Integrating Surface Water Management in Urban and Regional Planning

Case Study of Wuhan in China

Ningrui DU

International Institute for Geo-information Science and Earth Observation, Enschede, The Netherlands

ITC dissertation number 164
ITC, P.O. Box 6, 7500 AA Enschede, The Netherlands

University of Utrecht

ISBN 978-90-6164-283-1

Cover designed by Benno Masselink
Printed by ITC Printing Department

Integrating Surface Water Management in Urban and Regional Planning

Case Study of Wuhan in China

Het integreren van het beheer van oppervlaktewater in stedelijke en regionale planning

Een gevalstudie over Wuhan in China

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor
aan de Universiteit Utrecht
op gezag van de rector magnificus,
prof.dr. J.C. Stoof,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen
op vrijdag 29 januari 2010
des middags te 12.45 uur

by

Ningrui Du

born in Zhenning on May 3, 1966

Promotor: Prof. dr. H.F.L. Ottens

Co-promotor: Dr. R. Sliuzas

This doctoral dissertation was produced with the financial support of:

International Institute for Geo-information Science & Earth Observation (ITC)

And

Faculty of Geosciences of Utrecht University

Acknowledgements

This research was financially supported by the International Institute for Geo-Information Science and Earth Observation (ITC) and partly by Faculty of Geosciences of Utrecht University. I would like firstly to express my profound gratitude to these two organizations. Moreover, this research would not have been successful without the support from many people and I would like to thank all of them.

I am very grateful for the scientific guidance and much encouragement from my promotor, Professor Henk Ottens, who directed me throughout the study. His wisdom and knowledgeable remark greatly stimulated me to deepen my insight into the subject. His supervision considerably helped me to develop and formulate this research and his constructive and innovative comments contributed a lot to the academic qualification of the thesis. I feel I have been privileged to learn so much and enjoyed very much the discussion with him. I also would like to extend my gratitude to his family, especially his wife Willy, for the very kindness and hospitality to me and my family.

Many thanks go to my co-promotor, Dr. Richard Sliuzas. His critical comments always had challenge to my research work and his useful suggestions and English editing greatly contributed to improve the presentation and contents of this thesis. He was very supportive throughout the process of my study. I also would like to thank Dr. Stan Geertman from Utrecht University to give me valuable comments on the proposal at the beginning of my research.

Special thanks go to Prof. Martien Molenaar, Prof. Martin Hale, Mr. Paul Schoonackers and Ms. Marjan Kreijns for their kind stimulation for this study at the very beginning.. I would like to thank the staff in PGM department of ITC, especially Martin van Maarseveen, Petra Weber, Luc Boerboom, Frans van den Bosch, Mark Brussel, Emile Dopheide, Johannes Flacke, Yola Georgiadou, Liza Groenendijk, Monika Kuffer, Mike McCall, Chris Paresi, Bert Raidt, Sherif Amer and Sjef van der Steen for their encouragement and help. I am also grateful to Dick van de Zee who offered me useful information about spatial planning and water management in the Netherlands.

I would like to express my deep appreciation to Jan Turkstra, now senior expert of UN-Habitat, for his useful suggestion for my research proposal and constant encouragement from the beginning to the end. He shared his fruitful research and working experience with me and his enthusiasm for planning work highly impacted on me.

I would like to thank Loes Colenbrander and Paul van Dijk for their effective support for me during the research process. I also owe a great deal to Marga Koelen, Carla Gerritsen and Petry Maas-Prijs for their tremendous help to find literature in the library. Especially thanks also go to Marga for her nice friendship and for letting me enjoy the happiness with her husband Albert and three lovely daughters, Roos, Anna and Julia.

I am indebted to Willem Oosterberg, senior expert of spatial planning and water management in RIZA, who supported and assisted me tremendously during my fieldwork about the Dutch experience of water management at the national level. I have learnt a lot from the discussion with him and his colleague, Rob Gerits and Rob Peeters. Three of them gave me nice response and correction for my interview questions. I also benefited from the discussion with Dr. F.L. Hooimeijer and Dr. Sybrand Tjallingii from Delft University of Technology. I sincerely thank Herman Nijhof from Enschede Municipality for introducing water-spatial project in Enschede to me and Margo A. van den Brink from Nijmegen University to introduce a lot of useful information and knowledge. I thank Aat Hueting from KAN for his time and discussion with me about the Arnhem-Nijmegen regional planning. My special thanks go to Jos Verweij, senior urban planner in Arnhem, and his colleague Hans van Ammers and Ronald Bos. You kindly arranged the meeting and assisted me in Arnhem case study. He and Hans were so kind to answer my questions. Ronald Bos gave me the comments about the Dutch case study.

Without the help and support given by the people during my fieldwork in Wuhan, I do not think it would have been possible for me to keep on this study. I therefore would like to specially acknowledge them: Hu Xiaoling and Zhang Jianxin from Wuhan Urban Planning and Design Institute, Wang Xiang from Wuhan Geotechnical Engineering and Surveying Institute, Huang Hua and Tu Jinhua from Wuhan Water Affair Bureau, Hu Weizhong from Yangtze River Planning Committee, Ye Zhongyuan from District Urban Planning Bureau in Dongxi Hu, and Li Zhonghua from information center of Wuhan Urban Planning Bureau. I benefited enormously from the discussion with them.

I wish to thank several people who worked in ITC for their kindness to share their PhD research with me. They are Dr. Peter A. Minang, Dr. Jane Bemigisha, Dr. C.M. Joshi, Dr. Guofeng Wu and Dr. Tiejun Wang. Thanks particularly go to all my Chinese friends who brought a lot of happiness to me in Enschede. They are Fangfang Cheng, Pu Hao, Shi Pu, Xia Li, Tina Tian, Zhenshang Yang, Yijian Zeng, Lei

Zhong, Meng Bian, Teng Fei, Jing Xiao, Xiaogang Ma, Yixiang Tian, Xin Tian, Yali Si, Qiuju Zhang, Xi Zhao, Xiang Zhang and Liang Zhou. I would like to express my best wishes for their future.

I enjoyed and will always remember the good moments with Mrs. Nita Juppenlatz (‘Mummy’ as I call), and her daughters Bronwen and Zana. Mummy read every piece of my manuscript and critically corrected my English. I own many thanks to their encouragement and stimulation which greatly drove me to move forward.

Balancing PhD research with normal family life is not easy. Sun Kai and Yangyang have suffered more than I did. I am very grateful for their constant supporting and understanding and now it is my turn to do more for them. Particular thanks go to my parents for their endless love and I would like dedicate this thesis to them.

Table of Contents

List of figures

List of tables

List of Photographs

Chapter 1 Research Theme, Design and Methods

1.1 Subject and background

Due to the extensive urbanization and industrialization, urban land use change in many cities has resulted in irreversible disturbances of hydrological systems via reclamation, alteration and pollution. Human activities have significant impacts on water quantity, quality and aquatic ecology (Huggett et al., 2004, p256), but the negative effects of this anthropogenic intervention may not be immediately visible at an early stage. As a consequence, when the final negative results appear (e.g. flooding disaster, serious water pollution) after a long-term accumulation, it is normally impossible or costly to address these problems. Water crises, i.e. too much water (flooding), too little water (drought), and dirty water (pollution), may in turn become major obstacles to sustainable urban development.

Leopold (1968; cited by Douglas 1983, p51) summarized the hydrological effects of urbanization, as a change in total runoff with an alteration of peak flow characteristics, a decline in the quality of water and changes in the hydrological amenities of streams. Randolph (2004, p45) demonstrated that the increase of impervious surfaces (roads, parking lots, rooftops) associated with urban development affects the hydrologic system and pollutes surface and ground-water. In one way or another, many water related problems are the outcome of disordered or ill-conceived land use development. The capabilities of water storage or maintenance, runoff mitigation, infiltration and water purification all have a close relationship with the condition of surface land use. However, the linkage between the water system and land use has long been ignored because water and land are normally regarded as separate resources that are managed by different organizations.

This research explores the spatial issues of surface water systems in urban and regional planning by emphasizing the linkage between water and land management in an integrated way. The close connection between water management and spatial planning has been recently proposed as one result of an acceptance of 'water on land' in some European countries, especially the Netherlands (Woltjer & Al, 2007). Integrating water management in spatial planning is considered to be of importance in keeping the balance between urban development and the water system so as to attain a sustainable urban system. The limitation of former end-of-pipe measures and the essentiality of spatial and ecological measures require a positive relationship between spatial planning policy and surface water systems. However this view is still a relatively new topic in many developing countries.

Surface water, as opposed to the ground or atmospheric water system, normally consists of the water sources that occur on the Earth's surface. It is one of the most important components of the hydrologic cycle framework. The constituents of the surface water system comprise storm water runoff and surface water bodies. The European Water Framework Directive (WFD) (EC, 2000) describes bodies of surface water as discrete and significant elements of surface water such as lakes; reservoirs; streams, rivers or canals; part of streams, rivers or canals; transitional water or a stretch of coastal water. By this definition surface water bodies can take different forms, sizes and shapes due to local physiographic factors. The definition of WFD refers to the concept of wetlands, which has been widely discussed since the 1950s. Surface water bodies have a spatial location and form and should therefore be given appropriate attention in spatial planning. In this study, a fast-growing city with abundant surface water bodies is the main focus area due to its numerous conflicts between water and land.

Designing a good relationship between water and city needs efforts from many professional fields. In this research, the main focus is on the coordination between urban planners and water managers. In many developing countries, land-bound urban activities often have priority for their spatial requirements on account of the requirement for the pursuit of economic growth and wealth. In the urban region, the spatial aspects of the surface water system are often outside of the main planning themes. It is necessary to have more creativity and innovation for the new concepts and new approaches both in spatial planning and in water management. In fact, there has been a lot of discussion about non-structural measures for water management and much emphasis has also been put on the importance of integrated approaches (Jong et al., 1995; Rooy et al., 1998; Correia et al., 1999; Niemczynowicz, 1999; Gullstrand et al., 2003; Carter et al., 2005; Hwang et al., 2007). These previous researches have established the foundation for this study.

1.2 Urban development and water related problems in China

Like many other developing countries, China is entering upon a very dynamic stage of urbanization. Statistics shows that in 1980 only 19.6% of the total population lived in the cities but the figure rose to 36.1% in 2000 (National Fifth Census,) and 43.0% in 2005 (National_Bureau_of_Statistics_of_China). If the rate of urban population growth continues at an average of 1% annually, by 2050 urbanization level will be as much as 70%, which means that urban population will on average increase by an additional 10 million per year. This rapid urbanization has resulted in large-scale concentration of urban population and rapid urban expansion. Such processes will persist in the future. Recent studies showed that this extensive urbanization and urban expansion has created various negative impacts on the urban environment, e.g. deteriorating surface water quality (Li et al., 2006; Ouyang et al., 2006; Guneralp & Seto, 2008; He et al., 2008; Wang et al., 2008).

Because much of China has a monsoon climate, where 60-80% precipitation occurs in a regularly short rainy season (Qian, 2001), surface water is very unevenly distributed in space and time. Flooding and drought risk control are therefore major concerns of the traditional water management. Although the Chinese government has taken a lot of measures, such as constructing dikes to control flooding along the main rivers, building reservoirs, water transfer and irrigation facilities to guarantee water supply for urban and rural areas, and constructing water conservancy and hydropower plants for electricity, the issues of the water system and water environment as important parts of urban ecology have not gained enough attention. Waste water treatment both in urban and in rural areas has long been ignored. Until the 1990s, 90 % of wastewater was discharged to rivers and lakes without any treatment (Jin & Zhang, 1996). Even though many efforts have been made to improve the standard of urban wastewater treatment since the 1990s, the trend of water pollution has not been solved. A huge investment in treatment plants and the necessary networks will still be required and this situation is more urgent due to rapid urbanization and industrialization.

More than 60 % of China's cities have an inadequate supply of potable water sources and among them 25% are at the most serious shortage level (Song, 2003; Shen, 2005). In the meantime, 90% of the surface water in the urban area is seriously polluted (Song, 2003), which further threatens water supplies and aggravates the situation of water scarcity. In fact, urban water supply problems appear because of the shortage of potable water and the quick increase in demand. As estimated by the Project Group of the Chinese Academy of Engineering in its report, 'Strategic Research on Sustainable Development of Water Resource in China in 21st Century' (2000), scarcity of water resources in the future will become more serious in the light of the water resource availability per capita. The gap between the rapid increase in demand and the shortage of supply is becoming larger and the situation is being aggravated by serious water pollution.

Moreover, water systems (surface or ground) and the aquatic landscape in many cities have been greatly altered by the increase in impervious areas, occupancy and conversion of water bodies to other urban land use, and destruction of the natural shapes of creeks or rivers. The flooding risk persists and the aquatic eco-system in the urban area has badly deteriorated (Zhang & Cao, 2005). Several studies (Jin & Zhang, 1996; Qian, 2001; Song et al., 2004) have pointed out that at present the main water challenges (also called 'water crisis') in Chinese cities are flooding risk, water scarcity and wastage, over-exploitation of water resources, water pollution and water environment deterioration, which have already become constraints for contemporary sustainable development. Varis and Vakkilainen (2001) also summarized eight challenges to water resources management in China based on the context of the Yangtze River Basin, such as: non-uniform and scarce water resources, strong variations of climate which are difficult to forecast, extreme population density, very rapid urbanization, rapid environmental degradation, food security, wide disparities in economic and human development, and institutional mismatches.

1.3 Urban planning and water management in China

Chinese urban planning and water management is at present experiencing a complex transformation process in concepts, contents, working approaches and institutionalization. Especially after 2000, the new state development ideology of 'Harmonious Society' and 'Scientific Outlook on Development' has provided new opportunities for advocating sustainability in urban planning (Zhang & Zhang, 2007; Song & Ding, 2009) and water management. Local governments are encouraged to achieve not only economic development but also social justice and good environmental quality. Environmental and ecological issues now are widely recognized in national and local development policies.

The spatial planning system (which mainly focuses on urban areas) has undergone an evolving and exploratory process in the recent three decades. Urban planning principles and working methods have especially been characterized by rapid urbanization under the transitional context of social, political and economic reform (Yeh & Wu, 1999; Ma, 2002; Ma, 2004). Through the promulgations of the City Planning Ordinances of 1984, City Planning Act of 1989 (Act 1989) and Urban Plan Making Regulation of 1991, the status of planning work has been improved and widely recognized by society. Legislative activities have played an important role in the practice of urban planning to control and guide rapid urban development. In 2005, the new Urban Plan Making Regulation was announced. On 28 October 2007, the new City and Country Planning Act was enacted by the National People’s Congress and has been effective since 1 January 2008. Both the Regulations and the Act give extra attention to environmental values in planning, reflecting a major change in urban planning principles in China.

In the meantime, urban water management in many Chinese cities is now facing a new challenge of institutional reform. Although water management has a long history, its legislation is quite recent (Shen, 2005). The first Water Law was issued in 1988 and subsequently several other water related sub-sector laws were adopted; such as the Water Pollution Prevention and Control Law of 1984, the Water and Soil Conservation Law of 1991 and the Flood Control Law of 1998 etcetera.

Traditional water management mainly adopted technical and engineering approaches to solve water problems. Water management authorities have been formed in a hierarchical system which possesses coordination mechanisms that function well during disasters, but not in daily operation (Shen, 2005). Unlike the strong vertical setting of water management institutions, the horizontal cooperation is rather weak at the urban regional level. The government-dominant model with a ‘top-down’ structure created some institutional deficiencies (Chen, 2006). Facing many water-related challenges due to rapid urban development, the Water Law was amended in 2002 and institutional reform for urban water management at the local level has been undertaken since 2000. By 2004, most cities had established a new agency, the Water Affairs Bureau (WAB), or expanded the functions of the former Water Resources Bureau (WRB) (Chen, 2006; Shen & Liu, 2008). The main purpose of the amendment is to promote an integrated urban and rural water management system. Most water affairs, such as water supply, sewerage, flooding, water resources allocation, water/soil conservation and irrigation, are now embodied in one bureau.

As water issues involve the different interests of many stakeholders, it is especially important to harmonize the relationship among different organizations and the public. Moreover, water issues are spatially relevant, therefore the Water Affair Bureau and the Urban Planning Bureau need to cooperate and coordinate their efforts. The bottom-up institutional reform creates a new study topic for water managers and urban planners in order to facilitate negotiation and cooperation among different organizations tackling the spatial water-related problems in urban areas.

1.4 Research objective and the challenges

Spatial planning covers many different aspects in formulating policies that influence the future distribution of activities in space and time. Planning is essentially used as a tool to create a good quality of life for urban citizens by harmonizing the development components in the urban region. Planning can also play an important role in developing strategies and procedures to integrate the use and management of land and water (Carter, 2007). The central issues of this study are to explore the water-land relationship for spatial planning in theory and practice and to emphasize the need for cooperation between spatial planning and water management in rapidly urbanizing regions. The main goal is to examine and develop a spatial planning methodology that would enhance the sustainability of urban development by integrating the surface water system in the urban and regional planning process. It is also hoped that the results will contribute to the definition of new values and methods in the current Chinese planning system for sustainable development.

The urban region, as a typical landscape, is becoming the major place where people dwell. It is also the place of contradiction and juxtaposition of divergent spatial requirements. Various urban activities need land for accommodating their functional development. Therefore it is difficult to highlight water-land relationship in policies during the rapid development process. However, integrating surface water in spatial planning is crucial for mitigating the negative effects of land use and making the best of water systems to create a good quality of space. New paradigm shifts in spatial planning and in water management as well are obviously facing the following challenges:

Challenge 1: To develop common concepts and definitions about the spatial implications of water issues in spatial planning and water management in urban regions.

Water systems, as part of nature, occupy a certain kind of space which takes different forms, sizes and shapes due to various physiographic factors. But at the level of the urban region, their spatial implications are blurred. Sensitive spaces for water systems do exist but their spatial boundary is hardly delineated due to their features of fluidity and changeability.

Water management and spatial planning have both developed their bodies of knowledge over a long time but traditionally they have played separate roles in urban development. A lack of understanding and cooperation exists between these two bodies of expertise. In both domains, the idea has not been fully shared that surface water is also one of the components of the ecosystem and one that has a typical spatial meaning in a geographical region. The functions of water systems in spatial planning and spatial meaning in water management need to be re-evaluated. This requires professionals from both domains to open their minds, explore their differences and goals and seek to better understand each other. This is the basis for the cooperation in policy making and policy implementation. However, changing established habits of thought and behaviour is not easy.

Challenge 2: To improve integration and coordination between spatial planning and surface water management so that the problems are recognized, solutions are arrived and the negative impacts are avoided as early as possible

It is often difficult to identify the negative effects of land use changes on water systems at an early stage. The results of water crises are often partly attributable to the cumulative effects of a long-term negligence of negative land-use impacts. When spatially related water problems are revealed, it is always too late to take straightforward spatial measures. This is one of the reasons that quantitative and qualitative water problems are not successfully solved in many urban areas. Multi-disciplinary cooperation among ecologists, sociologists, economists, urban planners and water managers is needed in the planning process from the outset.

Challenge 3: To break through the institutional compartmentalisation in practice

Because land and water-related issues are tackled by separate departments, integrated decision-making is hardly achieved. Also, because different departments may make independent investments for water-related projects, integrated implementation is even more difficult. This separation of departmental interests may result in excessive exploitation of resources and the neglect of responsibilities for water systems protection by focusing on short-term benefit and ignoring the long-term sustainability. The institutional barriers may hamper the consideration of the long-term sustainability. Especially in the rapidly developing regions, as Page and Susskind (2007) pointed out, the cumulative impacts of local water planning decisions may produce serious problems. In practice water issues are the concern of many interests from different administrative sectors, but the overlapping governance in water management poses difficult obstacles to clarifying and sharing of responsibilities which ensure better utilization and protection of both water and land. Moreover, water has not yet gained the same importance as land in municipal physical planning, as a recent study demonstrated in Sweden (Gullstrand et al., 2003). It needs a new institutional approach to initiate cooperation and participation for better actions. Public awareness and attitude to the environment also need to be involved in the decision-making process.

1.5 Research questions

All the aforementioned challenges cover many issues in a wide range. This study endeavours to answer the following questions in order to reduce the gap between spatial planning and water management:

With regard to spatial concept of surface water systems in urban regions

1. What kinds of land and water spaces are sensitive for surface water systems and therefore need combined attention of urban planners and water managers?
2. How can the space for surface water be identified and classified?
3. What is the spatial impact of urban development on surface water system change in the Chinese context?

With regard to integration of surface water management and spatial planning

4. What kinds of new planning concepts and methods can be used to integrate surface water systems in spatial planning to create good quality urban space?
5. How can the institutional cooperation between spatial planning and water management be initiated in the Chinese context?
6. How should the current spatial planning system in China be reformed in order to integrate sustainable surface water

management in urban planning?

7. Can experiences of the Netherlands be helpful for the Chinese cities to find successful ways to integrate surface water management in spatial planning and close the gap between these two domains?

With regard to information for planning support

8. How can spatial information systems support suitable information provision for and sharing of the information by spatial planners and water managers in China?

1.6 Research design

1.6.1 Research framework

The framework of the research design is shown in Figure 1.1. The theoretical part of the thesis explores the spatial linkage of the water system with the urban system. This uses the principle of sustainability to define the spatial implications of surface water systems. It also raises the importance of tackling water-related problems at the very beginning of the spatial planning procedures and of advocating a common language shared by urban planners and water managers. New planning approaches and institutional development are explored and a conceptual model is formed for integrated surface water management and spatial planning.

The empirical part helps to establish the urgent need for and feasibility of integrated water management and spatial planning through a comparative study of China and the Netherlands. These cases respectively represent different situations in the developing and developed countries. The case study in China is designed to capture local knowledge in order to understand the constraints and opportunities for integrating water-related issues in spatial planning practice. The emphasis is on problem identification, evaluation of the former planning policy, the urgent reform in the current planning practice based on the new planning system, the development of new planning approaches and cooperation with water management. The supplementary case in the Netherlands focuses on the principles, contents and approaches of the spatial water policy at the national level and their application and implementation at the local level. The possible lessons which may be used as references for China are extracted.

Both theoretical and empirical studies finally lead to the development of a framework of integrated urban and regional planning for water systems based on sustainability principles.

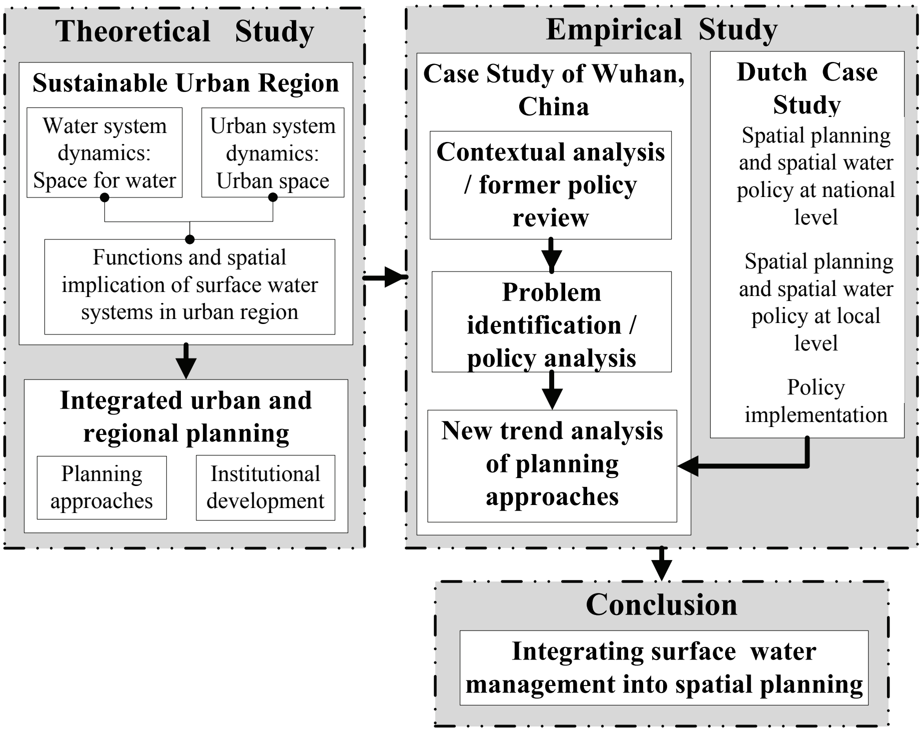


Figure 1.1 Research design framework

1.6.2 The case studies

Wuhan, the capital city of Hubei Province in central China, is selected as one case study. It is located at the confluence of the Yangtze River and its longest tributary, the Han River (Figure 1.2). The region has a subtropical humid monsoon climate with a very distinctive dry and wet season. The annual average precipitation is 1140-1265 mm, of which 80% falls from April to October. Wuhan Municipality is 8,549 km^2, of which 2,117 km^2, nearly 25%, is covered by surface water bodies (LEC, 2006). Due to its wet climate, the two main rivers and the large number of lakes, pools and ponds in and around the city, Wuhan is nicknamed 'Water City' (*Jiang Cheng*). It is one of the rapidly developing urban areas.

In the recent two decades, the city has experienced rapid urban expansion and witnessed many land use changes that have affected its surface water bodies. Some irreversible damage has been done to the city's surface water systems, both qualitatively and quantitatively. Several countermeasures have been taken recently, such as the promulgation of local regulation on lake protection and the project of lake ecological rehabilitation. However, the lack of integrated approaches has not radically solved the old and new water-related problems. Therefore, Wuhan is a relevant case to examine the water-land relation in a rapidly urbanizing area.

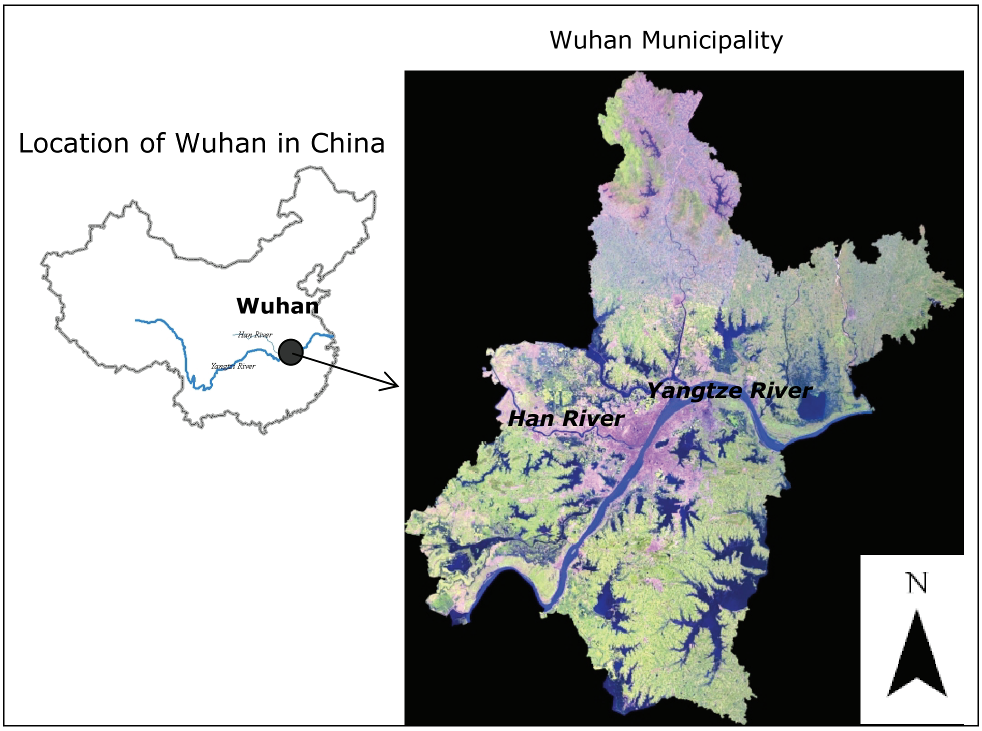


Figure 1.2 Location of Wuhan

The Netherlands, bordering the North Sea in Western Europe, has her nickname 'Low Country' because of the low-lying topographical feature. The total territory amounts to 41,160 km^2, including inland lakes, estuaries and territorial sea, while its land area is approximately 34,000 km^2 (Huisman, 2004). About 25% of the land area lies below mean sea level. As an illustration, without dikes and dunes, more than 65% of the country would be flooded at the high sea and high river levels (ibid). It is obvious how important the dikes and dunes, as well as efficient drainage system are, in protecting the

Netherlands from the sea and the rivers. As a small and densely populated country with a long history of water management and a mature context of political, economic and social development, the Netherlands has its typical experience of water management and spatial planning at different spatial levels. Due to the recognition of the impacts of climate change in recent decades, the Netherlands is changing its approach to water either from the point of view of water management or from that of spatial planning.

The new approach of integrated water management requires the concession of additional space for water in the regions, which requires innovative spatial approaches related to water. This trend recently has brought about the fundamental changes in spatial planning at the strategic level and the local action level. Such experience may provide useful knowledge for the developing countries. Therefore, this study reviews the experience of Dutch spatial planning and water management at national level on mindset, principles and approaches.

Thereafter, Arnhem and Enschede are selected as the case study areas (Figure 1.3) in order to understand how the concepts at strategic level are being implemented at the local action level. The Arnhem case is focused more at the city level and that of Enschede more on the project level.

Arnhem is located in the eastern part of the Netherlands, near to the River Neder-Rijn. In the last several years, a water plan has been made to deal with water quality and quantity issues in an integrated manner. The water plan advocates that integrated solutions and actions involving other policy areas such as spatial planning, environment and green space play a role in water management. Moreover, the involvement of interest groups and residents, entrepreneurs, nature and environmental organizations is emphasized for good communication so as to ensure a broad support for the spatial water policy.

Enschede is located in the east Netherlands. Although there is no major flood risk, the city still considers the question of retaining more water in its area based on the new spatial water policy. Some new spatial planning approaches have been used in the residential projects. These may provide good references for the challenges faced by Wuhan in China.

Figure 1.3 Location of case studies in the Netherlands

1.7 Research methods

The research methods and techniques used in this study are shown in Figure 1.4. An extensive literature review is done in order to establish a theoretical basis. Data collection is conducted in the case study areas to capture the local knowledge. Evaluation and data analysis are for understanding the local context. Comparative analysis is to create new knowledge for planning support in the future. Further details are given below.

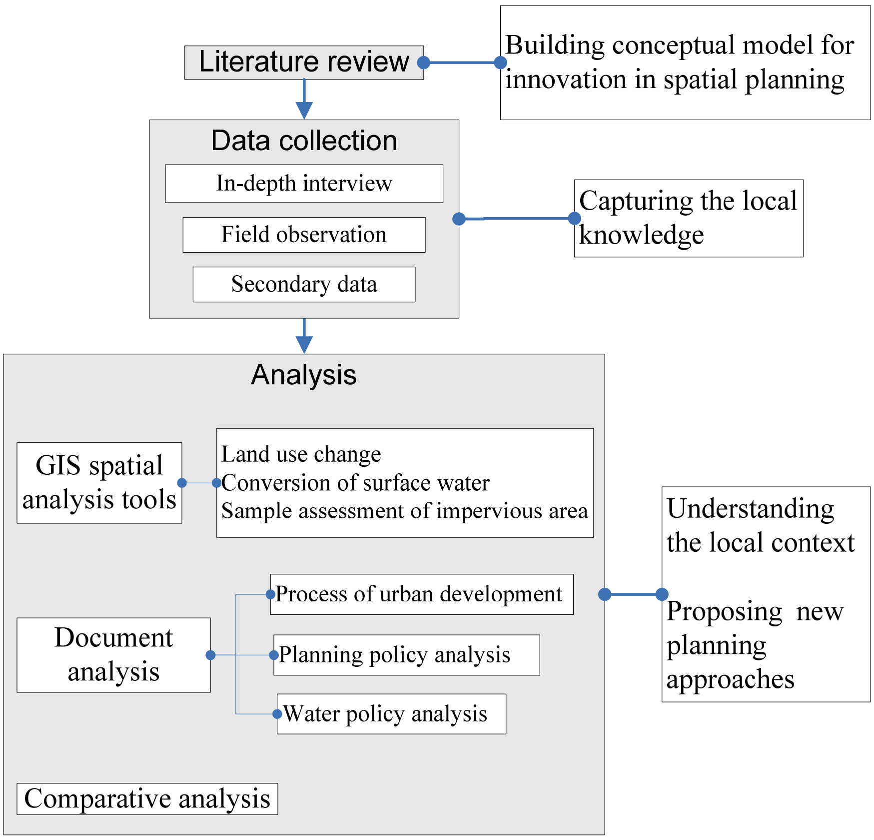


Figure 1.4 Framework of research methodology

1.7.1 Data collection

Primary and secondary data in this study were collected during the fieldwork. Primary data comes from site investigations, field observations and in-depth interviews of experts. Secondary data comes from official documents and reports (e.g. spatial plans and water policies), chorography and local literature, statistical data, digital spatial data and image data.

An in-depth interview is a good method for exploring the complexity and in-process nature of meanings and interpretations (Liamputtong

& Ezzy, 2005, p56). It is a qualitative method which is best used for 'problems requiring depth of insight and understanding' (Robinson, 1998, p409). Water-land issues involve various interests of different stakeholders and water-land management involve more than one organization. Different people, based on their position and experiences, may possess quite different opinions about the utilization and management of water, especially in urban areas. This brings about complexity of water management and spatial planning. Because technical experts and managers play an important role in information-supply and decision-making in practice, given the aim of this study, their opinions are important for understanding the policy context of the local situation. Therefore in-depth interviews were used in the case studies. The checklists in the Appendix A and B list the main interview questions and topics used in the cases. The experts were selected from the organizations which are listed in Appendix C. All of them are senior experts both in urban planning and water management and most play key roles in policy making. There are in total 15 interviews, 8 in Wuhan and 7 in the Netherlands (Appendix C). The interviewees have offered valuable information for understanding the local context and policy response concerning water in the spatial aspects. The results are further used for the qualitative analysis of policies.

1.7.2 Data analysis

The combination of quantitative and qualitative analysis methods is applied in this study to evaluate the impacts and interpret the policy effects of urban development on surface water systems. Due to the different functions of case studies in China and in the Netherlands, quantitative analysis methods are mainly used in the Wuhan case and qualitative methods are used in the cases analysis of the Netherlands and the future policy making and implementation in Wuhan.

Quantitative analysis is used to examine the impacts of urban land use expansion on the surface water system in Wuhan urban area. GIS spatial analysis tools within the ArcGIS environment are used to measure and evaluate the spatial-temporal data of Wuhan. The methods used will be elaborated in the later chapters.

Qualitative methods, such as document analysis and comparative analysis, are used to analyze the rhetoric concerning the water and spatial policy issues. The main purpose is to explore the driving forces, limitations of the present policies and potential innovation in the future policy-making.

1.8 Outline of thesis

Chapters 2 and 3 are theoretical exploration. Chapter 2 reviews the previous work of spatial planning approaches and the fundamental features of water-land relationship. The main intention is to examine the possibilities and feasibilities of the consideration for natural water systems in spatial planning and why it is of importance in the achievement of sustainability in urban regions. Chapter 3 explores planning approaches which may be used in integrated surface water management and spatial organization. Together both chapters establish the theoretical foundation for the further study.

Chapters 4, 5 and 6 are empirical case studies. Chapter 4 introduces the context of urban planning and water management in China and the case study area in Wuhan in order to understand their transitional characteristics at the national and local level. Chapter 5 elucidates the results of quantitative analysis on the relationship of urban land expansion and its impacts upon surface water system in the area of the case study. Policy limitations and the challenges are illustrated. Chapter 6 examines the Dutch cases regarding the practical experience of spatial planning and water management at the strategic and the local action level. The possible lessons are extracted for solving the problems in Wuhan.

Based on the theoretical and practical discussions, Chapter 7 extends the possible options of spatial water management and planning for the future development of Wuhan and integrated model based on Chinese background. The research limitation and suggestions for future research are presented in the final chapter.

Chapter 2 Spatial Planning and Surface Water Systems

This chapter consists of two main parts. The first part reviews previous scientific and policy-oriented work on spatial planning systems. Its focus is on the evolution and paradigm shift in planning approaches. The second part elucidates several water issues: the characteristics of natural water systems, the water-land relationship and the influence of adverse alteration in urban regions. The purpose of this chapter is to build the foundation to link these two separate disciplines (spatial planning and water management) in order to address the challenges and research questions mentioned in chapter 1.

2.1 Evolving spatial planning approaches

Modern planning activities originated from the massive industrialization and urbanization of the nineteenth century, which initially became manifest in the developed countries (Ward, 2002, pp11-43; Wegener et al., 2007, xv). Subsequently, urban and regional planning developed as a professional specialization at the beginning of the twentieth century. Planning theory and planning practice has thus evolved with the development of modern society for 'the interaction between [planning] theory, urban change, and planning practice is symbiotic and asynchronous' (Campbell & Fainstein, 2003, p12). As a consequence of this interaction, there have been many debates and long-standing disputes in this field. Such debates fuel the progress and evolution of planning approaches and planning practice, even today.

2.1.1 Spatial planning debates at a glance

As Rydin (1993, p1) pointed out, planning is about devising strategies for reshaping the built and natural environment. Spatial planning is a future oriented activity and a public sector activity that focuses on the physical environment. Because of this physical focus, planning theory has been dominated by design or blueprint approach for a long time. However, because of the close relationship of physical development with political, social and economic processes, planning theory has also included knowledge from many disciplines. In the light of the scientific exploration of planning theory, Faludi (1973, pp3-8) identified two types of theory in this field: theory of planning and theory in planning. The former is process-oriented i.e. 'theories of the planning process', also called procedural theory. The latter is about subject-matter i.e. theory concerning urban phenomena, also called substantive theory. He suggested that 'procedural rather than substantive theory should be regarded as planning theory proper' (ibid, p5). His viewpoint has aroused complementary and different standpoints. Archibugi (2004) added that besides the theory of/in planning, a sort of theory on planning to establish connections between procedural and substantive planning was needed. He proposed that planning theory could discuss logically and methodologically the connections among the different scales, sectors and units of planning. Paris (1982, pp10-11) regarded planning as an activity which is connected to the social, economic and political context and he insisted that exploring how this context changes over time is the essential task for planning. Beauregard (1990, p213) criticized that '[planning] theorists delved more and more into an abstract process isolated from social conditions and planning practice….few planning theorists concern themselves with the physical city'. Therefore, he proposed a city-centered theory which, as he defined it, 'could link structural forces, developmental trends, human intentions and everyday life thereby broadening the scope of planning theory'.

In the meantime, the debates of planning theory have involved many conflicts between comprehensive versus incremental planning, objectivity versus advocacy, centralization versus decentralization, top-down versus bottom-up leadership, and planning for people versus planning for place (Campbell & Fainstein, 2003, p12). Along with them, there are many conceptions, ideologies and views concerning planning content, planning procedure, planning role, planning equality etcetera (Taylor, 1980; Healey, 1996; Friedmann, 1998; Healey, 1998a, 1998b; Fainstein, 2000; McGuirk, 2001; Archibugi, 2004; Fainstein, 2005; Buitelaar et al., 2007). Although planning theory and practice varies among countries based on their different political and social background, the general evolution of planning systems based on the British experience can be summarized in Table 2.1. Thus it can be seen that since the post-war period, planning systems have been subjected much argument and evolution in planning ideologies or theories.

Table 2.1 Evolution of planning system based on the UK's experience

	From 19th century to 1910s	1920s - 1940s	1950s - 1960s	1970s	1980s	After 1990s
Economic / social context	Industrialization and urbanization in the Western countries	Economic recession; war; reconstruction	Postwar boom; mixed economy; consensus politics	Economic boom collapse; oil crisis; inner city decline; urban-rural shift	Recession and restructuring; new technology; collapse of mixed economy consensus	Economic globalization; environmental concerns; sustainability; information era
Key planning issues	Sanitary and public health; good conditions of houses; urban social unrest	Regional unemployment; regionally-based incentives to industrial activities; suburban growth	Rapid development; increasing living standards; multi-facet problems; urban de-concentration	Inner city problem; inequality; excessive substantial growth; environmental problems; complexity and uncertainty	Unemployment; economic development; restructuring development planning	Sustainable development from global recognition to local action; city competition capacity; good quality urban environment; climate change
Planning philosophy	Blueprint-based urban design; environmental determinism; utopian blueprint; technical process of design and drawing	Naive public administration; public sector direction of land use; comprehensive and compulsory planning	Procedural planning theory; the rationale of planning theory; system approach	Organization theory; political economy; political sociology	Economic development; land privatization and marketing in urban policy; community participation; institutional approach	The New Right, the New Left; liberal political economy; the institutionalist approach; urban governance
Planning concepts	Garden city, city beautiful movement	Garden city, satellite town; comprehensive, integrative planning; resource allocation for the best use of land	New towns; regional planning; two-tier system--structure plans and detailed local plans	Negotiation; policy implementation; local politics	Public transport; urban conservation; nature conservation	sustainable planning; strategic planning; environmental policy; compact city; smart growth
Planning approaches	Urban design, landscape design	Comprehensive integrated planning approach	Planning process model; strategy-led planning	Environmental policy; development control; urban conservation; countryside policy	Public-private partnership; urban development grants; planning as mediation	Environmental assessment of projects; leverage planning; enterprise zones; urban development corporation; growth management

(Continue)

	From 19th century to 1910s	1920s - 1940s	1950s - 1960s	1970s	1980s	After 1990s
Planning activities	Architectural professions, sanitary engineering	Residential development, house-building boom; Regional planning; protecting rural areas from unplanned growth	Implementation of new towns program; regional planning; transportation planning	Pollution control; Inner city renewal; housing redevelopment; transport program	Urban regeneration; nature and countryside conservation	Urban regeneration; waterfront renewal schemes; green movement
Legislative activity / Legal Framework	The Public Health Act 1848 and 1875; the Nuisance Removal Acts 1855; the Sanitary Act1866; the Housing, Town Planning, etc. Act 1909	The Housing and Town Planning Act 1919; the Town Planning Act 1925; the Town and Country Planning Act 1932 and 1947; The Distribution of Industry Act 1945; the New Towns Act 1946; The National Parks and Access to the Countryside Act 1949; special Roads Act 1949	The Town Development Act 1952; the Clean Air Act 1956; the Noise Abatement Act 1960; the Industrial Development Act 1966; Land Commission Act 1967; the Transportation Act 1968; the Town and Countryside Planning Act 1968; the Countryside Acts 1967 and 1968	The Town and Country Planning Act 1971; the Local Government Act 1972; the Housing Act 1974; the Control of Pollution Act 1974; the Health and Safety at Work Act 1974; the Control of Pollution Act 1974; the Town and Country Amenities Act 1974; the Community Land Act 1975; the Transport Act 1978; the Inner urban Areas Act 1978; Ancient Monuments Act 1979	White Paper *Lifting the Burden* 1985; the Wildlife and Countryside Act 1981; the Derelict Land Act 1982; Countryside Access Charter 1985; the Agriculture Act 1986; Water Act 1989; the Housing Act 1988	The 1991 Planning and Compensation Act; the White Paper on the environment; the Citizen's Charter
Some other ideas coming forth	Geddes' survey-analysis-plan methodology, Planning should adapt the physical environment	New town; national park; nature reserve; leisure, amenity and wildlife concerns; green belt	Urban heritage protection; pollution control; countryside protection; incremental planning	International concern with water-dependent areas (i.e. Ramsar Convention on Wetlands in 1976); participative planning	Environmentally sensitive areas; "best practicable environmental option" for controlling pollution; water quality control; environmental assessment;	

Note: Summarized from the books of Rydin (1993), Ward (2002) and Hall (1996, 2002)

Since the 1990's, however, the spatial planning system has given more consideration to the conflicts of managing natural resources, conservation of environment and economic competition. The planning process has emphasized more and more on good urban governance and more cooperation between professional, political and societal actors (Healey, 1997).

2.1.2 Paradigm shifts in spatial planning

Although numerous adjustments in planning theory might be identified, this part focuses the analysis on two major paradigm shifts. One shift is from the utopian blueprint to the rational and systematic approaches (i.e. scientific view). Another is from the scientific view of planning to a wider combination of scientific and political views that is encompassed in the idea of collaborative planning and sustainability that typifies current thinking and practice.

Design-centered view

The idea is not new that planning aims at a better urban future. The target of city planning was basically formed in the Garden City idea of Ebenezer Howard (1902, re-edited in 1965) and his contemporaries. According to Fishman (2003, pp21-60), the three foundational figures in planning history: Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier, were regarded as the pioneers at the beginning of the twentieth century. They attempted to define the ideal urban form for the industrial society. Their planning thoughts were characterized as utopian, anti-urban, spatially ordered and expert-oriented, and this thinking has shaped many cities in developed countries. Subsequently, their ideas have also influenced the developing countries. Their contribution helped to set up the orthodox city planning theory and widely influenced the planning conception and practice until the middle of the twentieth century.

Taylor (1998, pp5-17) described the main features of this pre-war planning in Britain as physical, design-centered and detailed blueprints. Because urban and regional planning was viewed as an exercise in planning and designing the physical form, the results were expressed as master plans for urban form, the planning theories were 'often similarly preoccupied with visionary plans or designs that showed how the ideal town or city should be spatially organized' (ibid, p16). However, since the mid-twentieth century in the developed countries, the concept and principle of 'ideal types' of cities for the future, such as 'Radiant Garden City Beautiful' (named by Jane Jacobs (1961, p25)) in planning history has been subject to much criticism.
The main criticism for this kind of paradigm of planning theory and practice is that it lacks consideration and understanding of the

difference and dynamics of specific urban areas. This traditional planning is targeted at physical results. Ultimately the City Beautiful movement was too expensive, costing more than the problems it was intended to solve. It was a thing apart, detached, unrelated to human affairs (Eisner et al., 1993, p109). In Taylor's words (1998, p55), 'what planners lacked, and what planning theory had failed to provide, was an adequate empirical understanding of the world they were seeking to manipulate'. Taylor (ibid, pp39-55) summarized several limitations: first, their physical and design bias neglected the social environment and social network by over-concentration on the physical environment so as to lack consultation with the people. Second, blueprint planning that created end-state documents did not satisfy the changes of ongoing continuous development of cities while planners failed to recognize the changing nature of cities. Finally, the normative and utopian ideals showing a pursuit of anti-urbanism exhibited very little desire to understand and address the problems of real-life cities during the plan-making process. Urban complexity and diversity was neglected without consideration of different interests and values of different people.

