, is crucial to achieve the industrial structure adjustment of cities and the growth, transformation, and upgrading goals. Also it is key to the "double optimization" of scale structure and spatial structure of urban and rural industrial lands.

3.4 Lots of Policy Measures but with Limited Effect

In the process of "selective spatial layout" and uncontrolled transfer of industrial lands, the urban and rural industrial lands have seen rising degradation of utilization efficiency, functional structural imbalance and disordered location. These issues have turned into the major obstacles to improving functional structure, urban and rural employment interaction, higher operation efficiency of the city, forming of reasonable ecological, living and production structure in the urban and rural areas and realizing sustainable development.

Usually research and practices for solving this problem put forward policy measures whose effect is not satisfying. Taking Shanghai as an example. Even the "three aggregation" policy executed in the 1990s had required "collecting to industrial parks". But due to various reasons, the result is not satisfying after execution (see Table 5). Since 2003, after two rounds of rectification and audit work, Shanghai announced 41 bulletin development zones (15 national, 26 municipal) from the 177 applications. But data from the year 2011 showed that, in the current 752 km^2 industrial lands, those within the above bulletin development zones were just 242.9 km^2, and the concentration rate was only about 32 %. This is not a high gathering degree (calculated according to research data). Even in the Pudong New Area, generally considered to have more emerging industrial space, only 38 % industrial lands are located within the industrial blocks (see Table 3).

In lieu of this situation, in order to reconstruct the industrial space and keep improving the spatial efficiency of the industrial land layout, Shanghai has implemented three industrial land policies to support each other in recent years. These include the quantity reduction policy of "198 zones" (outside intensive construction regions), "104 blocks" (planned industrial blocks) policy, and the policy of industrial transformation of "195 zones" (outside planned industrial blocks but in intensive construction regions), so that all kinds of industrial lands will gather within the industrial blocks. Among them, the quantity reduction policy of "198 zones" was implemented mainly through the countryside unit planning (see Fig. 7).[5]

In fact, Shanghai Municipal Government has found that just space policies (e.g. *104, 195 and 198 policy areas as mentioned above*) and related land policies (*for example, last year Shanghai started the "elastic year" policy of industrial land transfer, i.e. the tenant company will not use the industrial land for 50 years, but 15–20 years. When the renting period will ends, re-evaluation will be done before determining whether continue renting or not*) are not enough. The performance evaluation of local governments must be changed to support these policies. Therefore, based on the research of Subject One in early 2014, the Shanghai Municipal Government documents issued in 2015 have cancelled all tasks of foreign investment of township and street level governments, so that basic local governments will change from having economic functions to social and public service functions. Without economic pressure, the idea of spatial reconstruction becomes possible, and industrial space will not be affected by the spatial location of the government body. Reconstruction can move to industrial blocks.

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[5]Refer to: "Three-year Action Plan on Transformation and Upgrading of Shanghai Industrial Zones (2013–2015)" [Shanghai Municipal Government Office (2013) No. 56] issued by Shanghai Municipal Government in October 2013; "Provisions on Strengthening Management of Industrial Land Transfer (Trial)" [Shanghai Government Office (2014) No. 26] issued by Shanghai Municipal Government in March 2014; "Several Opinions on Further Improving Economical and Intensive Utilization of Lands" [Shanghai Government Office (2014) No. 14] issued by Shanghai Municipal Government in February 2014; and "Guidelines on Preparation of Shanghai Countryside Unit Planning (Trial)" in September 2013.

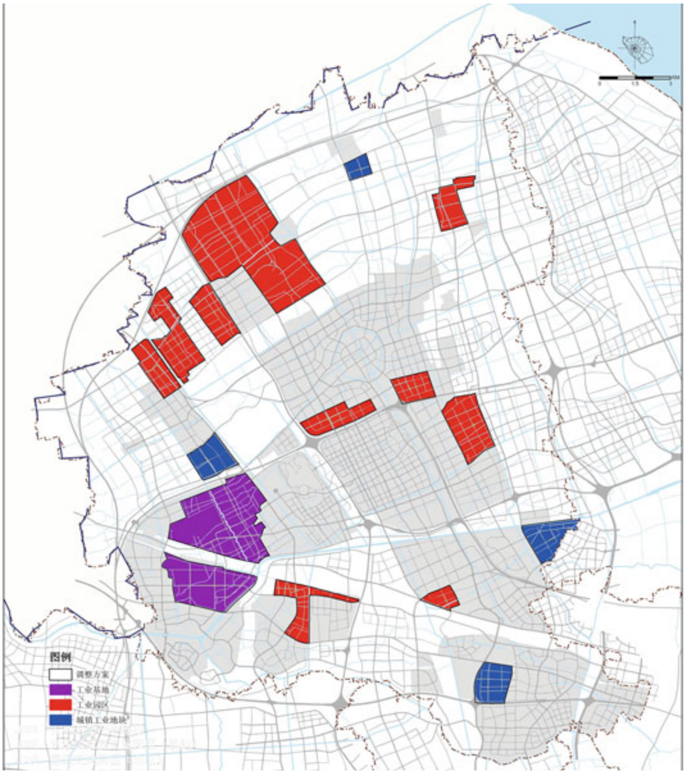

Fig. 7 Classification chart of spatial planning of industrial lands in Jiading District of Shanghai (target of policy guidance). *Notes Red blocks*, industrial parks; *purple blocks*, industrial bases; *blue blocks*, urban industrial lands. *Data sources* Drawing of the author according to research data (Color figure online)

4 Improvements to Research on Urban and Rural Industrial Land Regeneration

4.1 More Overall Urban-Rural Planning During Constructing the Theoretical System

First, we should recognize the limitations of international theories and methods on urban regeneration and revitalization of industrial zones. China's local governments have a lot of financial dependence on the land, and makes excessive interventions. China, by influencing the t market, neglects rules such as the industry life cycle, the industrial aggregation effect, knowledge spillover effect, etc. International regeneration experiences may not be able to solve the fundamental problems of the present time in Chinese cities.

Secondly, we recognize the formation of basic theories of industrial land renewal research and space reconstruction. Intensive use of construction lands, as an important concept of development, is the growth demand in the background of limited land resources, especially cultivated land resources.[6] It is reflected in two levels. One is better performance of land use, and the other, is a continuous renewal process. Better land use performance is based on intensive land use, scale effects and higher input-output intensity of lands. It requires making the best use of lands. A continuous renewal process is based on the industrial development path and rules of economic behavior. It requires dynamic configurations of industrial lands and adjusting their structure according to the stage and status of economic development in the city—it is a more meaningful concept of city regeneration. Policy guidance should be based on these two levels to construct the theoretical system of urban regeneration and space policy measures that have broader connotations.

4.2 More Spatial Performance Evaluation When Using Technological Systems

Traditional urban land planning does not have effective methods to evaluate the spatial performance of the spatial match between industrial land construction and the distribution of urban facilities and employment. Therefore, lots of theories and spatial planning methods cannot fit reality when applied to guiding renewal practice. With the possible constant evolution of the spatial configuration of urban functions, the traditional planning concepts based on per capita indices need to be changed. We need to pay more attention to the spatial meaning of industrial and social transformation. Moreover, the spatial reconstruction model of industrial lands, which includes the impact of the interaction of land development, supporting facilities, and employment distribution, needs to be set up through this performance evaluation. This gives spatial pattern and planning strategies based on dynamic optimization and evolution of urban-rural spatial structure.

Because of the transformation guidance of scale structure and spatial structure, every project of industrial land renewal shall be examined from both a partial and a whole angle of view. Therefore, to evaluate the spatial performance of industrial land renewal, we need to obtain the balance between the two evaluation standards, i.e. the land economy (input-output efficiency) and its space rationality (space performance). Obviously, industrial land reuse in rural areas under the city's administration jurisdiction needs to go together with that in industrial parks and zones and also the traditional industrial land in the urban built up area. Effectiveness at one part is only partial and temporary.

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[6]Refer to: "Notice on Promoting Economical and Intensive Use of Lands" issued by the State Council in 2008, and "Regulations on Economical and Intensive Use of Lands" published and implemented by the Ministry of Land and Resources in September 1, 2014.

The construction of technological systems of planning relates to the correct understanding of "industrial lands in inventory". More studies should be done on this topic. Industrial lands in inventory do not only refer to unused lands in the inventory, but those existing in large quantity with use approval and in the nature of industrial use. However, if the company declines or stops production in a short time, or it acquires the lands not for industrial production, but desires the profits from a higher land price spread, the lands become idle and unused to wait for purchasing or re-development.

The existence and number of industrial lands in inventory may cause some problems. Firstly, the waste of land index, although the industrial lands account for a high proportion, cannot show their scale and ability of having an economic contribution. Secondly, there is a waste of space; these lands occupy good locations and undermine the spatial structure of the city. Thirdly, they waste facilities—Industrial parks have good locations, facilities, and road and traffic conditions, but keep idle. Fourthly, they distort the market value of lands. The change of land classification will itself bring a large sum of profits, and the index of industrial land does not link with the residential population, so the transfer of industrial lands is unchecked and out of control. They make fewer other types of construction lands, which leads to the shortage of land resources.

5 Conclusion

Industrial land use efficiency and its relationship with urban and rural spatial structures have attracted extensive attention recently; this includes both the renewal of traditional industrial lands within the city, as well as that in various industrial parks in city and rural region. We shall keep an eye on the concept of continuous renewal of industrial lands due to the industry life cycle, as well as re-development and reuse of industrial land under the influence of land finance. In order to control total quantity, we need to also coordinate industrial land renewal and optimization of urban-rural spatial structure as a whole.

Forced mechanisms due to the "new urbanization" policy and related policies have made the long existing problems of industrial lands more serious and urgent, and we need to study them and set out policy as soon as possible. Based on domestic practical experience of urban regeneration, industrial land renewal is an important breakthrough to revitalize the inventory, discover the potential and improve the city's spatial structure. However, industrial land renewal will alter existing legal planning and have complex problems of power and benefit sharing. Therefore, we need to make institutional construction according to local circumstances for urban regeneration, to manage the urban regeneration activities effectively though measures of local legislation, the urban renewal plan, urban renewal unit, and renewal authority department, and to build the guarantee system for planning implementation. This is also an essential and important step in realizing industrial land renewal in the city.

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Following Natural Features—Planning Method Research on the Spatial Arrangement of Blue-Green Webs Around Urban Core Areas

Zhong Xing, Xizi Tang, Qiao Yu and Xiaobo Xu

1 Introduction

A city always prefers a site with well-endowed natural features as a locale for development. Our predecessors preferred following water for living, with town sites facing toward water bodies, leaning against mountain ranges. Feng and Shui are integrated into the town sites via "Blue-green space". However, natural features indicative of natural hue and form are now replaced with heavily engineered greens spaces. Meandering creeks are channelized or encapsulated into underground culverts, and even buried. Forests on foothill are scraped off, rolling terrain is graded or leveled for building convenience, and organic soil is trucked onto sites for the attempt of fertilizing barren soil. Natural blue-green spaces are fragmented due to intensive urban development. Smart growth focuses on "where" and "how" to develop wisely. New urbanization places importance on improvements of city development in which mountain ranges and water bodies are visible. To accomplish this, what other natural

Funded by: Chongqing University Postgraduates' Innovation Project CYB15036

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_14

elements and processes should be considered for embracing cities' distinctively perceptual character, as well as a broader range of urban form issues and creating appealing places? A focus on natural features will transform not only the way we preserve valuable blue-green spaces, but also the way we approach planning in fundamental ways, benefiting cities and the environment as well. Natural factors mainly include topography, geology, climate, soil, hydrology, flora, vegetation, and wildlife (McBride 2009). The recognition of natural factors in urban setting should be placed in a broad context as a cohesive whole based on natural process.

2 Related Research

Humans have a responsibility to steward and safeguard natural ecosystems (Leopold 1949). Associated research on blue-green space involves multifarious theories and methods of planning, such as traditional Chinese FengShui theory, pattern-corridor-matrix theory, landscape ecological networks, watershed planning, and ecological restoration of rivers.

2.1 Traditional FengShui Theory

More than two thousand years ago, our ancestors already recognized that running a well-kept environment—including geology, hydrology, ecology, and microclimate—is the prerequisite for maintaining a good urban condition (Wang and Zhang 2010). There is a typical diagram of environmental setting of traditional town site in China. The town stays attuned with the natural environment. Town area inside and natural surrounding outside co-exist in harmony (Wang and Zhang 2010). Theories developed in the process of urban development such as City Image, Sense Place Spirit, and respecting natural processes are of similar character with FengShui theory (Yu 2000).

FengShui theory sets forth the principles for selection of a lucky site for town construction: "southerly facing towards bow-shaped water body and northerly lean upon encircling mountain ranges, central area for town's construction resembles turtle's back". Southerly facing towards water helps maximize the sunlight gain, with the river not only carrying transport and feeding irrigation. A bow-shaped river efficiently reduces fast moving water-erosion to the rive-bank next to the town site, simultaneously gaining extra land resulting from soil sedimentation of the opposite bank over time. Northerly leaning upon encircling mountain ranges helps protect the town area from prevailing wind-attack in winter. The central area of town resembling a turtle's back suggests quickly draining away runoff water entirely relying on natural gravity without accumulation in the core area (Wang 2009). Natural features are substantially celebrated locally and naturally in the FengShui mode. Well-channeled wind and water systems animate the site as a vibrant place, leading to vital profusion within. This shapes the core of Feng Shui theory.