It was gradually realized that a plan cannot be a static document because the city is always confronted with changing social, economic and environmental circumstances. Following criticism in the late 1950s and early 1960s, the blueprint planning view shifted to the systems and rational process view of planning (Table 1).

Systems and rational process view

The emergence of the systems and rational process view of planning in the 1960s was seen as a logical response to the deficiencies of the design-based planning theory when it was realized that using a static way to deal with the dynamic changing problems was not appropriate. Understanding how cities work by system analysis was emphasized. Planning was seen as a trajectory and a continuous process of rational action reflecting the uncertainty of the future rather than producing an 'end-state' or 'blueprint'. This view initiated the first revolution bringing the interest of science into planning theory. Chadwick (1971) and Faludi (1973) clearly explained that such a process view of planning was more about the methods or means of planning. It was the systems view of urban issues and the procedural planning theory that provided a wider scope for spatial planning, especially at the strategic level.

However, the systems and rational process theory of planning, which paid much attention to the technical and scientific work, suffered another wave of criticism at the end of the 1970s. It was criticized for its abstractness and generality, its lack of substance, thereby being empty in terms of content. As Taylor summarized (1998, pp95-109), there were two criticisms of it. First, planning as a purely technical or scientific work did not develop further to empirically understand the real city, which persons like Jacobs (1961) and Alexander (1965) persistently called for. The nature of planning as being value-laden and political was downplayed, while it was realized after the 1970s that the political-economic context could significantly shape and constrain the nature and effectiveness of planning activities. The absence of a substantive core and political attention has led to planning's loss of direction, influence and legitimacy (Beauregard, 1990). The second criticism was on the false top-down view of planning that defines the planning process as different stages i.e. identifying aims, formulating alternatives, evaluating alternatives, implementing and monitoring. This view distracted attention from the crucial question of how plans and policies were implemented even though the stage of implementation and monitoring was included inside the process model. The linear and step-by-step planning process was criticized for separating problem/objective identification from implementation. The earlier stages gained much attention while the latter stage was largely ignored. Such a rational process model was 'generally described as a model of rational decision-making, rather than a model of rational action' (Taylor, 1998, p112) . As Taylor (ibid, p114) emphasized, it is dangerous to view and undertake the tasks of every stage in a separate and linear way.

There has been much attention in planning theory, since the 1960s, concerning social/political issues and implementation issues in the planning field (Allmendinger, 2002). Planning cannot be isolated from a social and political context and the implementation issues should be considered at the same time as plans start to be prepared. Since effective implementation requires the interpersonal skills of communication and negotiation among different stakeholders, planning was increasingly regarded as communicative and negotiated action. In addition, the substantive issues which planning deals with were also reemphasized and a problem-centered planning approach was brought forward. This is concerned with value judgments and problem-focused analysis as a basis for developing possible future policies. The planning paradigm was shifted on one hand to problem-centered research and on the other hand to the issues of institutional change and communicative approaches in plan-making and plan implementation.

Collaborative planning

By the 1980s the importance of understanding the political-social context of planning was firmly established, and communicative planning has since come to prominence. It is now realized that planning must involve more public participation and involvement. Collaborative or communicative planning has emerged in response to the challenge of the changing, increasingly complex society with social and political fragmentation, shared power and conflicting values. Seeing planning as a communicative or collaborative process 'is an attempt to find a way forward for planning, to justify its existence and provide a normative basis which it has lacked since the rational-comprehensive approaches of the 1970s' (Allmendinger, 2002, p206). Many researchers have contributed to the development of this planning theory.

As Lawrence (2000) pointed out, collaborative planning involves two overlapping components. One focuses on the communicative action and the other concentrated on consensus building. Innes and Booher (1999a, 1999b) advocated consensus building and insisted that planning through consensus building is not just communication, but learning, which transforms participants' previously held opinions and helps them to develop new shared meanings, purposes, and innovative approaches to otherwise intractable issues. Brand (2007) exposed the concept of collaborative planning through ontology, epistemology, ideology and methodology dimensions which offer insight into the assumptions about reality (collaborative planning is based on the complex context of society), knowledge (collaborative planning is concerned with facilitating the negotiation of emergent interest and a call for the 'co-construction' of knowledge), values (collaborative planners emphasize the importance of candid and explicit discussions about values in planning processes) and practice (collaborative planning demands new methods for policy-makers and planners, such as discursive and participatory forms of governance, modes of negotiable problem definition and consensus building).

Most prominently, Healey has made an outstanding contribution in advocating collaborative planning. As one of the leading proponents for this communicative turn in planning theory she regards it as a new approach to address the spatial organization of urban regions and spatial strategy (Healey, 1996). She explored and outlined the inclusionary communicative approach for strategic discourse construction and strategic consensus-building in five aspects, i.e., arenas for discussion, the scope and style of discussion, sorting through the arguments, creating a new discourse, and agreement and critique (ibid, p231). Based on collective concerns with quality of place in a 'stakeholder society', Healey (1998a, 1998b) emphasized the importance of an interactive and facilitative way involving many stakeholders in the process of collaborative planning and pointed out that this shifts the task of urban planning from 'building places' to fostering the institutional capacity in territorial political communities for ongoing 'place-making' activities.

In her book 'Collaborative Planning: Shaping Places in Fragmented Societies' (1997), Healey combined the value of environment sustainability in the exploration of collaborative planning. This book developed both an institutional approach to understanding urban and regional change and a communicative approach to the design of governance systems, focusing on ways of fostering collaborative, consensus-building practices based on the viewpoint of spatial planning as a 'field' of public policy (ibid, p5-6). Planning, in the multicultural world, is an interactive process undertaken in a social context, rather than a purely technical process of design, analysis and management (ibid, p65-68). This implies planning, as an approach to governance, embodies a policy-driven approach with a long-term and strategic orientation, and interrelates economic, social and environmental dimensions of issues in ways which recognize their complex space-time dimensions. Thus the definition of spatial planning is a focus on the qualities of localities, regions and places through the collective management of shared concerns about spatial and environmental qualities. For Healey spatial planning is an activity which is not just a response to problems, but rather a potential for shaping, or framing the ongoing flow of events and attitudes (ibid, p86).

Healey (ibid, p183) also suggested that how we view the environment is dependent on how we look at our place. The concepts of environment are socially-constructed and interlinked with the other preoccupations and ways of understanding. To go further, it means that enhancing the quality of urban environment needs clarification of the rights and responsibilities in the places where we live. The shared concerns with environmental problems contribute to create a respectful and collaborative attitude to the natural world. In order to strengthen the local capacities for managing various conflicts, she argued for attention at two levels: i.e. the soft infrastructure of inclusionary argumentation through which new understandings and new ways of framing policy and action could be developed, and the hard infrastructure of rules and resources of policy systems (ibid, p243-283). Collaborative planning could be realized by approaches combining these two aspects.

However, there have also been criticisms of theoretical and practical deficiencies of collaborative planning (Fainstein, 2000; Huxley & Yiftachel, 2000; Lauria, 2000; McGuirk, 2001; Margerum, 2002; Brand & Gaffikin, 2007). Fainstein (2000) criticized that communicative theorists neglect of the context and the outcomes of planning when highlighting the planner in the central element of discussion, therefore there is a gap between rhetoric and action in practice. Huxley and Yiftachel (2000) advocated more theoretical debate on issues of power, of the state and of political economy. Margerum (2002) called for attention to the effectiveness of implementation while Brand and Gaffikin (2007) exposed that collaborative planning as a conceptual tool for practitioners is in need of renovation. Apart from the challenges of its theoretical and empirical legitimacy, a communicative or collaborative trend does offer valuable insights for planning systems.

Towards sustainable development planning

Since the 1990s, the importance of sustainable development as a basic principle has been widely recognized in the planning field. The flows of planning ideas and practices have been influenced by the concept of sustainability. Greater attention has been given to the creation of a clean, healthy urban environment along with the aim for economic and social development. Urban planners have been required to be sensitive to the important ecological, aesthetic and physical features in the urban regions. On the other hand, planning has also been encouraged to become more knowledge-based, problem-oriented, public-participative, communicative and action-oriented (Taylor, 1998 p130-153). Therefore, it is timely to combine issues based on the principles of sustainability with collaborative efforts within the procedural process in the planning field. However, how to accommodate sustainability and good spatial quality issues within the planning process is still a big challenge for today's planners.

Cities, as the principal engines of economic growth and the places where most of humanity dwells, are also big contributors to environmental disruption along with their rapid development both within and beyond their boundaries (Newman & Jennings, 2008, p3). Recognition of the urban environment degradation problem has become particularly strong in recent decades. International concern about the global environmental problems after the 1970s has mounted and was reinforced in the wake of the Brundtland report in 1987 and the 1992 Earth Summit in Rio de Janeiro about sustainable development. In contrast to the anti-growth stance of the environmentalists in the 1970s, the concepts of sustainable development seem to offer a middle way that reconciles environmental priorities with the pressures for economic development at local, national and global levels (Ward, 2002, p308). As defined by the report of the World Commission on Environment and Development, sustainable development is 'a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations' (WCED, 1987, p46).

The basic aim of sustainable development is to emphasize the balance of the well-known three-pole sign, i.e. economic development, social equity and environmental protection (sometimes refers to profit, people, planet), so as to create a 'win-win' situation to meet the needs of not only the present but also the future generations. There are many sub-objectives under this main goal. Among them, due to the non-renewable resources in the earth, natural resources exploration cannot be endless; due to the limited elasticity of ecological recovery, environmental quality and its maintenance is an important foundation for economic and social development. That is to say, human development (economic and social) need to integrate the consideration of the natural systems in decision making at the very beginning in order to minimize the adverse impacts on the quality of natural elements (i.e. air, water, land, plants, living beings and other natural resources etc..) and sustain the ecosystem's overall integrity. At a minimum, development must not endanger the natural systems that support life on Earth according to the sustainability concept (ibid, p45). Moreover, sustainability requires the enforcement of wider responsibilities for the impacts of decisions therefore a change in attitudes and objectives and in institutional arrangement at every level is required (ibid, p62-63).

Campbell (2003, pp435-458) also used a simple triangular model to understand three divergent key goals in planning (economic growth, social justice and environmental protection) and the three resulting conflicts (the property conflict, the resource conflict and the development conflict), and further pointed out that the balance of these goals, which is at the center of the triangle, is representing sustainable development. In order to achieve this balance, planners need to combine both their procedural and their substantive skills and thus become central players in the battle over growth, the environment and social justice.

Searching for sustainable urban development was a major theme for planners by the early 1990s. But the connotation of sustainable development is too wide and has undergone much discussion and argument since it appeared. It was not at all clear how sustainable development mapped into actual everyday decision in everyday urban contexts (Hall, 1996, p412). Rather than win-win, during a real development process, there are many 'win-lose' strategies or decisions occurring (Ravets, 2000, p9). The conventional approach which regards economic growth as the essential way to improve the people's standard of living may conflict with equality of benefit distribution and the protection of the ecological environment. Moreover short term activities may conflict with long term benefits. There is more contradiction which is even harder to harmonize in order to organize spatial functions and spatial structure at the local level, such as the urban region. The tension between the shorter term imperatives of regional/global competitiveness and the longer term desires for sustainability often creates bias in local decision making, i.e. pursuing too much the maximization of Gross Domestic Product (GDP).

The urban region, with its interrelation of human and natural systems, is thus full of inherent complexity and uncertainty. Newman and Jennings (2008) advocated that cities should be regarded as sustainable ecosystems and argued that cities need to develop this perspective. They emphasized that 'the ecosystem viewpoint is an inclusive one that sees humans as part of local socio-ecological systems, from bioregions to the biosphere, in which the focus is on relationships and processes that support life in its myriad forms, especially partnerships and cooperation' (ibid, p4). With the growing interest in sustainable development in planning, it is apparent that we need a new paradigm for spatial planning to address the conflicts between economic growth, social justice and environmental protection in the urban region. As Taylor (1998, p168) concluded : '…… one of the most important tasks faced by town planning theorist now is the development of better theory about the environmental qualities which town planning practice should help bring into being'.

To summarize: it should be noticed that the foregoing streams of planning theory and practice do not supersede each other. On the contrary they compensate each other to some extent from different angles. At the local level the physical form and principle of good design remains a necessary and significant consideration for city planning. It is at the broader and more strategic level of planning that the concept of systems and rational process views of planning plays an important role. In the meantime, collaborative and participatory planning can help to move towards a common understanding about problems, objectives and alternatives so as to achieve good quality of urban environments. The new paradigm of planning emphasizes the need to be partial, experimental, incremental, working on problems as they arise (Hall, 1996, p332).

Global environmental problems must in part be tackled by initiating local actions. Localizing concern about the natural environmental health of areas is therefore necessary for sustainable development globally. But local environmental conflicts closely relate to the multi-sided interest groups with different lifestyles. When the objectives of sustainability are translated into actual local contexts, when planning turns to respect and advocate diversity and vitality in urban regions, and when more and more planning theorists realize that the planning decision-making process is often 'disjointed and incremental' or 'muddling through', new approaches and instruments should be more negotiation-oriented in order to reach agreement. Urban planners have to develop a communicative approach for attaining a spatial organization based on the sustainability principles. Actually it is the concern with environmental quality that justifies the communicative approach now emerging in planning theory, which is a foundation for a form of collaborative planning (Healey, 1997 p7). From the perspective of sustainable development, spatial organization needs public participation and communication, thus planning needs to be more open, negotiable and integrated. Therefore combining the sustainable development principle and collaborative planning approach could offer a new mode for problem-centered and procedural approaches in the planning practice. It is the basis in this study to explore the approaches integrating surface water system in urban and regional planning in the Chinese context.

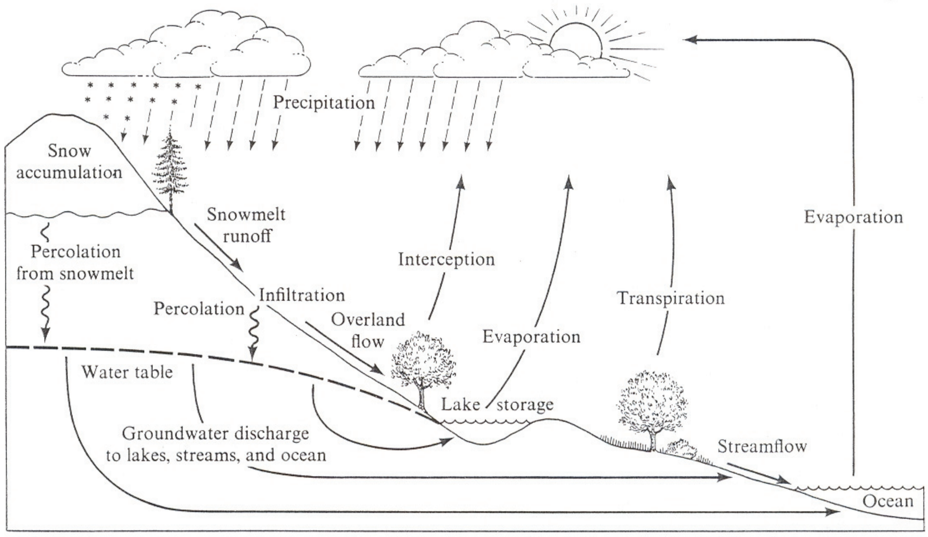
2.2 The hydrologic process and the water issues in urban region

As one of the indispensable components of the physical environment, water is one of the most important limiting factors to life and life support system on Earth. It is also an aspect with distinct but variable spatial claims in the watershed. This section discusses the issues and the challenges of water-related problems in the urban region. Because the quantity and quality status of surface water is related with the status of its surrounding surface land use, understanding the natural features of surface water systems and the spatial relationship with human activities in the urban region is helpful for urban planners and water managers to revalue its roles in spatial planning.

2.2.1 The features of the hydrologic cycle

As summarized by Marsh and Grossa (2005, p250), the Earth's water is held in five natural 'reservoirs': the oceans, glacial ice caps, groundwater, surface water (lakes, streams, wetlands) and the atmosphere. Around 97.4% of the water in the Earth is retained in the oceans, 2% in glacial ice caps of Antarctica and Greenland, and only 0.6% in the groundwater, surface water and atmosphere which belong to freshwater. Only the freshwater can be used as a water resource for humans and other terrestrial organisms. Land use change may influence the water availability noticeably (Klocking & Haberlandt, 2002). Understanding the hydrologic process as a dynamic system can be of great assistance in knowing why the capability of fresh water storage or maintenance, runoff mitigation, infiltration and water purification has close relationship with the condition of surface land use.

The hydrologic cycle (Figure 2.1) shows the ways in which water moves from ocean to atmosphere to earth and back to the ocean. During this endless circulation, water is stored temporarily in surface water or groundwater which becomes available for the use of humans and terrestrial flora and fauna (Dunne & Leopold, 1978, p4-5; Marsh & John Grossa, 2005, p 250-252). Afterwards, most water passes to the sea via rivers and streams, or evaporates to the atmosphere. This natural hydrologic process possesses the following characteristics:



Source: Dunne and Leopold (1978, p5)

Figure 2.1 Diagram of hydrologic cycle

(a) The hydrologic cycle has its own dynamic process. The components of the whole process include precipitation, evaporation, runoff, infiltration etcetera, none of which are static within the cycle. The cycle is driven by solar energy to evaporate water as water vapor originally from the oceans. When the atmospheric vapor condenses to form droplets, a portion of water is precipitated to the Earth, generally as rain or snow. About 22% of this precipitation falls on the continents and the remainder falls into the oceans. Precipitation delivered to the continents by the atmosphere is an important component of the weather and climatic system. The distribution of precipitation is highly uneven geographically and the rainfall in specific areas varies over time. This natural, perennial phenomenon has its own continuously changing patterns and is largely beyond human control.

(b) Water always has its own balance status. If we regard precipitation as a source of income of water, the outflow of water will be interception, evapotranspiration, overland flow, change of soil moisture storage, change of groundwater storage and groundwater runoff (Dunne & Leopold, 1978, p239). The intensity and duration of precipitation is continuously changing, also in areas characterized by intermittent wet and dry seasons. The balance of income and outflow of water determines the situation of the water environment of the area. The amount and type of outflow of water depends upon the conditions of land use cover, vegetation and soil texture etcetera. Keeping water longer in the lakes, wetlands, forest areas and groundwater is helpful in reducing the peak rate of runoff in the storm season and increasing supply of the base-flow in the dry season. It also helps to ensure enough water resources for human use, which is especially important at the local level.

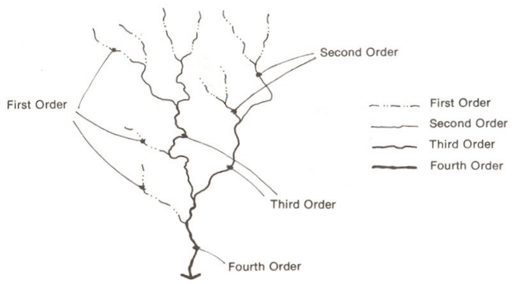
(c) The hydrologic cycle has a close relationship with the condition of the Earth surface. As Figure 2.1 shows, the precipitation that falls on the Earth has different ways to follow: some is intercepted by vegetation and returns via evaporation and transpiration back to the atmosphere; some infiltrates or percolates into the soil and underground water table, some is stored temporarily in lakes, wetlands or reservoirs, and some runs quickly down-slope into streams or rivers as overland flow. The conditions of surface land use can influence how much rainfall is infiltrated, run off or evaporated. As the vegetation cover can intercept much of the rainfall and evaporate it into the atmosphere, it 'performs a vital function of maintaining stream flows; reducing peaks and potential flooding, but sustaining flow in dry periods' (Hough, 2004, p27). Moreover, the infiltration capacity of the soil determines the volumes of storm runoff, its timing and its peak rate of flow. So 'vegetative cover and land use are very important controls of infiltration' (Dunne & Leopold, 1978, p167).

(d) Water-related problems are always interrelated with human activities. Generally, they can be classified as quantitative and qualitative water problems. For the quantitative water problems, too much water in the storm season increases serious flooding risks, and too little water in the dry season causes drought and water shortage. Both of these finally influence the safety of human life. Qualitative problems, e.g. water pollution, are largely ones which humans introduce into the hydrologic cycle. Based on the way in which the pollution is discharged, there are two categories of pollution, point source and non-point source. Point source pollution is released at a known discharge point or outfall, usually a pipe or ditch. Non-point source pollution represents spatially dispersed sources that are released in various ways at many points in the environment, such as via agricultural pesticides. The majority of surface water pollution comes from non-point sources which are generated from various land use types and land use density (Marsh & John Grossa, 2005, p 282-290).

2.2.2 Water-land relationships in the watershed

A watershed or drainage basin is the area of land where water drains downhill into a common outlet which could be a river, lake, wetland, sea or ocean (Dunne & Leopold, 1978, p495; Marsh & John M. Grossa, 2005, p228). It is separated topographically by a ridge, hill or mountain and can vary in size. 'All land surfaces, no matter how dry they may be, belong to a drainage basin of some size' (Marsh & John Grossa, 2005, p. p260). That means all land areas on the Earth are part of one watershed or another. Dunne and Leopold (1978), Marsh (1991; 2005) and Randolph (2004) expounded the relationship between water and land use in watershed from the environmental viewpoint. The same observation is that 'managing a water body requires managing the land that drains to it' (Randolph, 2004, p253).

A watershed is drained by a hierarchical network of channels, i.e. drainage network, which is organized like the branches on a tree: smaller ones, mainly on the perimeter, lead to larger ones towards the center. It can be shown as stream orders (Figure 2.2). The first-order streams are the most abundant streams in every drainage network (Marsh, 1991, p133). Accordingly, a drainage basin can be ranked as a nested hierarchy (Figure 2.2).



Stream order classification according to rank in the drainage network

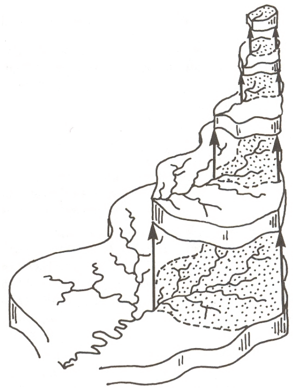


Illustration of the nested hierarchy of lower-order basins within a large drainage basin

Source: from Marsh (1991, p132-134)

Figure 2.2 Stream order classification and the nested hierarchy of watershed

In practice, the development of land use often alters drainage networks by obliterating natural channels, adding artificial channels, reclaiming lakes and wetlands, or changing the size of the drainage basin. These activities can bring about bad environmental consequences, such as flooding, dehydration, poor water quality, loss of aquatic habitats and lack of spatial amenity and identity. The water system in a watershed implies two interrelationships:

(1) The first is the relationship between land use and conditions of water bodies. The types and intensity of land use could result in the quantitative or qualitative water problems. Randolp (2004, p373) described clearly the influence of land use situation on water quantity problems (too much water or too little water):

> ……paving and covering the land with impervious surfaces and constructing drainage pipes and lined channels, acts to increase the peak discharge from a given storm event by (a) reducing the amount of water that infiltrates the ground, thus increasing the volume of surface runoff, and, (b) increasing the rate at which the runoff accumulates, reducing the hydrograph lag time. Because of impervious surfaces, less water infiltrates the ground, and, thus, less is available for groundwater-contributed base-flow between storms, especially in dry weather periods. As a result, urban streams run faster and higher during storms and often run dry between storms.

In addition, researches by Marsh (1991, p161) and Randolph (2004) have shown that land use not only affects runoff quantity, but also impacts water quality as surface runoff from cultivated, disturbed and developed land carries water contaminants to receiving waters. The water-land process in a watershed is an integrated system and, consequently, needs to be considered as a complete entity.

(2) The second is the relationship between upstream and downstream. Deforestation and development of land in the upstream often have a pronounced influence on the downstream. 'The lower the location in a drainage basin, the more likely are problems posed by upstream water use, flood sizes, land drainage, and flat, uninteresting terrain' (Dunne & Leopold, 1978, p501). Storing water in the upstream as long as possible is helpful to eliminate the inundation in the downstream, whereas keeping the meandering of small creeks or brooks in the upstream are important as well.

Watersheds vary in size and range from very large basins to very small catchments. Table 2.2 shows different characters of different watersheds, therefore the management approach selection is different. Thinking globally, acting locally is the basic principle for watershed (Randolph, 2004, p256).

Table 2.2 Characteristics of Watershed Management Units

Watershed Management Unit	Typical Area (Square Miles)	Influence of Impervious Cover	Sample Management practice
Catchment	0.05 to 0.5	Very strong	Practices and site design
Sub-watershed	1 to 10	Strong	Stream classification and management
Watershed	10 to 100	Moderate	Watershed-based zoning
Sub-basin	100 to 1,000	Weak	Basin planning
Basin	1,000 to 10,000	Very weak	Basin planning

Source from: (Randolph, 2004, p257)

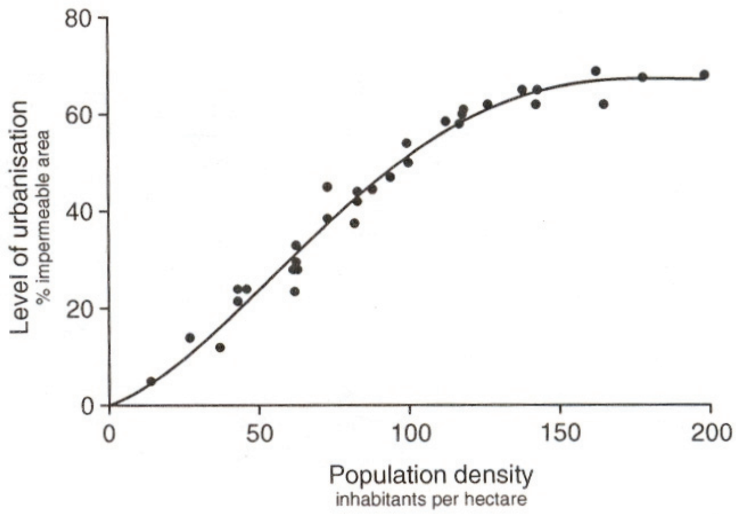
2.2 3 Damage to surface water systems by urban development

In a well-developed urban area, water-related infrastructure and conduit systems are generally constructed with the purpose for draining the runoff flow as soon as possible to create safe and clean environment for human settlements. However, the fact is that this drainage infrastructure significantly alters the original natural hydrologic system. In an unregulated development area, the drainage system is not well constructed but the natural water regime and environment may also be destroyed due to inappropriate land use. Randolph (2004, p373) summarized four damaging effects of hydrologic changes caused by land development and urbanization, such as: downstream flooding exacerbated by the increased peak flows; serious water contaminants carried by urban runoff to the receiving water; reduction of groundwater storage and dry weather stream flows because of reduced infiltration; and destruction of natural creeks and streams caused by urbanization directly and indirectly.

Douglas (1983, p51-59) examined in detail the modification of the hydrologic cycle in the urban area. He used a matrix to summarize the relationship of urban activities (including modification of land cover or landform, construction, water supply, waste disposal, channel modification) and their impacts on hydrologic parameters (such as water quantity, water quality and fluvial geomorphology). His study offers the fundamental knowledge to understand the modification of natural hydrologic processes in the urban area. The key points of the results in his study showed that:

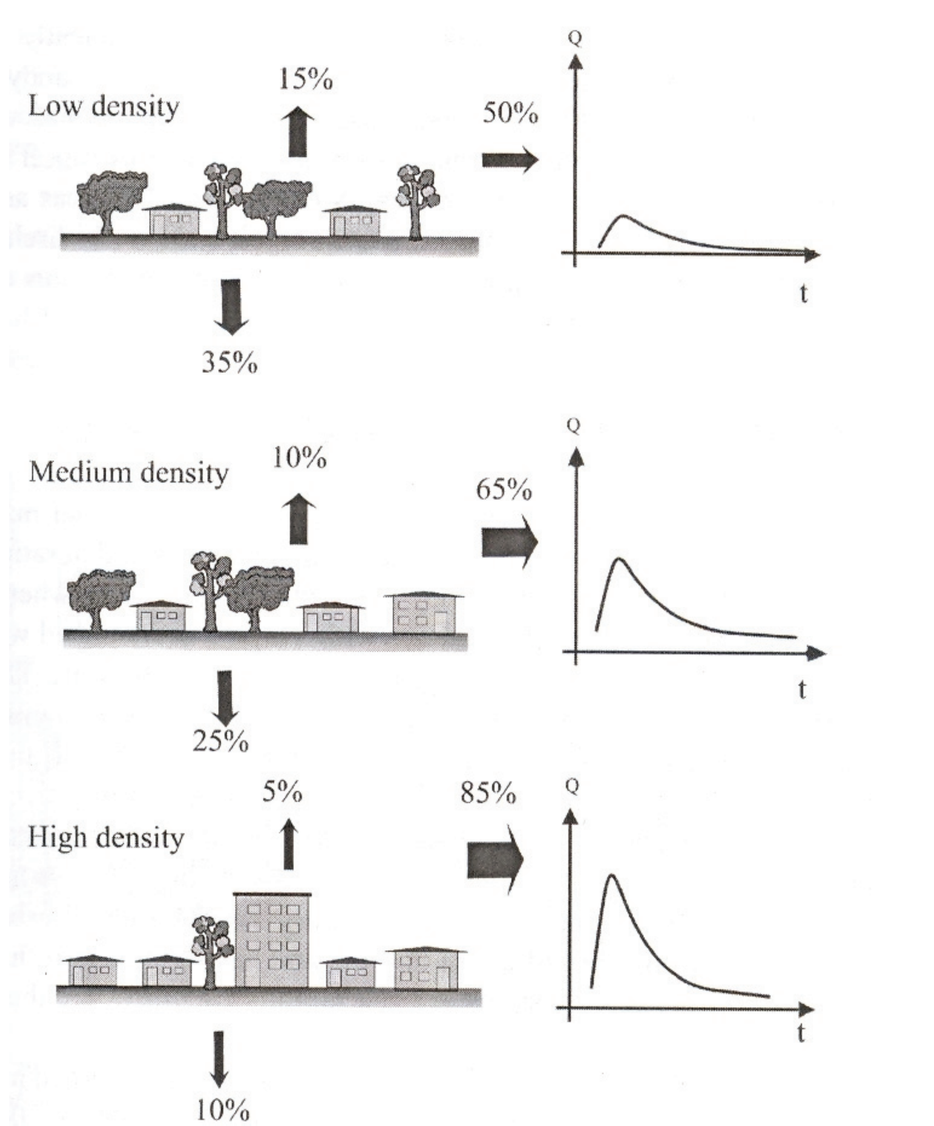
(1) Precipitation tends to increase on the download side of cities or large industrial complexes because increased thunderstorms create large quantities of storm water runoff.
(2) The evaporation in an urban area reduces due to the increase of impervious cover.
(3) Paving and roofing an area also decreases the opportunities for water to infiltrate. Reductions in infiltration and the redirection of water from paved surface directly to storm water drains and stream channels results in a loss of recharge to the groundwater reservoir.
(4) Runoff velocity, runoff volumes and discharge rates increases, so does the flood peak in urban area.
(5) Hydrologic effects (positive or negative) were different during urban transitional process through the stage of pre-urban, early urban, middle-urban, and late-urban.

The research by Parkinson and Mark (2005, p4-5) illustrates how the percentage of impervious areas increases with the population density (Figure 2.3) and the effects of such urbanization on urban storm-water runoff patterns (Figure 2.4). Although different development patterns in different cities may not have the same curves as shown in the figures, the basic trend is similar. It is obvious that high density can bring about high runoff volume, thus high risk for flooding after much accumulation. Several studies (Correia et al., 1999; Camorani et al., 2005; Stone & Bullen, 2006) also addressed the same effects of land use change on flood risk. Their research concluded that it is very important to consider flood management in the land use planning process in order to minimize flood risk and vulnerability.



Source from: Parkinson (2005, p4)

Figure 2.3 Level of urbanization (% impervious area) plotted against population density in Sao Paulo, Curitiba and Porto Alegre, Brazil



Source from: Parkinson (2005, p5)

Figure 2.4 Effects of urbanization on urban storm-water runoff patterns

Besides these water quantitative issues, Hough (2004, p30-33) indicates that water quality and aquatic life is impaired in the highly urbanized area because of a wide variety of chemical pollutants, salts, heavy metals and debris from roads and other paved surfaces. The storm runoff easily carries these contaminants into the receiving water bodies, especially in the forest-cleared land. The research by

Ngoye and Machiwa (2004) about Ruvu river basin in Tanzania showed that 'the stretches of the river in forested areas had lower levels of nutrients compared to areas close to human activities. The most affected areas were those close to human settlements'. Sliva and Williams (2001) demonstrated that urban land use had the greatest influence on water quality, the influence of agricultural land use was variable and forested land use appeared important in mitigating water quality degradation. The study of Hwang et al. (2007) revealed that land use within a watershed has a direct impact on the water quality of adjacent aquatic systems. The evidence has also been documented (Hall & Ellis, 1985; Kelly & Lunn, 1999; Tong & Chen, 2002; Morse et al., 2003; Conway, 2007; Bahar et al., 2008) that there is a strong link between land use changes and water quality decline through surface runoff which is an important source of non-point source pollution.

2.3 Summary

To summarize, the hydrologic cycle as a natural dynamic system implies a strong relationship between the water system and land. It is very sensitive to the disturbance from human activities. The former research shows that the natural water system in the urban region has been greatly damaged and replaced by artificial systems due to intensive land use cover change, which have brought about many quantitative and qualitative water problems. Therefore, it is necessary to emphasize integrated land-water management in the urban region (Carter et al., 2005) in the light of the hydrologic process. However, water and land has long been studied in separate disciplines and in practice managed by different organizations. Water management and land use planning (as part of spatial planning) are dominated by different expertise. It is obviously not easy to combine them.

Embedding sustainable development at the heart of the planning system means the pursuit of good quality of space by linking economic and social development with physical or spatial management. From the sustainability perspective, spatial planning at the urban and regional level can play an essential role by defining the nature, location and density of land use, and the ways and means for people to travel and goods to be transported, which also affects the urban ecological system. It is therefore necessary to involve surface water system in the planning contents and integrate surface water management in planning process, which is a precondition for creating good quality of space in urban region.

Chapter 3 Integrating Surface Water Systems in Spatial Planning

As explored in chapter 2, surface water systems are part of nature and undoubtedly play an important role in promoting the concern for urban sustainability. This chapter moves on to the discussion of the related spatial concepts, planning approaches and appropriate institutional development for surface water systems in spatial planning and design. A theoretical conceptual model for integrating surface water management in spatial planning is also brought forward.

3.1 Functions and spatial implication of surface water systems

Surface water systems possess at least three groups of functions in urban regions: natural ecological functions, social and economic functions and physical spatial functions (Figure 3.1). Proper utilization and protection of these functions are important for sustainable urban development. In this study, I argue that it is essential to understand the spatial expression of surface water systems through surface water bodies, riparian buffers and watersheds (Figure 3.1); these are elaborated in the following text.

A commonly accepted definition of surface water bodies does not exist. The definition of the European Water Framework Directive (WFD) (EC, 2000) about surface water bodies refers to the concept of wetlands. However, the WFD still does not provide a size range to indicate their dimension (Rodriguez-Rodriguez & Benavente, 2008). Wetland definition and classification is also confusing. Mitsch and Gosselink (2000, p25-34) summarized the definition from scientific and regulatory perspectives and pointed out three components as the basis of a wetland definition: hydrology, physicochemical environment and biota. The 1979 U.S. Fish and Wildlife Service defined wetlands as 'lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water' (Cowardin et al., 1979, cited by; Mitsch & Gosselink, 2000, p29). The Ramsar Convention 1971 gave a broad international definition of wetland as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters'. The two latter definitions are often used now.

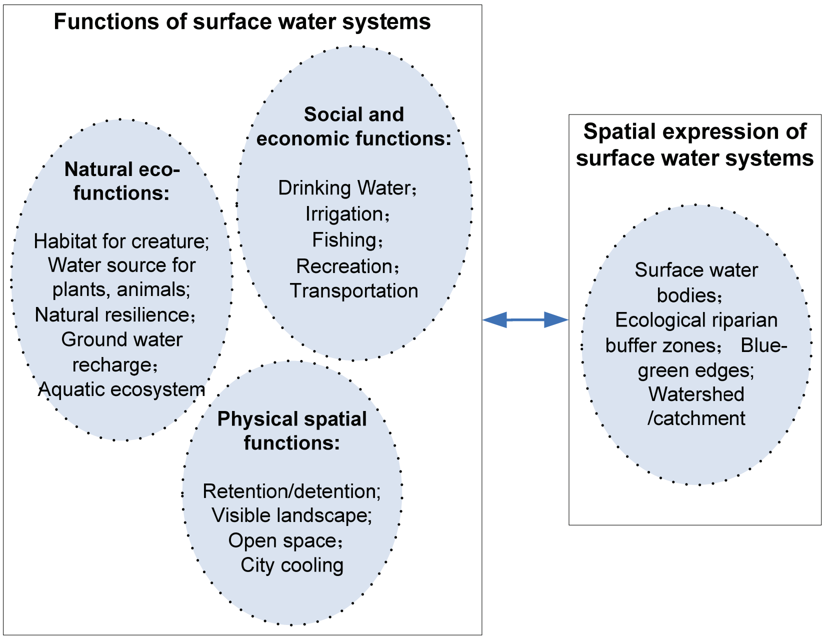


Figure 3.1 Functions and spatial expression of surface water systems

In nearly all publications, conservation and 'wise use' of all wetlands are promoted (Farrier & Tucker, 2000). This thesis does not intend to reformulate these definitions but rather to emphasize that surface water bodies, as wetlands, possesses very high ecological value and play an important role in a healthy and functional ecosystem. In the case study, two forms of surface water bodies are the subject of attention: lakes and shallow water bodies. Both forms commonly exist in urban regions along the middle and lower reaches of river systems, such as the Yangtze River basin. Chapter 4 will offer the explanation in detail based on the situation of case study area.

According to Marsh (1991, p138), a watershed, especially a small one, comprises three interrelated parts: an upland zone that generates over flow and ephemeral channel flows; a collection zone where runoff from the upland zone accumulates; and a conveyance zone containing the main stream and valley through which water is transferred from the collection zone to higher order channels. Each zone has different hydrologic behaviour and in turn calls for different development planning and management guidelines. The constraints and opportunities associated with each of these zones, as Marsh (ibid, p140) mentioned, '… provide a rationale for defining the spatial patterns of land units, including buildable land, open space, and special use areas on a basin-by-basin basis.' In addition, he (ibid, p141-142) emphasized the importance of utilizing and providing buffer zones to protect collection areas and streams from development zones. However in urban regions, these zones always interrelate with other urban land use and are therefore not easily delineated.

The riparian buffer zones that were regarded as terrestrial-aquatic eco-tones by Naiman and Decamps (1997), form important riparian ecosystems. As a transition area between the terrestrial and an aquatic ecosystem, it occupies a unique position in the watershed landscape. The riparian areas of water bodies are important for the quality of water bodies (Anbumozhi et al., 2005). Randolph (2004, p466) suggested that the riparian zone can be the lands proximate to lakes, streams, and estuaries and it is physically and ecologically related to the aquatic zone (also conveyance zone called by Marsh) and upland zone. The riparian zone can be divided into three sub-zones, i.e. streamside, middle and outer zones, each with their own characteristics (see Table 3.1). Correspondingly, different management approaches are needed in each zone.

The preservation and conservation of surface water bodies and their ecological riparian buffer zones is very beneficial to the natural system as well as to the urban environment. They possess high ecological values and are an important part of the natural environment; they therefore offer many opportunities for enhancing and improving the spatial quality and identity of both natural and urban areas.

Table 3.1 Characteristics of different parts in a riparian buffer zone

Characteristics	Streamside Zone	Middle Zone	Outer Zone
Function	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
Width	Minimum of 25 ft plus wetlands and critical habitat	50-100 ft depending on stream order, slope, and 100-year floodplain	25-ft minimum setback to structures
Vegetative Target	Undisturbed mature forest; reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turf-grass
Allowable Uses	Very restricted (e.g., flood control, footpaths, etc.)	Restricted (e.g. some recreational uses, some stormwater BMPs*, bike paths)	In-restricted (e.g., residential uses, including lawn, garden, compost, yard wastes, most stormwater BMPs*)

Note: *BMPS is the abbreviation of Best Management Practices. This term refers to a broad array of non-structural techniques and engineering structures used to improve the quality of urban stormwater, such as extended detention basins, retention basins, water quality trenches, sand filters, and stormwater wetlands etcetera.
Source from: (Randolph, 2004, p478)

Moreover, as mentioned before, storm runoff has an important influence on quantity and quality of the receiving water bodies. This implies that the condition of surface land use in the watershed may bring about either negative or positive impacts on surface water bodies. In order to mitigate the negative impacts and exert the positive ones, land use planning in watersheds must consider proper spatial organization and integrate water as a determinant of good quality of space. In this regard, the status of surface water bodies is closely interrelated with the land use conditions of riparian buffer zones and watersheds.

3.2 Spatial considerations for surface water management

Walesh (1989, p25) analyzed two approaches for the design and operation of the urban drainage system: a traditional conveyance-oriented approach and a storage-oriented approach. The system designed with the traditional conveyance-oriented approach intends to collect storm-water from the collection area and convey it efficiently to the discharge point in order to minimize damage and disruption within the collection area. But as Parkinson and Mark (2005, p33-34) criticized, this approach focuses too much on technical solutions in a fragmented manner and tends to address problems after they occur, with little attempt in advance to prevent or mitigate the problems in the collection areas as well as the problems happening down-stream or outside the collection area.

Realization of this shortcoming resulted in the shift during the 1970s to a storage-oriented approach (Niemczynowicz, 1999) with a focus on detention, retention and recharge. The storage-oriented approach provides for the temporary storage of storm-water runoff at or near the point of origin, with subsequent slow release to downstream storm sewers or channels, minimizing damage and disruption both within and downstream from the site (Walesh, 1989). The advantages of this approach are: possible cost reductions in newly developing urban areas, prevention of downstream adverse flooding and pollution, and potential for multiple-purpose use of retention areas. The principle elements of this approach are detention and retention facilities which can serve as several functions, including quantity control, quality control, recreation, and landscape aesthetics. The storage-oriented approach for surface water management needs space for its measures. These spaces always possess multiple and mixed functions. They are classified and described as follow.

(1) Space for detention/retention facilities. A detention/retention facility is a useful measure for sustainable surface water management. Detention facilities are used for temporarily holding or detaining surface water during and immediately after a runoff event by the natural swales, natural surface depression, infiltration or filtration basins which are normally dry during the dry season. Retention facilities are applied for containing or retaining a substantial volume of water during the normal season and for temporarily stored excessive water during the storm season. Natural or artificial lakes, ponds, reservoirs and wetlands can be used as this space with mixture of other functions such as recreational, aesthetic and water supply in urban area.

(2) Space for riparian corridors or buffer zones. Another effective measure is riparian corridor preservation and restoration for surface water bodies. Riparian vegetation, especially forest, plays an important role in filtering out contaminants from upland runoff, stabilizing stream banks, providing critical edges and corridors for wildlife habitat, maintaining lower temperatures by shading water, and providing cover and food supply for aquatic species. Thus vegetated riparian buffer zones offer good quality space not only for nature but also for human beings. Realizing the values of healthy riparian zones is important for surface water management and good land use planning and management. Rivers passing through a city form important ecological corridors. For lakes or wetlands, riparian area is also an important ecological buffer zone. In delineating stream/river corridor or lakes/wetlands buffer zones, land use in the watershed areas is considered of importance.

(3) Space in the watershed. The watershed is regarded as a useful spatial unit in considering on-site bio-retention, retaining site vegetation, using narrower streets and permeable pavements, minimizing impervious cover, and holding the buffer zones and vegetation of open spaces, which are all beneficial to good status of water systems. In addition, forested land use appeared important in mitigating water quality degradation (Sliva & Williams, 2001). Therefore, typical design measures in watershed which are called Low Impact Development (LID) (which will be discussed in detail in the next section), i.e. integrated management practices (Randolph, 2004, p442-443), have raised much attention in the land use planning and management of watersheds.

To summarize, natural drainage (i.e. meandering of rivers and creeks), open spaces with natural vegetation, existing lakes or wetlands and infiltration surfaces are all important for maintaining good condition of surface water systems. Retaining these lands, regulating impervious surfaces and reserving filter traps in the watershed are important measures which should be integrated into spatial planning and water management. Only through the cooperation between spatial planning and water management can these measures become effective.

3.3 Spatial planning approaches for surface water management

Hall (2002, p4) indicated that the central point of urban and regional planning concerns with the spatial impact of many different kinds of problems and with the spatial coordination of many different policies in the urban region. In general, the primary objective of spatial planning is to make decisions about the rational use of spatial resources to satisfy the demand for various urban activities without deteriorating the quality of space. In other words, spatial planning on the one hand need to seek the way to protect the natural resources where possible, and on the other hand utilizes suitable technologies to repair the natural system which has been negatively altered by anthropogenic disturbance. All the competition for space and other scarce resources needs to be balanced. In the context of sustainable development, the question as to where not to develop is of the same importance as the question as to where to develop. The previous analysis demonstrates that hydrologic regimes may be altered substantially or perhaps even permanently in the urban region due to intensive human impacts, therefore spatial planning has to involve water spatial issues in a substantial way.

However, in practice, urban planning and urban water management often have different and separate approaches to deal with the management of storm water, surface water bodies, water supply and wastewater. Urban planning regards these water affairs as belonging to the basic infrastructure and more attention is paid to urban land use development. In addition, urban water management focuses more on engineering techniques to build and manage these water infrastructures to satisfy urban demand. There has been a gap between the two fields in considering the spatial needs for the water system itself. Only in recent decades has it been appreciated that surface water management requires more than just drainage and treatment technology; corresponding improvements and innovations in land use practices are also required.