Unfortunately, city construction today disregards the wisdom of our ancestor, favoring development over environmental preservation.

2.2 Patch, Corridor, and Matrix

Based on the work of Richard Forman, Frederick Steiner, and others, the discipline of "landscape ecology" emerged in 1980s and 1990s and developed a new way of looking at landscape in urbanizing or rural areas, emphasizing "patches" of wildlife habitat, "corridors", "edges", and so forth while proffering a set of approaches for preserving and restoring natural landscape elements within cities and towns (Forman and Godron 1986; Farina 2000). Landscape ecology principles are integrated into nature conservation and landscape planning (Jongman and Pungetti 2004). Lately, a richness of spatial patterns and principles have been developed for the preservation of natural landscapes within or next to the built environment in urban regions (Forman 2008).

Landscape architects and planners such as Michael Hough, Anne Whiston Spirn, John Tillman Lyle, and Rutherford H. Platt argue that cities and natural landscapes are profoundly interrelated (Spirn 1984; Hough 1984, 1990; Lyle 1999; Hough 1990). Many movements pay particular attention to natural landscapes within urban areas. A major battleground between new urbanism and ecological design is the role of nature in the city and how it should be integrated. Natural systems are challenging the traditional ideal built form. This is particularly true from the current perspective of ecological design (Southworth 2003). An obvious priority for sustainability planning is to help communities coexist in a far better fashion with the natural environment (Wheeler 2004). "Making nature visible" is an ecological design principle that landscape architects such as Sim Van der Ryn argue can help the public understand the unique characteristics of each site or place (Van der Ryn and Calthorpe 1984; Van der Ryn and Cowan 1996) "Keep the 'Natural' in Natural Areas"[1] is the outcry for respecting natural landscapes.

2.3 Watershed Planning and Management

Water often flows across political boundaries such that contaminants put in waters by activities in one jurisdiction can affect the quality of water flowing to downstream jurisdictions[2] Watershed management is the emerging choice of many organizations to integrate and coordinate efforts. A common definition of a watershed is "an area of land from which all surface and ground water flows from higher elevations downhill to a common body of water such as a stream, river, lake, wetland, estuary, or ocean." In

[1]Natural Areas Association. Natural Areas Journal [J/OL]. http://www.naturalarea.org/joinrenew.asp

[2]Department of environmental quality land and water management. Land and Water Management Division [R]. Great lakes shorelands.

essence, watersheds are landscape units that integrate land-, air-, and water-related ecological processes. This, along with the fact that watershed boundaries can be identified with relative ease, makes watersheds practical management units for integrating efforts.[3]

To implement the plan and provide improved guidance for future development, community leaders need to take the results of planning and visioning exercises and organize them to support future analyses. There are land-use change models that may help accomplish goals and answer the following questions: Where are our precious community resources located? Given that we want to preserve wetlands, forested slopes, riparian buffer strips, and floodplain areas, what land is left for development? Where are our steep slopes, loose soils, and otherwise non-buildable lands located? (United States Environmental Protection Agency 2000)

2.4 River Corridor Restoration and Planning

River restoration has emerged as an increasingly important activity in North America and Europe to improve water quality, enhance aquatic and riparian habitat, and facilitate human uses (Downs et al. 2001; Bernhardt et al. 2005) Among the most visually striking types of river restoration worldwide are channel reconstructions: projects that involve the creation of a new channel, often in a new alignment and generally with a form and dimensions that are different from those of the pre-project channel. Many channel reconstruction projects have the objective of creating a stable, single-thread, meandering channel. Recreating meanders is a reasonable and obvious goal on rivers whose historical bends were lost to channel straightening projects, as is well-documented on many rivers and streams in Europe (Brookes 1987; Goldi 1991, 1989; Iversen et al. 1993). However, meanders have also been created in many channel reconstructions on rivers that were not historically meandering, and in some cases irregularly sinuous channels have been reconstructed into symmetrical meanders. In many cases, these meanders have subsequently washed out (Kondolf et al. 2001; Smith and Prestegaard 2005) and, even if they remain stable, they are unlikely to provide the habitat that would naturally exist at the site.

3 Focusing Issues, Practical Value, and Contribution to Associated Planning Methods

This paper focuses on the planning method to create blue-green spatial patterns around urban core areas: following natural features of catchment basins and incorporating functionally with urban land-use in the vicinity, bringing together

[3]United States Environmental Protection Agency. Distance learning modules on watershed management [R/OL].

solutions for conserving and celebrating diverse productive outcomes of natural process while addressing especially water-associated issues induced by urban spatial expansion. This method could be instructive for efficiently conserving and managing natural blue-green spaces within central urban authority areas, which is required as one of the main tasks of "improving construction ability" enabling new urbanization.

Following relevant ecological principles, planned and existing blue-green spaces are expected to be integrated components in the workings of natural systems, rather than isolated elements subjectively manipulated by planners, as in typical planning methods. As a result, the planned blue-green web performs multiple functions with low maintenance requirements. Detailed measures will enrich the planning drafting tools in rational and operational ways.

4 Research Method and Proposed Results

Survey, literature research, and qualitative research methods are employed in combination with a practical case study. Firstly, land-use cover inclusive of both buildable and non-developable land are clearly delineated based on GIS data and the urban general plan. Secondly, land-use pattern, size and environmental consequences are correlated and corrected to some extent through data analyses of present air quality and surface water quality. Thirdly, likely eco-functions of natural features are demonstrated and determined after study of natural catchment processes and literature research. Finally, a suggested land-use layout of buildable land is incorporated into the whole system as organic components with the least possible impact to the environment. Likely storm-water issues and potential induced by urban expansion are quantified.

5 Planning Method on Structuring Blue-Green Space Networks

5.1 Analyses on Coherent Relationship Associated with Spatial Patterns of Blue-Green Space and Urban Environmental Quality

Via the survey, literature research, and qualitative analyses, the research found that environmental quality is intimately bound up with the land-use of the watershed and spatial patterns of blue-green space. As an actual proof, monitor data on air and water quality of several spatial points are as follows.

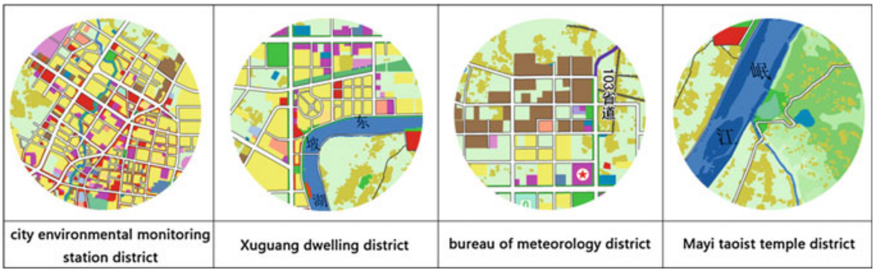


Fig. 1 Air quality detection point involved area present situation land use map

5.1.1 Analysis of Air Quality Monitoring Database

There are four monitoring points across the planning authority area (Fig. 1). Target monitoring aspects include air quality, SO_2, NO_2, and PM_{10}.

Related studies show that fuel combustion in industrial production will emit large quantities of dust, SO_2 and CO; and pollutant emissions from motor vehicles mainly contain nitrogen oxides, hydrocarbons, CO, lead dust, and the like. Based on the data of the monitoring points over the same period, the lateral and longitudinal comparative analysis of annual data obtained (Table 1) finds the following conclusions: (1) air quality has a significant seasonal variation; (2) air quality depends on the type and density of the surrounding road network and land use; (3) air quality and blue-green spatial structure is related; (4) regional climate formed by the terrain and buildings impacts air quality, to a certain extent.

5.1.2 Analysis of Water Quality Monitoring Database

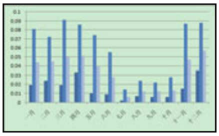
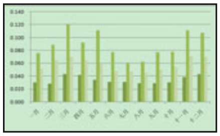
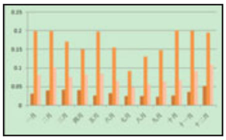
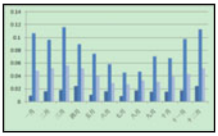
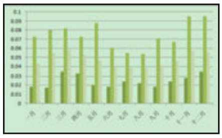
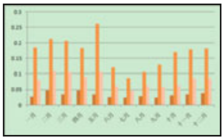
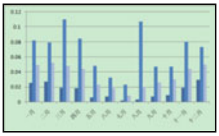
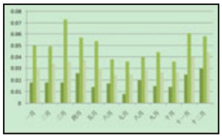
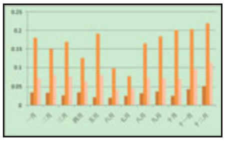
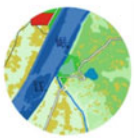
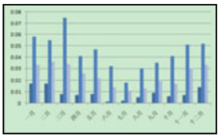
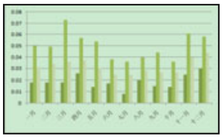
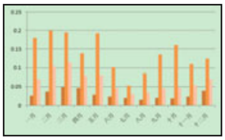
There are five monitoring points across the planning authority area monitoring the water quality and the main pollutants (Fig. 2).

The main pollutants in river water contain phosphorus, nitrogen, ammonia, etc. The authors compared the monitor data, finding the following conclusions: (1) woodland area and the water pollution index has a significant negative correlation; (2) large urban construction areas cause the increase of impermeable surface and point source pollution, resulting in increased runoff and pollutant concentration; (3) industrial land and the water quality pollution index has a significant positive correlation, while non-point source pollution of agricultural land is the main source of river nitrogen and phosphorus pollutants.

5.1.3 Identification of Natural Features

Identifying existing potential natural blue-green spaces and likely reclamation areas is a key step to building the blue-green spatial structure. we use GIS (Geographic

Table 1 The contrast table of air pollutants between different air quality detection points

			
city environmental monitoring station area	SO_2 concentration monthly change	NO_2 concentration monthly change	PM_{10} concentration monthly change
			
Xuguang dwelling district	SO_2 concentration monthly change	NO_2 concentration monthly change	PM_{10} concentration monthly change
			
Bureau of meteorology district	SO_2 concentration monthly change	NO_2 concentration monthly change	PM_{10} concentration monthly change
			
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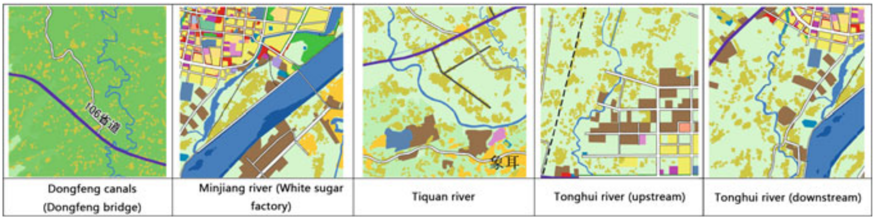


Fig. 2 Water quality testing point involved area present situation land use map

Information System) and digital aerial photo imagery to provide the city with picture of multiple layers of information about parcel size, land use, topography, and natural features. Existing natural landscapes within urbanized areas can be marked as reserved or abandoned, two types according to the existing status, laying the groundwork for further planning.

5.2 Natural Processes of Catchment Scale, Ecological Functions of Natural Factors, and Configuration of a Blue-Green Web

Catchment is delineated by ridge line as a natural conflux of a fixed area. Runoff water is captured through soil saturation or infiltration, or is transferred to a surface water system (Fig. 3). Natural elements within blue-green spaces play important roles in the process, such as: (1) detention and retention functions carried out by pool, wetland, and depression areas; (2) absorption and infiltration function executed by plant stems; (3) adjustment and packet functions possessed by soil and vegetation which could release additional water to surroundings in the way of natural flow (Fig. 4).

Natural blue-green space frameworks, water-rich in nature, spawn natural features deriving from the long-term interaction and evolution of natural factors, shaping the original blue-green framework into an urban setting morphology. The natural elements are gradually destroyed over time by increasing intrusion of urban development (Fig. 5). There is a realistic need to re-establish the natural blue-green framework in environmentally, socially, and economically viable ways.

Obliteration of well-endowed natural features for the purpose of maximizing real estate values induces damage to natural water system. Polluted particulates carried by runoff water are directly discharged into water bodies. Water quality decreases as a consequence. In order to avoid this, it is essential to bridge the gap of watercourses interrupted by land-use for construction purposes. Through GIS analyses, gaps could be identified. In this way, runoff water from development areas could be diverted and conveyed smoothly to wetlands outside of building units. In the process, the top priority of planners should be given to the control of strategic points within the blue-green system, which is important to maintain the integrity of watercourses.

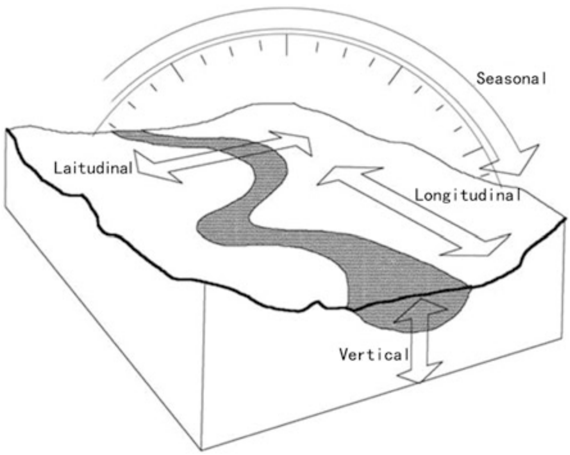


Fig. 3 Hydrological four dimensional characteristics. Source: Introduction to Watershed Ecology. http://www.epa.gov/watertrain

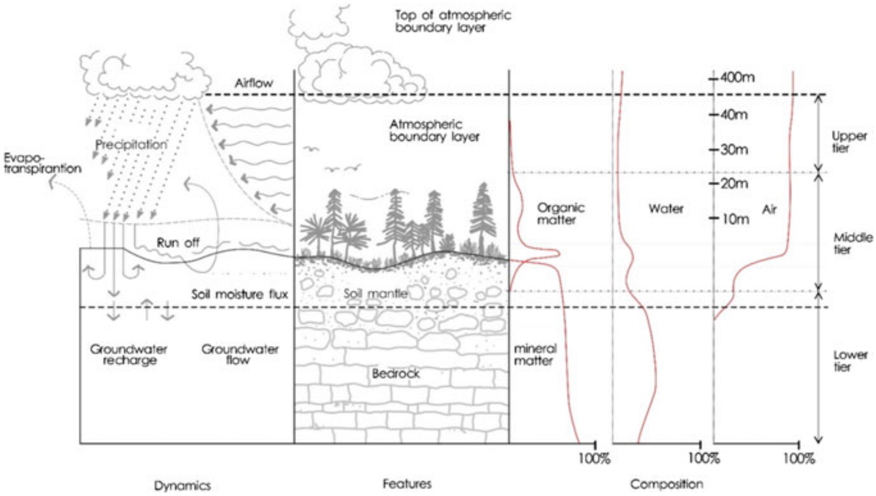


Fig. 4 The figure of hydrologic cycle characteristics. Source: Marsh 2010

5.3 Impacts to Blue-Green Spaces by Extension of Building Units and Ecological Restoration

5.3.1 Impacts Exerted on Blue-Green Spaces Due to Extension of the Built Environment

Secondary natural features on neighborhood scales usually appear with vague attributes, such as natural gutters and vegetated strips randomly distributed on the site. Viewing them separately, they may not deserve utilization. They serve as gateways to connect the neighborhood to larger scales of the blue-green space structure. The maintenance of relation to the whole system is critical, especially the maintenance of the watershed, and of convenient access to park patches.

Extension of urban land-use in the urbanization process inevitably imposes impacts on the integrity of blue-green space systems, especially on intermittent channels upland of the watershed. For example, the original impervious rate of a watershed unit is 12.55 % before development. The impervious rate of the same watershed unit is going to increase by 24.92 %, according to the planning forecast. Runoff water volume quantity is currently about 6,773,000 m^3; after development, the volume could reach around 12,245,000 m^3. Conversion of enormous agricultural arable land and woodland into impervious pavement results in the change of volume. Blue-green space could be of great help to the reduction of runoff water by way of absorption and diversion of additional runoff water outside of the urban core area. Ecological restoration is necessary for further and efficient function of blue-green space system (Fig. 6).

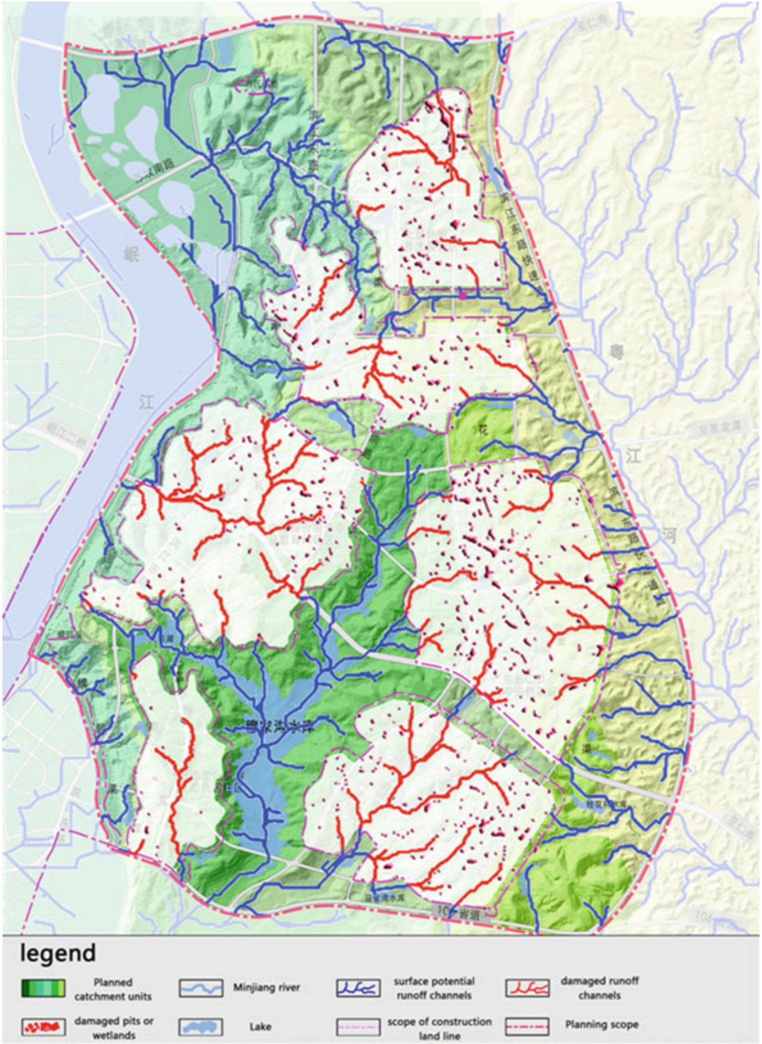


Fig. 5 The damaged surface runoff map

5.3.2 Configuration of a Blue-Green Corridor

Evaluation of the intrinsic and extrinsic value held by a natural landscape is fundamental work. Joe McBride set forth a comprehensive list of parameters used in evaluating vegetation in environmental planning processes. It is deserving of reprint as a reference for evaluating the value of natural landscapes. Nineteen vegetation parameters were grouped into five classes (McBrid 1977).

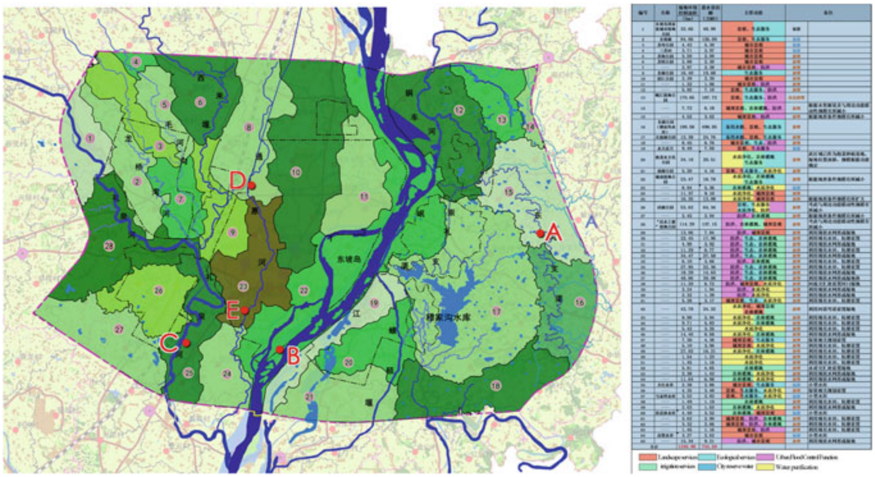
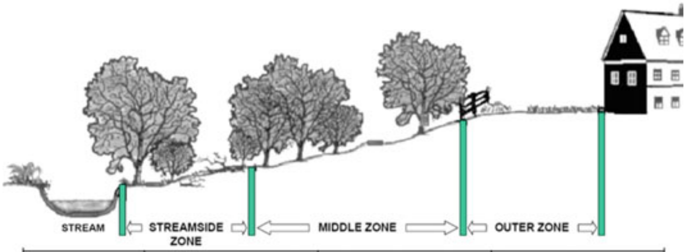


Fig. 6 Blue-green space diversity ecological function diagram

Class	Parameter
Amenity	Visual quality; Recreational potential; Noise abatement; Air pollution reduction; Climate amelioration; Historic value
Human safety	Fire potential; Withdraw and breakage potential
Ecological	Indicator of environmental condition; Erosion control; Wildlife habitat; Role in regional ecosystem; Succession potential; Fragility
Economic	Commodity resources; Tax revenues
Scientific	Rare and endangered species; Unique vegetation types; Gene composition

In 1991, the U.S. Department of Agriculture developed guidelines for restoring riparian forest buffers (Welsch 1991). These guidelines are based on a “three-zone approach” to restoring forest buffers, with each zone providing a specific function (Fig. 7). Zone 1 is nearest to the stream and is an area of undisturbed forest that stabilizes stream banks, provides shade, moderates stream temperatures, and provides large woody debris to the stream. Zone 2 is an area of managed forest adjacent to Zone 1. The purpose of Zone 2 is to improve water quality through vegetative uptake (of nutrients and toxins) and bio-geochemical processes in the soil. Native deciduous trees are recommended for planting in Zones 1 and 2 to maximize habitat value for fish and wildlife and water quality benefits. As the trees in Zone 2 mature, selective timber harvesting and timber stand improvements are necessary to promote vigorous growth of the remaining trees. Zone 3 is an area of dense grass that lies between the forest buffer and adjoining land uses. The purpose of Zone 3 is to slow and spread concentrated flows of water coming from the land, which will promote the release of suspended sediments and the infiltration of



	Streamside Zone	Middle Zone	Outer Zone
Width	Minimum 25 feet plus wetlands and critical habitat	Variable, depending on stream order, slope, and 100-year floodplain (min. 25 ft.)	25-foot minimum setback from structures
Vegetative Target	Undisturbed mature forest. Reforest if necessary.	Managed forest, some clearing allowed.	Forest encouraged, but usually turfgrass.
Allowable Uses	Very restricted (e.g., flood control, utility easements, footpaths)	Restricted (e.g., some recreational uses, some stormwater controls, bike paths)	Unrestricted (e.g., residential uses, including lawn, garden, most stormwater controls)

Fig. 7 River buffer zoning map. Source: Schueler 1995

surface runoff into the ground. Native warm-season grasses are recommended for planting in Zone 3 because of their tall, stiff stems and their deep root systems (Rietveld 1995).

5.3.3 Protection of Natural Features Nestled with Blue-Green Networks and Ecological Restoration of Riparian Areas

How to deal with natural landscapes in an urban context? The trick is not to replace nature with inert matter, but to learn to live with nature (McHarg 1969; Owens et al. 2002), creating places that are in harmony with the natural setting, that build on natural characteristics of the place (Van der Ryn and Calthorpe 1984; McHarg 1969; Spirn 1984).

In general, the natural green framework of the downtown area is structured based on natural creek corridors, supplemented by planned greens (Fig. 8). Creek corridors bridge outside a naturalistic ring belt composed of ecologically sensitive areas with public green spaces in the urban middle area, which function as flow channels, ducting cool fresh air inside to ventilate the intensive core. A hierarchy of a natural blue-green framework can be established by hooking subcategorized blue-green spaces onto the main framework, involving depression area, wetland, pools, and urban parks.

Mei Shan is located in the semi-tropical wetness-season-wind climate zone. Average precipitation volume is 1062.5 mm. The elevation of Min Dong district is about 400–500 m. Eight sub-catchments are subcategorized according to the plan. According to the research result that water volume of woodland per unit is

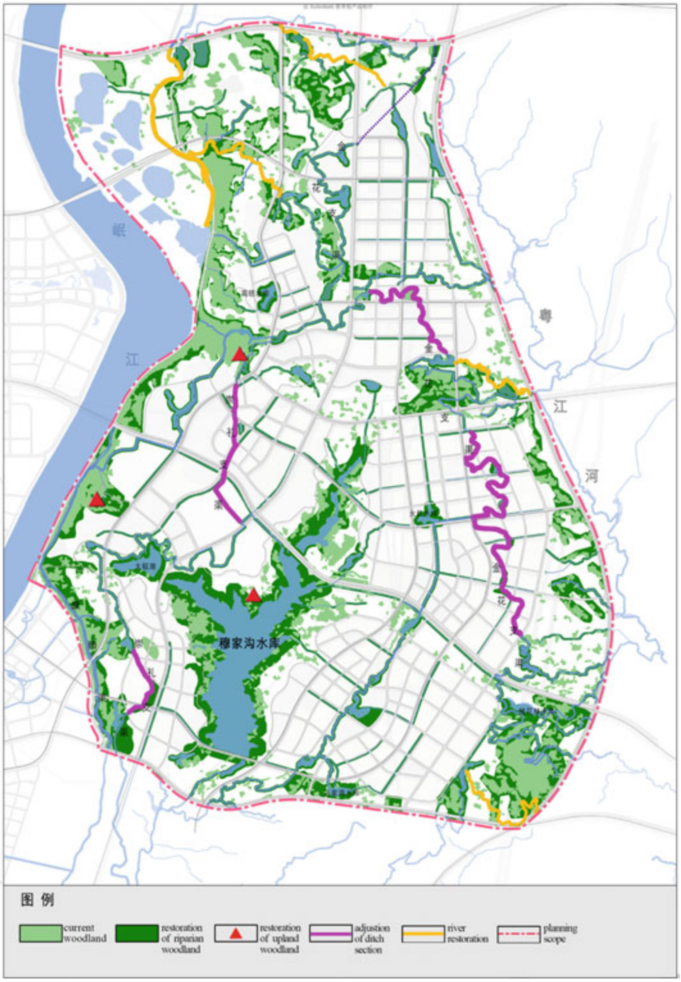


Fig. 8 The vegetation supply diagram along the river

852.45 m^3/hm^2 (Li et al. 2012), the size of 929.52 ha (Table 2) calculating woodland is required for the purpose of absorbing all of the runoff water produced.