There has been growing concern with the natural water cycle and ecological systems in urban region. Since the 1990's, so called Best Management Practices (BMPs) have been discussed and used in USA to control the pollution of urban runoff and protect the receiving waters to which the runoff drains (Roesner et al., 2001; Strecker et al., 2001; Perez-Pedini et al., 2005; Zhen et al., 2006). Strecher et al. (2001) defined the terminology of BMPs as 'device, practice, or method for removing, reducing, retarding, or preventing targeted storm water runoff quantity, constituents, pollutants, and contaminants from reaching receiving waters'. Perez-Pedini et al. (2005) concluded that examples of BMPs include infiltration trenches, pervious pavement, grass swales, buffer strips, detention, retention, and bio-retention basins, which are further classified as infiltration-based BMPs and storage-based BMPs. Moreover, there is also another kind of classification: structural BMPs (designed to trap and detain runoff to settle or filter out the constituents before it enters receiving waters) and non-structural BMPs (designed to control pollutants at the source to prevent or reduce contamination of storm water runoff) (Zhen et al., 2006). In order to be effective and practicable, BMPs have to involve technological, economic, and institutional considerations compatible with environmental quality goals. In other words, BMPs are innovative, dynamic and improved environmental protection practices with effective, practical, structural or non-structural methods applied to prevent or reduce the movement of sediment, nutrient, pesticides and other pollutants from the land to surface or ground water. The main principle is to balance between water quality protection and other development within natural and economic limitations.

Moreover, in recent years, there has been a rapidly growing interest in Low Impact Development (LID) as a way to mitigate the negative effects of increasing urbanization and impervious surfaces (Prince George's County, 1999; Zhen et al., 2006; Dietz, 2007). Perez-Pedini et al. (2005) deemed that LID offers a new approach by proposing the integration of storm water controls throughout an urban landscape in a more distributed manner than conventional structural BMP systems, while Zhen et al. (2006) considered it as part of BMP. In fact, as defined by Prince George's County in Maryland (1999, G-3), LID is 'the integration of site ecological and environmental goals and requirements into all phase of urban planning and design from the individual residential lot level to the entire watershed'. The overall goal of LID is to preserve the pre-development hydrology of a site by using site design techniques to store, infiltrate, evaporate and detain runoff. Dietz (2007) clearly pointed out that the LID approach advocates more careful site design in the planning phases. Zhen et al. (2006) also indicated that LID uses a systems approach that relies on natural landscape functions to manage runoff as close to the source as possible. This source control concept is quite different from the traditional end-of-pipe control approach and similar to the aforementioned non-structural BMPs. According to Prince George's County (1999), the fundamental principles which must be integrated into the site planning process include: using hydrology as the integrating framework, thinking micromanagement, controlling storm-water at the source, using simplistic and non-structural methods, and creating a multi-functional landscape (ibid, pp2-2 to 2-6).

The hydrologic tools used in LID design mainly include (1) preserving and protecting environmentally sensitive site features such as riparian areas, floodplains, stream buffers, wetlands, woodlands, conservation zones, valuable trees, steep slopes and highly permeable and erosive soils; (2) reducing/minimizing/disconnecting impervious surface by preserving more trees or meadows; (3) maintaining time of concentration of peak runoff by lengthening flow paths (ibid, p 3-11). Therefore several techniques are used in LID practices such as rain gardens or bio-retention, green rooftop, rain barrels and cisterns, sidewalk storage, grassed swales, vegetated buffers and strips, infiltration trenches, and permeable pavements etcetera.

In addition to the above research of BMP and LID, the other individual LID-BMP practices such as bio-retention (Davis, 2008), pervious pavement (Moglen & Kim, 2007), green roof (Carter & Jackson, 2007) and infiltration trench (Kronaveter et al., 2001) have been studied in recent years. It can be concluded that both BMP and LID are part of a new paradigm for surface water management. They both emphasize the making of onsite multi-functional, multi-beneficial and optimized treatment so as to allow the developed area to retain a better hydrologic regime in a watershed (Coffman, 2002).

Based on these principles and concepts, water sensitive planning and design have been advocated. Carmon et al. (1997) suggested that water sensitive urban planning has the potential to be viable technically, economically and socially, therefore it can contribute to sustainable development. The 'Handbook of Water Sensitive Planning and Design', edited by Robert L. France (2002) emphasized the importance of the paradigm shift not only on water management but also on planning and design. He comprised 17 chapters to deal with storm water management and wetland park creation (two important issues associated with water sensitive design); and another 17 chapters to deal with management of watershed and riparian buffer-corridors (two important issues associated with water sensitive planning). These researches and case studies show that advocating water sensitive planning and design is beneficial to water systems as well as to urban development in the watershed. Detention/retention measures and infiltration measures are helpful for water quantity and quality control in the urban environment. Preserving vegetated area and open space, surface water bodies (natural or artificial) and natural areas are similarly important. In the meantime, water is one of the important elements for urban planning and design to retain natural and cultural diversity, to create high quality urban space, and to entertain urban citizens, all of which implies spatial consideration. These water spatial issues may only be tackled when they are explicitly integrated into a spatial planning process.

Good planning helps to offer better choices for where and how people live. Integrating the above mentioned water spatial concepts may bring some new issues into the local planning system, including new problem areas, new claims for policy attention, new data collection and information analysis, new concepts of spatial organization and urban design, new criteria of plan alternatives and adoption, and new cooperation demands for implementation in existing administrative authorities. Because spatial planning organizes space through various scales, from large scale to small scale, with different objectives, spatial consideration of surface water system needs to be embedded from strategic level (i.e. master planning, land use planning) to action level (i.e. on-site design). Therefore the following points need to be emphasized in contemporary spatial planning.

1. The incorporation of LID or BMP principles in the planning system requires creation of new spatial concepts for water systems which better reflect natural hydrological processes. In this regard, the watershed or catchment could be a useful spatial unit to take into account the reduction of impervious area in land use planning. Existing surface water bodies and wetlands can be used as important elements for urban spatial structure so that they need to be preserved, conserved or restored as far as possible. Buffer zones or riparian corridors need to be involved in urban afforestation and the green system. Using water-related space in a multi-functional way in spatial planning is certainly helpful in creating good opportunities to control water problems as well as to improve the quality of space.

2. The taking of more implementation-orientated methods is helpful to mitigate the negative effects of urban development on hydrologic regimes. It requires that planning at the strategic level concerns not only the long term vision but also the short term action, offering an open, democratic, participative environment for plan-making and plan implementation. At this level, it is essential to consider hydrology in the planning framework to identify sensitive water spaces and integrate them in shaping spatial form and the multi-functional landscape. Land use principles are advanced and grounded on water spatial concepts. Cost effective on-site design is encouraged to preserve the hydrologic functions of the landscape. At the local level, zoning ordinances, subdivision land use regulations and other planning tools need to involve more specific items, including designation of water sensitive areas being protected, regulations of development density and onsite layout requirements for minimizing imperviousness. During the construction phase of the project, making water systems visible and aesthetical may be an important principle of on-site design

related to the natural features of the site. Design guidance and design techniques to limit imperviousness are also needed.

3. Public participation and consensus building needs to be encouraged in the planning process. As argued by Carter et al. (2005) that 'the concepts of integrated and sustainable management are germane to the coordination of land use planning and water management activities', it is necessary to achieve the professional agreement between urban planners and water managers at first, and more importantly to ensure that all other stakeholders have an understanding of, access to, and involvement with management practices. It is necessary to create collaborative planning processes aimed at strengthening and mobilizing social networks to support the initiatives, requirements and incentives of water sensitive planning and design which can stimulate household, communities, cities to take appropriate behaviours. In fact, enforcement can prove costly if it subverts useful customs, distorts professional judgment, or displaces democratic participation (Hoch, 2000, p21). Therefore, undertaking stakeholder participation during the preparation of a spatial plan is expected to be beneficial to the final implementation.

4. The utilization of information support systems is a precondition to reach consensus among the different interests during plan-making process. The information about the landscape features and water quantity and quality records is helpful for people to raise awareness and understand the problems, to reach the consensus of planning goals and finally solve the problems cooperatively.

3.4 Institutional development for spatial surface water policy

In this study, I argue that integrating surface water management in spatial planning means considering spatial requirement for water in advance and implementing it in a creative way. This raises a question of how the new concepts and approaches can be widely adopted. As aforementioned, an effective way is to raise awareness so that people understand how to define and measure the problems at the initiate stage and agree on the follow-up alternative solutions. How we perceive the human relations with the natural hydrologic systems may affect how we deal with the associated water problems. Therefore, in order to achieve a common awareness and prejudgment before the potential risk becomes reality, institutional development as a strategy is necessary for both the spatial planning and water management spheres.

Many researchers view institution as being different from organization (Hoek, 1992; Franks, 1999; Healey, 1999). Organization is defined as structures of recognized and accepted roles (Hoek, 1992), while institution is regarded as 'stable, valued, recurring patterns of behaviour' (Franks, 1999) or 'enduring regularities of human action in situations structured by rules, norms, and shared strategies, as well as the physical world' (Crawford & Ostrom, 1995). Israel (1987, p1) defined institutional development as 'the process of improving the ability of institutions to make effective use of the human and financial resources available'. In one way or another, institutional development has been advocated both in spatial planning (Healey, 1999) and water management (Franks, 1999) for involving more inclusionary approaches to integrative policy. From a perspective of institutional development, the integrated water-space policy has to be embedded in the social context or social networks in order to gain the support and cooperation of the public. Good performance of institutions on water-spatial issues in urban region rests with common public awareness as well as good urban governance concerning political and administrative elements. Healey (1997) has reviewed spatial planning as a field of public policy and perceived that the quality of space depends critically on local capacities for managing various conflicts of urban activities. She suggested that the institutional capacity building in governance should provide a 'hard infrastructure' of a structure of challenges to constrain and modify dominant centers of power (i.e. rights, duties and competence), and a 'soft infrastructure' of relation-building through which sufficient consensus building and mutual learning can occur (ibid, p200). In Healey's view, spatial planning cannot exist apart from the world of economic activities, social life and the natural environment.

Water is a very special sector which has a wide coverage in the urban region. In many countries, the administrative structure for water management and spatial planning has existed separately at national, provincial and local levels. This to some extent creates a kind of administrative inertia to cooperatively deal with water problems. Integration of surface water in spatial planning thus demands a broader societal framework within which there is a need for significant changes to existing administrative systems concerning water, land, and related resources. Such change should facilitate the interactions between different stakeholders within the spatial planning and water management spheres with divergent interests. However, alteration of conventional or established views, whether in spatial planning or water management, is not easy. In fact, it is a complex and controversial process which is fully backed by 'political will', 'appropriate information' and 'adequate administrative and managerial capabilities' (Sagasti, 1990). Hoch (2000, p21) pointed out that 'plans are more likely to be successfully implemented when they are based on shared beliefs, especially beliefs that are acquired through efforts to build consensus'. In other words, integrating water systems in spatial planning requires a paradigm shift of planning process towards more consensus building, participation and collaboration.

Klein (2000, p424) also encouraged planners to use consensus-building strategies to improve collaboration among citizens and interest groups. He put forward 10 consensus-building principles including: (1) involve interest as early as possible; (2) tailor the process; (3) be inclusive; (4) identify and nurture shared interest; (5) share credible information; (6) provide impartial and collaborative leadership; (7) consider using professional help; (8) maintain momentum; (9) validate results; and (10) involve the media (ibid, p430-438).

In this study, consensus building is regarded at two levels: professional level (especially between urban planners and water managers) and public level (among public officials, developers, property owners and citizens). Professional consensus is the priority of this research. Professional consensus building leads to the technical support for strategic policy formulation and action programming while public consensus building assists policy making and successful implementation. During the decision-making process, in order to emphasize a more continuous interaction among government, multi-disciplinary experts, business and citizens by consensus building, the following key issues need to be paid attention:

1. New concept formulation and acceptance at strategic level. Planning at strategic level (i.e. master planning, comprehensive planning or land use planning) normally covers a wide range of objectives. It is important to embody water-space or water-land issues among them. The guiding principles, location selection and preservation framework have to be put forward with the consideration of water systems in the contents of strategy. The analysis and formulation of space for water based on the local context needs the public involvement and motivation. The main purpose is to arouse public and professional attention and achieve the agreement of stakeholders with different interests so as to provide a broader framework for urban sustainable development

at the strategic level. Such agreement includes surface water problem definition and understanding the goal of using surface water as an element for ensuring quality of space. Urban planners and water managers need to work together at the outset of plan-making process to offer better information and new theory to emphasize the importance of keeping specific space for water. Moreover, it is the foundation for water sensitive on-site design to be applied at the local level not just as a single demonstration project but as a tool used widely in the urban region.

2. Regulations and rules at action level. Zoning and subdivision regulations of land use are common tools for plan implementation. Many property owners and developers might be affected by these regulations. In order to make their individual purposes consistent with the official plans, collaborative communication is needed before regulation is enacted, as well as public education.

3. Organizational structure. Overlapping and often undefined responsibilities make implementation difficult even though some good ideas are brought forward. Accordingly integrating water management in spatial planning is unlikely to be viable unless institutional barriers are removed and institutional incentives are in place. The functions of spatial planning and water management need to be linked and their administrative responsibilities need to be clarified. Water management needs to have more power and responsibilities for water impact evaluation and control, and spatial department needs to have more duty to water space protection and water-land use control. A water monitoring system needs to be established and used as a tool for plan appraisal and evaluation of implementation. This is a continual process of organizational restructuring or institutional capacity building for spatial organization.

3.5 Conceptual model development

What can spatial planning do for surface water systems in order to promote sustainability? Policy for water-land systems could be classified as 'reactive' and 'proactive', or 'sectoral' and 'integrated'. A 'reactive' policy is one which is taken after events happen while a 'proactive' policy refers to one which is seeks to alter the course of events before adverse events happen. Reactive approaches take measures when problems occur and hence need a large amount of investment to correct the prior damage. On the contrary, proactive approaches intend to prepare for and avoid the potential damage.

The ‘sectoral’ policy often tackles the problems within a single department while ‘integrated policy’ emphasizes the early involvement and substantive consideration among different departments. Consequently integrated approaches advocate more cooperation in the formulation of development plans and projects than sectional approaches.

Figure 3.2 shows four groups of policy and approaches by the combination of these two trends: (I) Reactive-sectional; (II) Proactive-sectional; (III) Reactive-integrated; and (IV) Proactive-integrated.

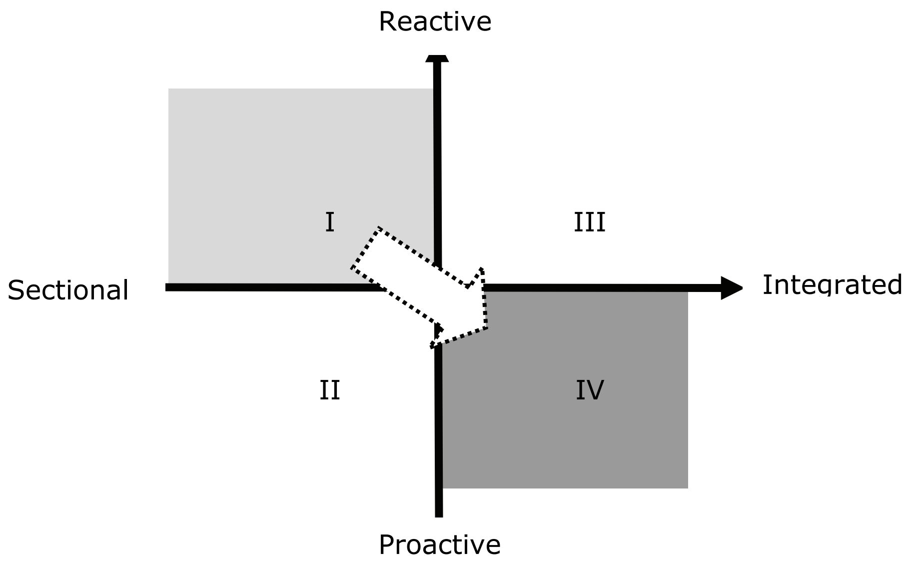


Figure 3.2 Conceptual model for approach options

As analyzed above, the effect of many water-related problems (water flooding, water pollution etc.) is often invisible at the outset. In addition, the negative impacts of human activities are not limited to the locality where the activity takes place, but adversely, they often spread into a larger area and are prolonged. These lag-effects normally make reactive-sectional approaches dominant in the field of water management and spatial planning spheres. But when problems happen, it is always too late to make up a deficiency. Therefore, in order to gain enough capacity to organize and preserve the space for water along with spatial requirement of urban development, proactive-integrated policy and approaches need to be promoted. In this regard, plan-making needs to take consideration of opinions from professional experts in different spheres and the opinions from public participation.

Chapter 4 Context and Study Area

This chapter firstly reviews the development of the spatial planning system and water management in China. The transitional trends and institutional reforms in both fields are examined. Subsequently, the setting of the case study in Wuhan is discussed, including some general city characteristics, and the specifics of local planning system and water management transformation. Some ideas for policy challenges to integrate surface water systems in spatial planning are then put forward.

4.1 Chinese spatial planning in general review

The Chinese spatial planning system has suffered a flexuous course since the 1950s. It was just at the end of the 1970s when China started its economic reform and open-door policy that urban planning began to recover its place in society. This transformation is still in progress. In the early 1980s, urban planning bureaus in many cities were re-established and spatial planning work was reemphasized as being an important task for local government. The Western design-based planning philosophy replaced the former Soviet model and the ideas of the garden city of Ebenezer Howard and the radial city of Le Corbusier were widely introduced. Although somewhat outdated, the urban planning system established at the end of 1980s is still influencing plan-making process in many cities.

The City Planning Act of 1989 established a two-tier comprehensive urban planning system. At the top tier is master plan (zongti guihua) and below it is the detailed plan (xiangxi guihua). For large or medium-sized cities, a district plan (fenqu guihua) is used to link these two tiers in order to strengthen master plan implementation. The contents of the master plan include the designation of city functions, development goal and city size, main construction standard and norm, overall layout of different types of urban land use, functional distribution and construction arrangement, comprehensive transport system, lake and river system, green space system, various specialty planning (i.e. electricity, water supply, sewage system, flooding protection) and short-term construction planning (Article 19, section 2). It covers the designated planning area and outlines the general land use pattern of the city within the planning period (normally 20 years). While detailed plans are to devise the spatial arrangement of the construction projects in a development area within a short-term period (normally 3 to 5 years) based on master plan or district plan (Article 20, section 2). It is a concrete and action oriented development plan. In the explanatory notes of the Act, there are two types of detailed plan – the detailed development control plan (kongzhixing xiangxi guihua) and the detailed construction plan (xiujianxing xiangxi guihua). The former is prepared for an area with uncertain development projects and the latter for the area with determined projects in immediate construction. Based on the two-tier system, since the 1990s some other plans such as strategic outline of master plan (zongti guihua gangyao), city-region plan (shiyu guihua), urban system plan (chengshi tixi guihua) have been added to the legal planning system, while the strategic development plan (fazhan zhanlue guihua) and concept plan (gainian guihua) have also been practised in many cities, but the precise distinction between these plan forms is not always very clear. The Urban Planning Act 1989 was a major milestone in the history of urban planning in China but, on the other hand it has faced a lot of challenges in urban development and planning practice in the context of political and economic transformation particularly in the 1990s, such as the establishment of a housing and land market. The main deficiencies of the Act were criticized and indentified by Yeh and Wu (1999, p246). One of their major concerns was the great powers of discretion for the administration and the lack of public participation. They (ibid, p247) suggested that this planning system should be streamlined and its utopian vision of 'comprehensive control' should be discarded.

Concerning the examination and exploration of the Chinese urban planning system and its transitions from 1949 to the 2000s, there are several notable studies in English (Khakee, 1996; Tang, 2000; Ma, 2004; Wei, 2005; Abramson, 2006). Tang's research (2000) examined the problems of literature in Chinese urban planning and expanded the understanding of its nature and role. He concluded that urban planning in China is situated in the political rationale and understood as a technology of government. Ma (2004, p257) also proposed that 'truly proactive, legal and more transparent planning …… that would make the cities aesthetically appealing, environmentally sound, economically dynamic and socially more equal, has been missing'. Wei (2005) and Abramson (2006) criticized the Chinese urban planning system as being incapable of responding to the market-driven growth and always lagging behind the general political-economic reforms. Moreover, Wei (2005) pointed out that confronting the unprecedented rapid urban change and institutional transition due to decentralization, marketization and globalization processes, the Chinese spatial planning system is facing new challenges in the coming decades. In Wei's view further changes and the formation of new planning approaches is required.

Despite its theoretical deficiencies, urban planning practice has been engaged widely in China over the last three decades. Institutionally urban planning has been assigned a prominent position in the administrative hierarchy and the status of urban planning among the administrative departments and publics has been strengthened. The enormous expansion of cities is a constant reminder of the current prominent role of urban planning.

However, many practice failures in Chinese cities have urged researchers and planners to re-examine the core of planning theory, such as basic principles, values, concepts and approaches. In recent Chinese planning literature, there has been more and more discussion advocating a reform of Chinese planning system in the new context of Chinese society (Ma, 2005; Yang, 2005; Zhang, 2005; Zhu, 2005; Zou, 2005; Sun, 2006; Legates & Zhang, 2007; Sun, 2007; Zhang, 2008). It has been realized that the lack of adequate basis in planning theory is one of the important reasons for the failure of planning practice when facing rapid urban change and political and economic transformation. The critique for the current planning philosophy and advocacy for further reform of the planning system is becoming more acute than ever before. These critiques focus on the following points:

1. Administrative power controls all stages of the planning process, i.e. initiating, organizing, implementing and monitoring. Planners collect information and make plans mainly by communication with government, seldom with the public. As planning is a state-lead activity with an elitist style the plan-making process occurs within a closed circle of insiders, and gatekeepers control access to the planning process. Public participation is therefore rather weak.

2. Planning focuses excessively on the physical space and mainly serves the economic development, thereby ignoring issues such as social justice and the ecological environment to a large extent. When economic efficiency becomes the major goal of governmental officials, planning is used as a technical tool to pursue their political achievement, which often exacerbates the situation of inequality and environmental degradation. This narrow view means that planning has lost its role for the maintenance of good quality of social and physical environment. The concept of sustainability appears in many plan documents recently, nevertheless it is difficult to implement due to the lack of public understanding and practical political support. An ethical value system for serving the public’s is urgently needed for spatial planning in China (Zhang, 2005).

3. Rational analysis and collaborative approach are found wanting in master planning. Rational and system approaches in the Chinese planning system are relatively immature (Sun, 2005, p30). The typical way of problem identification depends mainly on the intuition or political will or higher level governmental policy. At the strategic level, planning goals are easily changed and revision of master plans often happens when the main leadership is changed. Therefore, master plan, to some extent, losses its role as a guideline for urban development in a long term. Moreover, blueprint ideology in master planning fails in offering flexible management mechanisms to deal with the newly arising problems. Due to the lack of collaborative approach during the plan-making, some 'ad-hoc' procedures in plan implementation mean that it is difficult for planners to catch up with the pace of rapid changes in practice.

4. The contents of master plans are too comprehensive to undertake strategic and problem-oriented analysis. This is also one of the main reasons for delays in preparation and approval of master plans which in turn have increased skepticism about their effectiveness. Due to the occurrence of improper administrative interference and the irrational and illegal development in many cities public trust in planning authorities is weakening. Moreover, the utopian philosophies of master planning that pursues the ideal future city has largely prevented urban planners from expanding their knowledge base in engineering, architecture and design to a wider and more multi-disciplinary approaches. These limitations have become obstacles and major challenges for improving urban planning practice in China.

Since 2000, the new state development ideologies 'Harmonious Society' and 'Scientific Outlook on Development' both of which underline sustainable and balanced development have been reflected in the fundamental changes in China's spatial planning system. The matters of natural resources, environment, public safety and public interests are now required to be emphasized in the contents of master plans and other detailed plans. Correspondingly, several management regulations that aim for a better balance between urban land use and the land with natural or historical values were promulgated after 2002: examples are the 'green line regulation' (land for green area), the 'blue line regulation' (land for surface water systems), the 'purple line regulation' (land for historical heritage) and the 'yellow line regulation' (land for urban infrastructure). Among them, Urban Blue Line Management Regulation came into being on 1 March 2006. These documents (in Chinese) can be obtained from the book 'Explanation of Key Points on City and Country Planning Act' (CCPA-Editing-Group, 2007). The adoption of these regulations shows that the present Chinese planning system is currently experiencing a new transition and new planning methods that will support these regulations need to be developed. In this context, the new City and Country Planning Act of 2007 and Urban Plan Making Regulation of 2005 are the legislative results of this transformation. Some additional points about them need to be highlighted here:

1. Unlike the 1989 Act, which mainly focused on urban areas, the 2007 Act recognizes and emphasizes the harmonious relationship between urban and rural areas. It requires that spatial planning should consider development and construction not only in the urban area but also in the rural area. Planning for urban land use should not ignore the rural functions, especially rural housing, rural infrastructure and basic arable land protection. It sets the stage for tackling environmental issues over a more extensive area than was previously the case.
2. The master plan is required to append new contents of mandatory involving major matters of natural resources, environment, public safety and public interests. The mandatory components include designating the spaces that need to be strictly protected; furthermore the relevant regulations need to be highlighted in the plan document so as to ensure the final implementation. Such a requirement applies for the aforementioned management regulations for green, blue, purple and yellow lines. This regulatory innovation needs to be matched with new approaches and planning information support.
3. Based on the former two-tier urban planning system, the city and country planning system is expanded into a multi-tier system, involving State/Provincial Urban System Planning (*quanguo/shenyu chengzhen tixi guihua*), Urban Planning (*chengshi guihua*), Town Planning (*zhen guihua*) at strategic level, and County Planning/Village Planning (*xiang guihua/cunzhuang guihua*) at local level. Both Urban Planning and Town Planning retain the former two-tier model.
4. Short-term Planning (*jinqi guihua*) becomes a relatively independent planning activity rather than a subject included in the contents of the master plan. It becomes important in the implementation of the master plan and should be made every 3-5 years in order to increase the flexibility of planning management. The purpose is to have more elasticity in practice.
5. During the plan-making process, public hearings, expert consultation and negotiation with different departments are

required to be done and public participation is strengthened in the planning procedure although it is at a fairly low level.

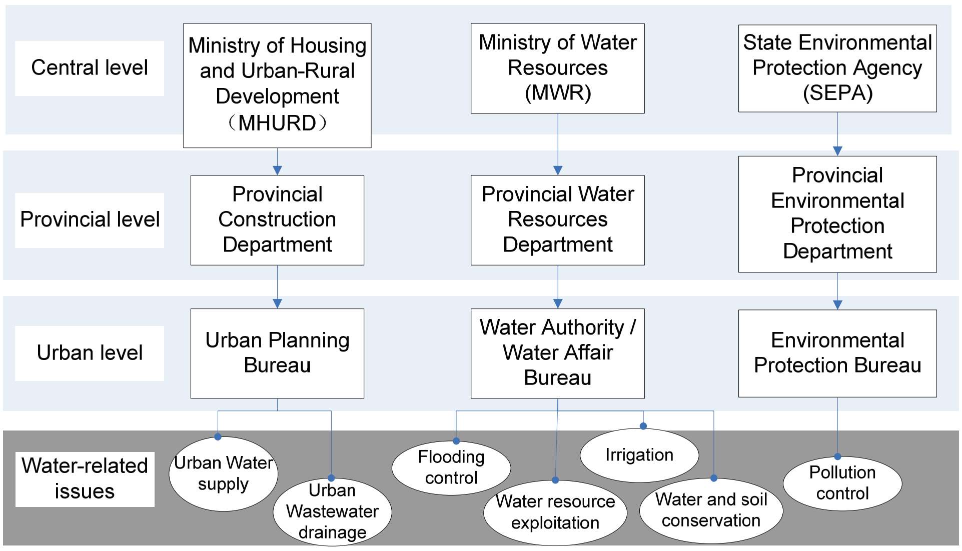
6. At the plan implementation stage, there are more detailed regulations for land use appeals, land use control and development, and plan monitoring. It is highlighted that the legal status of master and detailed plans should be enhanced, based on the legal procedures of implementation.

Under the current transitions Chinese urban planners are facing opportunities as well as challenges. The big opportunity lies in the fact that planning work has gained a leading position in urban development both institutionally and publicly. Urban planners may now have a more important role in decision-making on development. But the big challenge for urban planners is how to improve the substantive quality of planning that will satisfy the requirement for improved quality of life in fast changing urban regions. In order to make the planning and design process more open and transparent, to obtain support of the public and political will, and to enhance the democratic approach in the planning procedure, new spatial planning approaches and tools are needed. Having examined recent changes in Chinese spatial planning the following section examines the second major field of this research, Chinese water management practice.

4.2 Chinese water management in general review

In the past thirty years, China has developed a complex water management system with a strong hierarchical structure. The water management authorities have structured their agencies vertically distributed over central (Ministry of Water Resources), provincial (Water Resources Management Department), and municipal or county levels (Water Authority / Water Affairs Bureau) and shaped a top-down administrative model with bureaucratic characteristics. Their main responsibilities for water management focus on water risk control (e.g. dike construction), water resources exploration (e.g. building reservoirs, water transfer and irrigation facilities, and water conservation and hydropower plants) and water-soil conservation in a large-scale region (Figure 4.1). The demand- and engineering-orientation work model has dominated water management for decades (Long et al., 2003).

There is more than one sector involved in water-related administration due to various demand for water resources utilization. Figure 4.1 shows the complex administrative arrangement of different sectors concerning water-related issues from the central to the local levels. At the central level, the main functional organization whose mandates directly affect the water issues is Ministry of Water Resources (MWR), while Ministry of Housing and Urban-Rural Development (MHURD) and State Environmental Protection Agency (SEPA) also play their roles with respect to water. Besides, there are some other administrative sectors involved such as health, agriculture, forestry, transportation, as well as the State Development and Reform Commission. Through this top-down, vertical administrative system, at the local level a situation known as 'nine dragons controlling water without effects' comes into being. In other words, although there are many departments possessing the rights to manage water, no one agency can take effective measures to control water-related problems.



Note: Ministry of Housing and Urban-Rural Development (MHURD) gained its new name from former Ministry of Construction (MC) in March 2008

Figure 4.1 Major institutional structure of water management in China

In the urban area, such vertical organizational structures directly impacts the management of water affairs such as water supply, flood control and water pollution control etcetera, all of which are managed by separate sections. Water supply and waste water drainage is managed by the urban planning and construction sector, flood control by the water sector and pollution by the environment sector (Figure 4.1). Such organizational complexity contributes to many water-related problems especially when the institutional cooperation mechanisms are absent or poorly functioning (Song, 2003). The institutional cooperation is very difficult to be facilitated by this framework. This administrative separation also results in the benefit dispute and possesses the deficiency that it blurs the demarcation of the responsibilities of the individual department. It is therefore difficult to restrain excessive exploitation of water resources and there is little or no motivation, nor political-economic incentive to tackle water-related problems in a cooperative and effective way.

In this context, for many, water is regarded as a risk that needs to be defended, and as an endless usable source that can be explored according to the requirements of human society. This concept of water utilization and risk control has lasted for decades. The dispersed and multi-departmental management system reflects that water, as part of natural ecosystem and limited resource, has long been ignored. Demand- and engineering- orientation perspectives have encouraged a predatory approach to water resources exploitation and much dependence on manpower to tackle water risk.

The concept of hydrological cycle as a part of natural system and water with ecological functions has long been overlooked. For example, the prevalent practice is to adopt the 'end-of-pipe' model to deal with the waste water emission. During the process of urban expansion and construction, original spaces for water systems are replaced and destroyed by paved land. Water ecosystems are damaged by serious pollution from intensive agriculture, industrial waste water and untreated sewage from settlements. The perception of maintaining the resilience of the natural water cycle is far from being considered in both water and spatial policies. Moreover, the impacts on the natural hydrologic cycle from urban activities have not been adequately reflected in urban planning either. Measures, such as the spatial arrangement of detention/retention areas, have not been adopted effectively by urban land use planning. A multi-disciplinary approach to deal with the conflicts of water system protection and land use impacts in the urbanizing areas has not yet been fully developed.

Similar to the spatial planning reforms, since 2000 a bottom-up strategy has been initiated to develop new institutions and mechanisms related to water management. Many cities have established a new agency, the so-called 'Water Affairs Bureau', to expand the scope of water management and create more innovative and cooperative management mechanisms. However, due to conceptual and institutional deficiencies, many barriers to the required reforms still exist in the urban regions (Shen & Liu, 2008). For instance, although some cities are starting to emphasize the importance of lake protection after city lakes are exposed to seriously environmental problems, the measures taken invariably have a substantial time-lag effect. When a huge amount of money is needed for the required action to be undertaken, the practical effects are often rather limited, especially in a short period of time.

Water management in China urgently needs a new paradigm shift that emphasizes the preservation of good water systems and water environment. Given rapid urban expansion, it is necessary to have more research on the integrative space-water management involving water, spatial, environmental, social and economic items. As water issues cover different interests of many stakeholders, it is impossible for Water Affairs Bureau alone to tackle all concerns. Institutional cooperation is needed in order to facilitate negotiation and cooperation among different organizations tackling the water-related problems in urban areas. Especially, it is essential to harmonize the relationship between the Water Affairs Bureau, the Urban Planning Bureau and the Environmental Protection Bureau. Such bottom-up institutional reform creates a new study topic for water managers, urban planners and environmental managers, although the latter group is not considered in this study. However, water management and spatial planning have been dominated by different expertise and considerable institutional inertia exists that acts against the necessary change process. This study argues that professional consensus building is needed to initiate fruitful cooperation.

4.3 Background of study area of Wuhan

In this study Wuhan's municipal territory is regarded as the Wuhan Urban Region. It consists of the urban core (the main city within municipality, most of which is built-up) and suburban districts (Figure 4.2). The Wuhan Urban Region is geographically situated at the transition from a plain landscape (the flood-prone area) to mountainous region, forming a typical landscape with the mixture of mountain remnants, hills, and plains. More than 80 % of the total area is under the area of ridge plain, floodplain and lacustrine plain (Table 4.1). Surface water bodies are widely distributed across these plains. The urban core lies on a relatively flat and lower plain with an elevation around 19-24 m above mean sea level, which is lower than the water level of average annual river-flooding (25.5 m). Given the highest water level of flooding (29.73 m in 1954) (LEC, 2006), the flooding risk remains high, although it is now much better controlled by the recently constructed Three Gorges Dam on the Yangtze River.

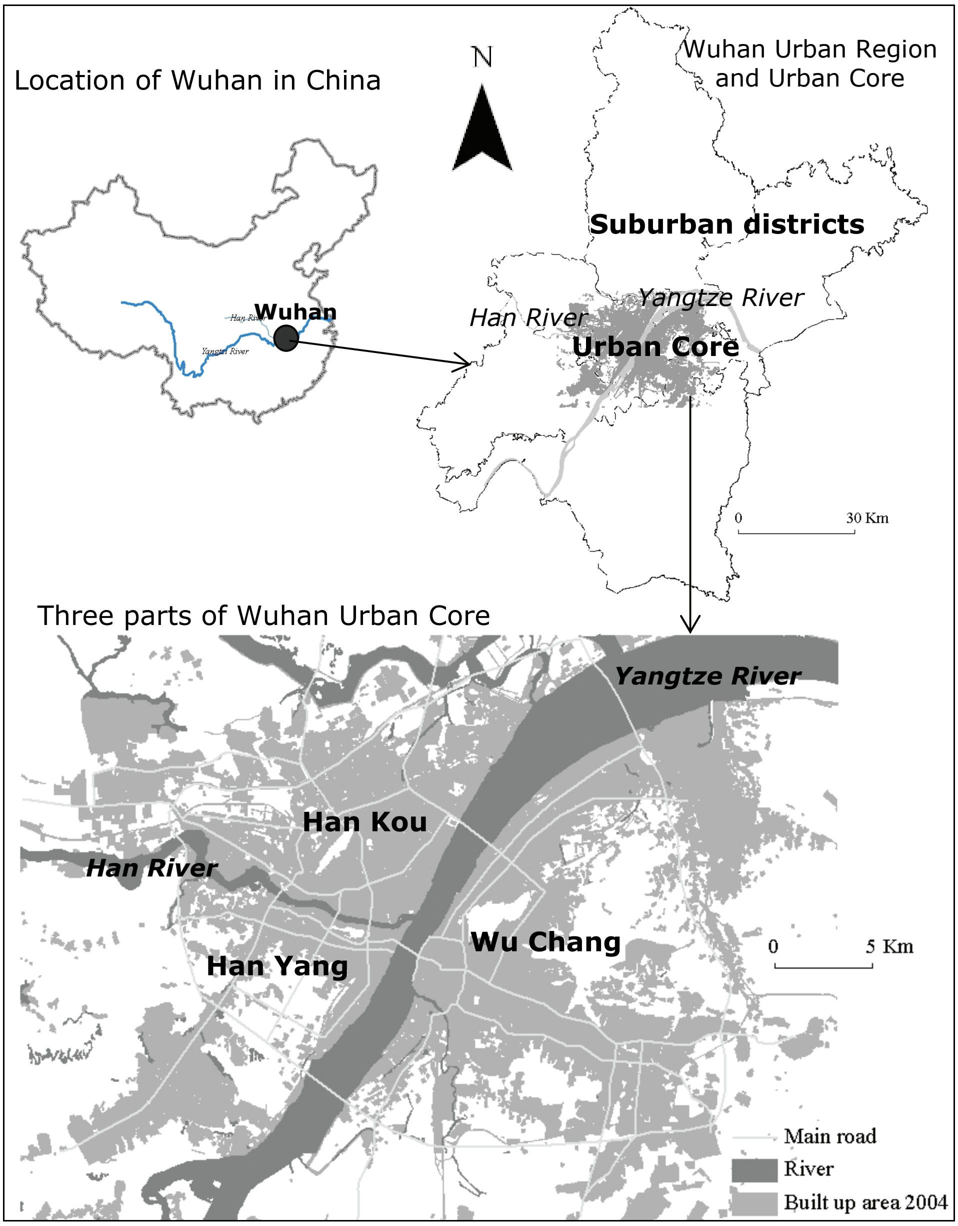


Figure 4.2 Location of Wuhan Municipality (Wuhan Urban Region) and Wuhan Urban Core

Table 4.1 Landform in Wuhan Urban Region (WUR)

Type of landform	Percentage of areas (%)	Elevation (m)
Mountain remnants	5.8	500-800
Hill	12.3	100-500
Ridge plain	42.6	30-100
Floodplain and lacustrine plain	39.3	15.6-30
Total area	100	

Source: (LEC, 1989, p32)

In 2004, the total population in the municipality was nearly 9 million (Hu, 2006), of which more than 66%, nearly 6 million persons, have an urban status. The urban core had 4.7 million habitants in its 355 km^2 built-up area with an average population density of 13,230 persons / km^2. Compared to the suburban districts where population density was less than 500 persons / km^2, it is obvious that the population density, urbanization and intensity of land use in the urban core are extraordinarily high, while the suburban districts consist predominantly of rural landscape and rural land use.

The urban core is divided into three parts by the Yangtze River and the Han River (Figure 4.2): Wu Chang (187 km^2), Han Kou (113 km^2) and Han Yang (55 km^2) (Hu, 2006) with respectively 2.2 million, 1.6 million and 0.5 million permanent residents in 2004 (WSB, 2006). All are densely populated areas and each plays a different role in the city. Wu Chang is the industrial, educational and provincial administrative center, Han Kou is the commercial and financial center and Han Yang is the traditional industrial base. Due to the influence of the Yangtze River and Han River, these three parts developed as separate entities for a century but they are now merged into a single municipality. They remain spatially divided but linked by a series of bridges and more recently tunnels. The urban core is the main study area of urban land impact analysis on surface water bodies in this study.

4.4 Urban development process of Wuhan

In order to provide more insight into Wuhan's structure and development problems a detailed description of historical and more recent developments is given below.

4.4.1 Historical review

Wu Chang, Han Kou and Han Yang historically developed as three separate administrative entities with different functions due to their physical separation by the Yangtze River and the Han River. In 1861, Han Kou was exploited as a colonial settlement with a strong influence of a western style industrialization and modernization. It developed major commercial and transport functions based on foreign trading. Wu Chang remained the regional political and military center with its own features of feudal administrative functions while Han Yang was the local political center.

The settlements in Han Kou were constructed according to plan with the idea of functional divisions of urban space for residential, commercial and industrial purposes; a road system with car and pedestrian separation; and allocation of public facilities i.e. water supply, electricity supply and telegraphic system, schools, hospitals, and entertainment etcetera. Some elements of modernization with a western style architecture emerged, which entailed both morphological and social impacts on this ancient city. When the iron and steel plant was built in Han Yang in 1890-1893 and the textile industry was developed in Wu Chang in 1892-1899, Wuhan was stimulated to be the leading city of industrialization in China.

From 1861 to 1949, Wuhan, like other places in China, experienced hard times and fluctuating fortunes due to wars and social turbulence. According to the records (LEC, 1989), in 1840 the built-up area was about 18 km^2 (12 for Han Kou, 5 for Wu Chang and 1 for Han Yang respectively) with a population of 0.3 million. By 1949, the built-up area had only increased to 34.7 km^2, with a population of 1.02 million (LEC, 1996).

Since 1949, the achievement has been great. Wu Chang, Han Kou and Han Yang were combined into one administrative entity. During the First Five-Year Plan (1953-1957), Wuhan was regarded as a national key industrial base and 1.5 billion RMB was invested from the central government for 32 national key industrial projects, such as a large iron and steel plant, a heavy machine tool factory, a boiler-making factory, a shipping factory, a meat processing factory, a textile factory and an electricity power plant etcetera. These industrial projects greatly contributed to the formation of the industrial zones, which provided the foundation of the city's urban spatial structure. Together with the industrial projects, the facilities of warehouses, railway transportation and bridges were constructed. The first of a series of bridges across the Yangtze River and Han River were finished in 1957 and 1956, forming the first permanent linkage between Wu Chang, Han Kou and Han Yang, enabling them to function more effectively as one city. As one of the most important locations of modern industrialization in China, Wuhan's industrial development has been the pivot of urban development since 1949. Stimulated by national investments in manufacturing, the built-up area of the city expanded from 34.7 km^2 in 1949 to 164 km^2 in 1978 (LEC, 2006).

However, it was a somewhat unbalanced development. Under the ideology of socialism and the centrally planned economic system, which was dominant until the end of the 1970s, industry and its relevant infrastructure (so called 'productive functions') were emphasised, while urban housing and tertiary industry (so called 'non-productive functions') was insufficiently addressed. This resulted in a serious shortage of houses and public facilities by the 1980s. In the meantime, environmental problems were also neglected to a large extent and little consideration was given to concerns of economic efficiency and a healthy living environment.

Since the initiation of economic reform in 1978, Wuhan has entered into a new era of dramatic urban transformation. Since the 1980s, the ideology of urban development has changed from emphasizing industrial production to a more balanced urban-economic base in which housing, transportation systems and public service facilities have gained more attention. The city's development objective has changed from being a single industrial production to a multi-functional economy combining industry as well as high level economic and personal services. The so-called 'non-productive' functions have gained increasing attention with housing, gas facilities and other urban services receiving more investment from the government. During the 1980s, the living conditions were substantially improved and increasing attention also was paid to environmental issues. Investment in the city's sewage system and pollution elimination increased. The first sewage treatment plant was built and finally put into use in 1993. It was also realized that green areas and historical and cultural heritage were important for the city and its residents.

In water management there has been a long history of embankment construction in Wuhan. Wu Chang was the first place to have dikes, followed by Han Yang and finally Han Kou. Most of these dikes were badly destroyed in the past. The only dike which is still working after maintenance is Zhanggong Dike (Figure 4.3) which was built in 1905. In 1954, Wuhan encountered serious flooding with the highest water level in history. Later, this water level was used as the standard for dike construction and both central and local governments have invested in dike construction. The basic dike system for flood control has been built (Figure 4.3) and is designed to protect the city against a 1 in 100 year flood event. Given their number, size and importance, dikes are important determinants of urban form and the construction of dikes has been both necessary and beneficial for urban expansion. However, they have also resulted in the disconnection of inner surface water systems from the outer river systems.