Reclamation of a watercourse is an effective way to restore natural blue-green space, and includes restoration of buried creeks, daylighting of covered creeks, rehabilitation of flood-prone areas and depression land for absorbing excess runoff water, and so on (Fig. 9). The essence of restoring a natural drainage way is to retrofit the natural circulation process, especially promoting the healthy metabolism of FengShui.

Table 2 Forest supply schedule

Catchment Number	Catchment Area (ha)	Catchment Runoff (10,000 m^3)	Forest area required (ha)	Status of forest area (ha)	Recharge forest area (ha)
1. Minjiang River catchment	1698.21	311.92	365.91	203.63	162.28
2. Chongli ditch catchment	763.93	140.32	164.61	14.64	149.97
3. Northern region catchment	486.60	89.38	104.85	13.25	91.60
4. Mu Ravine catchment	1438.81	264.28	310.02	109.7	200.32
5. East region catchment	866.65	159.18	186.73	15.7	171.03
6. Jinhua ditch catchment	900.18	165.34	193.96	69.06	124.90
7. Yuejiang river catchment	751.19	94.08	110.36	80.95	29.41
Total	6905.57	1224.5	1436.45	506.93	929.52

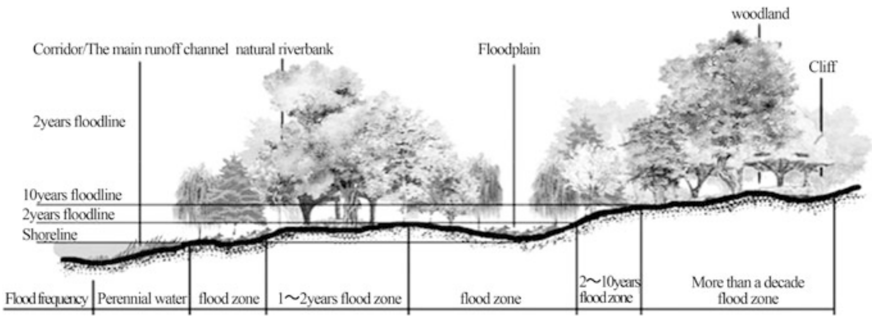


Fig. 9 The figure of river corridor restoration

5.4 *Land-Use Behavior and Functional Integration Between Building Units and Blue-Green Spaces*

5.4.1 Reshaping Catchment Units in Response to the Watershed Nature

Contiguous blue-green space based on catchment helps optimize system function as a whole (Fig. 10). Small patches formed by natural vegetated areas, fragmented urban forests, and street-side pocket parks can be pieced together by natural blue-green corridors and complementary green strips, fitting in with the urban fabric

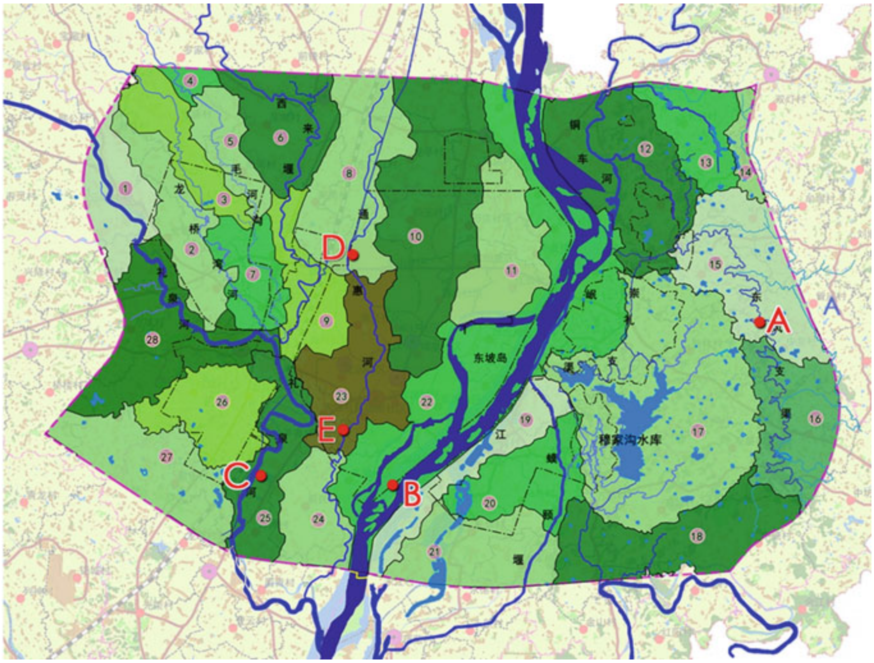


Fig. 10 The original basin units classification figure

at all scales of urban life. Selected valuable natural elements outside the existing town area identified during analyses should be included in the system for future use. Low impact development would occur if building units could follow the catchment hydrological process (Fig. 11). In combination with urban storm water pipe discharge, runoff water together is transferred into wetland or depression area outside of the urban core area alongside blue-green corridors.

5.4.2 Embedding of Ecological Infrastructure into the Blue-Green Space System

The survival of the natural green framework depends in part on the ability to deal with physical-form-related problems at scales larger than individual projects. Obviously, no matter the capacity or ability of handling runoff water, the natural drainage systems running within the natural blue-green framework throughout the urban area is far greater than that of segmented green streets with man-made swales, which provide neighborhoods with opportunities for reorganizing runoff water at an urban-wide level, simultaneously responding to water transport, recharge, storage, and recreation. The system can be strengthened in combination with green infrastructure, including flood-prone areas, natural depression lands, rain gardens, green roofs, street swales, and detention or retention facilities (Fig. 12). Runoff water

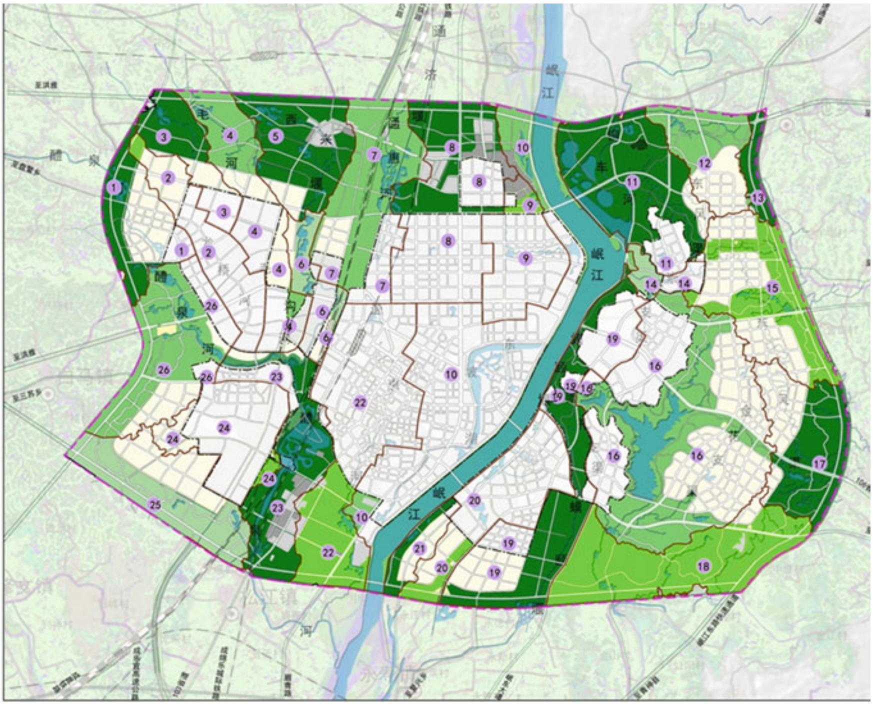


Fig. 11 Reconstructed catchment units classification figure

from storms or sprinklers will "take care of itself" by percolating right-of-way within drainage passage or slowly flowing downhill into water transport systems and are therefore needless of an auxiliary instrument.

5.4.3 Forging the Spatial Characteristics of Blue-Green Space

Due to common locations similar to ecotone in ecology, as well as systematic attributes and aesthetic quality, a natural blue-green network is of a composite function in nature, possessing potential for maintaining heterogeneity of the urban landscape, enhancing the urban physical appearance, and preventing adjoining built spaces from sprawling coalescence (Fig. 13). These attributes make a natural blue-green network not only able to ecologically deal with specific spatial problems, but also to positively address smart growth and some high-level concepts, which should lead the planning process: harmony, efficiency, health, and so forth—as set by the new urbanization policy. Enhancement of a natural green framework facilitates natural circulation process, and especially promotes healthy metabolism of wind and water, as Chinese called FengShui. Smooth running of blue-green spaces helps flush filth out produced by the built environment, bring fresh air and water in, leading to a vital and robust community.

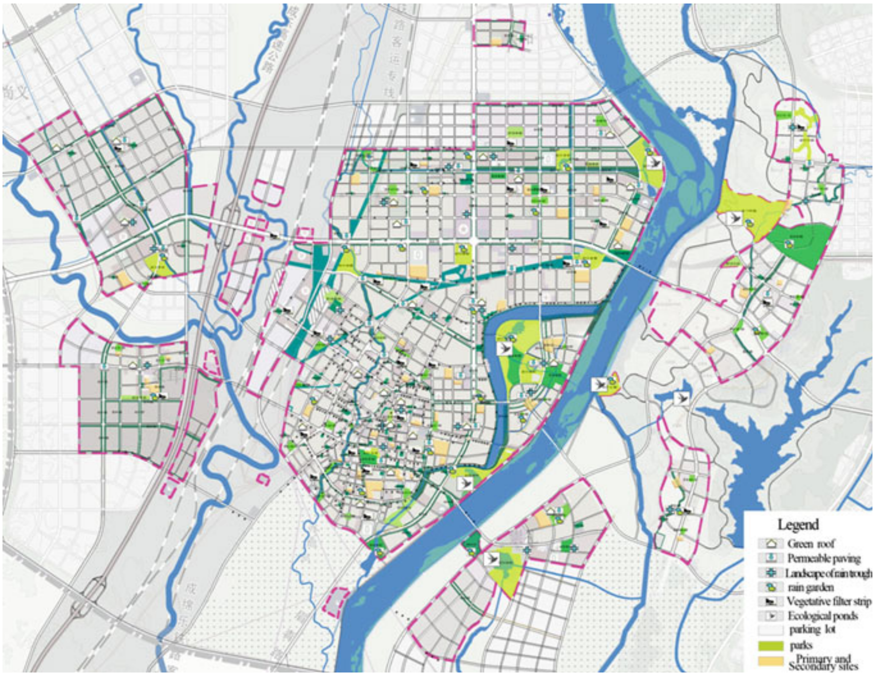


Fig. 12 Low-impact facilities layout mode image

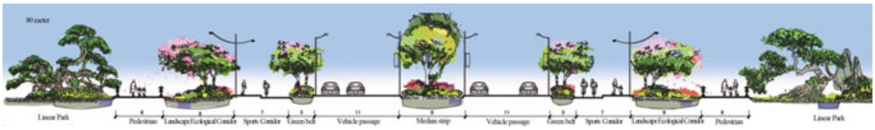


Fig. 13 The profile of green street

6 Concluding Remarks

1. Local environment quality on the catchment level is intimately bound up with both urban land-use property and qualified blue-green space spatial patterns.
2. Following natural features means integrating components of the workings of the natural system, rather than isolating elements subjectively manipulated by planners in typical planning method. As a result, the planned blue-green web is of a composite function with low maintenance needs.
3. Planning methods creating blue-green spatial patterns around urban core areas places primacy on: (a) following natural features of catchment areas, (b) incorporating functionally with urban land-use in the vicinity, and (c) bringing

together smart solutions to celebrate diverse productive outcomes of natural features while addressing especially water-associated issues induced by urban expansion.
4. The method is instructive for efficiently conserving and managing natural blue-green spaces within central urban authority areas, as required as one of the main tasks enabling New Urbanization.
5. Demonstration of catchment-basin natural process, contributions of natural factors, and enrichment of planning tools deserve further research for better application of the method.

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A Comparative Study of the Evolution of Greenbelts in London and Beijing

Mingfei Ma

1 Introduction

Urban expansion has been witnessed in many developed countries (e.g. US, Canada, UK, and France) as low density construction sprawling into suburbs, and also in many developing countries (e.g. China, India, and Mexico) as an outward expansion from the urban core to the edge in a concentric ring structure. An urban greenbelt is considered a key instrument for stopping excessive urban expansion. Established in the 1930s, London's greenbelt has been considered one of the most successful urban containment practices across the world. Beijing is in many ways a typical example of cities in emerging economies which attempt to establish a greenbelt to engender more compact growth, though the process has tended to falter; Beijing's first greenbelt disappeared during the urban expansion and the second one is now under similar threat.

The greenbelts policies tend to falter not because their environmental value has not been widely accepted, but because it is not economically possible. A greenbelt will have economic impacts on the whole urban area and its performance cannot solely be assessed by only looking at the greenbelt land itself. Although a greenbelt can be implemented through strong government enforcement and efficient urban management, without an integrated greenbelt land use-transportation design, it is difficult to put a greenbelt plan into practice. Therefore, in this paper we focus on the interactions between greenbelts and urban land use-transportation policies in a picture of the entire urban area. This will help to understand Beijing's failure from a dynamic urban expansion view.