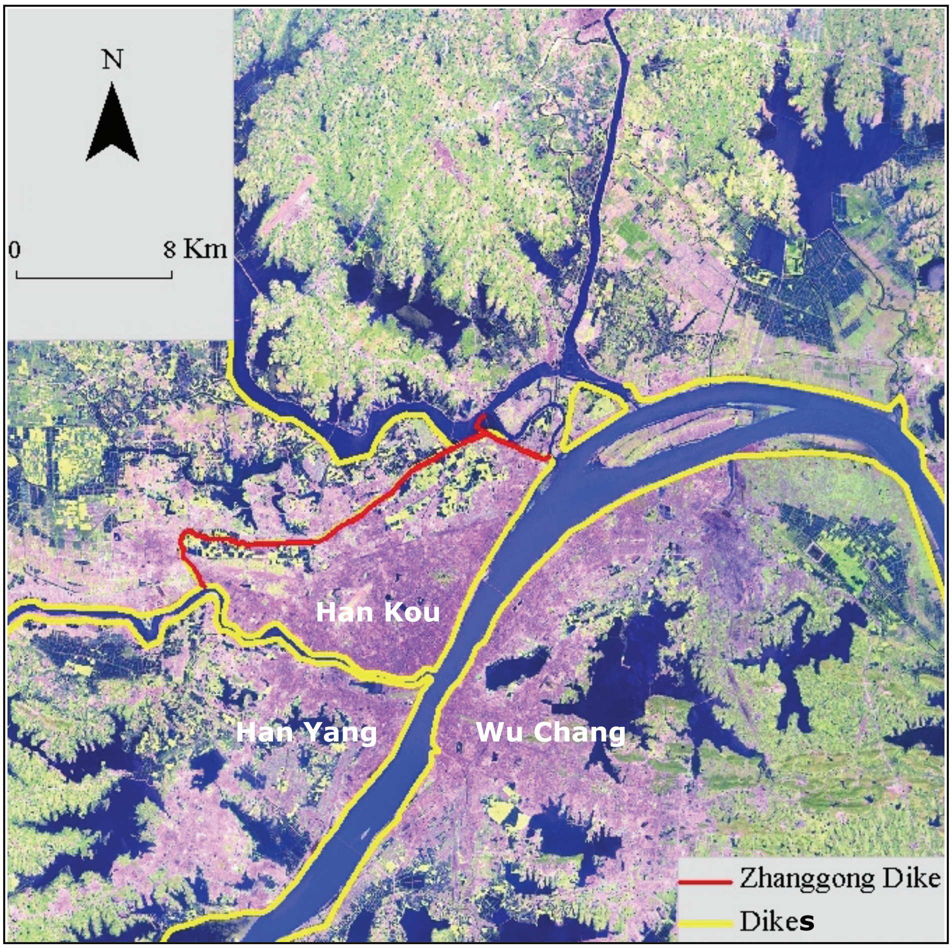


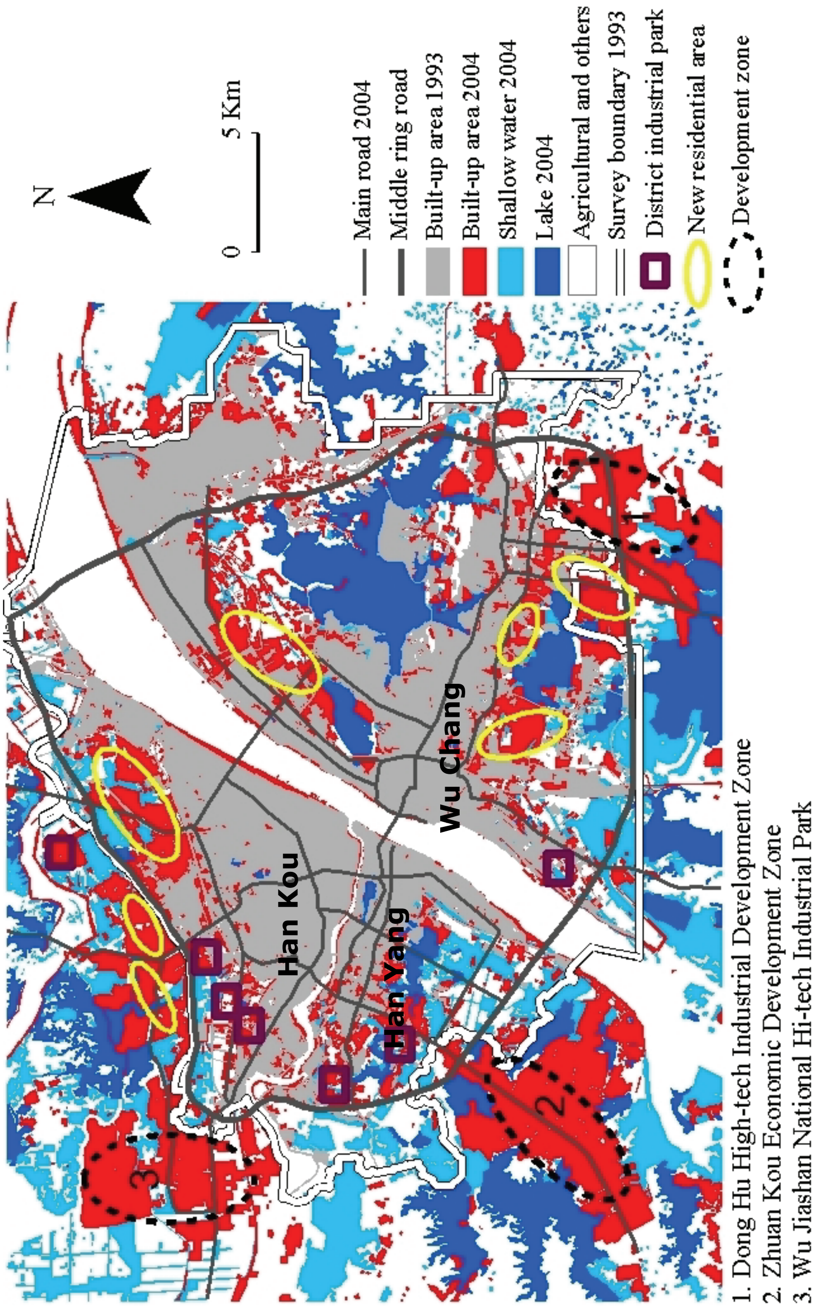
Figure 4.3 Distribution of Dikes in the urban core

4.4.2 The process of urban expansion after 1990s

Since 1990, especially after 1992 when reform policies accelerated in China, Wuhan entered into a phase of rapid urban expansion. In 1992, the central government designated Wuhan as an open economy city along the Yangtze River enabling it to share in a series of national preferential development policies that until then had been mainly focused on several coastal cities such as Shanghai, Shenzhen and Guangzhou. In addition, a land use right lease policy was implemented, which generated new funding sources for local governments from urban development and urban restructuring. These factors stimulated various international and domestic investments. The funding sources for urban development became more diverse and market players started to react to the new opportunities for urban construction.

Three large scale high-tech industrial or economic zones (Figure 4.4) were developed in the surroundings of the urban fringe, shaping the spatial framework for new development and expansion of the city. Dong Hu High-tech Industrial Development Zone in Wu Chang started in 1988 and Zhuan Kou Economic Development Zone in Han Yang started in 1991. Both were authorized by the central government, respectively in 1991 and 1993. They have attracted a large amount of investment for high-tech firms, the automobile industry, and other large scale manufacturing industries. Wu Jiashan Development Zone adjacent to Han Kou started to attract investment in 1992 and in 2000 it became a national-level hi-tech industrial park mainly dedicated to food processing. Dong Hu High-tech Industrial Development Zone and Wu Jianshan National Hi-tech Industrial Park both adjoin the built-up area. Only Zhuan Kou Economic Development Zone is located further out of the built-up area.

Together with requirements for industrial redevelopment and transformation of the urban core, local industrial economic zones at district level have been stimulated and relocated to the urban fringe, near to the built-up areas (Figure 4.4). Large scale infrastructure projects including main roads, ring roads and outer ring highways, subways and a high speed railway line have been constructed or are under construction. They have created and continue to create new opportunities for other development activities, i.e. commerce, housing, public facilities and local industry. Furthermore, connected to the fast development of the real estate industry, a large amount of residential houses comprising mainly multi-family apartments, have been constructed in the expanding urban core. Within the 1990s, Wuhan's urban expansion has massively encroached upon the water rich surroundings of the city, consequently giving rise to serious environmental problems.



Sources: (a) Land Use Surveys in 1993 (LUS1993) in 2004 (LUS2004);
(b) Wuhan Map 2007 (produced by Wuhan Geotechnical Engineering and Surveying Institute)

Figure 4.4 Urban land use expansion (1993 to 2004)

Table 4.2 shows that the annual increase in built-up area and urban population has been substantial since 1993, and more than doubles that of the former period from 1949 to 1990. The built-up area in 2004 covers more than 1.6 times that of 1993. Population has increased by more than 1 million, but gross population density has decreased slightly, from 144 to 132 persons/ha. The scale of urban construction is massive. Here, the urban population figures only include those people who are formerly registered as urban status in the identity system. The so-called floating population, without formal urban status but living and working in the city, is not included due to the different standard in different periods. Given to the large scale of migration since 1990s, the population in the urban area is likely to be considerably larger than the figures listed in the Table 4.2.

Table 4.2 Urban expansion of Wuhan (1949 to 2004)

Year		Built-up Area: Total (km^2)	Built-up Area: Average annual increase (km^2)	Urban Population: Total (million)	Urban Population: Average annual increase	Population density (persons/ha)
1949 to 1990	1949	34.7	3.8	1.02	47 000	294
	1953	37.5		1.22		325
	1958	108.0		1.95		181
	1978	164.0		2.29		140
	1984	178.0		2.66		149
	1990	189.3		2.95		156
1993 to 2004	1993	227.0	11.6	3.26	131 000	144
	1996	264.0		3.79		144
	2000	281.0		3.95		141
	2004	355.0		4.70		132

Source: Adapted from the PhD thesis by Hu (2006, p75) and Wuhan chorography (LEC, 2006)

4.5 Characteristics of surface water systems in Wuhan

The surface water system in Wuhan is composed of different spatial forms: lakes, shallow water bodies (ponds and pools), reservoirs, rivers, streams and canals. In this study, lakes and shallow water bodies are chosen as the main focus. They are both wetlands according to the aforementioned definition (see section 3.1) but have different characteristics. Lakes are normally permanent water bodies. The boundary of their waterline is clearly visible even though their water level can be variable due to seasonal climate change. Their permanence is one of the reasons that lake protection can gain public attention relatively easily.

Shallow water bodies, on the other hand, tend to have a more variable form and size as they are more sensitive to seasonal variation or as a result of artificial management of their water level. They are often located on low lying land adjacent to the rivers or lakes, often containing water cover only in the wet season. Their physical forms are mainly natural or artificial ponds, pools and swamps. Because of their changeable and sometimes invisible nature, shallow water bodies are generally easily drained and replaced by urban functional lands.

Lakes and shallow water bodies in Wuhan (Photograph 1) occupy more than two-thirds of the total water surface area, and therefore very significant elements in terms of spatial planning (Table 4.3).

Table 4.3 Distribution of surface water systems in Wuhan Urban Region

Type of area for surface water bodies	Areas (km^2)	Percentage of the total surface area (%)
Lake	779.56	36.8
Shallow water bodies (Ponds, pools)	729.43	34.4
Rivers, streams	471.31	22.3
Reservoir	83.87	4.0
Canals	53.43	2.5
Total	2117.6	100

Source: Wuhan Water Board, May 2006


Lake

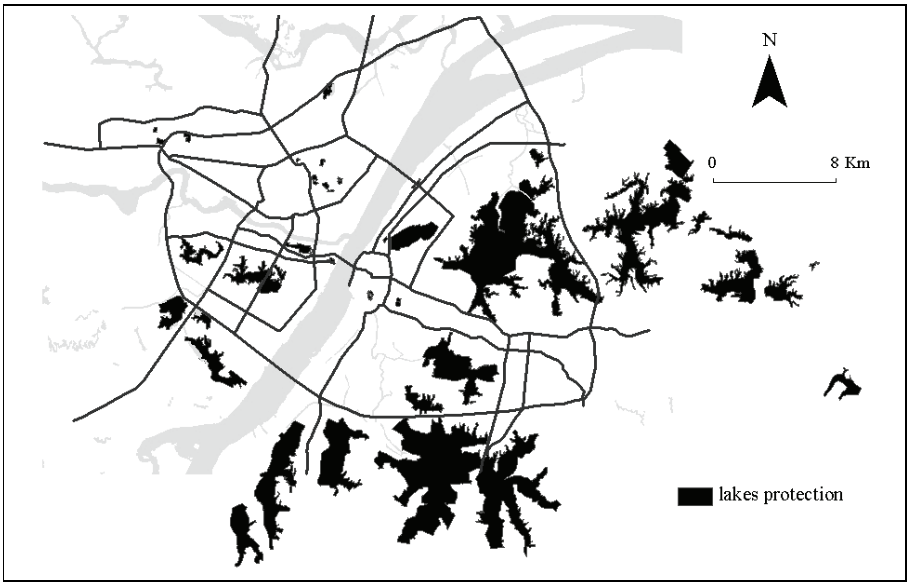

Shallow water

Source: taken by author in 2007

Photograph 1 Lake and shallow water body in Wuhan

Most of the lakes in Wuhan were shaped by the natural geographical processes of the rivers and their origin is closely related with the meandering of river courses over time. There are only a few tectonic lakes. Historically, most of the lakes were connected to one of the two main rivers through canals or streams. Some of the lakes merged with each other through the surrounding shallow water wetlands in the flood season. Since the dikes and embankments of the two rivers were constructed as flood prevention barriers, the majority of lakes and shallow water bodies have been cut off from the river systems. Due to a long history of human influence, these surface water bodies have been changed, resulting in a fragmented aquatic landscape. Nevertheless, the region still possesses a typical landform characterized by an aquatic landscape.

Most lakes in Wuhan possess both retention and detention functions (Appendix D and Figure 4.5). There are two main characteristics of the lakes: (1) river-side location; (2) shallow and flat-bottomed with an average depth of 2-3 m. This implies that a small change of water level can cause a big change of water cover area. The normal water level of lakes is 18.6 – 20.0 m, with the capability of 0.5-1.0 m rising for flood-water storage. Nowadays, their water level is controlled by pumping stations.



Source: Distribution map of the lakes in the protection list in Wuhan urban core (Produced in 2005 by Wuhan Geotechnical Engineering and Surveying Institute)

Figure 4.5 Distribution of the lakes within the urban core

Lakes and shallow water bodies are often closely connected with human activity. Most shallow water bodies have been converted into artificial fishing pools or cultivated land with the long history of human impacts. With the rapid urbanization and industrialization of recent decades, conversion to urban land use has become faster than ever. For many years lakes and shallow water bodies were also being used for discharging untreated sewage drained from their surroundings. Given the insufficient sewage treatment facilities and lack of connections between water bodies and the rivers, this has resulted in serious inland water pollution (Photograph 2).

Dead fish due to polluted water

Pollutants in the lake

Source: taken by author in 2007

Photograph 2 Water pollution of lake in Wuhan

Wuhan benefits from its location on a major waterway, which has enabled it to become the most important city in the central part of China, but it also suffers seriously from water problems, such as flooding, water-logging and water pollution. The history of its urban development is always directly connected to the construction of water protection measures. Dikes and embankments contribute to river flood control, but at the same time are barriers to the natural linkages of surface water systems. At present some large lakes are only connected to the rivers by sluices. Consequently, the surface water system in Wuhan is divided into the inner water system i.e. lakes, shallow water bodies, and the outer river system, i.e. the Yangtze River, the Han River and other streams. 'Excess water' and 'polluted water' are the two main water-related problems in Wuhan.

1. Flooding risk and water-logging: 'excess water' problems

Wuhan's flooding risk comes from two sides: outer river flooding and inner-dike water-logging (Photograph 3). Much more attention is given to river flood control so that the construction of the dikes and embankments is regarded mostly as a major measure for ensuring city development. Only in recent years has water-logging caught the attention due to the serious property loss by inundation at the local level. It has been gradually realized that mitigating water-logging is as equally important as river flood control. In fact, mitigating water-logging depends very much on the capacity of retention or detention provided by the lakes and shallow water bodies.

Water logging

flooding

Source: download from the website, 2008

Photograph 3 Flooding rick and waterlogging in Wuhan

2. Water pollution problems

The construction of sewage treatment facilities (i.e. treatment plants and collection network) has lagged behind urban development in Wuhan. Only in 1993 was the first sewage treatment plant put into use. By 2003, only 6 % of the total sewage in the urban core area had been treated before being discharged but by 2005 it had risen to 37% (WWAB, 2006). Still a large amount of un-treated sewage is released into the water system. In the suburban districts, the situation is much worse than in the urban core. Until now no treatment system has been built due to insufficient investment.

Table 4.4 shows the condition of water quality of 38 lakes in the urban core (Figure 4.5). More than half of the lakes hold a water quality rating V+ level, which is the worst polluted level according to the National Surface Water Quality Standard of 2002. This level means the water is too dirty to be directly touched by human skin, and may produce unpleasant odors that largely destroy the landscape value of the surrounding areas. Nearly 30% of the lakes are rated at V level, which is also with inferior quality. Table 4.4 also shows the condition based on the surveying of 67 lakes in the Wuhan Urban Region. Nearly 50% belong to V+ level. The overall situation is that the pollution of lakes in the urban core is worse than the one in the location far from the built-up area (Figure 4.6). The main pollutants are domestic sewage, so the indices such as TN (total nitrogen), TP (total phosphor), BOD5 (five-day biochemical oxygen demand), CODMn (index of permanganate) and DO (dissolved oxygen), are high.

Table 4.4 Condition of water quality in Wuhan

Water quality level	Condition in urban core Percentage (%)	Condition in Urban Region Percentage (%)
V+ level	52.63%	47.8%
V level	26.32%	13.4%
IV level	18.42%	25.3%
III level	2.63%	9.0%
II level		4.5%
	100%	100%
Source:	Wuhan Water Affairs Bureau, 2004	Wuhan Urban Planning Bureau, 2006

Note: According to the National Surface Water Quality Standard in 2002, surface water quality is classified into five levels in the light of the applicable functions:

I level: applies to headstream, national protection zone;

II level: applies to the first class protection zone of surface drinking water source, inhabitancy of rare water creature, egg-laid place of fish and shrimp and bait place for their young etcetera;

III level: applied to the second class protection zone of surface drinking water, place for fish and shrimp in winter and their travel gate, aquiculture area and swimming pool;

IV level: applied to industrial and entertainment function. It is not suitable for the human body to touch directly;

V level: applied to agricultural area and normal sight-seeing waters, which is worse than IV level.

V+ level: is used for the water quality that is much worse than that of V-level.

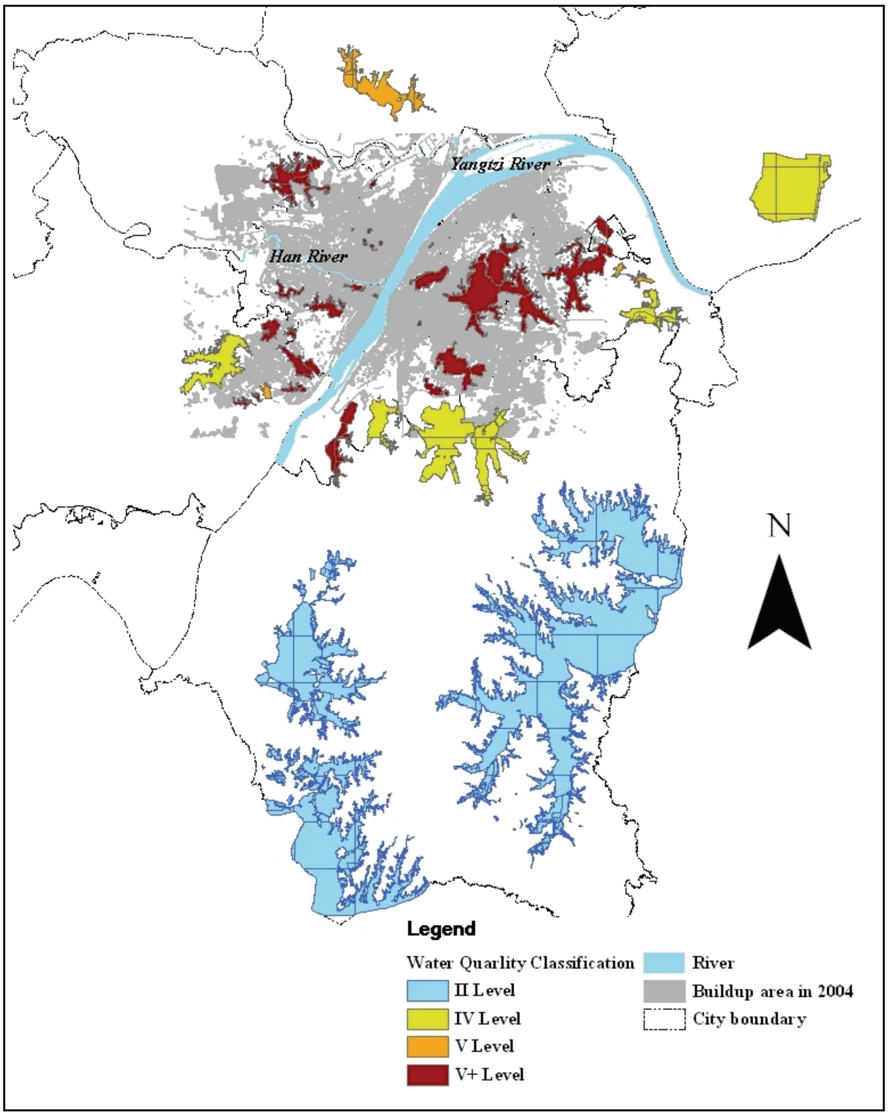


Figure 4.6 Spatial distribution of lakes' water quality in part of Wuhan urban region

4.6 Urban planning development in Wuhan

Building on the general description of Chinese urban planning in section 4.1, this section examines the specific development stages and characteristics of master planning in Wuhan. Each the city's master plans encountered different problems and requirements (Table 4.6). In the early stage (1950s to 1970s) the ideology of the former

Soviet Union was most important. In the 1954 master plan, planning was conceived of as the continuation and concretization of national economic planning in physical space. The main task was the layout of the major industrial and infrastructural projects of the central government. Main land use, such as industry, transportation, administrative organization and university were considered as the basic elements for city. New residential land use was developed, but residential function was actually regarded as an affiliated part of the other basic elements. The 1959 master plan mentioned the necessity of connecting lakes and rivers, but there was no instrument for the implementation of this policy. Partly because of strict migration, urbanization was limited from the 1950s to the 1970s, and so urban expansion was not prominently featured.

With the ideological changes of the 1980s master planning has evolved to be more concerned about efficiency of economic development, quality of ecological environment and social equality. However, such ideological changes have faced implementation obstacles in the context of a transforming society. Planning has also been facing knowledge limitations for the new challenge of rapid urbanization and large scale urban expansion. Figure 4.7 shows the layout of several master plans for the urban core area since the 1950s. Each master plan has tried to accommodate and control urban expansion in its own way, based on their expectations of future growth requirements. However, in practice rapid urban expansion cannot be fully controlled under the guidance of a master plan. This problem is discussed further in section 5.4.

In order to understand the conceptual transformation of the master plans after the 1980s, the analysis of the main contents of the 1982, 1988 and 1996 master plans is given below (note: the most recent master plan of 2006 will be discussed in Chapter 7 which deals with future policy-making).

Table 4.5 Master planning of Wuhan since 1950s

Issued year	Work year	Planning period	Key issues of planning	Population planned (Million)		Planned control urban area (Km^2)	Planned built-up area (Km^2)	
				Long term	Short term		Long term	Short term
1953	1953	1953 - 1973	Industrialization, large scale land use for industrial, transportation, warehouse of national projects	2.24		433		
1954	1954	1955-1972	Industrialization, land use demand for industrial, transportation and warehouse of national projects, new residential land use	2.3	1.76 (Year 1960)			
1956	1956	1956-1967	Industrial zones, transportation, reconstruction of old shanty houses, water supply					
1959	1958	1958-1967	New demand of industrial land use for the local projects, readjustment of industrial zones, new residential zones, parks and connection of lakes and rivers	2.4				
1982	1979-1981	1982-2000	Control the expansion of the built-up area by location and relocation of industrial projects in satellite towns, old city renewal, environmental issues	2.8	2.6 (Year 1985)		200	185
1988	1985-1987	1988-2000	Multi-function of old city, Wuhan economic development zones, historical and cultural heritage protection, improvement of infrastructure	4.2		650	245	
1999	1993-1996	1996-2020	Economic reform and market system, industrial restructuring and tertiary development, improvement of urban ecological environment, old city renewal and heritage protection, improvement of infrastructure and public facilities	5.0	3.79 (Year 2000)		427	281
In progress	2003-2006	2006-2020	Transformation of economic growth mode, harmonious society, healthy and friendly ecological environment, harmonious relationship of rural and urban area	5.02			450	

Sources: Wuhan Chorography: Urban Construction Section (LEC, 1989, pp112-150); Master planning report 1996-2020; Master planning report 2006-2020

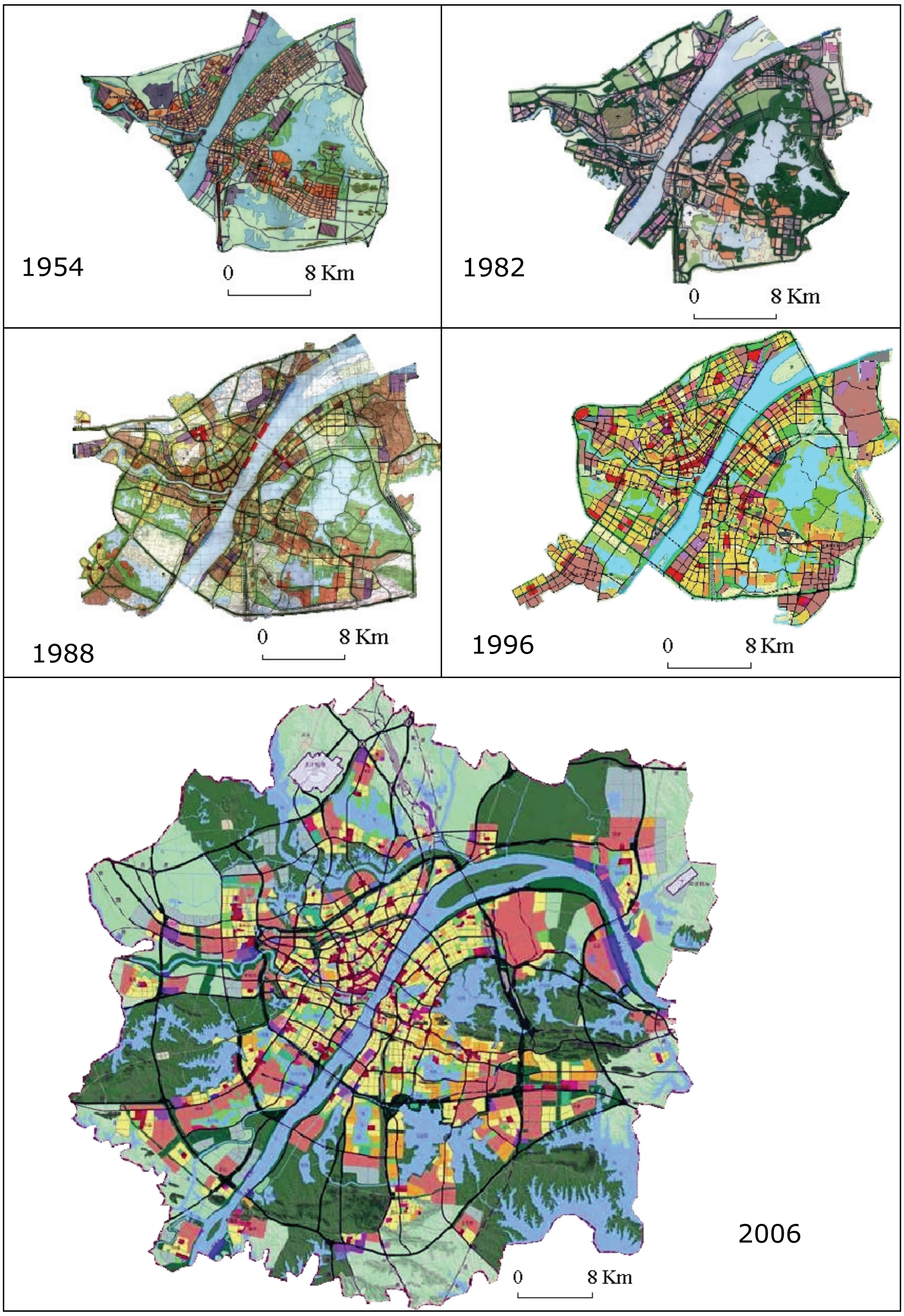


Figure 4.7 Layout map of Wuhan master plan (1950s – 2000s)

The main contents in the master plan 1982 include: (1) readjustment of urban spatial structure; (2) development of new industrial satellite towns; (3) reconstruction of old transportation facilities and new construction of road network and other public facilities; (4) old city renewal, new development of residential areas and the improvement of relevant service systems. The main concept of this plan is to limit the new industrial land use in the old built-up area and encourage new development requirements in several satellite towns. The purpose was to increase the scale and density of urban land use in the urban core so as to limit the rapid expansion of the urban area. Although lakes and green areas are shown in the map, no mechanism and approaches are indicated for the implementation.

The 1988 plan was an amendment of the 1982 plan. It possessed some new features: (a) the inter-relationship between the economic planning and urban planning was first put forward and urban planning was no longer regarded as just a continuation and concretization of the economic plan; (b) new economic development zones were put forward (i.e. Dong Hu High-tech Industrial Development Zone and Zhuan Kou Economic Development Zone, see Figure 4.4); (c) protection of historical and culture heritage in the old city and the importance of urban identity were emphasized; (d) urban population forecasting included the floating population for the first time; (5) the main road network system, including inner and outer ring roads were designated in the plan map. Despite good intentions the desire for rapid economic development resulted in a lack of enough attention for environmental protection.

On the whole these two plans played a necessary role in making governmental officials and common people realize the necessity of urban planning work. Public recognition of planning's role is obviously important for the future urban development. But it is evident that both these plans followed the blueprint-oriented paradigm and depended too much on an administrative controlling approach for land use management. Consideration of market forces was very limited, though planners of the time could be excused for they had little knowledge and experience with market-driven urban growth.

Due to the high land requirement for development at the beginning of the 1990s, the master plan had to be adjusted once more. Work on the new plan started in 1993 and the planning document was finished in 1996. It was finally authorized by central government in 1999. This can be regarded as important master plan which has had great influence on the city's development in the recent decade and even today. The key contents of this plan can be summarized as: (1)

promoting urban and rural integration so that the municipal area (Wuhan Urban Region) was involved in the urban master plan; (2) guiding the spatial development in a rational way by optimizing the spatial distribution of industrial, residential and commercial functions, and increasing the intensity of land use in the urban core; (3) encouraging the development of tertiary industry and improving the service sections in the old city; (4) protecting the cultural and historical heritage; (5) constructing the ecological framework and improving the urban physical environment; (6) improving the service quality of the infrastructure system. This plan has placed more focus on the quality of urban space and urban sustainability than the former plans. The new concept of an ecological framework for the urban form was brought forward and the protection and rational utilization of natural resources, such as surface water, gained some attention.

However, the reality still reflects planning's failure to some extent in protecting natural environment and regulating land use at the suburban areas. This point is discussed in detail in chapter 5. There are several deficiencies worthy of note. The first is that this plan mainly concentrated on physical patterns of urban development inspired by government initiatives without much public participation during the plan-making process. Second, the new concept of ecological framework has not been fully implemented due to the absence of proper instruments and institutional capacity. Third, the strategic consideration of spatial development largely neglected the relationship between the urban area and the rural area. Land use planning still focuses on the urban core area so that the space within the middle ring road is filled by urban land intensively according to the plan (Figure 4.7 and Figure 4.4). Even though the urban and rural integration was mentioned in the document, emphasis of the plan is laid on the urban part. Last, the effects of market forces generating new urban developments in the suburbs were insufficiently considered. A typical case is that of the Wu Jiashan Development Zone (Figure 4.4) which was not put on the agenda for the planning process and was not mentioned in the plan document and the plan map, yet it has been constructed.

4.7 Current water management policy and institutional transformation in Wuhan

Under the pressure of the deterioration of water quality and the increasing reclamation of water bodies, several local regulations (the relevant documents were obtained from Wuhan municipal websites) were decreed in Wuhan after 2000. These include 'Wuhan Building Regulation on the Three Edges (rivers, lakes, hills)' in 2003, 'Lake Protection Regulation' in 2001, 'Wuhan Sewage Drainage Regulation' in 2002 and the new version of 'Wuhan Urban Green Regulation' in 2002. Each is explained briefly below.

The 'Wuhan Lake Protection Regulation' was brought into effect on 1 March 2002. It was the first time for Wuhan to specifically regulate lake protection. 38 lakes (later increased to 43) in the urban core and 144 lakes in the suburban area were officially listed. It regulates that: (1) the protection area of lakes should be divided into water body, green buffer zone and periphery control zone respectively, the boundaries of which are called the three lines, i.e. 'blue line', 'green line' and 'grey line'; (2) it is forbidden to fill in and reclaim the water body of lakes; (3) it is forbidden to have buildings and structures in the green buffer zone except for some necessary facilities such as drainage and garden installations; (4) land uses in the periphery control zone should comply with the master plan as well as lake protection plan; (5) it is forbidden to drain sewage and dump household waste into the lakes and no new drainage outlet are allowed into the lakes. The existing drainage outlet will be removed as soon as possible; (6) the resources of lakes can only be utilized if there are no negative impacts.

Subsequently, in 2004, the Wuhan Lake Protection Planning in the Urban Core was made and, the key targets and functions for the 38 lakes (Figure 4.5) were identified. The boundaries of these lakes were already delineated and staked out in 2002, which to a large extent ensures that the lake protection has gained official recognition and practical control. The regulation is playing a necessary role in the protection of lakes in the Wuhan urban core. The sewage outlets of several lakes have been closed and this work is expected to be finished in 2009. Since 2005, the reclamation of these 38 lakes has been effectively stopped. However, the boundary of the lakes in the suburban area was only delineated in 2005 and the relevant work is now in progress.

The institutional structure of water management in Wuhan had experienced a large transformation from 1998 to 2001. Before 1998, the water-related affairs were dispersed in different bureaus or departments (Table 4.6). The so called 'nine-dragon' or 'multiple-dragon' institutional structure has resulted in many conflicts among different organizations. In 1993, when the National Water Conservancy Ministry initiated a new tax imposition on water resource fee, the conflicts among water-related departments became prominent. The consequence was that different departments may fight for sharing water resource fee, but no departments had the clear responsibilities to take care water-related problems. Furthermore, with the rapid urban development and the institutional reform of urban management, the conflicts between urban sections and water sections were quite severe.

The turning point happened in 1998 when Wuhan suffered a serious flood from the Yangtze River. After this the central government put forward a new guidelines on the water-control of the Yangtze River, which includes increasing land for reforestation, returning farm land for forestry, resettling people out of river courses to new areas, returning farm land to lakes and rivers, reinforcing main embankments and dredging the main river courses. Such guidelines require more cooperation among different organizations at the local level. In this context, Wuhan water management initiated the institutional reform in 1998 and its reorganization was finished in 2001. Such reform is also in the lead of the other cities in China, though there is still has room for improvement.

Table 4.6 Water-related organizations and their functions before 1998

Name of organizations	Functions and responsibilities
The Wuhan Water Conservancy Bureau	Rural water conservancy construction in the municipal area, including: reservoir, pumping-station, irrigation, water-soil conservation, embankment in the rural area
The Wuhan Flood-control Headquarter	Flood-control and embankment construction in the urban area
The Wuhan Public Utilities Bureau	Water-supply, the protection of potable water sources
The Wuhan Municipal Infrastructure Bureau	Urban rain and sewage water drainage and their relevant facility construction, water-logging mitigation
The Wuhan Mineral Resources Bureau	Ground water management

Sources: Interview of local water manager

In October 2001, the Wuhan Water Affairs Bureau was established. It was formed by the combination of four organizations: the Wuhan Water Conservancy Bureau, the Wuhan Flood-control Headquarters, the Wuhan Public Utilities Bureau and the Wuhan Municipal Infrastructure Bureau. Correspondingly, it attempts to take on all responsibilities for water-related affairs and can legally collect water-related management fees. In the meantime, the concept of water management is being transformed into an integrated approach combining water safety, water environment, water resources management and water ecology. In practice such integration is rather difficult. The Wuhan Lake Protection Regulation was promulgated in this background. According to the detailed rules for the implementation of Wuhan Lake Protection Regulation in 2005, the Wuhan Water Affairs Bureau started to take care of the demarcation of the lake water boundary (Blue line). It also has to cooperate with the Parks and Woods Bureau, the Forestry Bureau and the Urban Planning and Management Bureau to delineate the green line and grey line for lake protection. However sectoral segmentation still influences the effectiveness of the regulation in space and time.

4.8 Summary

Since 2000, various policy efforts either from the side of urban planning or from water management have gradually converged on environmental and ecological issues. However, institutional segmentation has influenced the effectiveness of policy implementation. Institutions of water management have just finished their administrative transformation. Some practical effects in the short term have emerged, but the long term effects have to be evaluated in the future. Despite the progress which has been made at present the gap between water management and spatial planning still exists in Wuhan:

1. Spatial concept of surface water in Wuhan has not been fully discussed among urban planners and water managers. In addition to lakes, the importance of other surface water bodies, such as shallow water bodies has not been fully recognized.

2. Understanding of the spatial consequences of surface water management in Wuhan needs more attention from spatial planners

3. A spatial policy framework for the surface water system has not been established. This is a barrier for knowledge sharing, technical discussions and implementation of cooperation among water management and spatial planning from strategic level to the local level.

Chapter 5 [*] Spatial Impact Analysis and Policy Response on Surface Water in Wuhan

In the case of cities located in alluvial river plains, surface water bodies may occupy large areas, yet, in one way or another, if they carry a limited weight in the planning and development processes the ecological and environmental consequences can be severe. In order to understand the connections between surface water bodies and urban land use, this chapter examines the specific situation in Wuhan. The quantitative analysis of this study focuses on three types of areas: surface water bodies, riparian buffer zones of surface water bodies and urban land coverage in the built-up area. For the first two types an analysis is made of land use conversion and imperviousness analysis is done for the latter type.

5.1 Introduction of case study

5.1.1 Data sources for analysis on surface water

This study is based on the results of two land use surveys, carried out in 1993 (LUS1993) and 2004 (LUS2004). Both surveys were made during the summer time (wet season) and prepared in order to support ongoing master-plan-making activities. Trained surveyors went to the field to identify the land use functions and delineate the boundary of land use classification based on topographic maps with a scale of 1/2000. The Wuhan Academy of Urban Planning and Design (WAUPD) organized and guided the whole process. WAUPD was responsible for establishing a standard system for land use surveying, training surveyors, discussing and identifying classification problems of land use type in the field, and carrying out quality control and data input. Aerial photographs were available to be used in simultaneously checking the result of LUS2004 during the surveying process. Landsat TM Images, of July 1991 with a resolution of 30 m, were used to check the data of LUS1993 on water and built-up areas. It could be concluded that the survey shows no major errors or inconsistencies.

The survey area of 2004 is larger than that of 1993 due to the expansion of the city. As a result, the comparative analysis of land use change on surface water bodies from 1993 to 2004 was limited to

---

[*] This chapter has been adapted from an article: (Du et al. 2009a). Based on the empirical analysis in this chapter and section 4.4, an article will be published: (Du et al. 2009b).

the 1993 survey boundary (Figure 5.1). The original spatial data was in AutoCAD DWG-format and later converted to ArcGIS for the further spatial analysis. The minimum mapping unit is approximately 100 m^2.

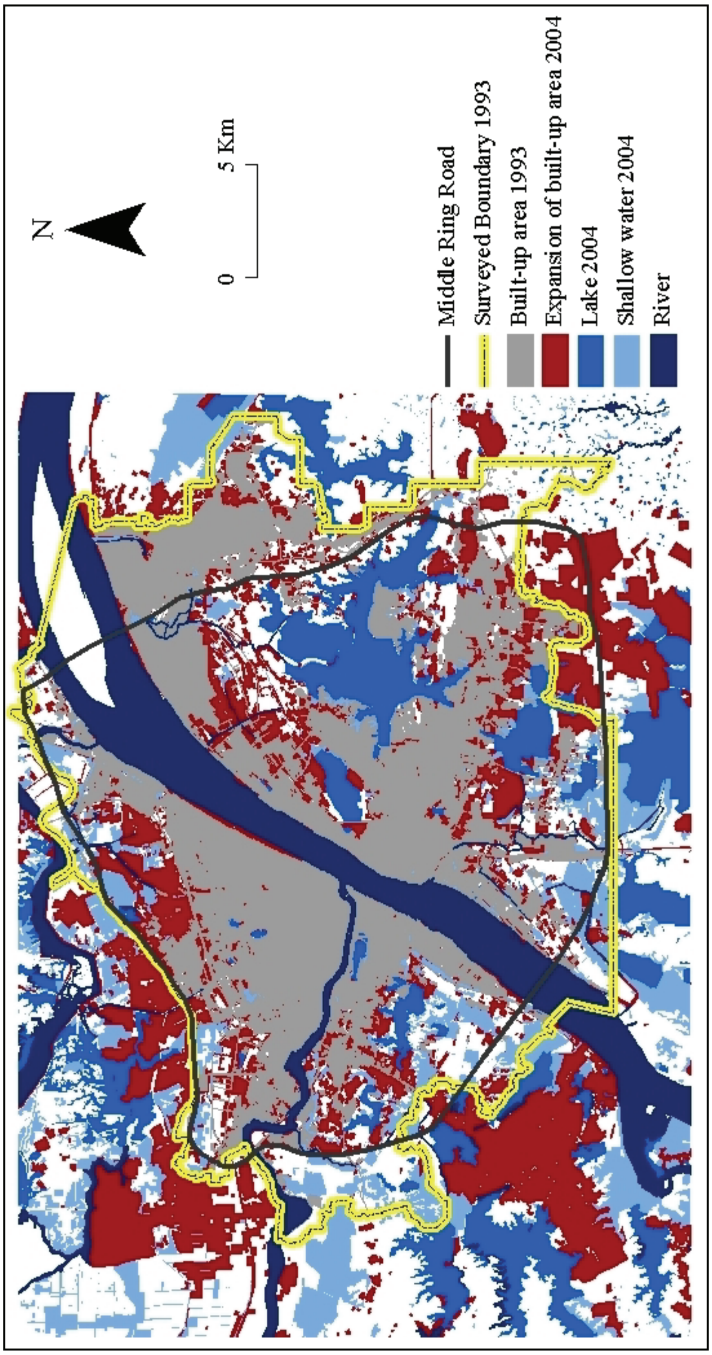


Figure 5.1 Built-up area and surveying boundary in 1993 and 2004

5.1.2 Locations and data sources for imperviousness analysis

Due to the limited access to the municipal database and limitation of research time, it was impossible to calculate impervious ratio for the whole built-up area of Wuhan city. Four sample fields were selected according to their different locations and functions with different development intensity (Figure 5.2 and Table 5.1). They respectively represent four different situations: (1) A mixed commercial-residential zone located in the center of the city; (2) A new residential area located at the edge of the main built-up area; (3) Educational and administrative units in the city; (4) A new industrial development zone outside the main built-up area. Relevant data was extracted from the following sources of the Wuhan urban core: the DOM 2006 (Digital Orthophoto Map) with resolution of 0.2 m, the DLG (Digital Line Graphic) with a scale of 1/2000 and the database of fundamental geographic information.

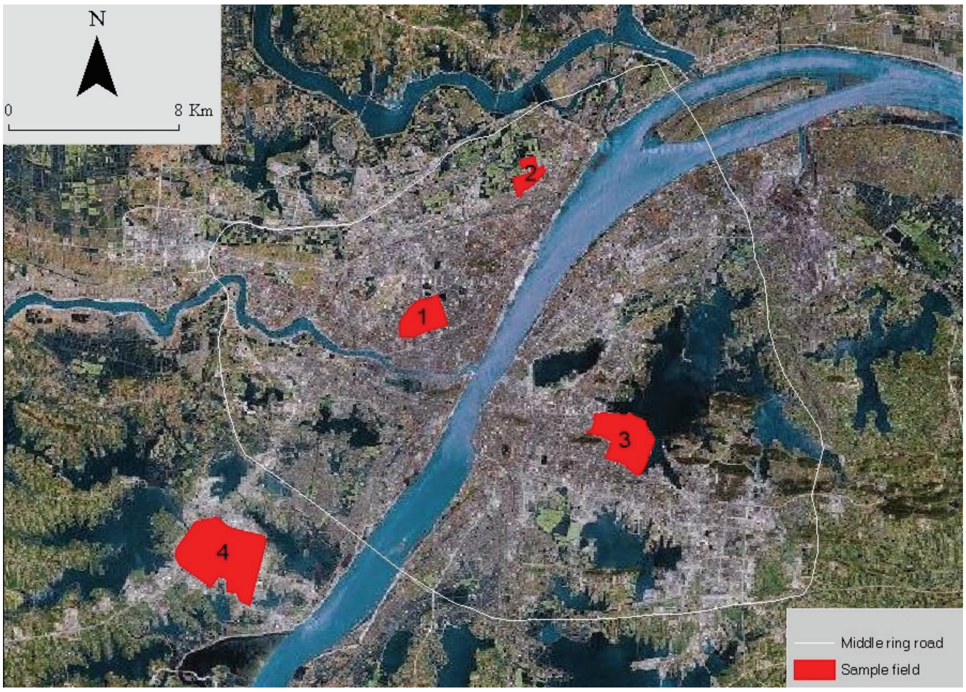


Figure 5.2 Spatial distribution of the sample fields in the urban core

Table 5.1 General features of sample fields

No.	Name of the sample fields	Functions	Area (km^2)
1	Wan Songyuan	Old commercial and residential mixture	2.95
2	Bai Buting	Newly residential area	1.29
3	Wuda – Shui Guohu	Schools, university, administrative units	5.54
4	Zhuankou	Newly industrial development zone	10.59

5.2 Research methods

5.2.1 Classification of urban land use and water

LUS1993 and LUS2004 employed the National Urban Land Use Classification and Planning Land Use Standard (NULUC) of 1991. According to NULUC, the land use in the urban area is classified at three aggregation levels: high (10 classes), medium (46 classes), and low (73 classes). Although in LUS2004, some new land use classes have been added in order to cover the local reality, the basic framework and main land use classes still follow the national standard and therefore the data is comparable for temporal-spatial analysis. The land use data in both datasets is sub-classified adopting the classification at the lowest level.

Table 5.2 Hierarchy of land use classification according to NULUC in 1991

Name of classes (high level)	No. of classes (medium level)	No. of classes (low level)
1. Residential	4	16
2. Commercial and public facilities	8	23
3. Manufacturing	3	
4. Storage facilities	3	
5. Transportation (external connection)	5	5
6. Road and square (internal connection)	3	8
7. Municipal utilities	7	10
8. Green space	2	4
9. Specially designated (e.g. military etc.)	3	
10. Water area and others	8	7
	46 (in total)	73 (in total)

Note: The map scale used is:
1/10 000 to 1/25 000 -- for the high level
1/5 000 -- for the medium level
1/1 000 to 1/2 000 -- for the low level

Urban land uses are commonly grouped in the first nine types (Table 5.2) and have the prime attention of urban planners. In master planning, only the urban land use classes are needed to calculate the balance sheet for planning purposes. Such a balance sheet is used as a method to quantitatively assess the rationality of land-use configurations in the different planning schemes. The last category, 'water area and others' includes: different types of surface water (such as rivers, canals, lakes, ponds, pools, swamps and reservoirs), agriculture, orchards, woodlands, grass lands, rural housing and rural industrial lands, mining and unused lands. This class is normally regarded as background and is to a large extent ignored in the urban plan-making process. Given the aims in this study, the main focus here is however on the water areas.

The most detailed land use level of the two datasets (LUS1993 and LUS2004) was aggregated into the 4 relevant categories for the research purpose (Table 5.3): 'Urban artificial', 'Rural artificial', 'Natural and agricultural' and 'Water'. The 'Urban artificial' and 'Rural artificial' refer to the built-up environment with intensive human activity and impact. Agricultural land use in and around the Wuhan urban region is intensive and accordingly has substantial negative ecological impacts on water.