We first explore the theories of urban expansion from an economic perspective to reveal the driving forces. Secondly we discuss the ongoing debate over greenbelt policies, which are put forward to alleviate problems caused by urban expansion.

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Q. Pan and W. Li (eds.), *Smart Growth and Sustainable Development*,
GeoJournal Library 122, DOI 10.1007/978-3-319-48296-5_15

Then we juxtapose the urban expansion histories of London (from 1890 to 1940, for the development process leading up to the establishment of the greenbelt) and Beijing (from 1950 to 2000) by investigating the determinants underlying the persistent urban expansion. We next compare the nature of greenbelt policies. Such comparisons reveal not only the differences in spatial land use patterns, but also the temporal dynamics of urban growth. Finally, we analyse the reasons behind different policy performances from the perspective of land use-transportation interactions in order to answer the question of why greenbelts have led to different outcomes in the two cities.

2 Theoretical Background of Urban Expansion and Greenbelt Policy

2.1 Determinants and Problems of Urban Expansion

There is an extensive literature explaining the evolution of metropolitan spatial structure in economic terms (Anas et al. 1998). The Alonso-Mills-Muth monocentric model (AMM model) revealed fundamental driving forces in urban expansion: population growth, income rise, decline in transportation costs and low agricultural land rent. In the monocentric model, jobs concentrate in the central business area and residents commute to the centre to work (Mieszkowski and Mills 1993). Land rent falls with distance from the centre. Locational choice essentially represents a trade-off between land and travel (Wheaton 1974, 1982). The spatial size of the city, which is represented by the distance to the city centre, grows as population or income increases, and as commuting costs or agricultural rents fall (Brueckner 2001).

Although the standard model sees urban expansion as a natural process and economically efficient, Brueckner (2001) notes three types of market failure which lead to the excessive spatial growth of cities: (1) a failure to take into account the social value of open space; (2) a failure to account for the social costs of congestion; (3) a failure to take into account the public infrastructure costs. These market failures explain the economic loss of urban expansion, associated with social and environmental problems, which have been witnessed in empirical studies in the forms of too much travel, pollution, and congestion and vanishing urban open spaces (Anas and Pines 2008).

In order to alleviate the market failures and promote sustainable development, governments have put forward various policies to deal with problems caused by urban expansion. Land use controls and the provision of transportation infrastructure play a major role (Anas et al. 1998). These include urban containment policies (greenbelts), fiscal rearrangements, infill and brownfield redevelopment, congestion tolls, and others.

2.2 *The Nature of and Debates Regarding Greenbelts*

As one of the urban containment policies favoured by policymakers, the greenbelt is considered a typology for controlling fringe growth in a sustainable way. The idea is for maintaining a ring of open green land as agriculture, forestry and open space for leisure, where urban expansion can be resisted. New development then should take place in the existing urban area or beyond the greenbelt.

Greenbelt policies are common in the UK's Town and Country Planning System. For example London had a greenbelt since the late 1930s, while other European cities including Paris, Frankfurt and Vienna have followed the same practice. It has also been implemented in the Asian-Pacific region, for example in Melbourne, Sydney, Hong Kong, Tokyo and Seoul. Portland, in the US, with its strict urban boundary, is also well-known. Cities in emerging economies also implement a greenbelt policy to form a compact urban pattern—examples include Sao Paulo, Bangalore and Beijing.

As the first country carrying out a greenbelt scheme, Britain claimed the fundamental purposes of a greenbelt were to check the unrestricted sprawl of the built-up areas and to safeguard the surrounding countryside against further encroachment (Ministry of Housing and Local Government 1955). The fundamental aim of a greenbelt policy is to prevent urban sprawl by keeping land permanently open (Department for Communicities and Local Government 1995).

However, the greenbelt debate never stops. One strand of debate is over its effectiveness as a planning mechanism; the other is over its role in environmental management (Natural England and Campaign to Protect Rural England 2010). From the planning perspective, people argue over whether greenbelts support compact development or prevent sufficient land supply; from the environmental perspective, people argue whether greenbelts prevent environmental degradation or discourage positive land use in the urban fringe. The fundamental questions are: (1) What exactly are the greenbelts for?; (2) What aims are they intended to achieve?; and (3) How successful are they in achieving them (Hall 1974)? These questions will be answered through critical views from the dynamic perspective of urban expansion: (1) Is a greenbelt a negative urban expansion stopper or a positive urban development director?; (2) Is a greenbelt a static land control tool or a dynamic planning policy?; and (3) Is a greenbelt a strict circle around the city or a mixed open space configuration in an urban system? These answers will inform an effective greenbelt design which provides a better economic foundation for further implementation.

2.2.1 Negative Development Control Versus Positive Guidance

Greenbelts originated from a British land use planning concept and had a presumption against development. It was a land use mechanism declared for the purposes of landscape and countryside conservation. However, as Hall (1974) commented in the early days, after 40 years of reiterations by successive governments of different political complexions, the greenbelts are, in effect, a sacred feature of the British planning system—their protection today seems to be less a matter of planning policy than of planning politics. Is it a purely negative policy towards their management correct, or should we now be thinking of a more positive policy for development purposes?

There are two contradictory ideas about the policy purposes. One concept stresses environmental protection and urban containment. Presumably, urban expansion is unwelcome; the town is an evil, the expansion of which should be stopped (Warren-Evans 1974). The other stresses the positive use of the greenbelt land, for example for mental hospitals, sports centres or golf courts, and its role on guiding further development.

It is valuable to combine the two ideas to define policy aims. As urban expansion is fundamentally propelled by population increase, greenbelts should not only define where development should not occur, but "whether within the green belt or not, to what use shall it be put (Warren-Evans 1974)" in the land. In this way, the greenbelt can positively handle urban expansion.

Inside the greenbelt, positive uses—including providing opportunities for access to the open countryside, for outdoor sport and recreation, and for attractive landscape—are compatible. The greenbelt land would not be considered wasted, but productive. Additionally, the positive function is a way of ensuring implementation (Amati and Yokohari 2006). For example, in Hong Kong, recreation was the initial planning emphasis for the greenbelt. The development potential within the greenbelt has not been completely eliminated. Uses for 'small house', and 'open storage' were favoured by the rural population to get benefits from land within the greenbelt (Tang et al. 2007).

Beyond the greenbelt, land use policy should define where new development should go. Development pressure cannot be eliminated because of a ring surrounding the city. Without redistributing development beyond the ring, greenbelt would be encroached anyway, no matter where planners drew the boundary. Therefore, 'new towns' are widely accepted as a supplement to the greenbelt policy. They absorb the overspill from the core city and incorporate with the greenbelt as a spatial development director. Adequate transportation support to new towns is crucial for successful implementation. In this way, the greenbelt can be preserved and play its role as an urban expansion stopper.

2.2.2 Static Land Use Control Versus Adaptive Planning Policy

As a large scale urban land use policy, a greenbelt is likely to have an enduring effect in the future. A static and strict greenbelt policy reflects a government's credibility and is easy to implement by an administrative power. For example, London's greenbelt has retained its shape since the policy was first launched in the 1930s.

However, critics have pointed out that greenbelts, as a static land use control tool, might be too rigid and have disadvantages in adapting to further urban development. As early as the 1970s, British planner and developer Warren-Evans (1974) criticised that the greenbelt policy represents a view of the world which has no future and ought to have had no past. He viewed the greenbelt as an antiquated planning idea from the 1930s that focused too much on the physical state of the land. Rydin and Myerson (1989) cast doubt on how greenbelts can cope with urban change and concluded that a blanket restriction on urban growth is not an adequate response to this problem.

Development pressures and demographic structures vary over time. If a rigid greenbelt fails to work with such changes, it might needlessly limit the land supply. When housing demand increases as population grows or family size shrinks, land scarcity leads to inappropriate escalation in housing costs and unwarranted increases in density (Brueckner 2001). For example, without a greenbelt, Seoul's average rent would have declined up to 13.7 %, thereby indicating that Seoul's greenbelt made a contribution to rising rents by limiting land supply (Jun 2011).

Moreover, a rigid greenbelt may lead to the dislocation of jobs and population as they are not guided by dynamic market rule to the economically productive areas, but by a static physical ring to new towns. For example, as London reached its greenbelt boundary in the 1940s, further development was redirected to either new towns or back to inner London. However out of eight new towns actually built, only two were in their proposed sites (Stevenage and Harlow) (Porter 1998, p. 350).

Therefore, though policy implementation should be strict, the greenbelt should be an elastic term, having quite diverse meanings across time and space in response to perceived needs and challenges (Freestone 2002, p. 97). As a spatial guide, a greenbelt should incorporate future transportation network changes as well. Hong Kong's experience proved that a greenbelt is a transitional zone for potential future development, rather than a zone for conservation (Tang et al. 2007). Many planners regard Melbourne's green wedges and greenbelt as 'holding zones' for urban development, to be released when needed (Buxton and Goodman 2003). In the US, the urban growth boundary in Portland allows sufficient land provided within the boundary to accommodate growth needs for 20 years (Buxton and Goodman 2003).

2.2.3 Rings Versus Other Configurations

Fifty years after its initial establishment, a research indicated that half of the visitors to London's greenbelt recreation sites live locally within the greenbelt and nearly 75 % live within 6 miles, with only 5 % coming from the inner cities (Rydin and Myerson 1989, p. 473). Even now, people tend to use parks near their homes for recreational purposes, rather than drive to the greenbelt. It is noteworthy that the strict belt configuration at the urban fringe does not offer the best amenity value and the most use of green spaces.

First of all, the location of a greenbelt should be examined. Studies have revealed that the ecological and amenity value of wasteland inside the city can often be higher than the farmland and golf courses preserved by the greenbelt (Amati and Yokohari 2006). Meanwhile, access to a greenbelt is not available equally. Surveys at greenbelt recreation attractions suggest that 95 % of visitors travel by car, and high proportions are in the managerial and supervisory socioeconomic groups. This problem is most notable around London where travel times and distances to the greenbelt are greatest, and costs are highest (Elson 1986, p. 202). Although green space in the city involves high opportunity costs as it requires land in areas where it is most valuable, it can benefit more residents.

Secondly, a discussion of the size of green spaces should follow. The green space size has been proven to have positive effects in increasing urban parks' marginal value; the value of the ecosystem services that parks provide is likely to be disproportionately high. But for green spaces at the urban fringe, size plays a less important role (Perino et al. 2014). A wider greenbelt occupying a larger area does not necessarily provide better amenity value. Meanwhile, the belt shape itself is hard to justify in amenity value (Amati and Yokohari 2006).

Combining the discussions of location and size of green spaces, new configurations are proposed to offer better accessibility and recreational and ecological value. Moreover, such configurations may deal with urban expansion better due to

Fig. 1 Copenhagen finger plan. *Source* Knowles (2012)

their flexibility, as they are subject to review each time a development plan is revised (Natural England and Campaign to Protect Rural England 2010, p. 19). For example, a ring can be broken into wedges to allow new constructions to happen in between to alleviate urban expansion pressure and provide better accessibility.

Green Wedges are distinctive features in Copenhagen's Finger Plan. There were five fingers, or corridors, of urban development along suburban railway lines from the centre. Each planned suburb would be linked to the next one and onward to Copenhagen's CBD (Knowles 2012). Green Wedges are kept for farmland and recreational land between each built-up finger and also stretched into the urban core to maximise its accessibility (Fig. 1).

The joint Green Heart-City Ring concept has been central to Dutch planning doctrine for years (Van Eeten and Roe 2000; Kühn 2003). The four major Dutch cities: Amsterdam, Rotterdam, The Hague and Utrecht are separated by a large green area in between, known as the "Green Heart". Instead of a greenbelt encircling cities, the four cities encircle the Green Heart, and are collectively called the Randstad City Ring. Further development can only happen along the Ring, not in the Green Heart (Fig. 2).

To sum up, the ongoing debate over greenbelts leads to a preliminary assumption that a successfully implemented greenbelt should act as a guide for urban development with land use and transportation integrated policies. As a large-scale urban land use policy, a greenbelt designation should avoid myopic development incentives, be concerned with longer term effects, and adapt to

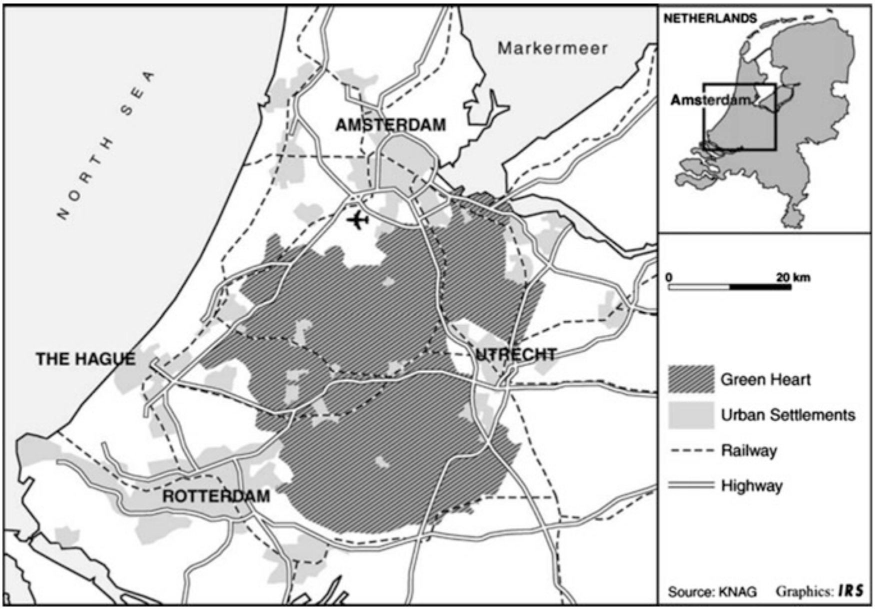


Fig. 2 The Netherland green heart plan. *Source* Kühn (2003)

development pressures and demographic changes. Besides a ring shape, other configuration including green wedges and green hearts have been proposed to work with transportation networks. By following such rules, London's greenbelt has stood for more than 70 years; because of ignorance, Beijing's greenbelts are under threat.

3 London's Greenbelts: Ideas and Reality 1890–2015

As the capital of one of the largest empires in history in the 19th and early 20th centuries, London is the first city that proposed and implemented a greenbelt, and also is one of the most successful cities that has a well-established greenbelt today. It provides the first and archetypal case to handle the overgrowth of a metropolitan area (Hall 1984, p. 433).

3.1 Expansion of London: 1890s–1940s

3.1.1 Urban Expansion with Population Increase

Before 1890, Victorian London's growth was essentially within inner London at a relatively high density. From the late Victorian time, development began to spread rapidly into outer London. From 1890 to 1940, London saw an aggressive population growth of 54 %, most of which was in the modern-day outer London boroughs. Inner London first experienced an increase from 1891 through the year 1911, when it arrived at its peak; from 1911 until 1941, population declined. But during the same period, outer London's population went up and the net increase of outer London was by 229 % (Fig. 3 and Table 1).

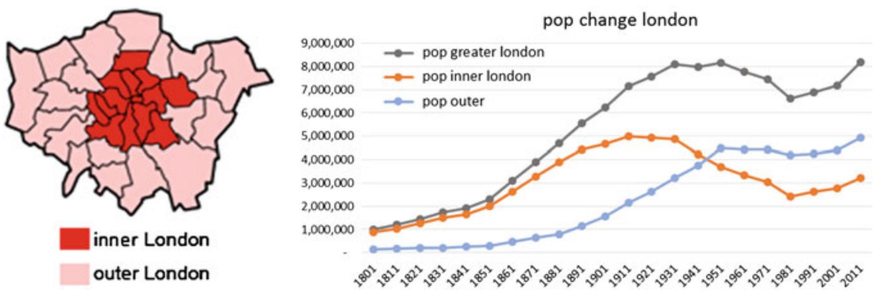


Fig. 3 *Left* Definition of outer London and inner London. *Right* Population change 1801–2011 (*Source* Census of Population GB Historical GIS/University of Portsmouth, Inner London through time |Population Statistics| Total Population, A Vision of Britain through Time. URL: http://www.visionofbritain.org.uk/unit/10076845/cube/TOT_POP. Date accessed: 7th January 2015)

Table 1 Population change 1801–2011

Year	1891	1941	Change	Overall change rate (%)
Inner London	4,422,340	4,224,135	−198,205	−4
Outer London	1,143,516	3,763,801	2,620,285	229
Greater London	5,565,856	7,987,936	2,422,080	44

Source Census of population

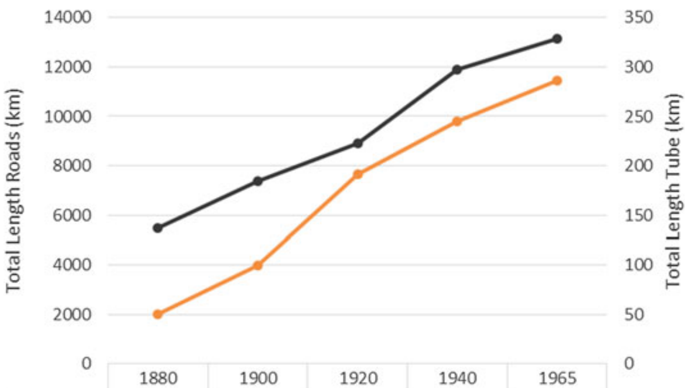
As central London became a horror of slums, barely fit for human habitation, people began to move outwards (Hall 2002, p. 14). First, suburban life became attractive to the middle classes. The new suburbs developed before the First World War were predominantly residential in character, containing few industrial establishments, as befitted their status as dwelling places for London's more senior clerks and executives (Garside 1984, p. 238). Secondly, a little lower down social groups, for example middle managers, supervisors, and better-paid clerks, also move to the fringe. Suburban houses offered more attractive and more sanitary alternatives to inner area properties, together with the opportunity, always eagerly grasped by this group, of improving their social status (Jackson 1973, p. 22). Thirdly, the working class also moved to the fringe area for cheaper housing, as commercial and administrative expansion in the central districts of London forced out residents as rents rose.

The population relocated to the suburbs with the outwards movement of industries and job opportunities. Development of new industries—for instance aircraft, electrical, motor vehicles and films—required larger plots to expand and lower rent. New industries located in outer suburbs and those with a growth potential tended to agglomerate. They expanded swiftly to meet the market demand.

3.1.2 Transport Cost Decrease by Technology Improvement

London's expansion has always been led by transportation development. Electrification throughout the London railway system quickened travel to the distant suburbs, which reduced the generalised cost of travel. Better transportation resulted in a mushrooming of rehousing in the outer suburbs along tram lines and undergrounds. From 1900 to 1940, the total length of the underground increased by 146 % (Stanilov and Jin 2013). Between 1902 and 1928 there was a 352 % rise in the number of passengers carried by public transit (Porter 1998, p. 327).

Road construction also triggered the population to settle in London's suburbs and gave superb transportation routes for industries. The flexibility of motor transport lessened the importance of a central location, and made possible the building of factories and warehouses along the arterial roads with no specific focal point (Garside 1984, p. 246). From 1900 to 1940, total road length increased by 62 % in the Greater London (Stanilov and Jin 2013) (Fig. 4).



	1880	1900	1920	1940	1965
roads	5465	7360	8902	11894	13148
tube	50	100	191	245	286

Fig. 4 Total length of underground and road (Stanilov and Jin 2013)

3.2 *Problems of Urban Expansion*

With such rapid expansion through 1939, the start of the Second World War, traffic became stalled and urban expansion became offensive (Porter 1998, p. 355). Overcrowding in central London was not relieved by outward movement of the population, because commercial, administration, professional services, specialized shops, and colleges still concentrated in the central area. Inner London experienced a decay as the result of urban expansion. Working-class jobs were taken by new unskilled immigrants. Meanwhile, suburbs spread outwards and occupied a massive land; from 1918 to 1939, within twenty years, the suburbs spread over a vast belt between six and fifteen miles from central London, multiplying the area of London about four times (Hall 1963, p. 28).

Commuting also became a problem although the transportation system developed at a fast speed. The ever-increasing burden of traffic along the main radial roads caused severe congestion. The action of simply widening the road failed to deliver solutions to the problems.

3.3 *Greenbelt Policies to Deal with Urban Expansion*

As problems intensified, Londoners began to realise that actions should be taken to deal with London's mess and muddle caused by this unseemly urban expansion. As Barlow said, employment in London would continue to grow unless the government restricted it. And the government should restrict it, because of the supposed disadvantages—social, economic, and strategic—which this growth brought in train (Hall 1963, p. 46).

Inspired by the Garden City idea (Howard 1902), Unwin, as the technical advisor of the Greater London Regional Planning Committee, argued that there was an urgent need to provide recreational fields within the Greater London Region by acquiring a green girdle (Greater London Regional Planning Committee 1933). The first official scheme in 1935 stemmed from this girdle theory. By 1939, 110 km^2 had been either purchased, covenanted, or was in the process of being acquired under that scheme (Munton 1983, p. 18).

In the Greater London Plan of 1944, the greenbelt acted as a barrier to the continuous expansion of London. In the greenbelt ring, there were numerous established centres and they will have strictly limited possibilities of extension. A series of new towns in the outer country ring were for the surplus population (Abercrombie 1945, p. 26). As shown in the maps, between 1954 and 1958, the relevant county development plans were approved by the Ministry of Housing and Local Government creating a real greenbelt similar in size to that proposed by Abercrombie (Thomas 1970, p. 86). This greenbelt successfully remains today.

Since the policy was first launched as a greenbelt, it had a very clear and preliminary policy aim to check the unrestricted sprawl of the built-up areas and to shape decentralised urban form. New towns were essential parts in the greenbelt plan to accommodate growth. As Unwin commented: London's development might be planned so that units spring up detached from the main mass of the town, each with a self-contained economic and social life and with the permanent reservation of belts of open space to prevent the units coalescing with one another or with the central mass (Garside 1984, p. 252).

After the World War II, the greenbelt has remained remarkably stringently enforced to coordinate with London's evolution; London's suburbs suddenly stop, frozen at the point they had reached in 1939. However, this caused unpredicted policy outcomes against objectives in the greenbelt policy implementation. The criticisms include that greenbelts increase car travel, divert development deeper into the countryside, increase development pressures within existing centres, and are a negative and inflexible means of development control (Freestone 2002).

Such a stringent greenbelt can be implemented not only because of the strong governance power, but also because it was rigorously designed according to the integrated land use-transportation development. A full set of policies—greenbelt, new towns and rail transit—were carried out to decentralise population and employment. The aims were not solely to stop central London's expansion, but to tell where new development should go. A reasonable greenbelt design coordinating land use policies (e.g. new towns) and transportation development (e.g. railways and undergrounds) gave rise to smooth policy implementation and adaptability to new development.

4 Beijing's Greenbelts in Transition: 1994–2015

Initially, Beijing's spatial planning was affected by the multi-nuclei garden city idea and the new town programmes in Britain (Yang et al. 2011). However, a strong monocentric pattern was established. Two greenbelts and new town programmes were unable to effectively divert the population. It is valuable to know why similar planning concepts lead to different historic outcomes.

4.1 Expansion of Beijing: 1950–2010

In the past 60 years, the population of Beijing has increased at an annual average growth rate of 2.3 % (1949–2008). After the Olympic Games in 2008, over the past 5 years, with rapid economic growth, the city accelerated its development and the annual population growth rate in Beijing has reached 3.8 % (from 2009 to 2013) and overall population has reached 21.1 million in 2013 (Beijing Bureau of Statistics 2014).

This development speed is relatively high compared with other mega-cities. Taking European cities as an example, from 1890 to 1940, the 50 years of the most rapid development, the annual growth rate of Greater London reached 0.87 % while its competitor Paris reached 0.94 %. Beijing, from 1950 to 2000, reached an even higher growth rate of 2.29 % over the same time span of 50 years. The total population of Greater London increased by 54 %, and Paris by 60 %, compared to that of Beijing, which increased by 210 % (Table 2).

As shown in Fig. 5, the registered population in the four inner city districts[1] remained steady with a slight decrease. This is due to the outward movement of local residents and old city demolition and relocation projects. Outer city districts became the most popular location for residents. The near suburb counties in the outskirts also increased in population size gradually with the satellite town movement of Beijing. Most townships served as residential locations where the bulk of housing was built, while there were also some townships such as Daxing and Shunyi that developed industries such as an airport logistic park and car manufacturing. The far suburban counties grew slowly and mainly served as ecological preservation zones.

With the suburbanisation trend of the population, the built-up area has been expanding rapidly from 100.2 km^2 in 1950 to 1210.2 km^2 in 2005 (Ai et al. 2008), following a concentric pattern of expansion (Figs. 6 and 7).

[1]Here the categories of districts and counties were: inner city districts were Dongcheng, Xicheng, Chongwen, Xuanwu; outer city districts were Fengtai, Chaoyang, Haidian, Shijingshan; near-suburb counties were Fangshan, Tongzhou, Changping, Shunyi, Daxing; far-suburb counties were Mentougou, Pinggu, Huairou, Miyun, and Yanqing.