Table 5.3 Classification of land use type for the case study

Land use class	Land use category	Explanation
Urban artificial	Residential and commercial land use (RC)	All kinds of residential, commercial and public facilities
	Manufacturing and storage (MS)	All kinds of manufacturing and goods storage
	Green space (G)	All kinds of parks and man-made green space
	Other urban land use (O)	All other urban land uses, including transportation, road and square, municipal utilities, specially designated etc.
	Urban transforming (UF)	Land parcels that are already claimed for future urban use, but temporarily idle due to urban renewal and change of purpose (e.g. due to the relocation of an old airport)
Rural artificial	Rural settlement (V)	All kinds of construction in the rural villages, such as housing, rural industry and related facilities
Natural and Agricultural	Agricultural land (A)	All kinds of cultivated lands, orchards, grass lands
	Woodland (W)	All kinds of natural and man-made woodlands
Water	Lake body (L)	Lakes which are designated by the local government
	Shallow water body (S)	All kinds of artificial or natural ponds, pools, marshes and swamps
	Rivers and Canals	

Note: The category 'urban transforming', is a new land use type used in LUS2004. These lands can be put into the land lease market in the near future, but their specific urban function was not determined at the time of the survey. Such land is considered to be a kind of urban artificial land use.

5.2.2 Measuring land use conversion of water surfaces

In the ArcGIS environment, data checking and pre-processing was performed so as to ensure the quality of the data. Spatial analysis functions were applied for measurement, classification, buffer analysis and visualization. Two measuring processes were carried out in this study: measuring water body reduction and their land use changes; and measuring land use changes in riparian buffer zones.

First, the amount of water body reduction was calculated and displayed spatially from 1993 to 2004. Furthermore, the conversion of these water bodies into different land use types was identified.

Second, the riparian buffer zones around lakes and shallow water bodies were spatially defined. Based on the water boundaries in 2004, the lakes and shallow water bodies with an area larger than 1 ha were selected. 'Wuhan Building Regulation on the Three Edges (rivers, lakes, hills) 2003' identifies the minimum distance between buildings and the edge of water bodies as 10 m. Xiang (1996) pointed out that the desirable buffer widths vary significantly according to the changes in slope, soil features and land surface conditions and they range from a minimum of 7.9 m to a maximum of as much as 176 m. Wenger (1999) advised that providing good control for reducing nitrate concentrations needs a buffer of 30 m; maintaining aquatic habitat requires a forested riparian buffer of 10 to 30 m; and protecting diverse terrestrial riparian wildlife communities demands buffers of at least 100 m. In this study, buffer zones of 10, 30 and 100 m from the edges of lakes and shallow water bodies were defined. A land use conversion table was made for each of these buffer zones. Land use changes from 1993 to 2004 within the buffer zones were calculated.

5.2.3 Calculation of impervious ratio in the sample fields

Impervious ratio refers to the percentage of impervious surface cover in the sample area. According to Schueler (2000) and Arnold et al. (1996), impervious surface is defined as any material that prevents the infiltration of water into the soil, including roads, parking lots, sidewalks, rooftops, and other impermeable surfaces in the urban landscape. In the Wuhan case, the impervious surface includes the components of paved roads, paved sidewalks, buildings, parking lots, and paved squares.

Two steps were taken for data processing. First, from the data source of DOM, the approach of supervised classification with the help of local knowledge was applied to classify the components of impervious land use. Second, the spatial boundary of the above components was extracted from the data source of DLG and the local database of fundamental geographic information system. All the spatial data was input into ArcGIS environment for validation, classification and final calculation. The impervious ratio was computed for each sample field based on the pixel values.

5.2.4 Flowchart of analysis process

The process of the quantitative analysis in this chapter is summarized in Figure 5.3. The results will be displayed in the next section.

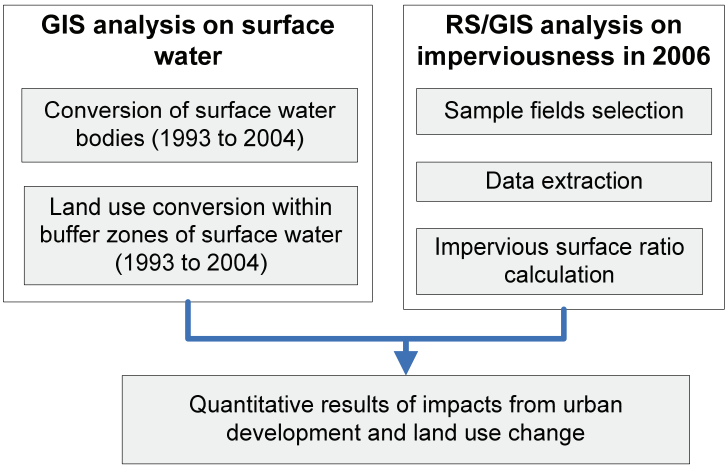


Figure 5.3 Flowchart of data processing and analysis

5.3 Results

5.3.1 Land use changes in surface water from 1993 to 2004

Surface water bodies in and around Wuhan urban core have changed substantially from 1993 to 2004. In the study area, nearly all the surface water bodies, both lakes and shallow water, have been subjected to various degrees of alteration (Figure 5.4). About 585 ha of lakes and 3454 ha of shallow water bodies have been transformed into other types of land use. In Wu Chang and Han Kou, most of the conversion of lakes and shallow water bodies happened in locations adjacent to the existing built-up areas. The tendency towards fragmentation in surface water bodies is evident. Moreover, because of the loss of shallow water bodies, most of the lakes have no surface connection to the main surface water network.

The extent of the various land use conversions affecting the surface water bodies are displayed in Table 5.4. About 54% of lake bodies have been changed into either the urban or the rural artificial class, with residential and commercial functions having a relatively large share of the change. Conversion to the class 'urban transforming', which refers to land that will soon be used for urban functions, has a high percentage, as is conversion to urban green space. Nearly 60% of the shallow water bodies have been converted to urban and rural artificial land use. Residential and commercial functions and 'urban transforming' are here again the main types of land use conversion. Change into agricultural land use from both lake and shallow water has, moreover, been sizable. There were also some conversions between lakes and shallow water bodies, but conversion from lake to shallow water was more common. Conversion from both lake and shallow water body to woodland was very limited. Photograph 4 shows different purposes of lake reclamation

For city road construction

For highway construction

For building construction

For new construction

Source: taken by author in 2007

Photograph 4 Lake reclamation in Wuhan urban core

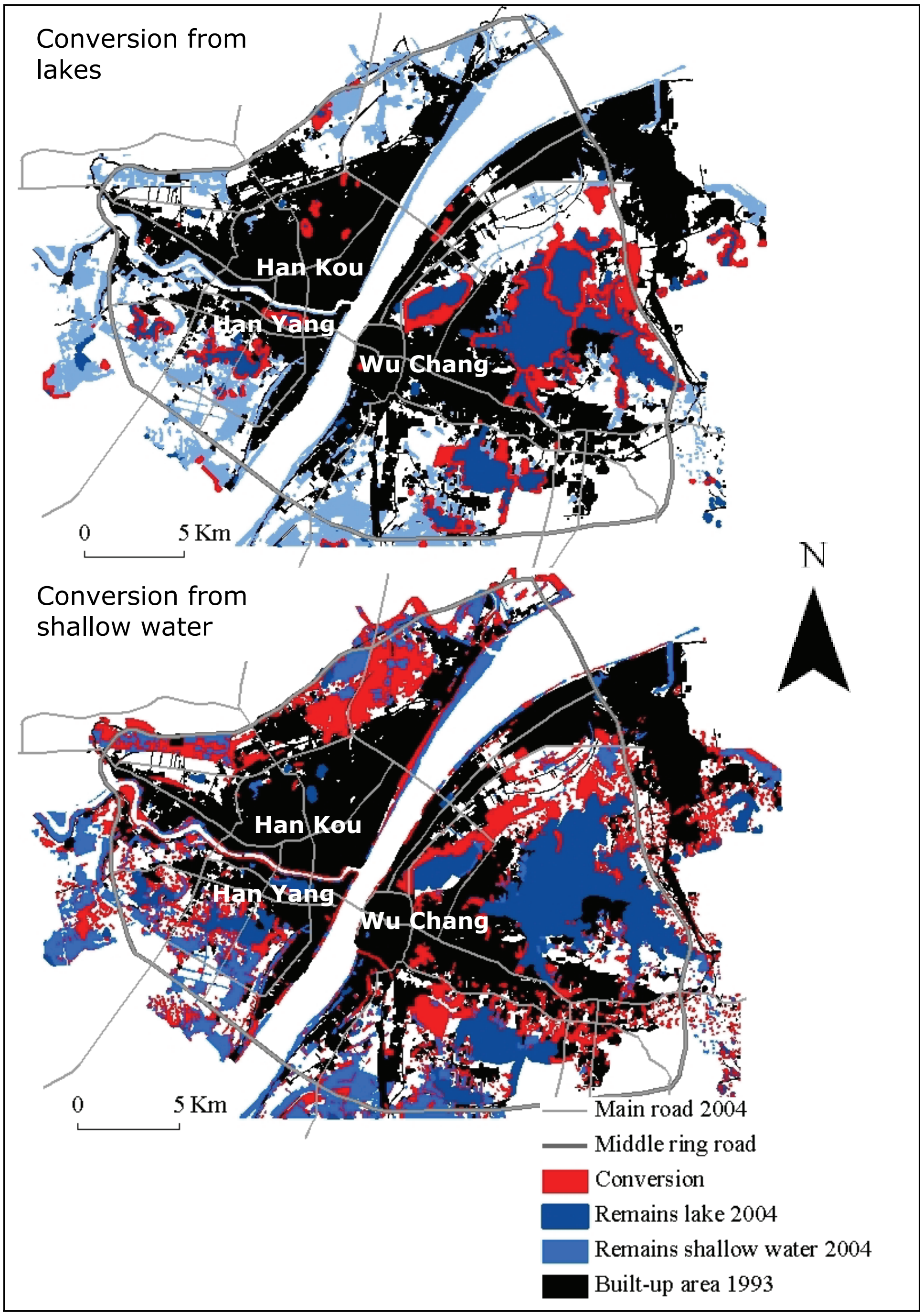


Figure 5.4 Conversion from water bodies into other land use (1993 to 2004)

Table 5.4 Land use conversion from water bodies (1993 to 2004)

	Converted to land use type	From lake		From shallow water	
		Area (ha)	%	Area (ha)	%
Urban and rural artificial	Residential and commercial (RC)	152	16.4	1441	26.4
	Manufacturing and storage (MS)	5	0.5	257	4.7
	Green space (G)	114	12.3	189	3.4
	Other urban land use (O)	45	4.8	265	4.9
	Urban transforming (UF)	149	16.0	919	16.8
	Rural settlement (V)	37	4.0	200	3.7
	Subtotal		54.0		59.9
Natural and Agriculture	Agricultural land (A)	266	28.6	1967	36.0
	Woodland (W)	2	0.2	37	0.7
Water	Lake body (L)			189	3.4
	Shallow water body (S)	160	17.2		
	Total	861	100.0	5464	100.0

Figure 5.5 shows the spatial distribution of conversion from lakes and shallow water bodies to urban artificial land and agricultural land. Adjacent to the existing urban built-up area, lakes are easily reclaimed, occupied and transformed into urban artificial functions, though such conversions are often spatially scattered. Most of the conversion from lakes to agricultural land happened at the edge of the large lake in Wu Chang. In the meantime, vast stretches of shallow water bodies were also converted into urban land use, especially near the edge of the built-up areas and the main roads. This is more explicit in Wu Chang and Han Kou than in Han Yang. Most conversion to agricultural land took place near to existing farm land.

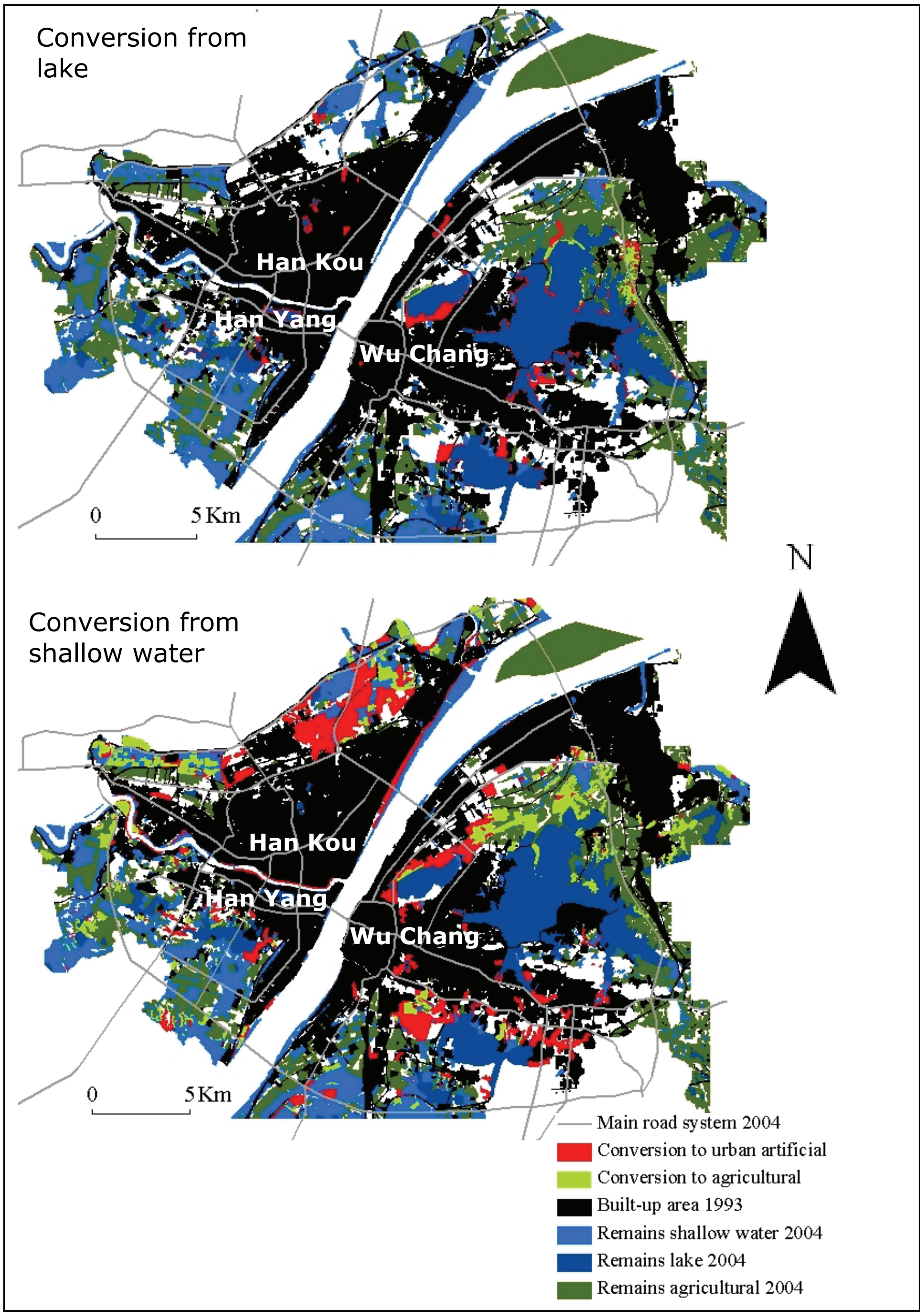
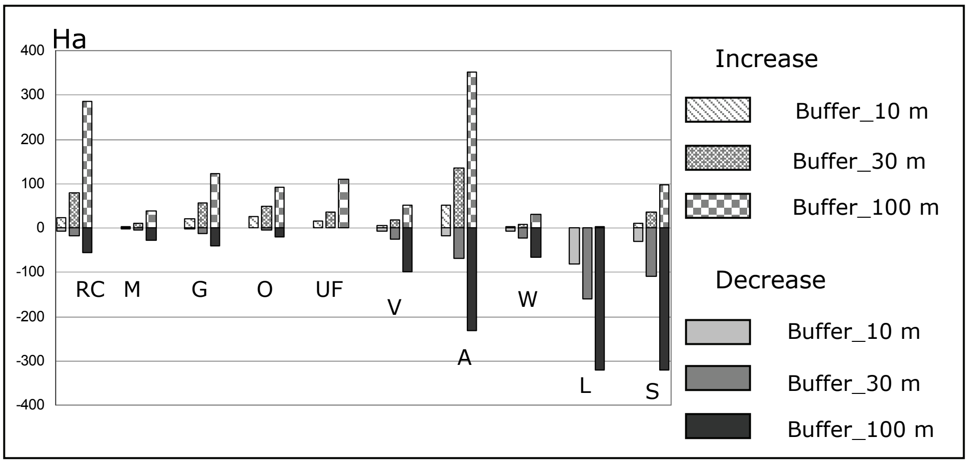


Figure 5.5 Conversion from water bodies into urban and agricultural land (1993 to 2004)

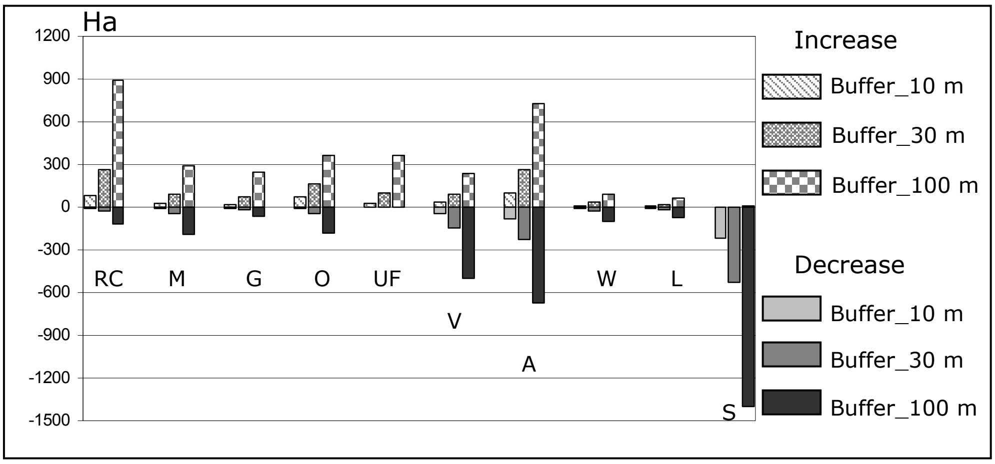
5.3.2 Land use changes within the riparian buffer zones of surface water from 1993 to 2004

The results of the land use conversion from 1993 to 2004 within the buffer zones of lakes and shallow water bodies are displayed in Figures 5.6 and 5.7 respectively based on the detailed land use conversion tables in Appendix E. In the buffers around the lakes there was hardly any land converted to water. A few lakes changed to shallow water bodies which tend to sustain lower ecological functions. Similarly, there was hardly any land converted to shallow water in the buffer zones of the shallow water bodies. The area of nearly all urban land use functions increased in the three calculated buffer zones around the two kinds of water bodies. Agricultural land decreased in some places but, surprisingly, increased in others, resulting in a net increase of agricultural land use around lakes and a stable situation around shallow water bodies. The area of woodland was quite small originally but still did decrease. It is clear that urban functional land and intensive agricultural land are the main land use classes benefitting from conversion.



Note: RC–Residential and Commercial; MS-Manufacturing and Storage; G-Green space; O-Other urban land use; UF- Urban transforming; V-Rural settlement; A- agricultural; W-Woodland; L-Lake; S-Shallow water

Figure 5.6 Land use conversion within the buffer zones around lakes (1993 to 2004)



Note: RC–Residential and Commercial; MS-Manufacturing and Storage; G-Green space; O-Other urban land use; UF- Urban transforming; V-Rural settlement; A- agricultural; W-Woodland; L-Lake; S-Shallow water

Figure 5.7 Land use conversion within the buffer zones around shallow water bodies (1993 to 2004)

The percentage of converted land within each buffer zone is presented in table 5.5. There is more conversion to urban and rural artificial use in the buffer zones of shallow water bodies than in those of lakes. Conversion to residential and commercial land increases considerably when wider buffers are taken into consideration (Table 5.5), a possible reflection of the benefit to residential properties in particular from water access and interesting views of the aquatic landscape. Such views have been found to be an important determinant of the value of residential properties in Wuhan (Xiong et al., 2006) and cause the increasing pressure on such aquatic locations from property developers (Ning, 2005). An interesting phenomenon is that artificial green area showed a net increase within the buffer zones of both types of water bodies, while natural forested land, such as woodland, shows a net decrease. Agricultural land also changed substantially and there has been a slight net increase in the study period. But, as substantial amounts of agricultural land have become urban, it appears that agricultural lands are also readily converted to urban development. Such new agricultural land may well represent an intermediate stage in the reclamation of water bodies for urban development. From the current data for two time slices, we cannot determine whether this is in fact the case, but a new study could address this issue and shed further light on the process. It is however clear that the riparian buffer zones were intensively influenced by urban development and other human activities.

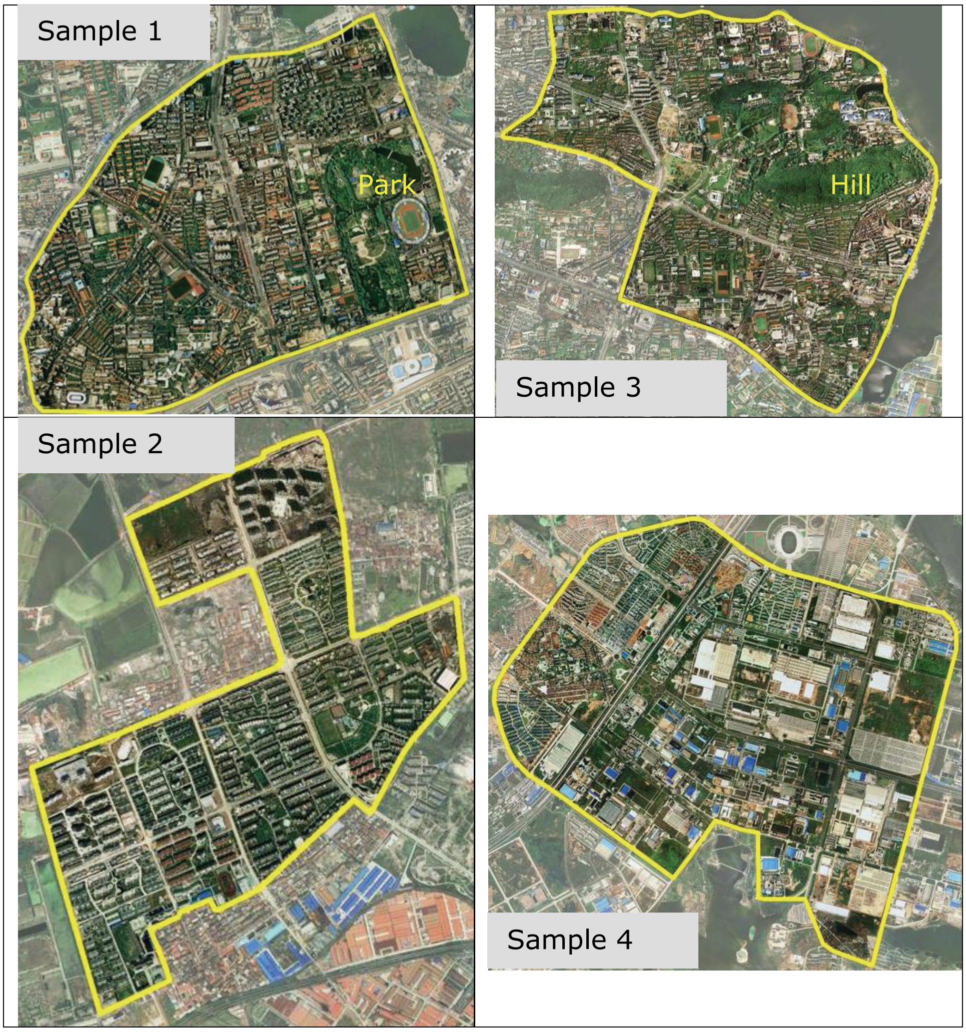
Table 5.5 Land use conversion within the buffer zones of lakes and shallow water bodies (1993 to 2004)

Buffer (m)	Land use conversion		Urban and rural artificial						Sub total	Natural, agricultural, water				Total
			RC	MS	G	O	UF	V		A	W	L	S	
10	Lake	Incr. (%)	14	2	14	16	9	4	59	32	2	0	7	100
	Shallow water		22	7	6	19	7	9	70	25	3	2	0	100
	Lake	Decr. (%)	5	1	2	1	0	4	13	11	4	52	20	100
	Shallow water		2	3	1	3	0	12	21	20	2	2	55	100
30	Lake	Incr. (%)	18	3	13	11	8	4	57	32	2	0	9	100
	Shallow water		24	8	7	15	9	8	71	24	3	2	0	100
	Lake	Decr. (%)	4	1	3	1	0	6	15	16	6	38	25	100
	Shallow water		3	4	2	4	0	13	26	21	3	2	48	100
100	Lake	Incr. (%)	24	3	10	8	10	4	59	30	3	0	8	100
	Shallow water		27	9	8	11	11	7	73	22	3	2	0	100
	Lake	Decr. (%)	5	2	3	2	0	8	20	20	6	27	27	100
	Shallow water		4	6	2	5	0	15	32	20	3	2	43	100

Note: RC–Residential and Commercial; MS-Manufacturing and Storage; G-Green space; O-Other urban land use; UF- Urban transforming; V-Rural settlement; A- agricultural; W-Woodland; L-Lake; S-Shallow water
Incr. – Increase; Decr. – Decrease

5.3.3 Imperviousness

Figure 5.8 shows the present condition of the sample fields and Table 5.6 shows the final results of the imperviousness analysis. In this study the built-up area in 1993 is regarded as old and the one after 2004 as newly developed area.



Note: Sample 1: Wan Songyuan; Sample 2: Bai Buting;
Sample 3: Wuda–Shui Guohu; Sample 4: Zhuankou

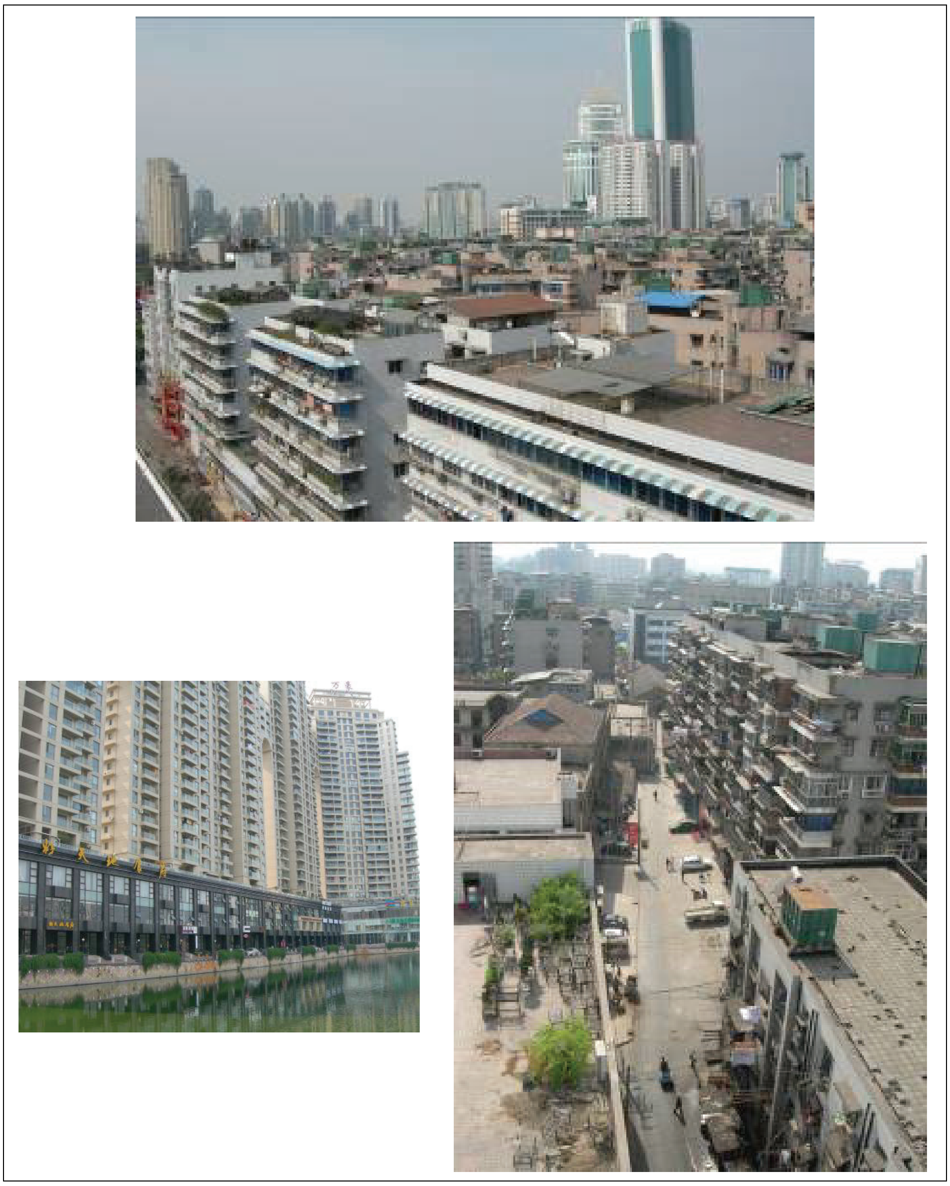
Figure 5.8 Images of the sample areas

Table 5.6 Imperviousness of the sample fields in the urban core

No.	Name of fields	Functions	Total Area (km^2)	Total impervious surface (km^2)	Impervious ratio (%)
1	Wan Songyuan	Old commercial and residential mixture	2.95	2.09	71
2	Bai Buting	Newly residential area	1.29	0.61	47
3	Wuda–Shui Guohu	Schools, universities, administrative units	5.54	3.04	55
4	Zhuankou	Newly industrial development zone	10.59	5.20	49

In Sample 1 (Wan Songyan sample) which is located at the old built-up area, there is a large percentage of the paved surface with high density of buildings even though there is a park of 32.8 hectares inside which offers a certain open space. Its impervious ratio is above 70%. In Sample 3 (Wuda - Shui Guohu sample), there are 3 universities, 3 primary schools, 2 training centers, 4 hospitals, several administrative units and residential areas with low density. Inside, there are 86 hectares as protection of green space and a protected hill, but the impervious surface is still more than 50 %. In the other two samples of the new residential (Sample 2: Bai Buting) and industrial areas (Sample 4: Zhuankou), according to the new development requirement for the amenity with good spatial quality, parks and open space are designed and density of buildings is reduced. Nevertheless, their impervious ratio is still nearly 50 %.

Sample 1 is the residential area with relatively good living environment and sample 3 is an institutional area with relatively high green space in the old built-up area. As aforementioned in section 4.4, the built-up area in 1993 and 2004 was 227 km^2 and 355 km^2 (Table 4.2). Approximately, the old built-up area occupies 64 % and the newly built-up area 36%. In spite of some urban renewal projects for improving the living conditions which have been implemented within this decade, the building density was still very high in the old built-up area (Photograph 5). In addition, the paved roads and parking-squares etcetera further increase the surface imperviousness. The samples selected in this study represent the average condition so that the impervious ratio can be expected to be higher in the other areas than in the samples.



Source: taken by author in 2007

Photograph 5 Densely built-up area of Wuhan urban core

The study in another large Chinese city, Nanjing (Chen et al., 2006) shows that the average impervious ratio in the urban built-up area is approximately 69%; varying from 82% in the old center, 77% in a large residential area and 45% in the university and institutional area. These results are relatively similar to the case in Wuhan.

Arnold et al. (1996) used 10% and 30 % impervious ratio as thresholds for indicating the relationship between impervious cover and water quality. In his view an area with an impervious ratio over 30% should be considered as a degraded level and remediation measures should be used. An area with an impervious ratio between 10% and 30% is impacted and preventive measures need to be considered. In comparison with the Wuhan case, the overall impervious ratio, either in the old built-up area or the newly developed area, is high even though the land use intensity has been decreased in the recent decade.

5.4 Discussion

5.4.1 Driving forces of urban expansion

Several recent studies in China (Liu et al., 2005; Li et al., 2007; Long et al., 2007; Long et al., 2008) show that industrialization, urbanization, demographic change and land use policies and regulations are the major driving forces for urban land use expansion. For the Wuhan case, since the beginning of the 1990s, the new economic and urban policies stimulated the city into a new development track which is quite different from earlier ones, as described in chapter 4. New industrial development, transformation of old industrial activity, real estate development and transportation infrastructure construction are the driving forces of city expansion. These driving forces can be further classified as either leading or following agents.

The leading agents comprise structuring activities including the designation of new development zones, construction of primary infrastructure (main roads, subways, railway lines and stations) etcetera. They have determined the orientation of urban development and the main spatial structure of the metropolitan area. These ‘location leading’ developments are to a large extent controlled and guided by local government. They tend to take the form of large contiguous expansion areas, or very long linear features, developed under tight planning control.

On the other hand, the second group of driving forces leads to more incremental urban growth and consists of initiatives in the sectors of real estate and housing, local industry, commercial and service facilities. The decision-making associated with them is mostly profit-oriented and to a large extent influenced by market forces. These land-uses supplement and fill in the city's new main developing areas. They could be either large or small scale, but most of them are managed by local players who are primarily profit-oriented.

5.4.2 Spatial features of urban expansion and their impacts on water systems

Until the end of the 1980s, Wuhan's urban expansion had a highly centralized character with most of land use transformation happening within or nearby the middle ring road (Figure 4.4). Since the 1990s, the leading developments such as the three economic zones and main roads have set up a new spatial structure framework of urban land use, driving the city to spread through and beyond the middle ring road (Figure 4.5). Simultaneously, the developments driven by following forces of district industrial parks and new residential areas, have contributed to fill in this framework and have finally consolidated the 'pancake' or 'carpet' style of urban expansion, albeit a 'pancake' that is punctuated by several hills and surface water bodies.

As aforementioned, nearly all surface water bodies within the middle ring road have been affected by this process of urbanization and urban land use expansion. The occupation of the water bodies and the urbanization of their buffer zones and highly dense land use have been stimulated by urban expansion, sometimes explicitly but often implicitly. In Han Kou and Wu Chang, hi-tech industrial development zones, district industrial parks, large scale residential areas are all located next to the urban core and have brought about the rapid increase of artificial impervious surfaces in urban areas. This to a large extent aggravates the disturbance in surface water bodies. In Han Yang, the new development zone is located out of the urban core and this 'leap frog' development pattern has to some extent relieved the pressure for intensive use of the land in and near the water bodies, but recent plans for new development areas now foresee the development of the intermediate land, which also includes some large water bodies. Moreover, impervious surface has shown a high percentage in the built-up area. The loss of surface water bodies and the increase of impervious areas are both contributing to qualitative and quantitative water problems in Wuhan.

As recent research revealed, the intensive use of water bodies and their surrounding land has led to serious water quality problems. The water of nearly all of the lakes inside the urban core has a quality rating of V+ level and the main pollutants are domestic sewage, which was mentioned in section 4.5. The quality of water in many lakes has deteriorated from the time when the surrounding construction began (Wang et al., 2004). Apart from quality issues, flooding risk still remains. As mentioned above, Wuhan's flooding risks come from two sides, river flooding and inner water-logging. Control of the latter mainly depends on the capacity for retention or detention provided by the lakes and other surface water bodies. Due to the reduction of their retention capability, flooding risk has increased for urban settlements (Tu & Yuan, 2000). In the meantime, due to the rapid decrease of shallow water bodies, some of the lakes have become disconnected from other components of the surface water systems, further reducing their usefulness for retaining and draining flood water. Furthermore, the increase of impervious surfaces has contributed to these problems. Although this also needs more specific studies to indicate such connections in Wuhan, other research (Arnold & Gibbons, 1996; Morse et al., 2003; Conway, 2007; Moglen & Kim, 2007; Pappas et al., 2008) has proved that the percentage of impervious surface is a measure of urbanization evaluation and can be used as an environmental indicator for healthy water system.

5.5 Policy responses

Wuhan's Master Plan of 1996 put forward the idea of building an ecological framework based on natural resources such as surface water bodies and hills. However, due to the lack of a systematic consideration, low public awareness and support, and a lack of political will, the concept of an ecological framework has, as yet, hardly been a subject of discourse, neither at the strategic level nor at the local level. The search for more developable land has been prioritized. Only after 2000 were several local regulations decreed, including 'Wuhan Building Regulation on the Three Edges (rivers, lakes, hills)' in 2003, 'Wuhan Lake Protection Regulation' in 2001, 'Wuhan Sewage Drainage Regulation' in 2002 and the new version of 'Wuhan Urban Green Regulation' in 2002, which contents were already described in section 4.7. These regulations have implications for land use control. Recently they have started to play a necessary role in the protection of lakes at the city level. In spite of that, in practice land use zones in and around water bodies were not defined until after the new Wuhan master plan revision in 2005. The time-lag between these two policy processes for water and urban development has made it difficult for urban planners and water managers to adopt effective measures to address the water-related problems in an integrated and coordinated manner. Moreover, the measures for protection of lakes in the suburban area are still not very clear due to the insufficiency of financial and expertise investment. What is more, the protection of shallow water bodies and other surface wetlands is still largely ignored.

It is also since 2000 that environmental and ecological issues have been widely recognized in national and development policies. The new state development ideology of 'Harmonious Society' and 'Scientific Outlook on Development', the new Urban Plan Making Regulation of 2005 and the new City and Country Planning Act of 2007, reflect a major change in urban development and urban planning principles in China. Lake or surface water protection policies have quite recently been initiated in China and their importance is gradually being recognized by local government. Some Chinese urban planners and landscape architects, such as Yu (2006), recently argued for harmonizing nature, people and the spirits, and designing a 'landscape infrastructure' that includes water features as a new approach for urban development. More and more environmental consciousness will expect to be found in the local planning documents and regulations in the future.

5.6 Conclusion

The research of ILEC (2005, p12-13) points out three important characteristics of lakes. First, their integrating nature means that they receive diverse inputs from their basin and so their problems can seldom be localized within the lakes themselves. Second, their long retention time means that they respond slowly to changes so that it can take a long time for many problems to become apparent. Third, they display complex response dynamics. This means that they respond to changes (e.g. pollution) in a highly non-linear way so that their ecological status may abruptly change due to the accumulative effects of a series of small changes in conditions. Even so it can be very difficult to reverse the process and restore such a lake to its previous state. Shallow water bodies share the similar characteristics. Consequently, water problems are not self-induced but mainly come from the conditions in their surroundings. To be effective, preservation action should also be focused on the surroundings of the water bodies. But in Wuhan, these characters have not been fully recognized in practice.

After examined the case of Wuhan, four main conclusions could be drawn: first, urban development has had a significant impact on the surface water bodies and their riparian zones either by size reduction or complete reclamation. The geographically outwardly expanding pattern and hierarchical-concentric urban form has increased such pressure.

Second, the reduction, disappearance and pollution of surface water may contribute to the undervaluation of the water bodies' ecological potential among the general public. This in turn, may further intensify the process of water-to-land conversions for urban construction.

Third, the vegetative cover on the riparian areas is limited and has decreased as a result of urban development. Their ecological functions for protecting surface water bodies have not yet been fully exploited.

Forth, regarding the land use in the urban area, the ratio of impervious cover seldom considers to be reduced, which has resulted high runoff in a large scale.

Last, the priority given to fast urban-economic development has led to the large scale utilization of surface water bodies and their riparian areas for building purposes. Despite the emphasis on ecological frameworks and environment in recent policies, current planning concepts and approaches that depend on the reclamation of water bodies need to be challenged.

Therefore, surface water bodies as important ecological entities, should be more carefully considered both at strategic level (i.e. urban and regional planning) and at local action level (i.e. zoning and on-site design).

At the strategic level, proactive land use planning for urban development should consider water issues at the initial stage before negative impacts occur. Clear lines of responsibility between different departments should be demarcated so as to harmonize the fragmental and dispersed local efforts dealing with the water-land related problems regionally and locally. Such efforts should also encourage public participation in order to achieve consensus among the different stakeholders.

At the local level, an on-site water-sensitive design approach should be advocated so as to eliminate the negative cumulative effect by local incremental construction. Using zoning to control the land use in and around the surface water bodies is now one of the commonly adopted measures, but the definition of such zones should reflect the consensus of views from various agents such as urban planners, water managers and the public at large, if it is to be effective and sustainable. This point will be illustrated in the following chapters.

Chapter 6 Spatial Planning and Water Management in the Netherlands and Possible Lessons for Wuhan

The Netherlands is a small and densely urbanized country with 16.5 million habitants (CBS, 2009). With a long history of struggle with flood hazards and land reclamation, every piece of land in this country can be considered man-made and man-controlled. Moreover, overcoming the physical difficulties of land development has led to a cooperative approach in the spatial planning system. A lot of valuable experience has been developed and accumulated in integrating spatial planning and water management. As discussed in chapters 4 and 5, water issues in Wuhan have so far not been tackled in an integrated way due to the lack of systematic policy arrangements at the strategic and local level, the lack of effective mechanism for institutional cooperation and the lack of approaches for incorporating water issues into spatial planning. This chapter reviews the main features, factors and recent trends of Dutch spatial planning and water management. The focus is especially on new policy strategies which aim to strengthen the linkages between spatial planning and water management. These experiences are used to derive lessons for the Wuhan case.

6.1 Principal features of spatial planning and land use planning in the Netherlands

The origin of Dutch spatial planning, also called physical planning (Brussaard, 1987), can be traced back to the Housing Act of 1901 (National Spatial Planning Agency 1996). It has thus developed from the housing sphere. Traditionally, the municipalities have played an active role in land development by acquiring land, providing infrastructure and selling the serviced plots to developers and housing associations (Altes, 2006). Only after the 1930s were the provinces given the power to make regional plans and after the Second World War, the national government started a tentative form of national spatial planning (EU, 1999, p20). The first comprehensive Spatial Planning Act, which was enacted in 1962 and came into effect in 1965, provided the legal framework for the planning system in the Netherlands. Although it has been modified many times in the following four decades, the basic principles have remained. This Act and its accompanying decree define the roles, scopes and responsibilities of each spatial planning institution at the national, the provincial and the municipal level (Table 6.1).

Table 6.1 Roles, scopes and responsibilities of spatial planning institution at different levels

Levels	Major tasks	Main policy instruments	Main planning body	Decision body
National level	Main principles and guidelines for national development for the medium and long term; responsibility for the legislation and an effective financial and subsidizing system; decision of major projects and policy issues; supervising and harmonizing the spatial planning policy of provinces and municipalities	National spatial planning policy document; National sectoral structure plan; National spatial planning key decision procedure	The National Spatial Planning Commission; the National Spatial Planning Agency; the Advisory Council for Spatial Planning; the Netherlands Environment al Assessment Agency	Parliament (First and Second Chambers); Central government
Provincial level	Outlining main aspects of future spatial planning policy in the whole or a part of the province; approving or rejecting land use plans of municipalities	Regional plan	The Provincial Spatial Planning Commission; the Provincial Spatial Planning Agency	Provincial Council; Provincial Executive
Municipal level	Outlining the future development of the entire or a part of the municipality; land use management; processing building permits; Building code	Structure plan; local land use plan; the urban renewal plan; living conditions ordinance	The Municipal Planning Department	Municipal Council; Municipal Executive

Note: The National Spatial Planning Agency is a part of the Ministry of Housing, Spatial Planning and the Environment (VROM).

Sources: The EU Compendium of spatial planning systems and policies: the Netherlands (EU, 1999); Spatial Planning in the Netherlands (National Spatial Planning Agency 1996); The Rules of Physical Planning 1986 (Brussaard, 1987).

According to the Spatial Planning Act, the National Government makes policies for the whole national territory, while provincial and municipal governments are responsible for the development of their own territory. However the Act requires that policies at the higher tier should be hierarchically reflected at the lower tier. In this regard, provincial planning agencies play a role in the coordination between the various government levels and translation of the national reports into regional and local plans (Berg, 1989). Spatial planning policy and spatial planning key decisions at national level, regional plans at provincial level and structure plans at municipal level provide framework plans and policy guidelines. They are traditionally indicative, not legally binding (EU, 1999, pp50-54). Only the local land use plans at municipal level, of which there are many legal consequences, are directly and legally binding on the actions of citizens and government bodies (National Spatial Planning Agency 1996). Once it is accepted by the municipal council and approved by the provincial authorities, the land use plan provides the legal basis for the granting or refusal of permission to develop land and build on it. It is the most important spatial planning instrument at the local level, and therefore the municipal government plays an important role in land development.

Recently, there has been fundamental revision of the Spatial Planning Act which came into effect on 1 July 2008. Needham (2005) presented the new changes in the Dutch Spatial Planning Act which aims at more speed and flexibility. The revised law offers the possibility of using a planning instrument at more than one governmental level (Spaans, 2006). On the one hand, the system of spatial planning organization still keeps the important position of municipalities, on the other hand, it challenges the NIMBY (Not In My Back Yard) phenomenon, by strengthening the importance of the negotiations between municipalities and developers and the negotiations between national government and municipalities (Needham, 2005).

There are several new characteristics of the revised Act: first it emphasizes the different roles and responsibilities of all three-tiers of government, especially provincial and national government. Second, the distinction between indicative plans and legally binding plans is made clearer. The land-use plan is becoming stronger and more important. Third, national and provincial governments can influence the content of municipal land-use plans. Fourth, project plans are being introduced as a pro-active approach for development and a complement to the land-use plan. Finally, more authorities can make legally binding plans. In the meantime, the legal procedures are being simplified and speeded up. The whole operation is an example of the incremental changes of the Dutch spatial planning system.

However, as Needham (2005) pointed out, in fact the basic law and principles of Dutch spatial planning remain. The people of the Netherlands have had a great concern for the quality of their spatial environment (EU, 1999), which is reflected by their consistent interest in spatial planning over a long time. Such long term ambition makes them willing to take a pragmatic attitude towards ensuring territorial safety and achieving a good spatial quality.

Five substantive principles of Dutch spatial planning have been embraced for many decades. They are: concentration of urbanization; spatial cohesion; spatial diversity; spatial hierarchy and spatial justice, all of which concern the location of development (Hajer & Zonneveld, 2000; Needham, 2007, p47-49). Besides these, Needham (2007, p50-52) has added six substantive principles which apply more to the form of development: quality rather than quantity: integral development; building with a layer-based approach; multiple use of land; intensive use of land and the regional scale. A brief explanation of all these principles is shown in Table 6.2. They are followed by each level of government and form the core of the professional approach to Dutch spatial planning. Applying these principles requires strong governance.

The Netherlands has quite a long history of the characteristics of democratic self-government and local autonomy being recognized (Morris, 1985). Although since the 1960s the government centralization has strengthened, strong expectations of self-autonomy remain at municipal and provincial level (Carter et al., 1996). This can explain to some extent that decentralization and self-autonomy at the local level still play an important role in planning issues even though the national government has also become an important player in spatial policy-making according to the New Act. At the same time, the Dutch people are also willing to introduce and accept a high degree of public regulation so as to achieve the desired spatial environment. As pointed out by Faludi and van der Valk (1994, p7), at the core of Dutch planning doctrine lies the predilection for 'rule and order'.

Table 6.2 The substantive principles of Dutch spatial planning

Concern	Principles	Key ideas
Location of development	Concentration of urbanization	Avoid urban sprawl; preserve open space; keep towns and cities viable; reduce mobility
	Spatial cohesion	Avoid large mono-functional developments; Encourage a good geographical relationship between the various activities
	Spatial diversity	Avoid uniformity and monotony; protect differentiation and stimulate it
	Spatial hierarchy	Create and maintain a hierarchical pattern of facilities and economic activities between and within urban centres
	Spatial justice	Ensure people to access equally to good facilities and services
Form of development	Quality rather than quantity	Maintain and create good spatial quality and housing quality; retain spatial identity and safety
	Integral development	Keep separate buildings and spaces relating well to each other within a whole area
	Building with a layer-based approach	Three physical layers refer to: the first layer of the soil and subsoil with its geological, morphological and hydrological qualities, the second layer of the constructed infrastructural networks and the third layer of the land uses. The first layer should be taken into account in particular.
	Multiple use of land	Encourage one piece of land to be used for more than one purpose at a time or over time by creating multifunctional spaces and by staggering the uses in different times of the day
	Intensive use of land	Protect more open space by using land intensively
	The regional scale	Encourage cooperating networks of cities in the same region

Note: adapted from Needham (2007, pp48-52) and Hajer et al. (2000)

In practice, coordination is strongly encouraged between the various levels of government (vertical coordination) through many consultations. The Spatial Planning Act sets down hierarchical powers for the three layers of government in the planning process, but importantly it also institutionalizes the consultation so that spatial planning policies can be discussed and negotiated so as to be adjustable for spatial development at the different levels (Needham, 2007, pp142-146). In addition, spatial planning is regarded as multi-faceted and the coordination between different responsible authorities at a certain level (horizontal coordination) is considered important too. Horizontal coordination, as Needham stated (ibid, 2007, p146-147), is relatively easy at the level of the municipality, but more difficult at the level of provincial and national government. The Act lays out some mechanisms to realize coordination between different policy sectors, such as the National Spatial Planning Committee, the consistent decision-making process in the council of Ministers (Cabinet) and the Provincial Spatial Planning Committee (National Spatial Planning Agency 1996). It is emphasized that spatially relevant issues in different sectors should be reflected in the plans before implementation. Therefore, 'the mechanisms for vertical and horizontal coordination are part of the structure of the planning system' (Needham, 2007, p148) and spatial planning is regarded as a coordinative discipline (Nieuwenkamp, 1985). In a manner of speaking, Dutch spatial planning is to some extent group cooperation toward the realization of common goals. This also reflects the typical characteristics of Dutch spatial planning which is traditionally defined as 'the search for and the establishment of the best possible mutual adaptation of space and society for the benefit of society' (Brussaard, 1987). As a whole, there is much agreement between national, provincial and municipal government about the content of spatial planning policy both by formal regulation and by informal practice (EU, 1999, p27).

However, it should be pointed that the Dutch spatial planning system also possesses some weaknesses. Needham (2005; 2007) has made a great effort to describe, analyse and explain the Dutch spatial planning system. Based on his research, some main weaknesses can be summarized: first, the time for making and approving a spatial plan is long due to the complicated and slow legal procedures, which creates a lower planning efficiency and less profitable development. Especially when everyone can make an objection or an appeal, the process of plan-making can be slowed down. Second, a good vision or an ambitious goal presented by the national and provincial government may not be fully achieved at the local municipal level. The municipal government may not follow all principles in its binding land use plans. Moreover, some land use plans may be outdated and a proposed development may require interim adjustment to the plan for the specific site. Therefore, in practice implementation has some deviations from the original plan. It is these demerits that the new spatial planning act is committed to overcome.

6.2 The water management paradigm shift in the Netherlands

6.2.1 An overview of water management

For centuries, the Dutch have built dikes and drainage systems to ensure a safe land to live on free from the threat from the sea and rivers. The technological and institutional achievement is great and development of urban and rural settlements depends very much on good water management. Historically speaking, Dutch water management has formed a typical 'polder model' (RIZA, 1999) which is later used as a concept to describe a corporatist tradition in the context of Dutch society (Schreuder, 2001). Dutch people take bottom-up and communal water control measures to search for cooperation and consensus building among different stakeholders to deal with water issues. According to van de Ven (1993), the inter-relationship between human activities and the natural water systems in the Netherlands has experienced a long-term transformation from passive adaptation to strong control and manipulation and finally to active adaptation due to continual technological improvement and knowledge development (See the details in Appendix F).

When the Netherlands entered into the era of modernization and industrialization, the human influence on natural water system became tremendous. Nearly all water levels are now controlled artificially after large-scale hydraulic infrastructure construction. The Netherlands now possesses advanced infrastructure systems of dikes, canals, waterways and drainage systems to control its water system very well. For the northern and south-western parts, dikes and dunes meet the safety standards of 1/4000 and 1/2000 years; for the densely populated western part, this standard is raised to 1/10 000 years; while river dikes meet the standard of 1/1250 years (NHV, , 2004, p47-48). The safety problem has been solved more or less through the 'pumping-drainage-dike raising' approach (Brugge et al., 2005). However, other water-related problems, i.e. water pollution and water shortage surfaced in the 1970s (van de Ven 1993, p178), and some other environmental problems such as desiccation were also recognized in the 1980s (van Ek et al., 2000). The resolution of these conflicts calls for new policy for integrated water management.

New water policy and approaches have been explored since the 1980s. The focus of attention shifted from the construction and maintenance of hard infrastructure to integrated water management. Such a shift becomes more and more fundamental due to the awareness of the new challenges of the rising sea level, land subsidence, pressure of urban expansion, and fragile natural resilience of the water system. It is realized that increasing the height and size of the dunes and dikes is not sufficient to withstand the expected storm surges and river floods. Suppressing natural processes could actually lead to loss of control and worse losses in the end (RIZA, 1999). In 2001, the Government and Parliament adopted a new water management policy for the 21st century entitled 'A Different Approach to Water' (NHV, 2004). Now the Netherlands is entering into the new era of 'accommodating water' (Drimmelen et al., 2005).

The evolution of Dutch water management is a successful process for dealing with the conflicts between human activities and ecosystems. The combination of hydraulic engineering and other requirements through institutions eventually tames though never vanquishes the 'water-wolf' in the Netherlands (TeBrake, 2002). Dutch hydraulic engineering has created practical, resilient surroundings that are beautiful without impinging on the man-made landscape. The innovations in hydraulic technology support the Dutch in protecting the land against the sea and rivers, while on the other hand the attention to ecological response and environmental changes is also embedded in the context of an evolving society (van Dam, 2002). Such environmental concerns play an important role in policy-making and may take new measures if the failure of some innovative technology occurs. Reuss (2002) highlighted Dutch water management as a good example concerning the blending of technology, institutions, and public and private objectives. He pointed out that the challenge today is not so much one of accepting technological limitations but of defining our own humanity. The view of how people live with nature is also an important issue for policy-making. It is because the ecological, social and cultural value of water has been highly recognized over the centuries in the Netherlands that the spatial water policy can be proposed and implemented in practice.

6.2.2 Institutional structure

Water management in the Netherlands is organized at three main hierarchical levels: national, provincial and regional. At the regional level, the water boards and the municipalities manage the water issues in their specific areas. Water boards, as early democratic institutions in the Netherlands, originated in the 13th century. The National government, provinces, municipalities and water boards all have their own responsibilities in elaborating the details of the water-related policies (Table 6.3).

The formulation and implementation of Dutch water policy follows a corporative way based on its institutional structure. Consultations take place at all levels of government (national, provincial and local) and at all stages (policy preparation, formulation and implementation). This has formed the foundation for further integrating water policy with the other policies on land use planning, environmental management, nature protection, agriculture, fisheries and transport.

Table 6.3 Government responsibilities for water management

Levels	Main tasks
National level (Ministry of Transport, Public Works and Water Management)	National water policy and legislation; Management of main water systems, such as major rivers and coastal zones.
Provincial level	Provincial water policy; Management of groundwater*: Regulations and supervision. *With the new policy named Waterwet of 1 January 2010, the management of groundwater is divided between the provinces and the water boards. The province stays responsible for the large extractions (>150.000 m^3/y).
Local/regional level (Water board)	Management of regional water system (water level); Management of water quality; Flood defence in the region; Treatment of urban and industrial wastewater; Small extractions of groundwater
Local (Municipal level)	Urban water policy; Sanitary sewage and storm-water facilities.

Sources: Adapted from Woltjer at al. (2007).

6.2.3 New approach: integrated water management

Integrated water management was proposed in the third national water policy document in 1989 and has gradually become the main guiding principle of Dutch water policy. It represents a break with the traditional view that pumps should discharge water as rapidly as possible. The basis of this policy is to pursue both internal and external functional connections. Internal functional connections are the connections between quality and quantity aspects of surface water, ground water and the water beds, while external functional connections are the mutual interrelation between water management and policy areas such as physical planning, nature and environmental policy, sewerage management and rural planning (van de Ven 1993, p179). This means that water-related issues should not be examined in isolation but be considered in the context of all relevant policy themes and in relation to other phenomena (RIZA, 1999). The quantity and quality of surface and ground water is considered in an integrated way with a strong emphasis on nature protection (Mostert, 2006). The fundamental shift from 'technocratic water engineering' to 'integral and participatory water management' (Brugge et al., 2005) has had great influence on the work methods and organization of Dutch water management in the last two decades.

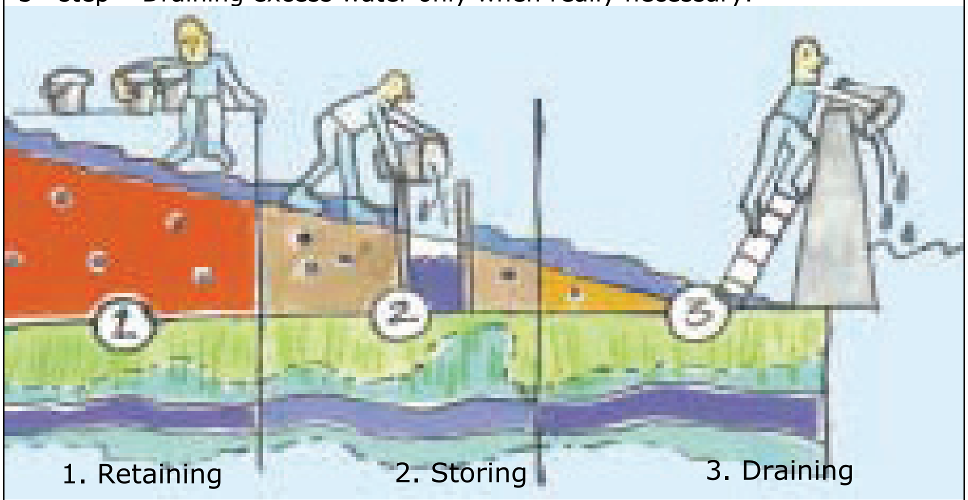
Since the Netherlands experienced the risks of river water rising to extreme levels in 1993, 1995 and 1998, the shift to integrated water management policy has been speeded up. The Fourth National Policy document on water management (1998) entitled 'A Framework for Water' has further developed the concept. 'A good mix of spatial and technological measures' is regarded as a good way to address safety requirements and reduce water-related problems (Rijkswaterstaat, 2000). This document proposes an integrated area-specific approach and uses water flows as a guiding principle in spatial planning (RIZA, 1999). 'From blocking water out to accepting water on land' (Woltjer & Al, 2007) has become the dominant trend. For water in the urban area, some measures were proposed, such as water-saving measures in the home, separate drainage of storm water, holding rainwater in lakes and underground and paying more attention to water systems when planning new residential areas (RIZA, 1999).

The document, 'A Different Approach to Water: Water Management Policy in the 21st Century' (Rijkswaterstaat, 2000), summarized the ideas which have been adopted by the Dutch Cabinet. Allocation of extra space for water is regarded as essential. This new approach follows three underlying principles (ibid, p27-33):

1. 'Anticipating instead of reacting': this means trying to handle the uncertainty through more consideration of climatic changes and land subsidence. Therefore more study about the ramifications needs to be done.
2. 'More space in addition to technological measures': this means a constant consideration of spatial measures in addition to technological measures. Space for water systems must be maintained. Therefore, spatial planning decisions need an integrated assessment.
3. 'No passing on responsibilities': this means 'precipitation should be held as long as possible in the catchment area where it falls'. The three-step strategy of 'retaining – storing – draining' is used as the guideline for each catchment area (Figure 6.1). So it is encouraged to widen or lower flood plains and construct water

retention and storage areas. It is obvious that this strategy demands a lot of 'regionally-tailored efforts'.

1st step – Retaining as long as possible in the catchment area;
2nd step – Storing water temporarily in the storage areas created specifically for this purpose;
3rd step – Draining excess water only when really necessary.



Source: A Different Approach to Water: Water Management Policy in the 21st Century (Rijkswaterstaat, 2000, p32)

Figure 6.1 Three-step strategy to avoid passing on water-related problems

Giving space for water needs a lot of cooperation among different interests. Spatial planning and water management have to work together to indicate the spatial requirement for the water systems. The provincial, regional and local authorities need to formulate their own spatial policies according to their different problems and opportunities. To implement the idea, more transition in practice is still needed and the process of adaptation is now going on.

In order to review how much space and where the space is required, the Cabinet requested the provincial authorities, water boards and municipal authorities to draft an 'Outlook on Water Management' by 2002 including 'Water Opportunities Map' (Rijkswaterstaat, 2000). The recent document 'Safeguarding Our Future: the Government's vision of National Water Policy' (Ministerie van Verkeer en Waterstaart 2007), presented the 'Water Vision' about the main policy issues for the next few years. It highlights the impacts of climate change and asks for the choice of the right measures to deal with all water-related problems, including flood risks, damage from water-logging, quality deterioration of surface- and ground- water, and negative influence on the water ecosystem. In the meantime, the Vision points out that it is possible to seize the opportunities to combine the new water measures with the development of habitat, housing, recreation, urban areas, industry, infrastructure, mobility, nature and agriculture in a creative, innovative and sustainable way. Five priorities of the water policy are discussed in this document: 'Working together towards a climate-proof situation in the Netherlands'; 'Using water to build a stronger economy'; 'Living sustainably with water'; 'Using water expertise to provide assistance worldwide'; and 'Rediscovering how to live with water'. In fact the policy is the first step on the way to the National Water Plan in 2009.

6.3 Water as a prominent issue in national spatial planning

The Fifth National Policy on Spatial Planning in 2000 postulated water as a 'guiding principle' in spatial planning. The new National Spatial Strategy, which was adopted by the Senate on 17 January 2006, identifies water as a 'structuring principle, which will be an integral element in the spatial planning processes' (National Spatial Strategy 2006). The significance involves two sides: on the one hand, water is reinforced as an important element for the basic quality standards and the national spatial structure, therefore, more space for water offers good opportunities for water recreation, water landscapes and improvement of quality of living places. On the other hand, the National Spatial Strategy takes the spatial water policy into account, which means that spatial choices need to be made on the basis of the characteristics of water systems. The aim of spatial water policy is 'to introduce (spatial) order into the water system and to maintain that order' (National Spatial Strategy 2006). Spatial water policy requires that the necessary space along the major rivers and the coast will be reserved or created when necessary, the so-called 'Giving space for water', 'Giving room for rivers' principles. The previously mentioned 'retain-store-discharge' strategy will help to prevent quantitative problems of excessive or insufficient water. In order to prevent problems concerning the quality of surface- or ground- water, the three-step strategy (prevent-separate-purify) is applied. The available space for water needs to be zoned, designed in spatial planning and used by combining water management and other functions if possible.

The national, provincial and municipal governments and water boards have their own responsibilities in dealing with these issues.

Even though the concept of comprehensive or integrated water management and land use planning has been discussed in many other countries (Saeijs, 1991; Carter, 2007; Correlje et al., 2007; Mylopoulos & Kolokytha, 2008; Chene, 2009), the Netherlands has developed its own course. Water has to compete with other interests for the limited remaining space. Particularly, the western part of the Netherlands is facing an increasing scarcity of space for economic and social development. Spatial water policy means that location choices and design and management measures in the spatial plan should explicitly consider the requirement of water management. Therefore a useful tool 'Water Test' or 'Water Assessment (WA)' is recommended. A WA is an attempt to involve water interests explicitly in spatial planning from the bottom up, which means even though policy starts from national level, practical work starts at the local level. Before 2001, there was relatively poor contact between spatial planners and water managers. They worked independently using their own language. Water managers focused on engineering and technical water-based solutions while planners and urban designers focussed more on the spatial development and urban form. After 2003, WA has become obligatory for the formal plans and architecture design. The basic idea for WA is to create an open and good environment of communication for water managers and spatial planners working together at the very beginning of planning in order to prevent potential negative consequences for water management. Therefore, WA is regarded as a process instrument which improves the attention of the spatial planners for water interests at the very first stage of planning. In practice it has stimulated the dialogue between water managers and spatial planners using the same language about the water system. Expert interviews during this research agreed that it is successful and has tightened up the relationship between both sides.

A WA is a cooperative tool for water board and planning authorities. Water managers agree that it easily works at the project level and that it needs to be integrated at the very beginning of spatial design. At the municipal level, especially for new development areas, a WA is obligatory. At the provincial level, it is much more difficult for the water manager to understand the strategic and abstract concepts of regional planning. Moreover, because the regional plan has its own time-span and the time for revision is not matched exactly, a WA is not very popular at regional level. There is no water assessment at national level at this moment.

Because of the heterogeneous characteristics of the water system in different areas, WA is a flexible process with tailor-made criteria originating from national and provincial policies. At the first stage of planning, water managers work together with spatial planners to decide upon the key issues of the water system that play a role in the spatial plan and the relevant criteria and how to translate the technical water criteria into spatial criteria. Then planners make the plan according to these criteria. As various disciplines are engaged, a WA is a positive way to regard water as an opportunity and creates the possibility to use the space of water for the good spatial quality in urban development.

The criteria of WA concern water quantity, water quality, safety and water-dependent nature. This is one of the examples:
(1) safety issues, including river flooding risk (areas free of development), dike safety, high-risk functions safety (such as hospitals, schools, should be safe);
(2) waterlog risk (mainly for property, not for people);
(3) public health (such as not close to the warm water discharged from a power-plant);
(4) soil subsidence;
(5) open water of good quality;
(6) water-dependent nature (such as buffer zones for water systems, groundwater)

A WA enables and obliges water management to participate at an early stage of the spatial planning process and allows the consequences of water-related issues to be assessed before any construction on the surface of land. Although in reality there is still a gap between the obligation and implementation, ideally it is expected to be applied to all scales of spatial planning from national to local and to all types of spatial planning decisions, such as amendments to regional plan, zoning plans, new plans for infrastructure, residential construction, business parks and redevelopment plans in urban and rural areas (Rijkswaterstaat, 2000). In that, a WA is playing a key role in guaranteeing the recognition of sustainable water issues and the necessary spatial provisions in spatial plans.

6.4 Spatial water policy implementation at the local level

From the interviews with Dutch experts it appeared that at the local level there have been some implementation projects since the 1990s. Based on water storage requirement, it has become commonly accepted to have 10% of the area used as open space for water in the urban land use plans (Woltjer & Al, 2007). In this study, the focus is on exploring an urban water plan and a water-rich residential project to learn how the spatial water policy is implemented at the local level.

Together with WAs, urban water plans have started to be prepared in many Dutch cities since 2001. According to Urban Water Plan Guide (VNG and UvW 2004), the content may include water quantity, water quality, water in the built environment, urban groundwater, the disconnection of wastewater and rainwater, management and maintenance of urban water. The urban water goal should be harmonized with the regional water goals and vice versa. Although it is not obligatory, many provinces support and subsidize the water boards and the municipalities to make an urban water plan. Normally, the water board and municipality put forward the problems and the ideas, achieve the basic agreement and consult engineers, planners and other professionals. The final document is used as a guideline for the urban water system management. Some budget from the municipality may be used in the projects of the water board. Thus, the knowledge and funding sources from both sides are linked together so as to obtain common positive effects. For the new development area, funding for taking spatial water measures is available so that the water board can play an effective role at the beginning of the plan. Since 2003, a Water Test is compulsory for most spatial plans. As a result, a water paragraph based on the urban water plan is required for any new spatial plan. These instruments substantially integrate water issues in spatial planning.

6.4.1 Urban water plan: case study of Arnhem

Arnhem is the capital of the province of Gelderland. The municipal area is approximately 100 km^2 with 144 101 population in 2008. It belongs to the city region of Arnhem–Nijmegen covering an area of over 1000 km^2 with 726 300 population. The River Neder-Rijn divides the city into the northern part and the southern part (Figure 6.2, Photograph 6). The city center is located in the northern part. The southern part has been largely developed since the 1960s due to the government's decision to prevent housing construction in the north (Hooimeijer et al., 2005). Now the city is developing along both sides of the river. There are various visible water forms in Arnhem: rivers, streams, ditches, brooks, ponds, and fountains. The national spatial water policy 'Room for the river' has also had a direct impact on the city's development, such as the decision to stop the housing construction project in the Stadsblokken area, a floodplain along the southern bank of the river and opposite the city center. The work of the urban water plan started in 2001. Until now, two water plans have been made: the Water Plan Arnhem 2003 and the Water Plan Arnhem 2009 (Arnhem Municipality).

The first Urban Water plan of Arnhem was for the short term (2003-2007) and long term (till 2015). A lot of local water partners were involved in the plan, including the Municipality of Arnhem (Department of City Management), the Water Board Rijn-IJssel, the Water Board Polderdistrict Betuwe, the Water Board Rivierenland, the Province of Gelderland, Gelderland water company, NUON water and energy company etcetera. The plan covers the entire territory of the city. Several water issues are mentioned: (a) water quantity problem, i.e. minimal surface water occupation (2-3%) in the northern part and river flooding risk for the southern part; (b) poor water quality due to a mixed sewerage system, lack of water circulation, unfiltered polluted runoff etcetera; (c) poor water soil quality; (d) excessive groundwater extraction and high groundwater levels in some places; (e) outdated sewerage system; (f) more space required for the river; (g) natural streams being only partially visible; (h) limited water awareness.

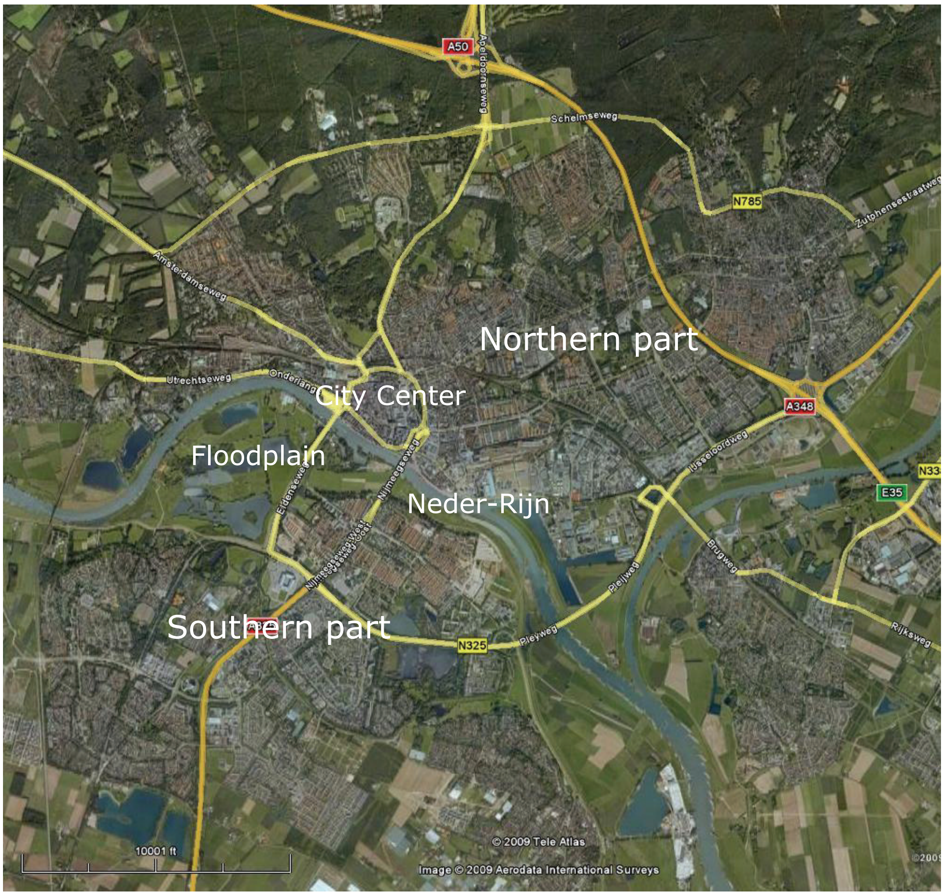


Figure 6.2 City of Arnhem

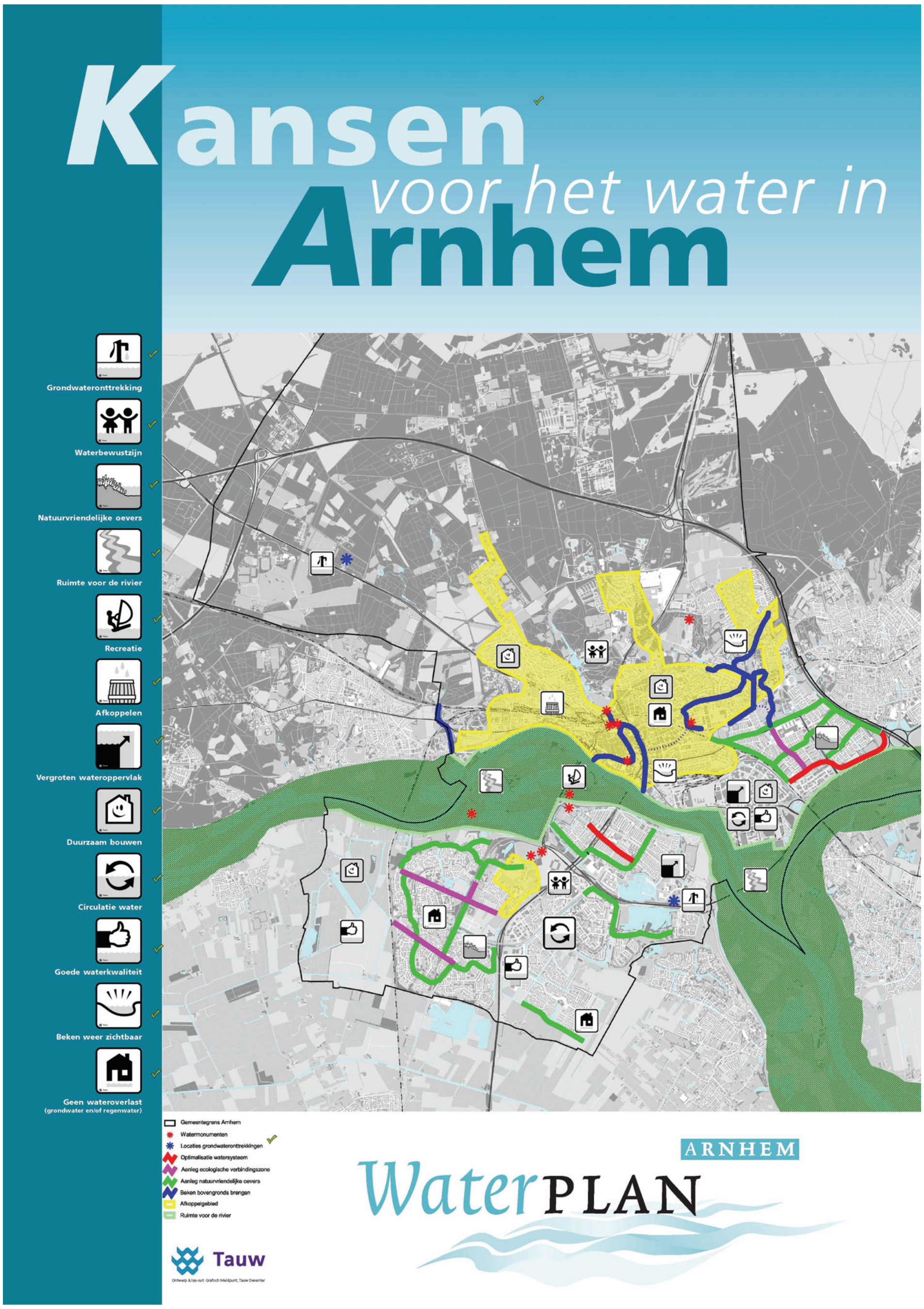
	
Northern side of the river	Southern side of the river

Source: taken by author in 2009

Photograph 6 The River sides of Arnhem

The goals are to improve the water system and the water chain on the one hand and for increasing the attractiveness of the water on the other hand. The plan explicitly points out that water needs sufficient space in case of overflow, and requires effective water management. The water space has also to make a positive contribution to public space e.g. via recreational functions. It emphasized that water forms one of the policy principles of spatial planning. Making a healthy and resilient water system is important to ensure an attractive and healthy environment. The water opportunity map (see Figure 6.3 as an example) was offered and useful information about the water system was supplied for spatial planning. Actions are arranged based on seven themes which are related to the water issues mentioned above. Five special actions which are also called the 'sparkling projects', are initiated and regarded as important for the water partners due to their visibility and potential for increasing awareness for water. Implementation and relevant financial issues are considered carefully. Moreover, good communication and partner cooperation are emphasized. It is required that the plan implementation should be evaluated every year. As shown by the evaluation (Arnhem municipality 2006), the results are very positive and more importantly water awareness has been increased.

The second Water Plan Arnhem, published in 2009, provides a long term vision to 2040 and concrete measures and projects for the period till 2015. Ensuring water to be beautiful, clean and safe in Arnhem is the continuing general aim. But unlike the former plan focusing on themes, this plan is much broader and has more integrative objectives. There are 4 main objectives, namely an attractive waterway in order to make the city attractive; a climate-proof water system (water quantity) to mitigate flooding and water shortage; a good water quality to meet the objectives of EU WFD; and water awareness to ensure that water has a clear role in every spatial project.



Source: Arnhem municipality

Figure 6.3 Example of the Water Opportunity Map for Arnhem

Thus it can be seen that this plan goes further to emphasize water as an indispensable element for spatial structure and spatial development. The innovative measures include: the restoration of natural streams and making them visible, construction of eco-zones and nature-friendly river banks, green-blue belts, green roofs, fountain maintenance, more space for retaining rainwater, disconnection of rainwater and sewage, pollution source control and purification, good maintenance and management of sewage systems. Five new sparkling projects are put forward. Unlike the five sparkling projects in the first water plan which were completely water-linked, these new projects are mostly space-linked and emphasize the city climate control and the interaction with the green and ecological effects. The areas for water are highlighted. In addition to the technical measures, good communication and cooperation of the residents and organizations with the public partners are emphasized, therefore, a research group called 'independent brain trust of residents' is needed for giving advice and opinions to the partners.

The experience of the urban water plan in Arnhem shows that it is possible to consider the components of water systems in a spatially integrated way. Doing so also brings opportunities for making an attractive city (Photographs 7 & 8). Nevertheless the implementation process is not easy and much depends on a good communication and cooperation with different groups of residents, entrepreneurs, natural and environmental organizations and other stakeholders.

Source: Taken by author in 2009

Photograph 7 Water as a fun of life in Arnhem

Source: Taken by author in 2009

Photograph 8 Water as an element for good quality space in Arnhem

6.4.2 Spatial water policy in a housing project: case study in Enschede

Enschede is located in the eastern Netherlands (Figure 1.3). The municipal area is approximately 140 km^2 with 154 000 population in 2007. The range of altitude between the lowest and highest point is from 20 to 65 m. This is comparatively highly uneven geomorphology in the Netherlands. The formal city water drainage system was a combined system, which raised water quantity and quality problems in the past due to the capacity limitations of waste water treatment. It was realized that rainwater is relatively clean and can be valuable for human utilization, and a separate system has been built. Nowadays, the newly developed areas have a separate system, which creates a good opportunity for more space to store rainwater and to keep natural streams and brooks visible. Making water visible is one of the aims of the recent urban development policy. However, the inner parts of the city are still dominated by the combined sewer system due to the high cost of replacing it.

Protecting the ecological framework is considered important for future urban development. According to the principle of spatial water policy, ‘No passing on responsibilities’ (see section 6.2.3), the city has paid more attention to the combination of water and ecological systems in the urban area in recent years. At the city level, combination of red (construction), green (natural vegetation areas) and blue (water) systems is being pursued. Retention or detention areas are arranged and water-rich residential areas are encouraged, such as the residential project in the Ruwenbos (Photograph 9).

Source: Taken by author in 2008

Photograph 9 Ruwenbos residential project in Enschede

The project of Ruwenbos started in 1993 and most of the construction was finished around 1997. The area is approximately 20 ha with 400 houses. The residents are mostly higher middle income groups. The initiative started with using solar energy so that the houses are arranged as north-south standing. Because there are many existing trees which need to be preserved, the 'wadi' idea was adopted. 'Wadi' means a special water system formed by the combination of red, green and blue structures. Water retention became one of the principles of the project design. Expertise from different fields, such as urban planning, landscape and green planning, water engineering and management, worked together and tried a new working approach of integrated planning and design.

The final result is very positive. The spatial quality is much higher than that in traditional projects, and gets many favourable comments from the public due to the relatively low land price and the availability of more open space with multi-functional use, either for human use or for the natural water system. The natural environment is very attractive for the local people. The useful experiences of this project can be summarized as follows:

(1) Working together at the beginning of plan-making. This multi disciplinary approach is quite different from the former one (figure 6.4). The important thing is that the local people have learnt from this project and have started to combine different expertise from different organizations to work together at the very beginning of planning and design.

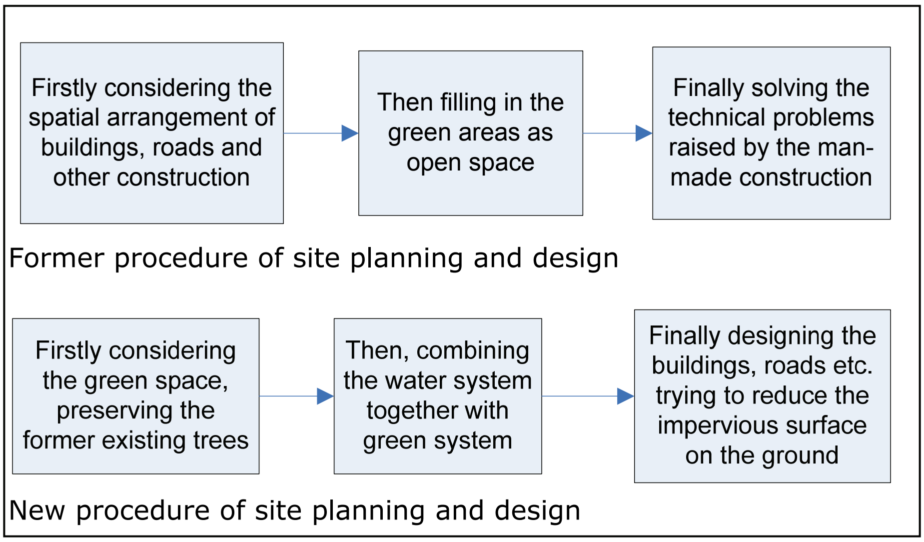


Figure 6.4 Different procedures for planning and design

(2) Water issues can be considered at the very beginning of the plan-making, such as the materials used for the roofing of houses which can retain the rainwater, the separate rainwater collection system and open space used as 'wadi' and retention function (Photograph 10). In this project, there are three kinds of 'wadis' constructed, 'red wadi' used for play-ground and other entertainment functions, 'green wadi' with existing trees and green space, 'blue wadi' with small ditches. These three 'wadis' are typical integrative spaces of green and blue system and become the main spatial structure of this area. So using a multi-

functional land use principle can create a vivid spatial function in the same quarter. Figure 6.5 show this layout of this area.

'wadi' as a spatial structure

Ponds at the edge

Source: Taken by author in 2008

Photograph 10 'Wadis' and ponds with functions of retention and recreation

Source: Enschede municipality

Figure 6.5 Layout of Ruwenbos in Enschede

(3) The streets between the paralleled houses are only 3 m wide based on the subsurface drainage system. The green backyards and parking lots are distributed to every house (Photograph 11). No public space is arranged here, except for the three kinds of 'wadis' and retention areas at the edge of the residential area which is taken care of by the municipality. So the responsibilities of maintenance are clear and good for the preservation of water quality and spatial quality of this area. This also depends very much on public awareness.

Source: Taken by author in 2008

Photograph 11 Streets between the paralleled houses

6.5 Possible lessons for Wuhan and China

The experience of Dutch spatial planning and water management offers many valuable lessons not only in planning content, but also planning process for Wuhan or other cities in China. Some concepts, i.e. 'space for nature', 'space for water', 'green-blue network', 'climate-proof city' may be a good practice for Chinese urban planners and water managers. The following listing summarizes the key points in this chapter and will be elaborate further in the next chapter on the future of Wuhan.

First, as spatial planning covers a very wide spectrum of physical and social issues, it is important to work with clear objectives and general guidelines of spatial development for the long term and short term future. Governments at different levels play different roles therein. The Dutch experience dealing with spatial relevant issues shows that government at the highest level is responsible for safeguarding basic spatial quality standards and the main spatial structure, for providing opportunities for negotiation and communication, and for creating mechanisms to avoid 'NIMBY' behaviour. Local authorities are responsible for taking care of their local environment but also have certain rights to adapt national or regional policies based on their local situation. Therefore good horizontal and hierarchical cooperation should be maintained during the plan-making process and plan implementation.

Second, public participation should start at the beginning of a plan-making process. It is a very essential step to generate understandable and acceptable objectives so as to ensure efficient implementation. The Dutch experience shows that although the consultation and consensus building make policy-making a slow process, the final policy decision when taken is more likely to enjoy wide support and good implementation. However, in the Chinese situation of highly dynamic urban development, lengthy plan-making processes should be avoided and a balance suitable for the context should be found.

Third, concurrence of the possibility for negotiation and a general acceptance by the public of the 'unwritten rules' is a typical feature of planning and management in the Netherlands. The precondition for this is to allow the conflicts to be discussed before the final decision-making and to create accepted procedures for implementation. It is good to learn from the Dutch spatial planners and water managers to deal with conflicts and arrive at compromises.

Fourth, spatial water policy is possible and beneficial for both urban development and for water systems, even though it is not an easy process from the beginning of concept development to the implementation in practice. The success of the Dutch cases presented is that this policy is of benefit not only for the natural water ecosystem but also for the spatial quality of human settlements.

Fifth, the early cooperation of spatial planning and water management authorities is crucial for aiming at and realizing both a sustainable urban development and water management. Interdisciplinary cooperation is necessary both at strategic level and at local level. Sufficient awareness and knowledge about spatial water issues helps in changing attitudes and finally also changing day-to-day behaviour. Therefore, it is the government who needs to initiate and promote such collaborative approaches.

Chapter 7 Spatial Planning Options for Sustainable Surface Water Management in Wuhan

Like many other Chinese cities, Wuhan has undergone a radical and rapid change, and this trend is expected to continue during the next decades. The former chapters showed that such changes happen so quickly that public decision-makers hardly have time enough to carefully consider the urgent urban planning issues. The imbalance between natural systems and urban development has created serious environmental problems. This chapter discusses new policy trends for urban development and their consequences for pressure on water systems in Wuhan. A conceptual model for integrated plan-making is presented and discussed, including suggestions for better information support for planning. An informed, forward looking policy process is essential to be able to take proactive, integrative approaches and decisions that will lead to a sustainable urban future.

7.1 New trends and pressures from urban development planning

In 2003, the concept of the '1+8' Wuhan Region was proposed by the provincial government and planning for this territorial entity was initiated. The '1+8' Wuhan Region specifically refers to the extended urban region that includes Wuhan municipality and its neighbouring eight medium-size municipalities (Huangshi, Ezhou, Huanggang, Xiaogan, Tianmen, Xiantao, Qianjiang, Xianning) (Figure 7.1). The main cities of these eight municipalities are located within a distance of around 100 km from the Wuhan urban core. In 2004, this region occupied more than 57, 800 km^2 (31% of the total territory of the province) and has 30.9 million population (51 % of the province) and a GDP of 0.38 billion Chinese RMB (60 % of the province) (Hubei Provincial Governmen 2004). It is the most important urban-economic core region in Hubei Province. But inside the region development is very unbalanced with a very dominant position being held by Wuhan and much weaker positions by the other eight municipalities, and even lesser positions in rural towns and villages. The initiation of the '1+8' concept is aimed at pursuing a more even development by strengthening the economic linkage of the nine municipalities through urban network-building. Five issues of integrated development are put forward: infrastructure; industrial development concerning reconstruction and spatial reorganization;

the regional market unification; urban and rural development; and environmental protection.

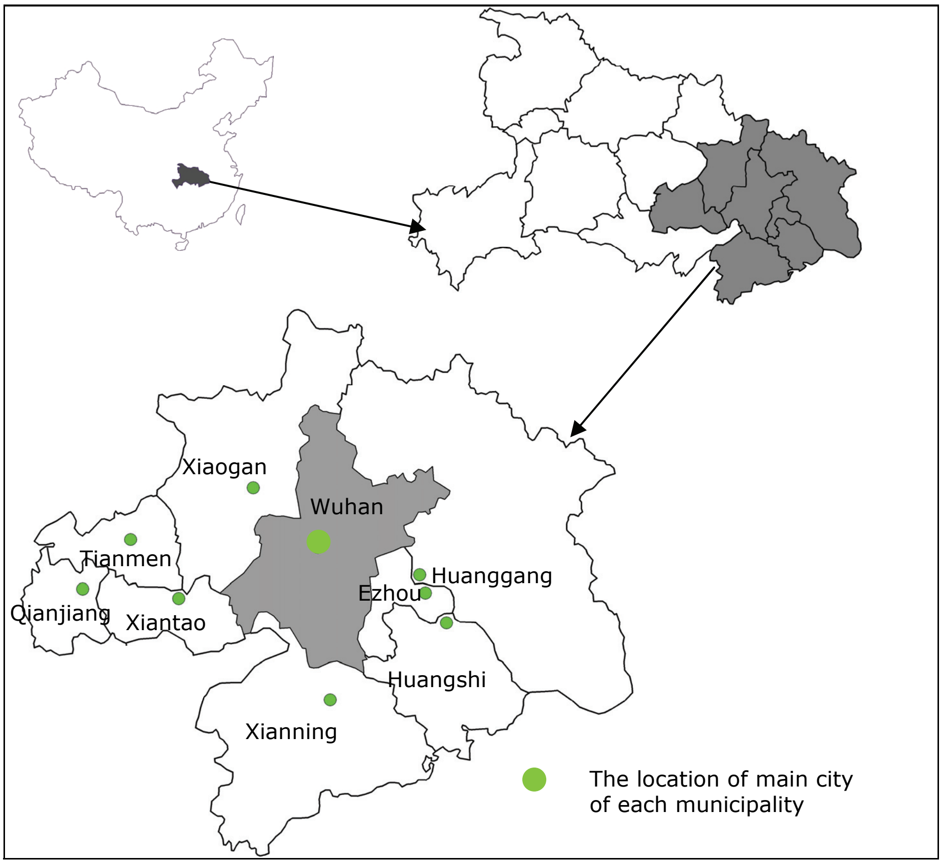


Figure 7.1 Location of the '1+8' Wuhan Region

In December 2007, the State Council of China approved the '1+8' Wuhan Region as one of the pilot areas of 'State Comprehensive Coordinated Reform'. This new national reform policy started in 2005 and covers only six regions in China. The policy includes institutional innovation, exploration of new development modes, regional competitive capacity building and approaches to harmonious society construction (Chen & Li, 2008; Yu & Bai, 2009). It opens a new door for and speeds up the development of the '1+8' Wuhan Region in an innovative way. Until now, 177 key projects have been accepted, their implementation will require approximately 1300 billion Chinese RMB for the next three years (2009-2012) (Hubei Provincial Government). These funds will partly come from government but most of the money is expected to be obtained from other sources.

The governmental construction funds, either from provincial and central government or from municipal governments, will invest mainly in the public domains, such as transportation, environment and public facilities. The provincial government is expected to design a new investment policy to encourage more partnerships and private investment as the other funding sources. Therefore, development in this region is expected to remain fast in the near future. However, most of this region is located in a lake-dotted plain which is a flood-prone area with abundant surface water bodies, except for some part of the mountainous area in the north and the south (Figure 7.2). The average elevation is 21-35 m above sea level, which is lower than the flood water level in some densely populated areas. As the main goal of the '1+8' Wuhan Region is to stimulate more rapid economic development, the pressure on the regional water environment will remain high. Consequently, both old and new water-related problems have to be faced. Due to the time limitation, this study could not probe into these problems for the whole region but focuses on the impacts from new urban development in Wuhan.