Table 2 Population growth of Greater London, Paris, Greater Berlin 1890–1940 (Porter 1998, p. 306) Beijing 1950–2000

	1890	1940	Annual growth (%)	Change rate (%)
Greater London	5,638,000	8,700,000	0.87	54
Paris	4,128,000	6,598,000	0.94	60
	1950	2000	Annual growth (%)	Change rate (%)
Beijing	4,393,000	13,636,000	2.29	210

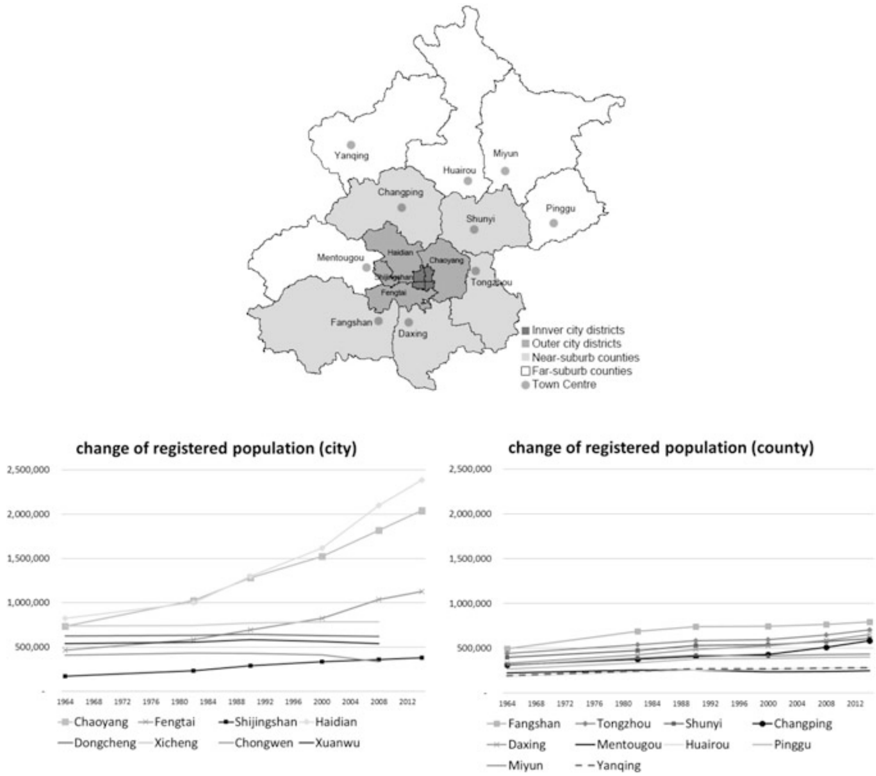


Fig. 5 Population change in urban districts (*left*) and surrounding counties (*right*) *Source* Beijing Bureau of Statistics and NBS Survey office in Beijing (2009)

4.2 Problems of Excessive Urban Expansion

As the central area has spread, some suburban towns have been amalgamated into the urbanised area. Individual suburban villages have also been growing very fast and many of them have merged into each other. There were once green spaces between the settlements which could separate built-up areas, but now they are filled up as the 'pancake' spreads.

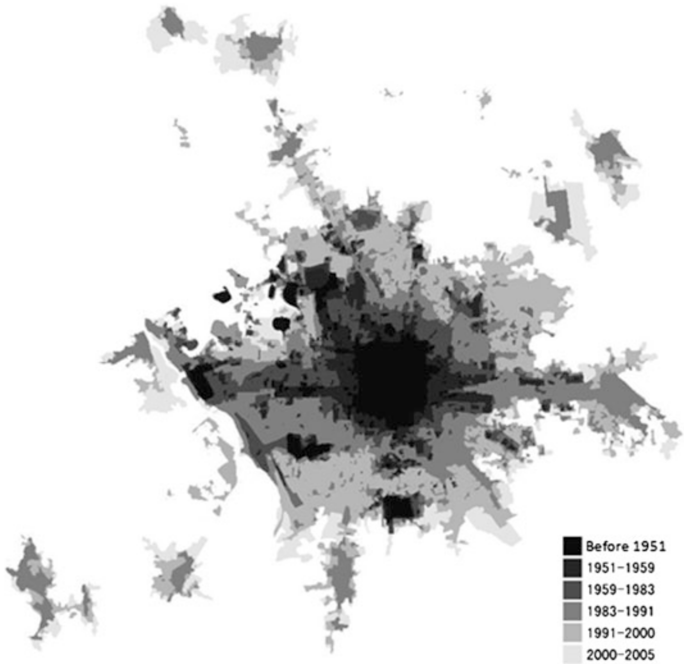


Fig. 6 Expansion of built-up area of Beijing 1951–2005 (Wu 2010)

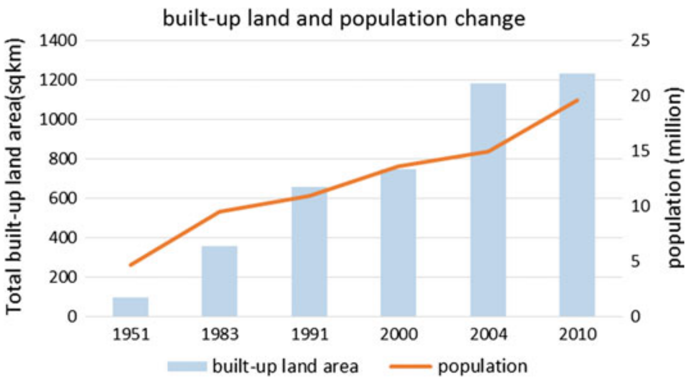


Fig. 7 Built-up land and population change of Beijing 1951–2005 (1951–1991 built-up area data from Wu (2010), measured by the author, 2000–2010 built-up area data from China Urban Construction Statistical Yearbook 2001, 2005, and 2011)

Inner Beijing has never found relief. Administrations and commercial districts still stay in the centre while finance and banking have mushroomed. Workers and customers travelled from suburbs to the centre by underground and caused congestion and long queues at peak hours at underground stations. Most suburban villages suffer from dirty, noisy and disorderly living conditions. The high criminal rate, which results from poor living conditions and a high density of transitory population with low income, causes severe social problems (Zhang et al. 2014). Although the gated neighbourhoods for middle class have better sanitary conditions, such housing without facilities such as schools and hospitals makes the fringe area under-provisioned "dorm-towns".

With the shuttering of many factories in inner Beijing, others that were no longer accepted in the main city moved to the fringe from the 1970s, seeking lower rents, space to expand, better communications and lower labour costs. However, they also brought contamination to the suburbs. Out of the 375 contaminating factories listed as "should be shut down" in 2014 (Zhang 2014), 273 were in near-suburban counties.

As constructions spreads to the fringe, most job opportunities remain in the central city. Congestion is commonly found on main ring roads and radial roads. On average, every worker spends 97 min per day commuting (Lai et al. 2014).

4.3 Greenbelt Policies to Deal with Urban Expansion

The multi-nuclei decentralisation idea to mitigate urban expansion problems is not new in Beijing. The first Beijing Master Plan in 1958 proposed to limit the growth of the central city and relocate industries to the suburbs. Green spaces were embedded in the city to separate residential and industrial districts. This plan was not applied and construction spread arbitrarily without a clearly defined spatial plan. In the Beijing Master Plan 1982, the idea of "to separate built-up patches" was reinforced. However the development inertia could not be deterred by one plan. Beijing Master Plan 1991 emphasised the decentralisation concept and proposed the satellite town development plan. There were several pilot projects to establish greenfields as segregations; however, the outcomes were not satisfactory and buildings without permits corroded the greenfields. Beijing Master Plan 2004–2020 introduced a polycentric urban structure to stop urban expansion. However, this pancake-like expansion has not shown any signs of abating. In order to tackle the expansion pattern, two successive greenbelt policies have been put forward within the Master Plan (Beijing Municipal Government 1994, 2003).

The first greenbelt policy was introduced in 1994 as an integral part of the decentralisation concept from Beijing Master Plan 1991. 240 km^2 of green areas around the fourth ring-road of Beijing were designated as the First Beijing Greenbelt (1994_No.7 policy). The aims were to stop the central city expansion and separate built-up settlements and to improve living conditions for the farmers in the urban-rural fringe which were currently dirty, noisy and disorderly (Beijing Municipal Government 1994). The long-term goal was that by the end of the 20th century, 35 % of the total area of Beijing would be greened. Recreational facilities were allowed to be built in the greenbelt but only 2–3 % of the land could be used for construction.

The nature of the 1994_No.7 policy was negative stopper. First of all, a decentralisation strategy and new town ideas were proposed in the Beijing Master Plan 1991, but greenbelt policy 1994 did not cooperate to accommodate over-spilled population. The two plans were isolated. Secondly, if we look at the 1994_No.7 itself, it stated the function of a greenbelt as an antidote to urban expansion and it also identified settlements beyond the greenbelt as local farmers' new homes. But it did not clarify where the development pressure from the central city should be shifted to. The 2000_No.12 greenbelt policy, as a supplementary to 1994_No.7 policy, shifted policy aims such as: better environment and richer life for farmers in the greenbelt. The following supplementary 2000_No.20 greenbelt policy even allowed commercial housing built in the greenbelt to balance upfront investment. Nothing about the polycentric pattern was mentioned.

From the perspective of urban containment, the first greenbelt was a failure; the urban expansion spread. The total built-up area within the designated first greenbelt increased from 33.3 % in 1993 to 49 % in 2005, with a corresponding decrease in the green area from 66.7 to 44.3 % (Han and Long 2010).

The Second Beijing Greenbelt was introduced in 2003 and was emphasised in the Beijing Master Plan 2004–2020 and Beijing Main Functional Areas Plan 2012, with a designation of 1650 km^2 of green areas between the fifth and sixth ring-roads. The primary aim was to limit the successive wave of urban expansion and to shape a polycentric urban structure. Satellite towns were mentioned in this version's greenbelt as the main area where dislocated populations should go. The long-term aim is that in 2020, 50 % of this area will be covered by vegetation.

From the perspective of urban containment, the second one is more close to the nature of London's greenbelt: as a positive guide. However, in the implementation document (2003_No.15 policy), only the ecological element is emphasised. This document mainly explained how to achieve the target area of green space and market mechanisms to fund vegetation planting.

The second greenbelt policy had some effects as the total green area increased from 366 to 566 km^2 from 2001 to 2008 (Gan 2012). However, this number is still lower than the original total green area in 1990s, which was 757 km^2, and is far from the policy aim (Fig. 8).

To sum up, Beijing's expansion originated from population aggregation and economic ascendancy. Although the polycentric pattern has been mentioned several times in master plans and the ecological benefits of greenbelts are widely accepted

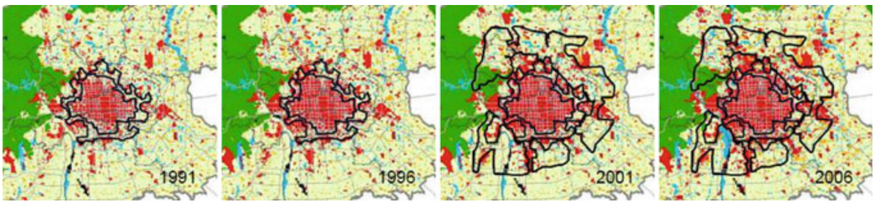


Fig. 8 Urban land use change before and after greenbelt policies, *Source* Long et al. (2012)

by the public, such a pattern has not been well formed. In implementation, the main focus of a greenbelt is not to stop urban expansion and shift new development to new towns, but to urbanise the fringe area, plant trees and relocate farmers. Such efforts are of course crucial, but with such a nature, the greenbelt policy must be seen as a failure, assessed from the perspective of effectively stopping urban expansion.

5 Comparisons and Analyses

Both London and Beijing introduced a greenbelt as a policy instrument to check urban expansion and solve environmental, social and economic problems caused by excessive urban expansion. While London's greenbelt stands out as a successful example, Beijing's greenbelts were ineffective at forestalling city growth. Different implementation efforts are, of course, one of the reasons contributing to the success or failure of greenbelts. However, here we try to unveil the differences in policy design which led to different implementations. The main argument is that a rigorously and dynamically designed greenbelt interacting with land use-transportation policies, such as new towns and rails, is likely to be effectively and smoothly implemented.

5.1 Greenbelt and Self-contained New Towns

When London's greenbelt plan was first launched, most local planning officers agreed that the greenbelt should be primarily regarded as a planning tool coordinating with new towns (Munton 1983, p. 34). Ten new towns were to be built beyond the greenbelt (8 towns were actually built, based on the older towns or the newly spawned transport nodes) to receive thousands of former Londoners, some commuting to London and others forming local centres of employment.

London's new town development was not simply an outcome of moving-out of population and industries from the centre. The agglomeration of population and industries generated demand for housing and infrastructure investment. Such investment then created employment locally and funded reinvestment in new towns. As new town commerce emerged, jobs no longer concentrated in the central London but were also generated locally. Recreational activities also localised with more local pubs, shops and cinemas opening. The strict greenbelt reservation prevented them coalescing with the main city and the detached new towns then had self-contained economic and social lives.

However, Beijing's new towns are not self-contained and employment is not generated locally. In 2000, the near suburb counties where new towns were located hold 36 % of the population but only 12 % of the jobs, which implies most of workers cannot work locally and have to travel to the city. Local amenities are

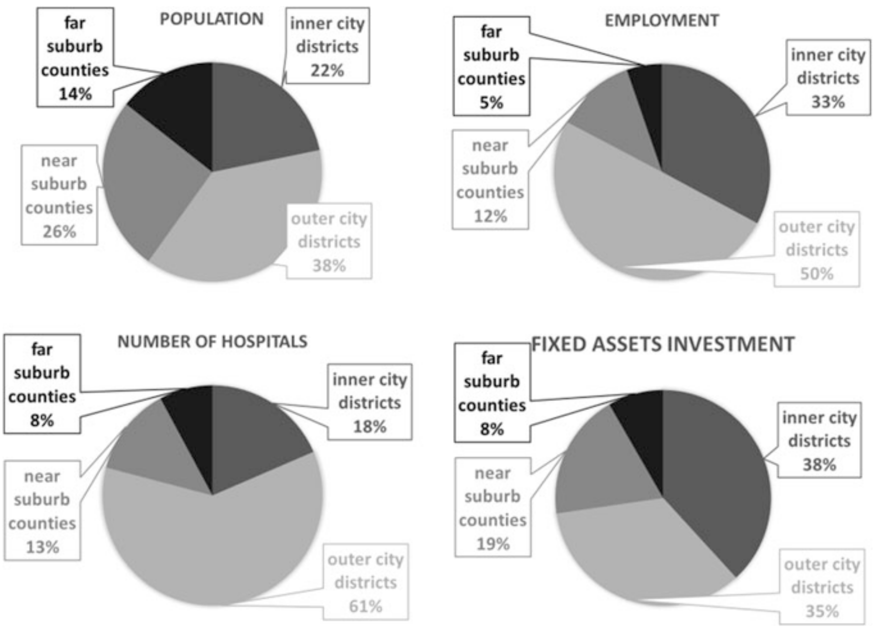


Fig. 9 Percentage of population, jobs, hospitals and FAI in different parts of Beijing. *Source* Beijing Statistical Yearbook (2000)

under-provisioned. For example, only 60 hospitals (13 % of the total 459 hospital in Beijing) serve 2.8 million population. Suburban agglomeration of population and jobs has not met the level to attract abundant investment. More than 70 % of the FAI (fixed assets investment) went to the inner and outer city. Near suburb counties (including new towns), although benefiting from special investment policies,[2] only attracted 19 % of the FAI. It was therefore hard to generate local employment and made reinvestment in the new towns less possible (Fig. 9).