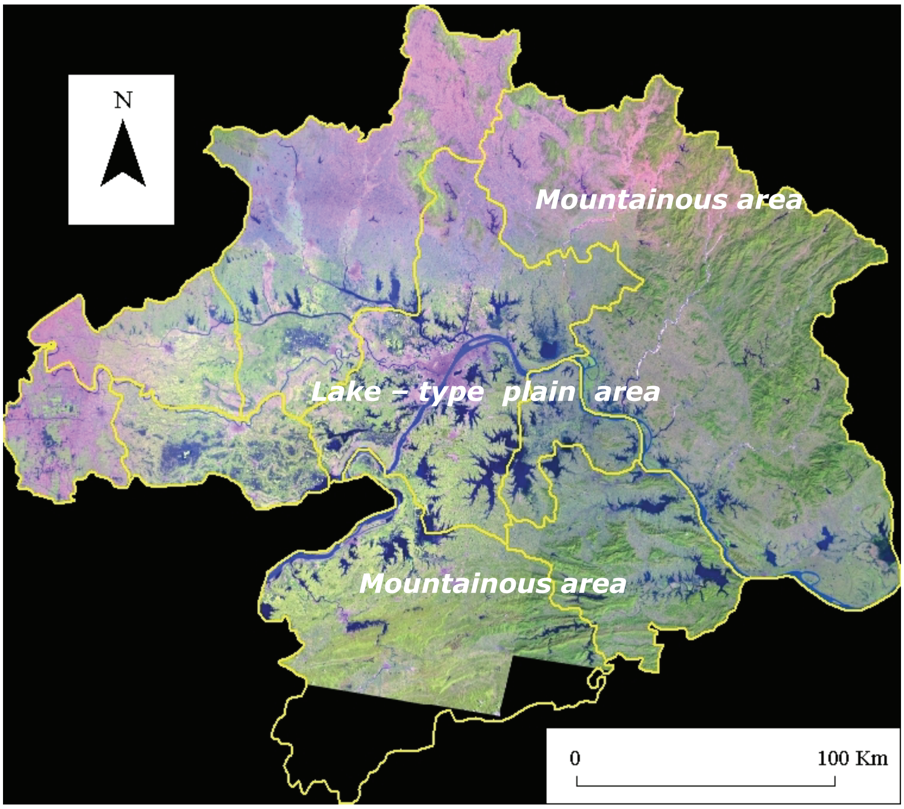
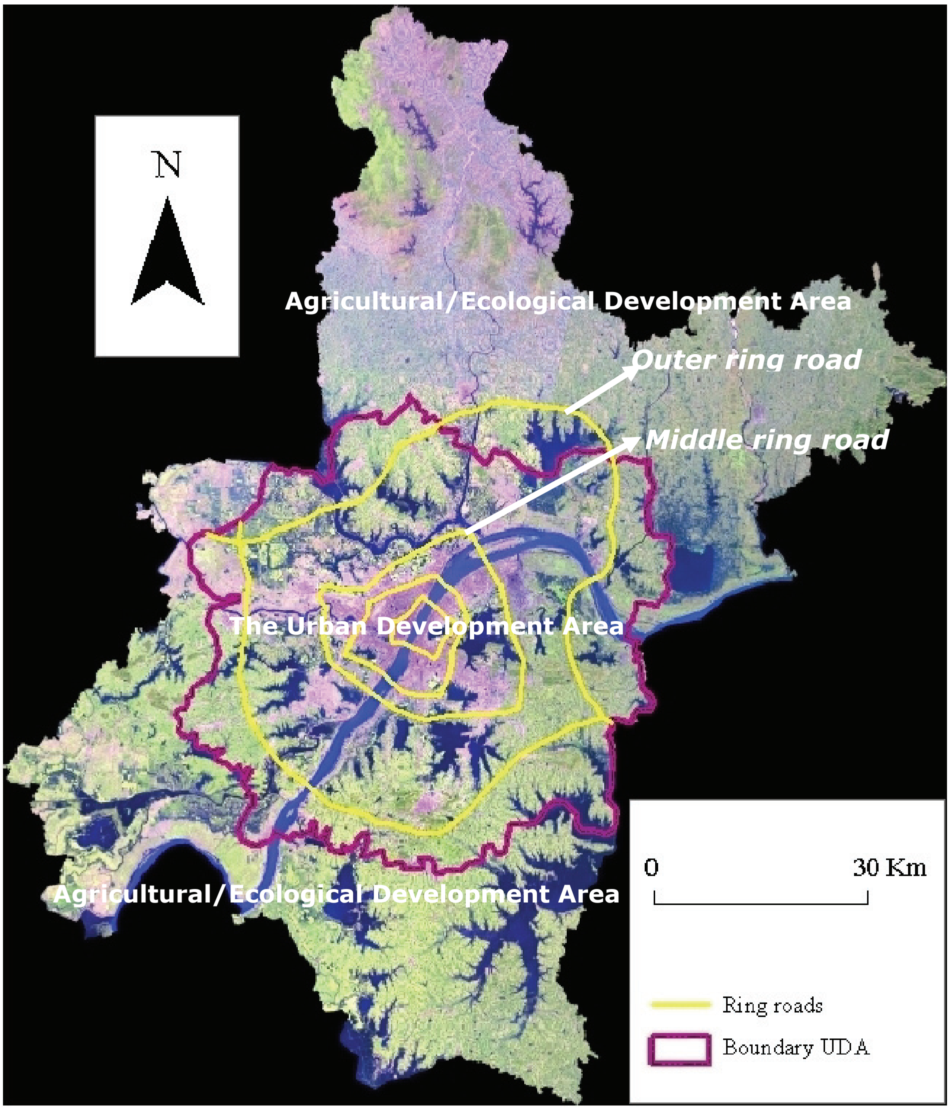


Figure 7.2 Image of the '1+8' Wuhan Region

Wuhan municipality, with its dominant position in this region, is playing a leading role in the future development path of the whole region. According to the new master plan (2006-2020), the population increase will be more than 3 million and 320 km^2 of newly built-up areas will be needed within the next 15 years. The spatial structure of Wuhan municipality will be organized for two subareas: the Urban Development Area (UDA) and the Agricultural/Ecological Development Area (A/EDA) (Figure 7.3). Most of the UDA is mostly located within the outer ring road and outside this road is the A/EDA. The UDA occupies more than 3200 Km^2 and is also the main core of the '1+8' Wuhan Region as designated by the '1+8' regional plan (2005-2020). It is clear from the map that within the UDA many surface water bodies exist (Figure 7.3).

Table 7.1 shows the planned distribution of population and urban land use in 2020. More than 90 % of the urban population and nearly 90 % of the urban land use will be concentrated in the UDA. Comparing to the situation in 2004 (Table 7.2), within the middle ring road the population will be reduced and the urban land use area will only be slightly increased. This means that the population density is expected to decrease. However, the space outside the middle ring road in the UDA will be the major area for future development. Population will be increased and urban land use area will be expanded. It will be the main location for the large industrial projects, for new housing, and for relocated functions from the urban core. The size of the urban expansion of Wuhan will be larger in the coming 15 years than in the period from 1993 to 2004 which was discussed in the former chapters. It can be expected that new pressures will occur on surface water systems outside the present urban core area. As discussed before, Wuhan is now facing serious water-related problems due to the poor land use control in the urban core. Some countermeasures have been initiated in recent years, but the effect of the new policies still need to be evaluated. Especially because an integrated solution of water-related problems has not been fully realized, the reclamation and water pollution which may emerge on an even larger scale will make the situation more serious and complicated. There is an urgent need for urban planners and water managers to cooperate seriously on all issues of common interest. In order to deal with the major water-related problems, implementing institutional reforms that are focussed on applying proactive approaches within the current spatial planning systems is a great challenge.



Note: UDA – The Urban Development Area

Figure 7.3 The Urban Development Area in Wuhan Municipality

Table 7.1 Distribution of population and urban land use in 2020

Area		Pop. (mil.)	Perc. of the total pop.	Urban pop. (mil.)	Perc. of the total urban pop.	Urban land use (km^2)	Perc. of the total urban land use
UDA	Within middle ring road	4.2	36%	4.15	43%	350	35%
	Outside middle ring road	5.6	47%	4.63	48%	540	54%
	Sub-total	9.8	83%	8.78	91%	890	89%
A/EDA		2	17%	9	9%	110	11%
Municipality		11.8	100%	9.68	100%	1000	100%

Note: UDA – the Urban Development Area
A/EDA - the Agricultural/Ecological Development Area
Pop. – Population; Mil. – Million; Perc. – Percentage
Source: Report of Wuhan master plan (2006-2020);
Official report on Wuhan master plan (2006-2020) (Wuhan Municipality)

Table 7.2 Distribution of population and urban land use in 2004

Area		Pop. (mil.)	Perc. of the total pop.	Urban land use (Km^2)	Perc. of the total urban land use
UDA	Within middle ring road	4.54	51%	289	42%
	Outside middle ring road	*	*	294	43%
	Sub-total	*	*	583	85%
A/EDA		*	*	101	15%
Municipality		8.96	100%	684	100%

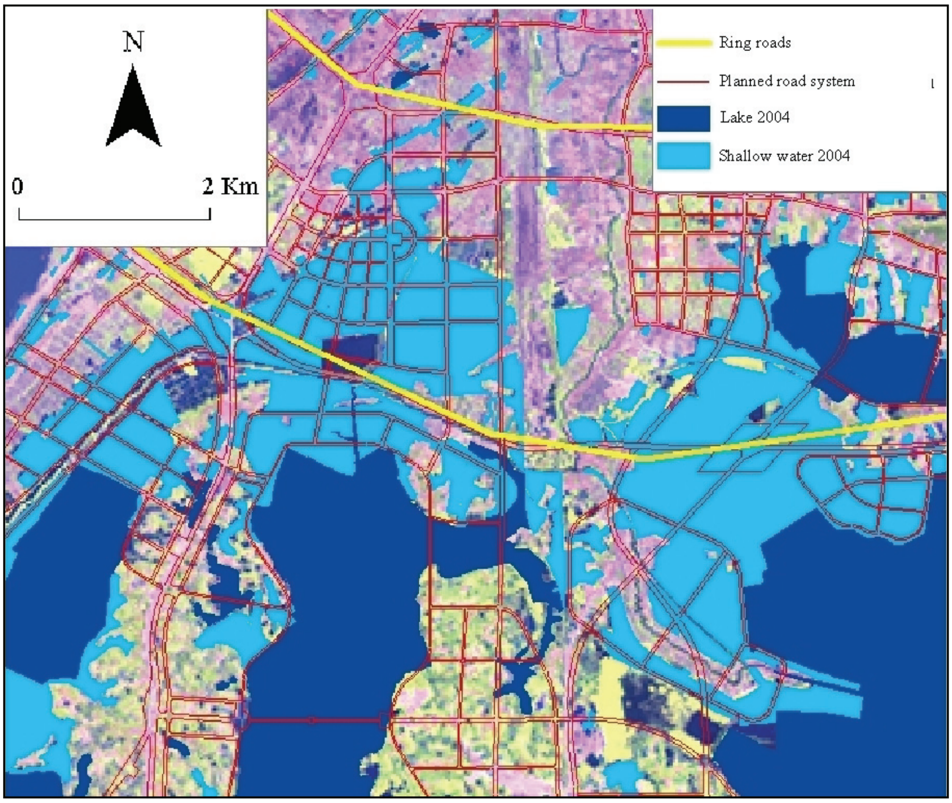
Note: UDA – the Urban Development Area
A/EDA - the Agricultural/Ecological Development Area
Pop. – Population; Mil. – Million; Perc. – Percentage
* - no data exists for these fields
Source: Report of Wuhan master plan (2006-2020);
Official report on Wuhan master plan (2006-2020) (Wuhan Municipality)

Although the water system and its environmental protection are mentioned in the '1+8' Wuhan Region Plan (2005-2020) and are given special attention in the Wuhan Master Plan (2006-2020), the implementation measures seem to be inadequate to stop the trend of deterioration of the water environment based on the expected urban development pressure. In the Wuhan master plan (2006-2020), the planned main road system plays an important role in structuring land use development. Figure 7.4 shows the spatial form of the planned road system within the Urban Development Area. Presently, the construction process is following this vision. Because lake protection is emphasized in the local regulation of 2002 (see Chapter 4), this planned road system takes the protection of the lakes into consideration to some extent, but it ignores the protection of the related water areas, such as shallow water bodies. Figure 7.5 shows an example of the conversion of shallow water bodies to the urban land use as a consequence of the implementation of the new road system and related urban land use expansion. Due to the lack of sufficiently detailed land use data, it is impossible to indicate how much water-related areas or wetlands will be lost in the next 15 years. Nevertheless, the example shown indicates that the protection of whole water systems has not yet been fully incorporated as an important issue in the plan-making. Therefore, given the largely unchanged priority on an economically-oriented urban development process, the realization of the environmental goals is not assured. A big obstacle appears to exist in the separate spheres of the sectors and their institutions, and the absence of a mechanism for institutional cooperation. Therefore, integrated spatial planning for surface water management is urgently needed in this region

The experience of spatial planning in Wuhan shows that the focus on economic development has dominated for a long time and is expected to continue, while effective spatial policy for environment protection is still in its infancy. It needs to be emphasized that a good quality and status of surface water is a precondition for a good quality of urban space. In other words, the surface water system should play a positive role in the sustainable development of natural and human systems in urban areas.

Source: Wuhan Urban Planning Bureau

Figure 7.4 Planned road systems within the UDA (Urban Development Area) in 2020



Source: Wuhan Urban Planning Bureau

Figure 7.5 Planned road system and surface water bodies at the local level (See A on Figure 7.4)

7.2 Integrated spatial plan-making model for surface water protection

Due to the specific features of the hydrologic cycle elaborated in chapter 2, spatial issues of surface water systems are impossible to tackle in a small scale area in a short period of time. Consideration of medium- and long-term developments in a large-scale region needs integrated planning attention from the strategic level to the local action level. Based on the case studies in Wuhan and in the Netherlands, an integrated spatial plan-making model that seeks to create a framework for such an approach is proposed in Figure 7.6. It entails a comprehensive plan-making system which covers the key issues from the strategic to the local level and, as argued in the former chapters, is based on a multi-sector/multi-disciplinary approach to spatial planning and surface water management. It is also the reflection on and development of the conceptual model presented in chapter 3 (see Figure 3.2).

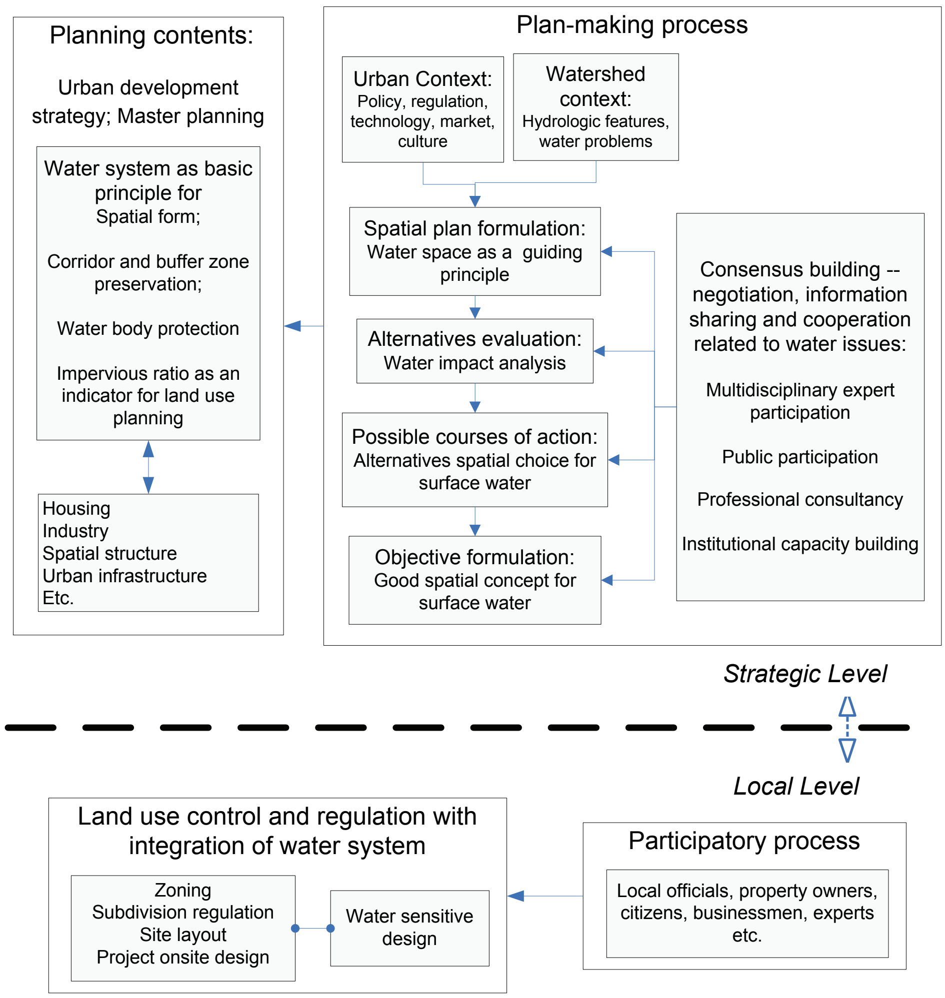


Figure 7.6 Proposed integrated spatial plan-making model incorporating the surface water system

In Wuhan, integrating surface water management in spatial planning is a relatively new concept, both for the urban planners as well as for water managers. It therefore requires some fundamental changes in planning concepts and practices. Because the main emphasis in urban planning during the rapid economic growth since the 1980s was the building of houses and physical infrastructure, land use planning has been dominated by design, layout and location issues. Because of the continuing rapid development at present and in the near future, the facilitation by rising GDP levels and more attention for spatial quality, it is urgent to build up a kind of consensus about sustainable urban development among technical experts (i.e. urban planners, urban designer, water engineer and water managers), officials, developers, property owners and citizens. Making use of the public concerns and opinions, a new approach to explore the problems, solutions and plan-making could be possible. In these plans a compromise between the aims and needs of economic and urban development and surface water protection is beneficial to the water system as well as to urban development.

At the strategic level, it is important to achieve awareness and agreement about the problem definition and goals. Strategic development planning, master planning and related land use planning should involve the spatial expression of the water system (e.g. water bodies, appropriate riparian buffers, retention of watershed) in the planning content and in the plan-making process. A conventional way of regarding water just as an unlimited resource for human needs should be replaced by an ecological conceptualization of water systems, with greater emphasis on reducing waste and pollution. This new concept and its spatial considerations should be part of the planning process and documents.

As the case studies from the Netherlands showed, the concepts such as 'Giving space for water', 'Giving room for the river' and 'Climate-proof city' all include clear goals at the strategic level so that it is relatively easy for the public to understand the benefits and the relevant spatial requirements of water systems. For the case of Wuhan, such spatial concepts are still missing, both in urban planning and in water management. Until now only the lake protection has become a common, space-related concept. As this study showed, the water problems of lakes do not come from the lakes themselves but from their surrounding land use. The future spatial structure and land use planning need to link water systems, green systems and natural forest systems together as a combined eco-system. The urban construction activities should be arranged in a way that they respect the eco-system as a basic quality control standard. Therefore, urban spatial structure, location of residential and industrial land use, infrastructure (especially highway and road systems) and other facilities have to take the water systems seriously into consideration.

In the meantime, successful management of natural assets relies heavily on the thorough understanding and cooperation of the public. Multidisciplinary expert participation and public participation is necessary to reach a consensus which offers the foundation for the cooperation of different administrative departments. In the context of the Chinese urban and regional planning practice, public participation is still in its initial stages. Given the fact that water-related problems concern a large region and many different interest groups, innovation is required. During the plan-making process, especially before the final decision is made, the participation and negotiation should be in the hands not only of the policy-makers and the expert groups, but also of representatives of citizens. Moreover, the expert group should include more multi-disciplinary interaction, in particular at the first stages of the plan-making process when the basic decisions for further strategic development are made.

At the local level, based on the guiding principles and the objectives decided on at the strategic level, specific land use control measures and instruments concerning surface water systems should be implemented by regulations or legislation. In the Wuhan case, water sensitive planning and design is still quite a new approach for many urban planners and water managers and plays no role in the process of issuing land use permits. The concepts of Best Management Practices or Low Impact Development which were described in section 3.3 should be advocated, as a supplement to the present 'blue line' and 'green line' regulations. Planners, designers, water managers and administrative officials are responsible to present spatial layouts with enough information concerning spatial water issues for the public. Public participation should be encouraged during the planning process in order to achieve common awareness and support.

For the Wuhan situation, community organizations are basic local governmental entities and it is possible to involve the citizens in sharing the responsibilities for water system protection through their power at the local level. The key point is to achieve an agreement regarding the goals and action measures, and that is what urban planners, water managers and officials need to pursue. A well supported agreement among the divergent interest groups of stakeholders (e.g. developers, residents, officials, water-users) on the design scheme and final action plan is helpful for a smooth implementation. These agreements should respect the principles and objectives decided on at the strategic level.
On the whole, the measures for surface water management must integrate into spatial strategies, with guidelines both for the urban region as a whole and for local actions as small-scale solutions. From

the point of view of urban and regional planning, there are some spatial concepts which should be emphasized for the '1+8' Wuhan region plan and Wuhan master plan:

(a) In order to preserve the natural surface water bodies and their connections, it is necessary to identify the specific space for natural water bodies, including the meandering of the upstream creeks or streams and the natural shorelines of lakes and rivers. Given the spatial form of the water systems in the territory, it is not advisable to continue the former 'pancake' or 'carpet' style of urban expansion. Spatial orientation policies should pursue a balanced and polycentric development to avoid further excessive economic and demographic concentration in the core area. It also means that the main infrastructure construction (highways, main-roads and metro etcetera) should break the ring-model and allow the insertion of natural water and green spaces into the fabric of the cities. Therefore the prevailing concept of regional and urban spatial structure should be changed.

(b) In order to retain and maintain buffers, filter strips and other vegetation along the lakes and rivers, it is important to collect and analyze the watershed data for the delineation of the boundary between development and non-development areas. Shallow water bodies are also important for the natural water system and should be combined with the urban green systems. 'Green corridor' or 'green belt' planning tools which have been used in the present master planning, can be integrated with water system so that combined green/blue systems can be created that will contribute to good quality of space.

(c) In order to retain open spaces and natural vegetation areas of the upland regions of watersheds, land use regulations and new design approaches that regulate imperviousness and surface water runoff should be promoted for new construction. The indicator of imperviousness may be used to assess the layout and site design in order to encourage better practice with respect to water-sensitive planning and design.

In order to use proactive measures at the strategic and local level, the planning methodology during the planning and design process may be generalized as:

(a) Explicitly considering the natural landscape and, in particular the water systems, in spatial structure plans;

(b) Identifying the important water space i.e. water bodies and the space of the buffer zones and ecological corridors;

(c) Reducing the disturbance to the relevant water spaces from infrastructure, especially major road systems;
(d) Establishing land use regulations and guidance concerning the reduction of impervious surface as early as possible;
(e) Establishing a water impact evaluation system for land use development;
(f) Ensuring multi-disciplinary expert participation in both water management and spatial planning;
(g) Encouraging community participation and awareness among the city residents.

7.3 Information support for integrating surface water protection in spatial planning

Geertman and Stillwell (2003, p6) defined Planning Support System (PSS) as 'a subset of geotechnology-related instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools) that collectively support all of or some part of a unique planning task. PSS may aid the planning process by providing integrated environments usually based on multiple technologies and a common interface'. Klosterman (2001, p14) also suggested that PSS 'should be designed to provide interactive, integrative, and participatory procedures for dealing with non-routine, poorly structured decisions' and 'must also pay particular attention to long-range problems and strategic issues, as well as explicitly facilitate group interaction and discussion'. In this section, information support for integrated spatial planning for water systems is discussed.

An essential prerequisite for integrated spatial planning is the availability of an information support system. The city is viewed as a complex system combining characteristics of uncertainty, diversity, multi-level and dynamic. The political decision-making regarding spatial problems is complex, highly interrelated and uncertain due to influence of factors beyond the direct control of the decision makers. This is especially true in the developing countries which are experiencing the most rapid urban growth.

Because integrated spatial planning is holistic in scope, strategic and scenario-oriented in content, and interactive and collaborative in nature, relevant information systems which support the activities of planning are important tools. They allow for knowledge creation to meet the needs mentioned in Section 7.2. Therefore, the input, throughput and output of information to support planning and design are essential steps in providing interactive and participatory procedures.

As water-related issues in Wuhan often concern a large area (i.e. watershed), sometimes far beyond the municipal or even the provincial boundaries, it is hard to raise the consciousness of people for the problems occurring. However when the problems do become reality, it may be too late or at least costly to tackle them successfully. Proactive spatial measures are needed to deal with and prevent water-related problems. These also need enough information and knowledge during the decision-making process. Therefore, the information on the hydrologic effects of land use changes is very useful (Tong & Chen, 2002). It supports communication between urban planners and water managers and is also essential for public participation. Moreover new knowledge can be created and understood and mutual trust can be established by information sharing.

Information technology has been developed very fast in China and many organizations in cities, like Wuhan, have built up their information centers to manage data collection, construct digital databases, update data and perform spatial data analysis. However, many information gaps still exist due to problems with respect to data standardization, data exchange and data-sharing caused by sectoral bias and organizational segregation in the Chinese political and administrative systems. Duplication of data collection and database construction and obstacles in information-sharing have made it difficult to create useful information and knowledge to support communication and decision-making. During the fieldwork of this study, such information flaws in different departments made data collection difficult. Moreover, different data reference frameworks and the lack of unified spatial data classifications also hamper in-depth analyses. The development of local spatial data infrastructures (SDI) is urgently needed. Related to the integrated spatial plan-making model for surface water systems mentioned in the former section, the following steps should to be taken into consideration at the strategic level.

(a) Creating data standards, including a reference framework and data dictionary, standardized spatial units, open data formats and interoperability of different datasets and systems. Spatial planners and water managers need to cooperate to achieve such a situation.
(b) Developing a data-sharing policy to allow easy data access. This needs inter-agency and inter-governmental cooperation for data

collection, management, and dissemination for the public and the private sectors.

(c) Encouraging urban planners and water managers to work together to develop more information and knowledge through modelling and/or scenario construction, based on the shared use of databases. Such professional cooperation needs a useful and effective way to share data and create new information so as to apply new and better concepts for the future.

(d) Training of urban planners with the knowledge and skills to truly master the new information technology is definitely necessary in China. The present education of urban planners focuses mainly on architectural and blueprint planning skills. As a consequence, many urban planners lack awareness and capabilities to understand the complexities of urban development in practical situations. Also, analytical expertise, such as the understanding and use of geographical information systems (GIS), is often limited. Such deficiencies hamper communication with water managers and other experts from different fields. Therefore urban planners have to change their way of thinking and working. The integrated spatial planning for water requires both spatial planners and water managers to adopt a cooperative working method, which is still quite new in China.

Chapter 8 Conclusions and Discussion

The aim of this research is to explore the water-land relationships of surface water systems that are relevant for spatial urban planning. The study covers theory and practice in order to develop a strategy to initiate and improve the cooperation between spatial planning and water management in urban areas. The focus is on urban planning in China, with a case study of Wuhan.

This chapter summarizes the major findings for each of the research objectives, challenges and questions presented in Chapter 1. Next, suggestions for future research are presented based on a discussion of limitations encountered in the research for this thesis.

8.1 Conclusions

8.1.1 Understanding the spatial concept of surface water systems in urban regions

Research question 1: *What kinds of land and water spaces are sensitive for surface water systems and therefore need combined attention of urban planners and water managers?*

As discussed in chapters 2 and 3, surface water, as part of ecological and natural systems, is an essential component of the natural and environmental quality of the region within the watershed. The land use conditions in the watershed are also closely interrelated with the status of the surface water bodies. In order to retain a healthy aquatic ecosystem, it is therefore important to protect surface water bodies, reserve riparian buffer zones and carefully consider the land use within the watershed. Moreover, aquatic ecosystems protection is also beneficial for urban spatial quality. Therefore, the presence of surface water systems as open space in the city and as linkage to unspoiled places outside the city is vital, both for the urban environment as well as for the surface water systems. It is an asset of great economic value as environmental quality is a major contributor to urban land value. It also adds to the marketability and may help to attract capital to the city.

Question 2: *How can the space for surface water be identified and classified?*

From the perspective of surface water management, it is very important to consider three kinds of spaces: space for detention/retention facilities, space for riparian corridors or buffer zones, and land use for water space in the watershed. However, despite this recognized need, without cooperation between spatial planning and water management, such spaces are not easy to identify, define and protect in practice. That is to say, on the one hand, spatial planning should recognize and include these water related lands into the overall spatial organization; on the other hand, water management practice should consider the spatial implications in their technical measures. Paradigm shifts in approaches to and conceptualizations of water spaces are necessary for both spatial planning and water management.

Question 3: *What is the spatial impact of urban development on surface water system change in the Chinese context?*

In China, water systems in the urban region inevitably suffer from the impact of human activities through alterations in the hydrologic cycle. Given China's population size and the current phase of massive urbanization, keeping natural water systems intact has been almost impossible. Many water-related problems have a close relationship with the poorly guided land use changes in the watershed. In chapters 4 and 5, the case study of Wuhan shows that rapid urban development has had a significant negative impact on the surface water bodies and their riparian zones by size reduction, complete reclamation and pollution. Moreover, urban land use development has largely altered the land surface by increasing the imperviousness ratio, which has had a deteriorating effect on surface water conditions. With the disappearance of water bodies within the urban fabric, environmental problems become more pronounced. This trend is expected to continue in the near future, although since 2000 various policy initiatives from the sides of urban planning and water management have gradually converged on new and ambitious aims regarding environmental and ecological issues. The findings of this study reveal that in order to efficiently eliminate the negative impacts of urban development, the spatial articulation of water systems should be an issue to be considered in the making of spatial visions, plans and programmes, in particular under the circumstances of rapid urban land expansion.

8.1.2 Integration of surface water management and spatial planning

Question 4: *What kinds of new planning concepts and methods can be used to integrate surface water systems in spatial planning to create good quality urban space?*

The sustainability of surface water systems requires balance and maintenance of system resilience within the context of natural and human development processes. This research shows that based on the principles of LID (Low Impact Development) or BMP (Best Management Practice), water sensitive planning and design needs to consider new spatial concepts and methods for water systems in spatial planning. Examples are: the reduction of the impervious area within watersheds or catchment areas, protection of existing surface water bodies and wetlands as important elements for urban spatial structures, and involvement of buffer zones or riparian corridors in urban green structures. Multi-functional land use is helpful to offer good opportunities to control water problems as well as to improve the quality of space. The surface water systems should be more carefully considered both at strategic level and at local action level.

Question 5: *How can the institutional cooperation between spatial planning and water management be initiated in the Chinese context?*

In the Chinese context of rapid urbanization, the relationship between nature and urban space has been ignored to a large extent, as is reflected by the urban development processes of Wuhan. The mandates of the local urban planning authorities and the water management agencies in Wuhan currently prevent an adequate tackling of surface water problems. Institutional compartmentalisation is the major obstacles for pursuing the goal of sustainable development. As emphasized in this study, consideration of surface water management as a component in spatial planning needs addressing reform of two aspects of planning. The first is related to planning content, meaning new planning knowledge, concepts, and aims leading to pursuing other spatial forms of urbanization. The second is the planning process itself, which includes acceptance of and support for spatial water policy and its implementation, as well as participation of stakeholders, the public and decision makers to raise awareness and organize commitment. Institutional segmentation has to be broken down to remove barriers for cooperation. Therefore, more efforts for practising effective consultation and negotiation in the planning process have to be made.

Question 6: *How should the current spatial planning system in China be reformed in order to integrate sustainable surface water management in urban planning?*

The negative impacts of urban land expansion on surface water systems reflect the imperfections of spatial planning as demonstrated in the Wuhan case study. A main problem is that proactive approaches have not been taken into consideration. Relatively little knowledge has thus far been generated to fully understand the long term impacts of surface water body reduction. Because the spatial planning and management of water systems needs to be guided at a strategic level but operates at a local level, the implementation of an integrated spatial planning model as discussed in chapter 7 is useful for pursuing an innovative and effective approach to spatial water planning.

The loss of farm land as result of urban expansion has caught the attention of the central or local government because it is related to safeguarding sufficient production of food. This has reduced the speed of arable land loss to some extent (Liu et al., 2005). However, ecologically valuable land (forest land, grasslands and wetlands) continues to be adversely affected and degraded (Zhang et al., 2007). The value of the surface water system as a whole has so far been largely unnoticed in the policy field. This partly explains that in contrast to the strict control on the conversion of arable land for urban development, land reclamation and building activities in and around surface water bodies is not yet subject to the same level of management from the central and local governments. Better management will not be the case until such time as the essential role of surface water systems is recognized in urban spatial policy-making.

Question 7: *Can experiences of the Netherlands be helpful for the Chinese cities to find successful ways to integrate surface water management in spatial planning and close the gap between these two domains?*

The experience of Dutch spatial water policy demonstrates that the traditional end-of-pipe techniques are not sufficient to deal with water-related problems. Bringing together water management and spatial planning creates the opportunity to protect both the water system and an adequate level of spatial quality by 'making space for water'. With adaptations in land use planning, from the strategic to the local level, it is possible to solve some of the quantitative and qualitative water problems and mitigate the negative impacts of human-related land uses on the water system. This appears to be only possible with institutional cooperation of sectoral authorities and agencies and with innovative approaches for spatial planning and water management. The Dutch spatial water policy offers an example for a new perspective that requires innovation in the planning process, new planning methods, institutional reform, especially the organization of negotiation and cooperation. But the Dutch case also shows the complexity of the issue and the thread of lengthy procedures. Although the social and political context in China is quite different from the one in the Netherlands, these experiences are still valuable for Chinese spatial planners and water managers, not so much as recipe books for change but as demonstrations of the value of working together to tackle the various water-related problems in an urban region.

8.1.3 Information for planning support

Question 8: *How can spatial information systems support suitable information provision for and sharing of the information by spatial planners and water managers in China?*

The findings of this research show that the results of spatial data analysis, based on both qualitative and quantitative methods, were helpful for urban planners and water managers to understand the spatial issues, problems and solutions concerning water and land. In the Chinese context, major efforts for data standardization and data-sharing are necessary to create the conditions for urban planners and water managers to work together successfully. Developing Spatial Data Infrastructures (SDIs) is a well worked-out approach to this end. Another necessary condition is raising awareness among both professional groups and acquiring new practices and skills by the members of these groups.

8.2 Discussion

Spatial planning and water management have for a long time been developed in different disciplines and been practised in different departments of national, regional and local governments. This study analyses the negative consequences of this situation for sustainable urban development and attempts to break the segmentation by developing a new conceptual approach and an accordingly designed new practice. However, such a 'clean break' is not easy to implement, especially in the context of the rapid social, economic and urban development as is witnessed in China. Surface water has always been regarded as less valuable than urban land use, so conversion to urban purpose usually gets priority above water body protection. To change this situation requires a context-sensitive approach, which is explored in this study. However, as is the case with all studies, this research also has its limitations. In this final section a number of these limitations will be discussed and directions for new research to overcome the limitations will be indicated:

(a) Lack of data and data access for the Wuhan case study.

The main source of data used in this study is the municipal land use surveys of the Wuhan Planning Department. It is almost impossible to get these spatial data for the urban watershed. One reason is that the urban watershed is not easily delineated due to the rapid construction and other changes in the Wuhan urban area. Another reason is that the digital datasets of the water management department are difficult to access due to institutional compartmentalization and autonomy. Moreover, much of water-related data collected during the fieldwork was not properly geocoded and therefore not suited for spatial analysis. The idea of using spatial water-related concepts in the water management authority is still quite new and the spatial units employed are different from those used in the planning field. These data limitations have restricted more extensive analysis on the impacts of land use changes on water systems through hydrological indicators and scenario analysis for the future development. Progressing towards a combined municipal and regional spatial data infrastructure will greatly enhance research possibilities in this field.

The whole range of relevant stakeholders could not be interviewed. This study also relies on evidence from and the perspectives of a selected group of experts because they have a relatively large impact on the actions in reality. Due to the complexity of issues related to integrated policy approaches and to time constraints, the selected interviewees are mainly senior experts on urban planning, water management, environmental protection and relevant key policy officials. There is no investigation of the opinions of the public, relevant non-governmental organisations and property owners. Therefore this study lacks an analysis of the views of the wider 'users' of the water bodies. This aspect needs more study in the future.

(b) Limitations with respect to the actual situation

At present the Chinese planning system is changing rapidly with new policies and new approaches coming out, like the new Urban Plan-making Regulation in 2004 and the City and Country Planning Act in January 2008. These changes of the national policies and approaches are bringing or pushing a reform of the urban planning system at the local level. In the meantime, the local policies in Wuhan have been laid out relentlessly in recent years. This PhD research started in August 2005 and has been facing these radical changes in urban development and planning systems. Unavoidably, updating of data, document information, and survey information is needed for further research. In the meantime, water management at the urban region level has undergone and is undergoing a radical institutional reform and the effects of such changes should be evaluated in the future. Concerning spatial water issues, water management in China has not truly realized its potential, let alone practical implementation, which is quite different from the situation in the Netherlands.

Nevertheless, it can be expected that the aforementioned efforts on planning reform and institutional changes are going to tackle the environmental and ecological issues in a more profound manner than is the practice today. The new Planning Act is attempting to improve the quality of planning in substance, to increase the efficiency of plan-making and the approval processes, to enhance the implementation of plans, and also to encourage more public participation. The institutional reform in water management is attempting to tackle more water environmental issues in an integrated way. From this point of view, it is now much more feasible to implement integrated spatial planning and water management. However, more research work needs to be done concerning this field:
First, in the particular social and political context, how to advocate and promote that planning should be regarded as a conscious human activity to create a workable, well informed and substantiated vision for future development.
Second, how to develop information support systems, in particular knowledge systems based on scenario analysis to link spatial issues and water issues to provide a platform for effective negotiation and discussion.

As institutional reform and development is evolving rapidly in China, the monitoring and evaluation of their effectiveness and efficiency should be one of the key issues for the future study. This line of research should include theoretical reflections on necessary adaptations of (urban or spatial) planning theory and theories of social change relevant for the situation in China. Spatial planning covers and links many related fields, and it is therefore essential to overcome the obstacles of institutional barriers to achieve the final goal of sustainable development.
A final observation is that more attention must be given to the issue and implications of climate change on Wuhan's urban environment and liveability. This issue has received only fleeting attention in this

study but it does have numerous connections to both spatial planning and water management. Aspects of climate change related to changes in rainfall patterns and their implications for drainage and flooding are obviously related to surface water. More over, large surface water bodies may provide a mechanism to retain and store additional run-off as well as combat urban heat island effects that are generally expected more extreme. More detailed examination is needed to analyse the nature of local climate change challenges and to determine how an integrated spatial planning and water management approach can help mitigate and adapt to the effects of climate change.

References

Abramson, D. B. (2006). Urban Planning in China: Continuity and Change. Journal of the American Planning Association, 72(2): 197-215.

Alexander, C. (1965). A City is not a Tree. Architectural Forum, 122(1,2).

Allmendinger, P. (2002). Planning Theory. New York: Palgrave.

Altes, W. K. K. (2006). Towards Regional Development Planning in the Netherlands. Planning, Practice & Research, 21(3): 309-321.

Anbumozhi, V., Radhakrishnan, J., & Yamaji, E. (2005). Impact of Riparian Buffer Zones on Water Quality and Associated Management Considerations. Ecological Engineering, 24: 517-523.

Archibugi, F. (2004). Planning Theory: Reconstruction or Requiem for Planning. European Planning Studies, 12(3): 425-445.

Arhnem municipality. (2006). Uitvoering Waterplan Arnhem 2003-2008. Retrieved 10 June, 2009, from http://www.schoonwaterhoujehelder.nl/content.jsp?objectid=73833

Arnhem Municipality. Waterplan Arnhem 2003. Retrieved 15 June, 2009, from http://www.schoonwaterhoujehelder.nl/content.jsp?objectid=73833

Arnhem Municipality. Waterplan Arnhem 2009. Retrieved 15 June, 2009, from http://www.schoonwaterhoujehelder.nl/content.jsp?objectid=73833

Arnold, C. L., & Gibbons, C. J. (1996). Impervious surface coverage - The emergence of a key environmental indicator. [Article]. Journal of the American Planning Association, 62(2): 243-258. [English]

Bahar, M. M., Ohmori, H., & Yamamuro, M. (2008). Relationship between River Water Quality and Land Use in a Small River Basin Running Through the Urbanizing Area of Central Japan. Limnology, 9: 19-26.

Beauregard, R. A. (1990). Bringing the City Back in. Journal of the American Planning Association, 56(2): 210-215.

Berg, M. v. d. (1989). Dutch Experience, Plans and Visions. Cities, 6(4): 277-281.

Brand, R., & Gaffikin, F. (2007). Collaborative Planning in an Uncollaborative World. Planning Theory, 6(3): 282-313.

Brugge, R. v. d., Rotmans, J., & Loorbach, D. (2005). The Transition in Dutch Water Management. Regional Environmental Chang(5): 164-176.

Brussaard, W. (1987). The Rules of Physical Planning 1986. National Physical Planning Agency, the Hague, Netherlands

Buitelaar, E., Lagendijk, A., & Jacobs, W. (2007). A Theory of Institutional Change: Illustrated by Dutch City-provinces and Dutch Land Policy. Environment and Planning A, 39: 891-908.

Camorani, G., Castellarin, A., & Brath, A. (2005). Effects of Land-use Changes on the Hydrologic Response of Reclamation Systems. Physics and Chemistry of the Earth, 30: 561-574.

Campbell, S. (2003). Green Cities, Growing Cities, Just Cities? Urban Planning and the Contradictions of Sustainable Development. In S. Campbell & S. S. Fainstein (Eds.), Readings in Planning Theory (second edition). Malden: Blackwell Publishing Ltd.

Campbell, S., & Fainstein, S. S. (2003). Introduction: the Structure and Debates of Planning Theory. In S. Campbell & S. S. Fainstein (Eds.), Readings in Planning Theory (second edition). Malden: Blackwell Publishing Ltd.

Carmon, N., Shamir, U., & Meiron-Pistiner, S. (1997). Water-Sensitive Urban Planning: Protecting Groundwater. Journal of Environmental Planning and Management, 40(4): 413-434.

Carter, J. G. (2007). Spatial planning, water and the Water Framework Directive: insights from theory and practice. Geographical Journal, 173: 330-342.

Carter, N., Kreutzwiser, R. D., & Loe, R. C. d. (2005). Closing the Circle: Linking Land Use Planning and Water Management at the Local Level. Land Use Policy (22): 115-127.

Carter, N., Oxley, M., & Golland, A. (1996). Towards the Market: Dutch Physical Planning in a UK Perspective. Planning, Practice & Research, 11(1): 49-60.

Carter, T., & Jackson, C. R. (2007). Vegetated Roofs for Stormwater Management at Multiple Spatial Scales. Landscape and Urban Planning, 80(1-2): 84-94.

CBS. (2009). Statistics Netherlands. Retrieved 15 May, 2009, from http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLEN&PA=37296eng&D1=a&D2=0,10,20,30,40,58-59&HD=090302-1045&LA=EN&HDR=G1&STB=T

CCPA-Editing-Group. (2007). 城乡规划法要点解答(Explanation of Key Points on City and Country Planning Act (CCPA)). Beijing: Law Press. [in Chinese]

Chadwick, G. (1971). A System View of Planning: Towards a Theory of the Urban and Regional Planning Process. Oxford, New York: Pregamon Press Ltd.

Chen, H. (2006). 水管理体制的法律思考 - 以水务局为中心的考查 (Reflections upon Water Affairs Management System from Legal Perspective - A Survey Centered on Water Affairs

Bureau). Journal of South-Central University for Nationalities (Humanities and Social Science), 26(3): 127-130. [in Chinese: English Abstract]
Chen, S., Zhang, X., & Peng, L. (2006). Impervious Surface Coverage in Urban Land Use Based on High Resolution Satellite Images （基于高分辨率卫星影像的城市用地不透水率分析）. Resources Science, 28(2): 41-45. [in Chinese: English Abstract]
Chen, Z., & Li, D. (2008). 国家综合配套改革试验区的实践探索与发展趋势（Practical Exploration and Developmental Trends in the State Comprehensive Supporting Reform's Pilot Area）. Chinese Public Administration, 281(11): 78-84. [In Chinese: English Abstract]
Chene, J. M. (2009). Integrated Water Resources Management: Theory versus practice. Natural Resources Forum, 33(1): 2-5.
Coffman, L. S. (2002). Low-Impact Development: An Alternative Stormwater Management Technology. In R. L. France (Ed.), Handbook of Water Sensitive Planning and Design (pp. 97-123). Boca Raton, Florida: CRC Press LLC.
Conway, T. M. (2007). Impervious Surface as an Indicator of pH and Specific Conductance in the Urbanizing Coastal Zone of New Jersey, USA. Journal of Environmental Management, 85: 308-316.
Conway, T. M. (2007). Impervious surface as an indicator of pH and specific conductance in the urbanizing coastal zone of New Jersey, USA. Journal of Environmental Management, 85(2): 308-316.
Correia, F. N., Saraiva, M. d. G., Silva, F. N. d., & Ramos, I. (1999). Floodplain Management in Urban Developing Area, Part I: urban Growth Scenarios and Land Use Controls. Water Resources Management, 13(1): 1-21.
Correlje, A., Francois, D., & Verbeke, T. (2007). Integrating water management and principles of policy: towards an EU framework? Journal of Cleaner Production, 15(16): 1499-1506.
Cowardin, L. M., Carter, V., Golet, F. C., & LaRoe, E. T. (1979). Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC.: U.S. Fish and Wildlife Serice, FWS/OBS-79/31.
Crawford, S. E. S., & Ostrom, E. (1995). A Grammar of Institutions. American Political Science Review, 89(3): 582-600.
Davis, A. P. (2008). Field Performance of Bioretention: Hydrology Impacts. Journal of Hydrologic Engineering, 13(2): 90-95.

Dietz, M. E. (2007). Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions. Water, Air, & Soil Pollution, 186(1-4): 351-363.

Douglas, I. (1983). The Urban Environment. London, Caufield East Australia, Baltimore USA: Edward Arnold.