5.2 *Greenbelt and Transportation Links*

London's development has always been led by infrastructure investment. When the Greater London Plan was proposed in 1944, there were already nine metro lines in London, connecting the centre to the suburbs. New towns beyond the greenbelt were treated as "a railways state … a state of existence within a few minutes walk of the railway station, a few minutes walk of the shops, and a few minutes walk of

[2]There are special policies for new town development in Beijing. For example, companies that hire local farmers in new town area can obtain pension from the municipal government; apart from zero tax, there is award for business incubator to attract professionals.

the fields." (Hall 1973, p. 741). Railways and arterial roads would provide links so that new town residents could commute easily to the centre. Lines which stopped abruptly in the inner edge of central London were extended to serve farther suburbs. Not only were new stations opened along the main trunk lines, branches were also thrown out to open up the profitable areas between them (Hall 1964, p. 64). Population distribution followed a pattern of very high densities within walking distance of the town centre and falling off quite rapidly outside that radius to rural levels. Before long, buses served at the suburban stations about a 4-mile radius as supplementary in 1920s (Hall 1964, p. 73).

Although the Beijing Master Plan proposed several new towns to accommodate the overspill population, infrastructure never met the demand of decentralisation. Master Plan 1991 designated 10 "fringe settlements" beyond the first greenbelt for the purpose of stopping urban expansion and decentralising the population. When the first greenbelt policy was introduced in 1994, Beijing had only two metro lines that could link only one fringe settlement with the central city. The total metro length was 54.1 km, most of which served the central city. Private cars were not an option until the Auto Mobile Industry Policy 1994 (The State Council 1994) announced the first time that the state encouraged private car ownership and legal private car ownership was protected by the law. Under-provisioned public transport links discouraged the decentralisation to "fringe settlements" and spontaneous expansion took place in the immediate fringes of the main built-up area and forced through the first greenbelt.

When the second greenbelt policy was introduced in 2003, only one new metro line was added and one metro line was extended to support such a massive decentralisation ambition. Line 1 extended eastwards from 31 to 50 km by the end of 2003. Line 13 opened in 2002 to support the development of the northern part of the city. More "fringe settlements" were connected by metros with the main city. The total length reached 114 km. New lines encouraged the population to live beyond the first greenbelt but forced through the second greenbelt. People who lived beyond the second greenbelt have to suffer long distance travel and extreme crowding in metros and buses. Considering time, money and degree of comfort, the generalised travel cost is rather high, which failed the purpose of decentralising the population (Fig. 10).

Now, after 12 years of implementation of the second greenbelt, half of the new towns are connected with metros. But when the greenbelt was launched, without sufficient rail transit, most residents still concentrated in the main built-up area and were not able to move beyond the greenbelt. New road construction led them to the fringe of the main city, which caused the spontaneous main city expanding in concentric circles into the greenbelts. With ring roads and radial roads adding accessibility to undeveloped land planned for greenbelts, developers competed for those land parcels that were adjacent to the central built-up area and served by roads. This choice was backed by the government's interest in land-lease revenue. These infill parcels were more likely to be leased with a high land price than those in the suburban communities. The revenue-seeking governments were more likely to prioritise these infill parcels than others (Yang et al. 2011). This trench war

(1)

(2)

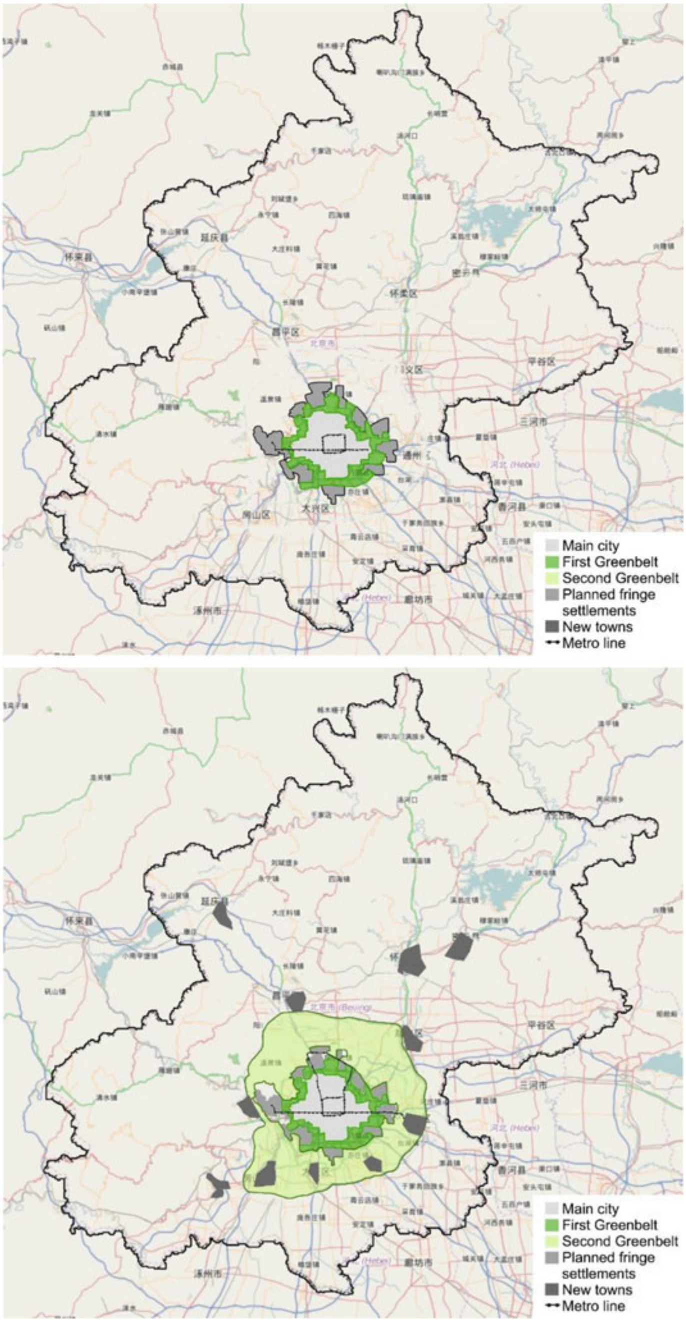


Fig. 10 1: Beijing's metro system when first Greenbelt was introduced in 1994. 2: Metro system when second Greenbelt was introduced in 2003. 3: Current metro system in 2014

(3)

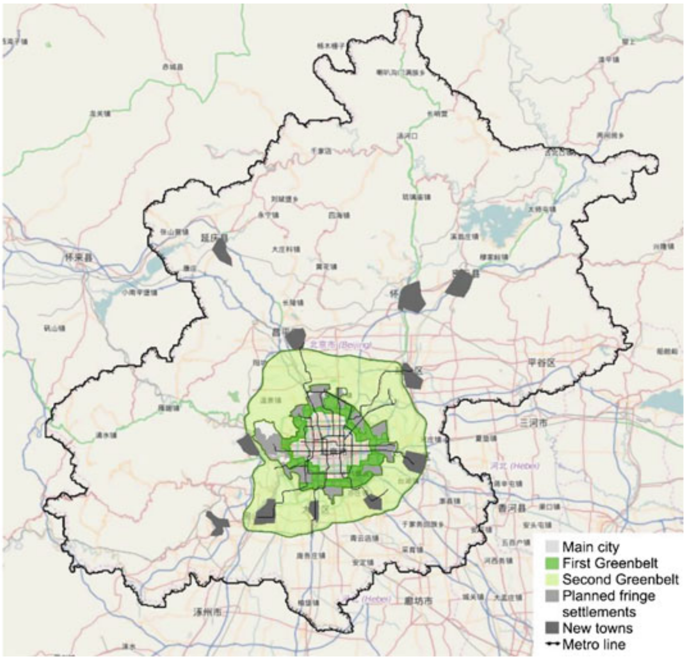


Fig. 10 (continued)

between those who want the greenbelt and those who want short term economic gains leads to a concentric fringe expansion.

The popularisation of cars after 2005 increased accessibility to the suburbs, but in a haphazard way. By the end of 2014, the total number of automobiles in Beijing had reached 5.4, 4.3 million of which are private cars (Beijing Bureau of Statistics 2015). As shown in Table 3, cars became the most popular travelling mode in 2012. Cars enable people to travel further within the same time, which decreases the generalised travel cost but pushes the urban boundary outwards. Unlike rails, which confine social activities within a distance of the station, cars spread people everywhere (Fig. 11).

Table 3 Travel mode in Beijing

Mode	1986 Share (%)	2012 Share (%)
Bus	26.5	27.2
Subway	1.7	16.8
Taxi	0.3	6.6
Car	5.0	32.6
Bike and walking	62.7	13.9
Other	3.8	2.9
Total	100	100

Source Beijing Transportation Research Centre (BTRC) (2013)

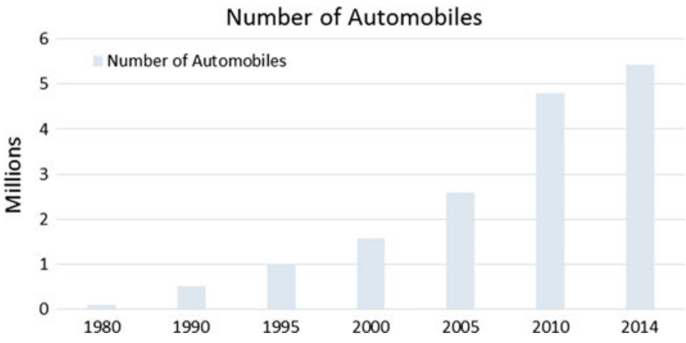


Fig. 11 Number of automobiles in Beijing. *Data source* http://www.bjjtgl.gov.cn/publish/portal0/tab118/ http://www.people.com.cn/GB/jinji/32/178/20020912/821181.html drawn by the author

5.3 Policy Adaptability and Other Configurations

London's greenbelt is not just a ring around the city. In the policy design process, it dynamically adopts various forms of green spaces to manage growth and gives elastic zones for future development. For example, Metropolitan Open Land (Greater London Authority 2008)—including strategic gaps, countryside buffer zones and green wedges—proposed new forms to maintain the environmental quality as well as to stop urban expansion. All these were helpful to shape the polycentric urban patterns. Moreover, these green spaces can be applied as alternates to greenbelts in areas which were not statutorily approved as a greenbelt. These new patterns had lower control power than a greenbelt and they were welcomed because of their flexibility.

On the contrary, although not accomplished, Beijing's greenbelt in policy is an inelastic line. Such a line would eliminate future possibilities for development and therefore would not be easily carried out by the government and not welcomed by developers and landowners. Beijing also proposed green wedges and patches (Beijing Urban Planning and Design Institute 2007). The ecological functions of the wedges have been emphasised, though they have not combined with entire greenbelt and urban land use-transport structure. They are therefore no help to shape a polycentric urban structure.

6 Conclusions

Assessed as an urban containment policy, London's greenbelt stands out as a spatial development guide and has remained steady in the past 70 years with stringent implementation. Its greenbelt policy is positively involved with public transportation development. Meanwhile, urban activities are generated locally from new towns to support the polycentric pattern shaped by the greenbelt. However, the rigidness of London's greenbelt caused several market distortions, for example increasing land rent and car usage, which arouses debate regarding the flexibility of greenbelts in practice. Various green spaces have been proposed to adapt development change and coordinate with the strict greenbelt.

Initially put forward as an urban containment policy, the Beijing greenbelt gradually moved its focus on environmental benefits. Its first greenbelt almost disappeared and its second greenbelt is being encroached gradually. Insufficient infrastructure provision and less developed new towns with rigid design caused difficulties in implementation and resulted in an ineffective policy outcome.

Although London's experience cannot be copied entirely due to different social and legal backgrounds, what we can learn from London is to decentralise the population with public transportation investments and self-contained new towns. Urban expansion is a dynamic process and cannot be stopped by a physically static boundary. Therefore, it is crucial that a greenbelt works with economic mechanisms to measure the overall costs of such a policy, including infrastructure investment and new town development.

Current policy should be modified to accommodate the fast growth of Beijing. A greenbelt may not be the only solution for Beijing's moving urban fringe. Also, as shown in London's experience, a fully-realised greenbelt may cause unwanted results because of its stringency. Green wedges, strategic gaps, and countryside buffer zones should be rigorously considered based on the land use-transportation pattern. The remnants of Beijing's left-over greenbelts also point to the wedges as an alternative. Further analysis and quantitative assessments are needed to rigorously design the configuration of Beijing's urban fringe.

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