Drimmelen, C. v., Oosterberg, W., & Vlist, M. v. d. (2005). Urbanized Flood Prone Deltas: New Solutions for the Dutch Rhine - Meuse Delta. Lelystad: RIZA, Rijkswaterstaat, the Netherlands.

Du, N., Ottens, H. F. L., & Sliuzas, R. (2009a). Quantifying changes in land use and surface water bodies in Wuhan China. In J. Feyen, K. Shannon & M. Neville (Eds.), Water and Urban Development Paradigms: Towards an Integration of Engineering, Design and Management Approaches: Proceedings of the International Urban Water Conference, Heverlee, Belgium, 15-19 September 2008. London: CRC Press, Taylor & Francis Group.

Du, N., Ottens, H. F. L., & Sliuzas, R. (2009b). Spatial Impact of Urban Expansion on Surface Water Bodies - A Case Study of Wuhan, China. Landscape and Urban Planning: (accepted for publication, doi:10.1016/j.landurbplan.2009.1010.1002).

Dunne, T., & Leopold, L. B. (1978). Water in Environmental Planning. New York: W. H. Freeman and Company.

EC. (2000). Directive 2000/60/EC of the European Parliament and of the Council: Establishing a Framework for Community Action in the Field of Water Policy (the Water Framework Directive). Official Journal of the European Communities L327, 1(73).

Eisner, S., Gallion, A., & Eisner, S. (1993). Urban Pattern (Sixth edition ed.). New York: Van Nostrand Reinhold.

EU. (1999). The EU Compendium of Spatial Planning Systems and Policies: The Netherlands. Luxembourg: Office for Official Publications of the European Communities.

Fainstein, S. S. (2000). New Directions in Planning Theory. Urban Affairs Review, 35(4): 451-478.

Fainstein, S. S. (2005). Planning Theory and the City. Journal of Planning Education and Research, 25: 121-130.

Faludi, A. (1973). Planning Theory. Oxford: Pergamon Press.

Faludi, A., & van de Valk, A. (1994). Rule and Order: Dutch Planning Doctrine in the Twentieth Century. Dordrecht / Boston / London: Kluwer Academic Publishers.

Farrier, D., & Tucker, L. (2000). Wise Use of Wetlands under the Ramsar Convention: a Challenge for Meaningful

Implementation of International Law. Journal of Environmental Law, 12(1): 21-42.
Fishman, R. (2003). Urban Utopias: Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier. In S. Campbell & S. S. Fainstein (Eds.), Readings in Planning Theory (Vol. second edition). Malden: Blackwell Publishing Ltd.
France, R. L. (Ed.). (2002). Handbook of Water Sensitive Planning and Design. Boca Raton, Florida: CRC Press LLC.
Franks, T. (1999). Capacity Building and Institutional Development: Reflections on Water. Public Administration and Development, 19: 51-61.
Friedmann, J. (1998). Planning Theory Revisited. European Planning Studies, 6(3): 245-253.
Geertman, S., & Stillwell, J. (2003). Planning Support Systems: An Introduction. In S. Geertman & J. Stillwell (Eds.), Planning Support Systems in Practice. Berlin Herdelberg: Springer.
Gullstrand, M., Lowgren, M., & Castensson, R. (2003). Water Issues in Comprehensive Municipal Planning: a Review of the Motala River Basin. Journal of Environmental Management, 69: 239-247.
Gullstrand, M., Lowgren, M., & Castensson, R. (2003). Water Issues in Comprehensive Municipal Planning: a Review of the Motala River Basin. Journal of Environmental Management(69): 239-247.
Guneralp, B., & Seto, K. C. (2008). Environmental impacts of urban growth from an integrated dynamic perspective: A case study of Shenzhen, South China. Global Environmental Change – Human and Policy Dimensions, 18(4): 720-735.
Hajer, M., & Zonneveld, W. (2000). Spatial planning in the network society - Rethinking the principles of planning in the Netherlands. European Planning Studies, 8(3): 337-355.
Hall, M. J., & Ellis, J. B. (1985). Water Quality Problems of Urban Areas. GeoJournal, 11(3): 265-275.
Hall, P. (1996). Cities of Tomorrow: An Intellectual History of Urban Planning and Design in the Twentieth Century (Updated Edition). Oxford, UK: Blackwell Publishers Ltd.
Hall, P. (2002). Urban and Regional Planning (fourth edition). London: Routledge.
He, H. M., Zhou, H., Wu, Y. G., Zhang, W. C., & Xie, X. P. (2008). Modelling the response of surface water quality to the urbanization in Xi'an, China. Journal of Environmental Management, 86(4): 731-749.
Healey, P. (1996). The Communicative Turn in Planning Theory and Its Implications for Spatial Strategy Formation. Environment and Planning B: Planning & Design, 23: 217-234.

Healey, P. (1997). Collaborative Planning: Shaping Places in Fragmented Societies. London: Macmillan Press LTD.
Healey, P. (1998a). Collaborative Planning in a Stakeholder Society. Town Planning Review, 69(1): 1-21.
Healey, P. (1998b). Building Institutional Capacity through Collaborative Approaches to Urban Planning. Environment and Planning A, 30: 1531-1546.
Healey, P. (1999). Institutional Analysis, Communicative Planning, and Shapiing Places. Journal of Planning Education and Research, 19(2): 111-121.
Hoch, C. J. (2000). Making Plans. In C. J. Hoch, L. C. Dalton & F. S. So (Eds.), The Practice of Local Government Planning (Third Edition). Washington D. C.: The International City/County Management Association.
Hoek, A. v. d. (1992). Planning as a Learning Process. Unpublished PhD thesis, Agricultural University Wageningen, Wageningen.
Hooimeijer, F., Meyer, H., & Nienhuis, A. (Eds.). (2005). Atlas of Dutch Water Cities. Amsterdam: SUN Publishers and Authors.
Hough, M. (2004). Cities and Natural Process: A basis for sustainability (second edition ed.). London and New York: Routledge.
Howard, E. (1902, re-edited in 1965). Garden Cities of To-morrow. In F. J. Osborn & L. Mumford (Eds.). London: Faber and Faber LTD.
Hu, X. (2006). 武汉工业与城市发展时空演变研究 （Study on the Spatial and Temporal Evolution of Industry and Urban Development in Wuhan）. Nanjing University, Nanjing. [in Chinese: English Abstract]
Hubei Provincial Government. (2004). Report of General Planning of the '1+8' Wuhan Region. Retrieved. from. http://www.whcsq.gov.cn/hezuo/zuixingdongtai/zonghe/2009/07/21092757.html
Huggett, R., Lindley, S., Gavin, H., & Richardson, K. (2004). Physical Geography: a Human Perspective. London: Arnold, a member of the Hodder headline Group.
Huisman, P. (2004). Water in the Netherlands: Managing Checks and Balances. Utrecht: the Netherlands hydrological Society (NHV).
Huxley, M., & Yiftachel, O. (2000). New Paradigm or Old Myopia? Unsettling the Communicative Turn in Planning Theory. Journal of Planning Education and Research, 19(4): 333-342.

Hwang, S.J., Lee, S.W., Son, J.Y., Park, G.A., & Kim, S.J. (2007). Moderating Effects of the Geometry of Reservoirs on the Relation between Urban Land Use and Water Quality. Landscape and Urban Planning, 82: 175-183.

ILEC. (2005). Managing Lakes and Their Basins for Sustainable Use: A Report for Lake Basin Managers and Stakeholders: International Lake Environment Committee Foundation: Kusatsu, Japan.

Innes, J. E., & Booher, D. E. (1999a). Consensus Building as Role Playing and Bridge: toward a Theory of Collaborative Planning. Journal of the American Planning Association, 65(1): 9-26.

Innes, J. E., & Booher, D. E. (1999b). Consensus Building and Complex Adaptive Systems: A Framework for Evaluating Collaborative Planning. Journal of the American Planning Association, 65(4): 412-423.

Israel, A. (1987). Institutional Development: Incentives to Performance. Baltimore and London: The Johns Hopking University Press.

Jacobs, J. (1961). The Dearth and Life of Great American Cities: Random House Inc.

Jacobs, J. (1961). The Death and Life of Great American Cities. Toronto: Random House Inc.

Jin, L., & Zhang, C. (1996). 我国水资源面临的问题及保护对策（The Problems and Protective Proposals of Water Resources in China）. Ecological Economy (1): 25-29. [In Chinese: English Abstract]

Jong, J. d., Rooy, P. T. J. C. v., & Hosper, S. H. (1995). Living with Water: at the Cross-Roads of Change. Water Science and Technology, 31(8): 393-400.

Kelly, C., & Lunn, R. J. (1999). Development of a Contaminated Land Assessment System Based on Hazard to Surface Water Bodies. Water Research, 33(6): pp 1377-1386.

Khakee, A. (1996). Urban planning in China and Sweden in a comparative perspective. Progress in Planning, 46(2): 91-140.

Klein, W. R. (2000). Building Consensus. In C. J. Hoch, L. C. Dalton & F. S. So (Eds.), The Practice of Local Government Planning (Thire Edition, pp. 423-438). Washington D. C.: The International City/County Management Association.

Klocking, B., & Haberlandt, U. (2002). Impact of land use changes on water dynamics--a case study in temperate meso and macroscale river basins. Physics and Chemistry of the Earth, Parts A/B/C, 27(9-10): 619-629.

Klosterman, R. E. (2001). Planning Support Systems: A New Perspective on Computer-aided Planning. In R. K. Brail & R. E. Klosterman (Eds.), Planning Support Systems. California: ESRI Press.

Kronaveter, L., Shamir, U., & kessler, A. (2001). Water-Sensitive Urban Planning: Modeling On-site Infiltration. Journal of Water Resources Planning and Management, 127(2).

Lauria, M. (2000). The Limits to Communicative Planning Theory: A Brief Introduction. Journal of Planning Education and Research, 19(4): 331-332.

Lawrence, D. P. (2000). Planning Theories and Environmental Impact Assessment. Environmental Impact Assessment Review(20): 607-625.

LEC. (1989). 武汉市志：城市建设志（Wuhan Chorography: Urban Construction Section） (Wuhan Local Edit Committee (LEC) ed.). Wuhan: Wuhan University Publishing Company. [in Chinese]

LEC. (1989). 武汉市志：总类志（Wuhan Chorography: General Section） (Wuhan Local Edit Committee (LEC) ed.). Wuhan: Wuhan University Publishing Company. [in Chinese]

LEC. (1996). Wuhan Chorography: Construction Section (Wuhan Local Edit Committee (LEC) ed.). Wuhan: Wuhan University Publishing Company. [in Chinese]

LEC. (2006). 武汉市志 1980-2000.第一卷：总类，城市建设（Wuhan chorography 1980-2000. No.1: General Section, Urban Construction） (Wuhan Local Edit committee (LEC) ed.). Wuhan: Wuhan Press. [in Chinese]

Legates, R., & Zhang, T. (2007). Guide of Western Urban Planning Literatures for Planners in China. Urban Planning Forum, 170(4).

Leopold, L. B. (1968). Hydrology for Urban Land Planning - A Guidebook on the Hydrologic Effects of Urban Land Use: US Geological Survey Circular.

Li, G. L., Chen, J., & Sun, Z. Y. (2007). Non-agricultural land expansion and driving forces: a multi-temporal study of Suzhou, China. International Journal of Sustainable Development and World Ecology, 14(4): 408-420.

Li, Y., Zhao, S. Q., Zhao, K., Xie, P., & Fang, J. Y. (2006). Land-cover changes in an urban lake watershed in a mega-city, Central China. Environmental Monitoring and Assessment, 115(1-3): 349-359.

Liamputtong, P., & Ezzy, D. (2005). Qualitative Research Methods. Oxford: Oxfor University Press.

Liu, J., Zhan, J., & Deng, X. (2005). Spatio-temporal Patterns and Driving Forces of Urban Land Expansion in China during the Economic Reform Era. Ambio, 34(6): 450-455.

Liu, J. Y., Zhan, J. Y., & Deng, X. Z. (2005). Spatial-temporal patterns and driving forces of urban land expansion in china during the economic reform era. Ambio, 34(6): 450-455.

Long, H. L., Tang, G. P., Li, X. B., & Heilig, G. K. (2007). Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. Journal of Environmental Management, 83(3): 351-364.

Long, H. L., Wu, X. Q., Wang, W. J., & Dong, G. H. (2008). Analysis of urban-rural land-use change during 1995-2006 and its policy dimensional driving forces in Chongqing, China. Sensors, 8(2): 681-699.

Long, T., Jiang, W., & He, Q. (2003). 水问题反思与水资源承载力研究（Research on Water Problems and Carrying Capacity of Water Resources）. China Water & Wastewater, 19(7): 20-23. [In Chinese]

Ma, L. J. C. (2002). Urban Transformation in China, 1949-2000: a Review and Research agenda. Environment and Planning A, 34: 1545-1569.

Ma, L. J. C. (2004). Economic Reforms, Urban Spatial Restructuring, and Planning in China. Progress in Planning, 61: 237-260.

Ma, W. (2005). The Essential Return of Urban Planning. Urban Planning Forum, 155(1): 16-20. [in Chinese]

Margerum, R. D. (2002). Evaluating Collaborative Planning: Implications from an Empirical Analysis of Growth Management. Journal of the American Planning Association, 68(2): 179-193.

Marsh, w. M. (1991). Landscape Planning: Environmental Applications (Second Editor ed.). New York: John Wiley & Sons, Inc.

Marsh, W. M., & John Grossa, J. (2005). Environmental Geography: Science, land use and earth Systems (3rd Edition ed.). United States of America: John Wiley & Sons, INC.

Marsh, W. M., & John M. Grossa, J. (2005). Environmental Geography: Science, land use and earth Systems (3rd Edition ed.). United States of America: John Wiley & Sons, INC.

McGuirk, P. M. (2001). Situating Communicative Planning Theory: Context, Power, and Knowledge. Environment and Planning A, 33: 195-217.

Ministerie van Verkeer en Waterstaart. (2007). Safeguarding Our Future: the Government's Vision on National Water Policy. Retrieved 29 May, 2009. from

http://www.verkeerenwaterstaat.nl/english/Images/0418.1037%20Brochure%20Watervisie%20ENG1_tcm249-212287.pdf.
Mitsch, W. J., & Gosselink, J. G. (2000). Wetlands (Third edition). New York: John Wiley & Sons, Inc.
Moglen, G. E., & Kim, S. (2007). Limiting imperviousness - Are threshold-based policies a good idea. [Article]. Journal of the American Planning Association, 73(2): 161-171. [English]
Moglen, G. E., & Kim, S. (2007). Limiting Imperviousness: Are Threshold-Based Policies a Good Idea? Journal of the American Planning Association, 73(2): 161-171.
Morris, A. E. (1985). Historical Roots of Dutch City Planning and Urban Form. In A. K. Dutt & F. J. Costa (Eds.), Public Planning in the Netherlands: Perspectives and Change since the Second World War (pp. pp50-71). London: Oxford University Press.
Morse, C. C., Huryn, A. D., & Cronan, C. (2003). Impervious Surface Area as a Predictor of the Effects of Urbanization on Stream Insect Communities in Maine, U.S.A. Environmental Monitoring and Assessment, 89: 95-127.
Morse, C. C., Huryn, A. D., & Cronan, C. (2003). Impervious surface area as a predictor of the effects of urbanization on stream insect communities in Maine, USA. Environmental Monitoring and Assessment, 89(1): 95-127.
Mostert, E. (2006). Integrated Water Resources Management in the Netherlands: How Concepts Function. Journal of Contemporary Water Research & Education, December (135): 19-27.
Mylopoulos, Y. A., & Kolokytha, E. G. (2008). Integrated water management in shared water resources: The EU water framework directive implementation in Greece.
Naiman, R. J., & Decamps, H. (1997). The Ecology of Interfaces: Riparian Zones. Annual Review of Ecology & Systematics (28): 621-658.
National Bureau of Statistics of China. (2000). National Fifth Census. Retrieved 10 June, 2009, from http://www.stats.gov.cn/TJGB/RKPCGB/qgrkpcgb/t20020331_15434.htm
National Bureau of Statistics of China. (2005). Population Statistical Data. Retrieved 10 June, 2009, from http://www.stats.gov.cn/TJGB/RKPCGB/qgrkpcgb/t20060316_402310923.htm
National Spatial Planning Agency. (1996). Spatial planning in the Netherlands: course in regional planning for integrated land

utilisation: module III.1: National Spatial Planning Agency of the Netherlands.

National Spatial Strategy. (2006). Summary National Spatial Strategy: Creating Space for Development. Retrieved 1 January, 2009, from http://international.vrom.nl

Needham, B. (2005). The New Dutch Spatial Planning Act: Continuity and Change in the Way in Which the Dutch Regulate the Practice of Spatial Planning. Planning, Practice & Research, 20(3): 327-340.

Needham, B. (2007). Dutch land use planning : planning and managing land use in the Netherlands, the principles and practice. Den Haag: SDU.

Newman, P., & Jennings, I. (2008). Cities as Sustainable Ecosystems: Principles and Practices. Washington: Island Press.

Ngoye, E., & Machiwa, J. F. (2004). The Influence of Land-use Patterns in the Ruvu River Watershed on Water Quality in the River System. Physics and Chemistry of the Earth, 29: 1161-1166.

NHV. (Netherlands Hydrological Society), 2004). Water in the Netherlands -- Managing Checks and Balances. Rotterdam: DrukZaken.

NHV, N. H. S. (2004). Water in the Netherlands -- Managing Checks and Balances. Rotterdam: DrukZaken.

Niemczynowicz, J. (1999). Urban Hydrology and Water Management - Present and Future Challenges. Urban Water (1): 1-14.

Nieuwenkamp, J. K. (1985). National Physical Planning: Origins, Evolution and Current Objectives. In A. K. Dutt & F. J. Costa (Eds.), Public Planning in the Netherlands: Perspectives and Change since the Second World War (pp. pp72-86). London: Oxford University Press.

Ning, L. (2005). 武汉市湿地景观格局的变化与城市景观建设（Changes in Urban Wetland Landscape Pattern and Construction of Urban Landscape Mosaic: a Case Study of Wuhan City）. Journal of Lanzhou University (Natural Science), 41(3): 6-9. [in Chinese: English Abstract]

Ouyang, T. P., Zhu, Z. Y., & Kuang, Y. Q. (2006). Assessing impact of urbanization on river water quality in the Pearl River Delta Economic Zone, China. Environmental Monitoring and Assessment, 120(1-3): 313-325.

Page, G. W., & Susskind, L. (2007). Five Important Themes in the Special Issue on Planning for Water. Journal of the American Planning Association, 73(2): 141-145.

Pappas, E. A., Smith, D. R., Huang, C., Shuster, W. D., & Bonta, J. V. (2008). Impervious surface impacts to runoff and sediment discharge under laboratory rainfall simulation. Catena, 72(1): 146-152.

Paris, C. (1982). Introdution. In C. Paris (Ed.), Critical Readings in Planning Theory. Oxford: Pergamon Press.

Parkinson, J., & Mark, O. (2005). Urban Stormwater Management in Developing Countries. London, Seattle: IWA Publishing.

Perez-Pedini, C., Limbrunner, J. F., & Vogel, R. M. (2005). Optimal Location of Infiltration-Based Best Management Practices for Storm Water Management. Journal of Water Resources Planning and Management, 131(6): 441-448.

Prince George's County, Maryland. (1999). Low Impact Development Design Strategies: An Integrated Design Approach: Department of Environmental Resource Programs and Planning Division, Largo, Maryland.

Project Group of 'Strategic Research on Sustainable Development of Water Resource in China in 21st Century', Chinese Academy of Engineering (2000). 中国可持续发展水资源战略研究综合报告（Strategic Research on Sustainable Development of Water Resource in China）. Engineering Science, 2(8): 1-17. [In Chinese: English Abstract]

Qian, Z. (2001). 中国水资源战略研究中几个问题的认识（About Some Problems in Research of Water Resources Strategy of China）. Journal of Hehai University, 29(3): 1-7. [In Chinese: English Abstract]

Randolph, J. (2004). Environmental Land use Planning and Management. Washington, USA: Island Press.

Ravets, J. (2000). City-Region 2020: Integrated Planning for a Sustainable Environment. London: Earthscan Publications Ltd.

Reuss, M. (2002). Learning from the Dutch - Technology, management, and water resources development. Technology and Culture, 43(3): 465-472.

Rijkswaterstaat. (2000). A Different Approach to Water: Water Management Policy in the 21st Century. Retrieved. From http://www.waterland.net/index.cfm/site/Water%20in%20the%20Netherlands/pageid/D2774C85-EC80-5390-4F4E3ADCA322F13E/index.cfm/water%20management.

RIZA. (1999). New Deal with an Old Enemy: Water Management in the Netherlands: Past, Present and Future. Ministry of Transport, Public Works and Water Management, the Netherlands

Robinson, G. M. (1998). Methods and Techniques in Human Geography. Chichester: John Wiley & Sons Ltd.

Rodriguez-Rodriguez, M., & Benavente, J. (2008). Definition of wetland typology for hydro-morphological elements within the WFD. A case study from southern Spain. Water Resources Management, 22(7): 797-821.

Roesner, L. A., Bledsoe, B. P., & Brashear, R. W. (2001). Are Best-Management-Practice Criteria Really Environmentally Friendly? Journal of Water Resources Planning and Management, 127(3): 150-154.

Rooy, P. T. J. C. v., Jong, J. d., Jagtman, E., Hosper, S. H., & Boers, P. C. M. (1998). Comprehensive Approaches to Water Management. Water Science and Technology, 37(3): 201-208.

Rydin, Y. (1993). The British Planning System: an Introduction. London: The Macmilian Press LTD.

Saeijs, H. L. F. (1991). Integrated Water Management - A New Concept from Treating of Symptoms towards A Controlled Ecosystem Management in the Dutch delta.

Sagasti, F. R. (1990). An Institutional Approach to National Development Planning. Technological Forecasting and Social Chang, 37(4): 321-334.

Schreuder, Y. (2001). The Polder Model in Dutch Economic and Environmental Planning. Bulletin of Science, Technology & Society, 21(4): 237-245.

Schueler, T. (2000). The Importance of Imperviousness. In T. R. Schueler & H. K. Holland (Eds.), The Practice of Watershed Protection. Elliot, MD: Center for Watershed Protection.

Shen, D. (2005). Water-Related Risk Management in China: a Legal, Institutional, and Regulatory Overview. IWRA, Water International, 30(3): 329-338.

Shen, D., & Liu, B. (2008). Integrated Urban and Rural Water Affairs Management Reform in China: Affecting Factors. Physics and Chemistry of the Earth, 33: 364-375.

Sliva, L., & Williams, D. D. (2001). Buffer Zone Versus Whole Catchment Approaches to Studying Land Use Impact on River Water Quality. Water Research, 35(14): pp 3462-3472.

Song, J. (2003). 浅谈当前城市水环境现状及发展对策（Researches on Water Environmental Problems and Solutions in Chinese Cities）. Research of Soil and Water Conservation, 10(3): 114-116. [In Chinese: English Abstract]

Song, X., Wang, C., & Wang, Y. (2004). 我国城市化进程中的水资源环境问题（Water Resources and Environment Problem during the Urbanization Process in China）. Resources & Environment (2): 29-32. [In Chinese]

Song, Y., & Ding, C. (2009). Introduction. In Y. Song & C. Ding (Eds.), Smart urban growth for China (pp. 287). Cambridge: Lincoln institute for land policy.

Spaans, M. (2006). Recent Changes in the Dutch Planning System: Towards a New Governance Model? Town Planning Review, 77(2): 127-146.

Stone, B., & Bullen, j. L. (2006). Urban Form and Watershed Management: How Zoning Influences Residential Stormwater Volumes. Environment and Planning B: Planning and Design, 33: 21-37.

Strecker, E. W., Quigley, M. M., Urbonas, B. R., Jones, J. E., & Clary, J. K. (2001). Determining Urban Storm Water BMP Effectiveness. Journal of Water Resources Planning and Management, 127(3): 144-149.

Sun, S. (2005). 年会自由论坛：城市规划方法论 (Annual Conference Forum: Urban Planning Methods). City Planning Review, 29(11): 28-34. [Chinese]

Sun, S. (2006). The Unbearal Burden of Urban Planning in China: The Impairment of the Pursuit of Efficiency on Urban Planning. Urban Planning Forum, 161(1): 11-17. [Chinese]

Sun, S. (2007). The Dilemma of the Rationality in China's Urban Planning. Urban Planning Forum, 168(2): 1-8.

Tang, W.S. (2000). Chinese Urban Planning at Fifty: An Assessment of the Planning Theory Literature. Journal of Planning Literature, 14(3): 347-366.

Taylor, N. (1980). Planning Theory and the Philosophy of Planning. Urban Studies, 17: 159-172.

Taylor, N. (1998). Urban Planning Theory since 1945. London: SAGE Publications Ltd.

TeBrake, W. H. (2002). Taming the Waterwolf - Hydraulic engineering and water management in the Netherlands during the middle ages. Technology and Culture, 43(3): 475-499.

Tong, S. T. Y., & Chen, W. (2002). Modeling the Relationship between Land Use and Surface Water Quality. Journal of Environmental Management, 66: 377-393.

Tu, J., & Yuan, L. (2000). 人类活动与武汉市洪涝灾害（Mankind Activities and Damage or Crop Failure by Flood and Waterlogging in Wuhan City）. Urban Roads, Bridges & Flood Control (4): 28-31. [in Chinese: English Abstract]

van Dam, P. (2002). Ecological challenges, technological innovations - The modernization of sluice building in Holland, 1300-1600.

van de Ven, G. P. (Ed.). (1993). Man-made Lowlands: History of Water Management and Land Reclamation in the Netherlands. Den Haag: uitgeverij Matrijs.

van Ek, R., Witte, J. P. M., Runhaar, H., & Klijn, F. (2000). Ecological effects of water management in the Netherlands: the model DEMNAT.

Varis, O., & Vakkilainen, P. (2001). China's 8 Challenges to Water Resources Management in the First Quarter of the 21st Century. Geomorphology, 41: 93-104.

VNG and UvW. (2004). Urban Water Plan Guide (Handleiding Stedelijk Waterplan).

Walesh, S. G. (1989). Urban Surface Water Management (first edition ed.). New York: John Wiley & Sons, Inc.

Wang, C., Wu, Y., & Liu, J. (2004). 武汉城市湖泊水环境现状及综合整治途径（Quality status in Urban Lake Water in Wuhan city with Integrated Approaches on Restoration）. Resources and Environment in the Yangtze Basin, 13(5): 499-502. [in Chinese: English Abstract]

Wang, J. Y., Da, L. J., Song, K., & Li, B. L. (2008). Temporal variations of surface water quality in urban, suburban and rural areas during rapid urbanization in Shanghai, China. Environmental Pollution, 152(2): 387-393.

Ward, S. V. (2002). Planning the Twentieth-Century City: the Advanced Capitalist World. Chichester, UK: John Wiley & Sons Ltd.

WCED. (1987). Our Common Future. Oxford: Oxford University Press.

Wegener, M., Button, K., & Nijkamp, P. (2007). Introduction -- Planning History and Methodology: Scoping the Scene. In M. Wegener, K. Button & P. Nijkamp (Eds.), Planning History and Methodology. Cheltenham, UK. Northampton, MA, USA: Edward Elgar Publishing Limited.

Wei, Y. D. (2005). Planning Chinese Cities: The Limits of Transitional Institutions. Urban Geography, 26(3): 200-221.

Wenger, S. (Ed.) (1999). A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation, Institute of Ecology, University of Georgia.

Woltjer, J., & Al, N. (2007). Integrating Water Management and Spatial Planning: Strategies Based on the Dutch Experience. Journal of the American Planning Association, 73(2): 211-222.

WSB. (2006). 武汉统计年鉴（Wuhan Statistical Yearbook） (Wuhan Statistical Bureau (WSB) ed.). Wuhan: China Statistical Press. [in Chinese]

Wuhan local governmental websites. Retrieved 1 May, 2008, from http://ghfj.wuchang.gov.cn/fzyd/law/2008-07-25/146.html, http://www.whwater.gov.cn/lawsCollection.html, http://ylj.hongshan.gov.cn/n1539563/n1540277/1548685.html

Wuhan Municipality. Official report on Wuhan master plan (2006-2020), Retrieved 1 May, 2007, from website of Wuhan government. www.whrd.gov.cn

WWAB. (2006). 武汉市水生态系统保护与修复规划 (Wuhan water eco-system protection and rehabilitation planning). Wuhan Water Affair Bureau. [in Chinese]

Xiang, W. (1996). GIS-based Riparian Buffer Analysis: Injecting Geographic Information into Landscape Planning. Landscape and Urban Planning, 34(1): 1-10.

Xiong, J.-p., Liu, C.-l., & Yuan, J. (2006). 武汉市住宅小区的空间结构与区位选择（On the Characteristics of Housing Spatial Structure and Location Selection of Residential Communities in Wuhan City）. Economic Geography, 26(4): 605-609. [in Chinese: English Abstract]

Yang, F. (2005). The Argumentation about Some Issues in Theoretical Research on Urbaan Planning. Urban Planning Forum, 160(6). [in Chinese]

Yeh, A. G. o., & Wu, F. (1999). The transformation of the urban planning system in China from the centrally-planned to transitional economy. Progress in Planning, 51(3): 167-252.

Yu, K. (2006). The Art of Survival: Recovering Landscape Architecture. In K. Yu & M. Padua (Eds.), The Art of Survival: Recovering Landscape Architecture. Hong Kong: China Architecture & Building Press.

Yu, L., & Bai, Z. (2009). 国家综合配套改革试验区的绩效评价研究（Research into Performance Evaluation of National Comprehensive Complement Reform Test Area）. Journal of Chongqing Technology and Business University (Social Science Edition), 26(1): 39-43. [In Chinese: English Abstract]

Zhang, B. (2005). Normalization of Planning Research: A Way to Improving the Political Situation of Planning Work. Urban Planning Forum, 156(2): 21-24. [Chinese]

Zhang, K., Yu, Z., Li, X., Zhou, W., & Zhang, D. (2007). Land Use Chang and Land Degradation in China from 1991 to 2001. Land Degradation & Development, 18: 209-219.

Zhang, T. (2008). 转型时期中国的规划理论和规划改革(Planning Theories and Reform in Transitional China) City Planning Review, 32(3): 15-24. [in Chinese: English abstract]

Zhang, X., & Cao, G. (2005). 城市水环境质量问题与改善措施（Problems and Solutions for Water Quality in Urban Aquatic Environment）. Urban Problems, 126(4): 35-38. [In Chinese: English Abstract]

Zhang, Y., & Zhang, R. (2007). 基于科学发展观与构建和谐社会的城市经济学变革（The Reform of Urban Economics Based on the Scientific Development Approach and Construction of a Harmonious Society）. Urban Studies (Chinese), 14(1): 74-76. [in Chinese: English Abstract]

Zhen, J., Shoemaker, L., Riverson, J., Alvi, K., & Cheng, M.-S. (2006). BMP Analysis System for Watershed-Based Stormwater Management. Journal of Environmental Science and Health Part A, 41(7): 1391-1403.

Zhu, J. (2005). The Logics of the Development of China's Urban Planning Theories under Market Economy. Urban Planning Forum, 155(1): 10-15. [in Chinese]

Zou, B. (2005). Recognition of The Nature of Urban Planning Study and Consideration of The Development of Urban Planning Study. Urban Planning Forum, 155(1): 28-30. [in Chinese]

Appendices

Appendix A: Checklist of interview questions for Dutch Experts

Appendix A1. Interview questions for RIZA:

1. Conceptual and Practical aspects

(1) What are the major problems of surface water and how it is related to spatial policy and land use planning in the Netherlands?

(2) What are the main functions of surface water in the Dutch spatial planning policy and how does 'giving space for water' insert as a primary principle in land use planning at national, provincial and local levels?

(3) From 1850 to 1940, the amount of water surface had greatly decreased when water lost its regulating role in the design of urban development.

   a. What is the main water problem raised from this transformation?
   b. From spatial planning perspective, what are the lessons which could be learned from this experience?

(4) After 1970s, there is the renewed interrelationship among urban planning, landscape design and hydraulic engineering. 'Giving space for water' becomes a primary principle of Dutch spatial policy. Moreover, it implicates the creation of new water bodies.

   c. What kind of benefits has the new spatial concept brought about on the relationship between urban development and water?
   d. Where and how is the new water body located and created? What are the conflicts for such an approach?
   e. Is the space-for-water policy being relaxed now because of local/regional opposition?

(5) What are the major problems concerning the river cities in the Netherlands? How can urban network planning be useful for conflict reduction of space for urbanization and space for river?

2. Procedure aspects

(6) During the planning authorized, what kind of process should spatial planning follow when involving 'space for water' issues

in? Which organizations play the important role of the decision-making? How are conflicts between surface water management and land use (especially for urban development) resolved?

(7) Which organization play the major role in the implementing the spatial planning policy concerning the space for water and to what extent can they play?

(8) What is the percentage and respective purpose of the financial support for the surface water management at national, provincial and local level? What is the effect in recent years?

(9) What is the role of the various levels of government in managing the relationship between surface water and land management (national, provincial and local)? Are the roles and responsibilities clearly defined?

3. Information aspects

(10) Are the risk calculation models necessary for spatial plan-making for the river cities in the Netherlands?

(11) Is the development of spatial scenarios for surface water management an important instrument in the Netherlands?

(12) What organizations have a leading role in the development of spatial scenarios and how is the participation of other organizations with complementary or conflicting mandates arranged?

(13) What are the current gaps in knowledge in relation to the interface between surface water management and urban development (land use) that are now being addressed or should be addressed by research?

Appendix A2: Interview questions for KAN

1. About the organization:

(1) What kind of organization it belongs to, inter-governmental or non-governmental?
(2) Why is it necessary to organize this kind of united entity in this area?
(3) What are the relationship of KAN with National, provincial government, and with local governments, including water board?
(4) Which level of government offers its financial support?
(5) About the organization structure, are there any problems encountered in the operational stage at present?

2. About the workings and operation

(6) How to combine the opinions from 21 municipalities to achieve the cohesion among of them? How to deal with the conflicts between each other?
(7) What is the main task of KAN and how to divide and share the responsibilities with municipal government?
(8) What scope is there for public participation in spatial planning process?
(9) What kinds of analysis tools, such as GI systems, image processing and modeling, have used for spatial planning and policy making? What is the role of information support system for concept/idea sharing in planning process?
(10) How about the legal status of KAN's plans and what kind of procedures to implement them?

3. About the working contents of spatial planning

(11) What are the situations of spatial development in this area, including key problems, expectation for the future, driving forces for the urban expansion?
(12) How does spatial policy deal with the conflicts between the requirements of space for urban development and the requirement of space for nature, especially for water?
(13) Is water a real problem in this area? What kinds of measures have been taken for that? And how is the effectiveness of these measures?
(14) Is water regarded as the most important factor for the quality of living environment? If so, how to integrate it inside spatial spanning?

Appendix A3: Interview questions for Arnhem:

1. Problems recognition

(1) What kinds of extra space does water need in Arnhem concerning water quantitative, qualitative problems?

(2) Do water managers and spatial planners share the same concept of the space for water in Arnhem? What kinds of conflict do there exist?

(3) Does space for water contradict the space for urban development in Arnhem? Are there examples for that?

(4) What kinds of role does surface water play in recreational / ecological / aesthetic functions in Arnhem at present?

2. Planning issues

(5) What kinds of *impact* does the National policy 'giving space for water' bring to Arnhem (such as new approaches for structure plan and land use plan ect.)? Are they positive or negative impacts from the local point of view?

(6) Are there some changes in the current structure plan and land use plan concerning to water principle? What about them?

(7) Where and how is the new space for water located or created? What are the conflicts existing? What benefits does the city get and hope to get? How is the benefits realized and are they equitable (i.e. do all citizens benefit equally)?

(8) Is the space-for-water policy being relaxed because of local/regional opposition?

(9) What are the basic contents of urban water plan? What is the relationship between urban water plan and water assessment?

(10) What kinds of criteria and key issues of water have been raised by water manager for spatial planning in Arnhem? How can they transfer to the criteria for spatial planning?

3. Procedure aspects

(11) How are conflicts between surface water management and land use (especially for urban development) resolved during the plan-making procedure?

(12) What kinds of role do the water plan and water assessment play in spatial planning authorized? Which organizations play the important role for such decision-making?

(13) What is the source of the financial support for the surface water management? What is the effect in recent years?

(14) What is the role of the various levels of government in managing the relationship between surface water and land management (national, provincial, regional (KAN) and municipal) in Arnhem? Are the roles and responsibilities clearly defined?

4. Information aspects

(15) What organizations have a leading role in the development of spatial scenarios and how is the cooperation among municipality, academic entities and consultancy?

(16) What format do such scenario development/review sessions have? How are they facilitated, who has the lead, what software support tools are used (eg GIS, PSS)?

(17) What are the current gaps in knowledge in relation to the interface between surface water management and urban development (land use) that are now being addressed or should be addressed by research?

Appendix B: Interview questions for Chinese experts

Appendix B1: Interview questions for urban planners in Wuhan

1. What kinds of categories is the surface water in Wuhan classified based on planning standard?
2. Which kinds of water-problems are being faced by urban planning in recent years?
3. What kind of work has urban planning department done to deal with the present water-related problems?
4. Has the research on hydrologic effects of land use been done before?
5. How is the process going on the lake restoration in Hanyang and What are the roles of urban planners in it?
6. How is the cooperation of urban planners and water managers to define 'blue', 'green' and 'grey' lines and what are the major obstacles for the implementation?
7. What are the major responsibilities of urban planners to deal with water-related problems?
8. How do the urban information systems support for the water-related problems analysis and what are the major achievement and barriers?

Appendix B2: Interview questions for water managers in Wuhan

1. What kind of work has water affair department done for tackling water-related problems?
2. Has the research on hydrologic effects of land use been done before?
3. What is the role of water affair department in the lake protection in Wuhan? What are the obstacles for implementation?
4. How is the process of institutional reform in Wuhan and what are the effects of it?
5. What are the comments and suggestions on the cooperation with urban planning department?
6. How is the process of the construction of spatial information system on water system? What are the achievement and obstacles for using it to support the analysis on water-related problems?

Appendix C: Hierarchical organization and interviewees concerning water management and spatial planning in the Netherlands and Wuhan, China

	In Wuhan, China	Interviewees		In the Netherlands	Interviewees	
		Expertise	No.		Expertise	No.
National Level	Changjiang Water Resources Commission (CWRC) Ministry of Construction of the People's Republic of China	Water manager	1 0	Institute for Inland Water Management and Waste Water Treatment (RIZA) Ministry of Housing, Spatial Planning and the Environment (VROM)	Water manager Urban planner	2 2 0
Provincial Level	Hubei Water Resources Department Hubei Construction Department	Water manager Urban planner	1 1	Gelderland Province KAN	Urban planner	1
Municipal Level	Wuhan Water Board Wuhan Urban Planning and Design Institute Wuhan Environmental Protection Research Institute	Water manager Urban planner Environmental expert	2 2 1	Arhnam Municipal Town Hall	Urban planner Water manager	1 1

Appendix D: General conditions of the existing lakes within the urban core

Name of the lake	Normal water area (ha)	Catch -ment area (ha)	Normal water level (m)	Highest water level (m)	Cubage (10^4 m^3)	Amount of sullage ($10^4 m^3$)	Existing functions
Huanzi Hu	10.3	150	18.12	19.13	16.5	7.2	Retention / detention, recreation, landscape
Xi Hu	5.0	93	18.17	19.23	6.3	3.5	
Xiaonan Hu	3.6	18	17.78	18.55	5.4	2.5	
Bei Hu	9.4	777	18.35	19.15	18.8	6.6	
Lianhua Hu	7.4	36	20.96	21.77	7.	5.2	
Shuiguo Hu	12.6	330	19.15	19.65	11.0	8.8	
Zhiyang Hu	15.5	306	19.33	19.65	12.4	10.8	
Simei Tang	7.8	89	21.40	21.50	15.7	5.5	
Sai Hu	12.8	306	19.33	19.65	14.9	8.9	
Lingjiao Hu	9.2	57	18.60	19.10	11.0	6.4	
Yue Hu	67.6	200	21.15	21.65	115.7	47.3	Retention / detention, recreation, landscape, aquaculture
Nan Taizi Hu	658.5	2640	18.63	19.13	526.8	460.9	
Moshui Hu	481.3	1950	18.65	19.65	1227.4	336.9	
Longyang Hu	190.0	940	19.15	20.15	142.5	133.0	
Sanjiao Hu	234.6	1225	18.63	19.13	360.0	199.4	
Dong Hu	4027.8	12170	19.15	19.65	6870.9	2819.4	
Wanjia Hu	105.2	1240	19.15	19.65	232.1	58.1	
Xibian Hu	52.9	400	19.00	19.50	66.4	15.3	
Tang Hu	106.1	1217	19.00	19.50	93.7	32.3	
Lanni Hu	118.9	330	18.50	19.50	247.0	52.2	
Zhushan Hu	250.0	1880	19.00	19.50	820.8	268.8	
Yangchun Hu	60.4	400	19.15	19.65	78.5	42.3	
Qingshan Bei Hu	221.5	7950	19.13	20.13	332.3	330.0	Retention / detention
Houxiang He	4.0	559	18.10	18.80	8.1	2.8	
Neisa Hu	7.6	442	19.15	19.65	6.9	5.3	

(*Continue*)

Huangjia Hu	851.5	3060	17.63	18.63	1447.5	596.0	Recreation, landscape, aquaculture
Tangxun Hu	5218.6	20680	17.63	18.63	8349.7	2922.4	
Ye Hu	204.3	966	17.63	18.63	286.1	143.0	
WaiSa Hu	319.7	1880	19.15	19.65	260.0	223.8	
Nan Hu	764.0	4470	17.63	18.63	790.0	534.8	
Yezi Hu	172.3	584	17.63	18.63	220.0	120.6	
Qingling Hu	1099.6	6850	17.63	18.63	1319.5	769.7	
Yanxi Hu	1573.6	6830	19.13	20.13	2989.8	1101.5	
Bei Taizi Hu	51.2	372	18.50	19.30	65.6	46.1	
Tazi Hu	30.0	96	18.60	19.10	66.0	21.0	Recreation, landscape
Jiqi Dangzi Hu	11.7	157	17.40	18.17	23.4	8.2	
Zhangbi Hu	54.8	183	22.00	22.50	109.7	38.4	
Zhuye Hai	18.0	60	22.00	22.50	18.0	12.6	aquaculture
Total area	17049.1	81893			27193.5	11407.5	

Source: Wuhan water eco-system protection and rehabilitation planning, Wuhan Water Affair Bureau, May 2006

Appendix E: Land use conversion table

Appendix E 1: Transition matrix of land use changes within the buffer of lakes

Buffer_10m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr. total
RC	8.6	0.3	2.8	1.1	3.4					0.1	7.7
MW	0.4	0.8		0.3	0.1					0.5	1.3
G	1		12.6	0.7	0.4					0.3	2.4
O	0.2		0.6	12.3				0.2		0.1	1.1
UF											0
V	1.0	1.1	0.4	1.6	1.0	1.1	1.5			0.2	6.8
A	6.3	1.3	3.7	0.7	1.2	2.5	44	1.2		0.8	17.7
W	1.5		1.5	1.0		0.3	2.5	2.0			6.8
L	10.0	1.1	8.6	16.8	5.3	2.2	28.6	0.9		8.4	81.9
S	2.3		4.0	2.8	2.9	1.2	18.1	0.4		17.5	31.7
Incr. total	22.7	3.8	21.6	25	14.3	6.2	50.7	2.7		10.4	

Buffer_30m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr. total
RC	23.5	1.3	9.2	3.5	1.3			0.2	0.2	0.9	16.6
MW	1.4	3.9		1.5	0.4	0.4	0.2			1.7	5.6
G	4.9		41.2	2.0	1.0		4.0	0.1		1.0	13
O	1.0	0.1	2.6	27.9	0.5		0.3	0.4		0.6	5.5
UF											0
V	5.3	3.7	1.1	4.0	3.1	3.7	6.0	0.3		0.9	24.4
A	20.1	4.4	11.1	2.4	6.0	5.6	152.2	4.6		13.7	67.9
W	4.6		5.7	2.6	1.1	1.0	8.9	7.0		0.1	24
L	20.2	1.7	15.5	24.4	13.2	6.4	60.0	1.4		17.2	160
S	21.4	0.2	10.2	7.1	9.1	3.2	56.3	1.0		61.2	108.5
Incr. total	78.9	11.4	55.4	47.5	35.7	16.6	135.7	8	0.2	36.1	

Buffer_100m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr. total
RC	161.5	5.2	28.5	10.7	5.4		0.1	2.0	0.6	3.3	55.8
MW	10.0	18.6	0.1	7.7	2.1	2.4	0.4	0.5		4.7	27.9
G	17.9		129	2.6	1.9		12.9	1.0		3.3	39.6
O	6.5	0.3	5.5	80.4	2.1	0.3	2.2	1.6		1.8	20.3
UF											0
V	36.7	14.4	4.2	5.9	10.8	18.8	22.2	2.9		2.7	99.8
A	73.1	14.0	26.6	10.5	20.5	18.5	551.0	19.7	0.3	48.4	231.6
W	14.8	0.3	18.4	3.5	0.5	3.6	23.9	31.6		0.7	65.7
L	45.9	1.8	22.3	36.1	38.7	18.3	123.5	1.6		33.0	321.2
S	80.0	1.3	17.1	15.6	28.7	7.7	166.9	2.5	0.6	215.3	320.4
Incr. total	284.9	37.3	122.4	92.6	110.7	50.8	352.1	31.8	1.5	97.9	

Note: RC–Residential and Commercial; MS-Manufacturing and Storage; G-Green space; O-Other urban land use; UF- Urban transformation; V- Rural settlement; A- agricultural; W-Woodland; L-Lake; S-Shallow water

Incr. – Increase; Decr. - Decrease

Appendix E 2: Transition matrix of land use changes within the buffer of shallow water bodies

Buffer_10m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr. total
RC	17.1	2.2	1.2	2.3	0.9	0.6	0.9		0.2		8.3
MW	5.4	13.9	0.1	3.4	1.6	0.8	0.3				11.6
G	1.3		5.9	0.5	0.2	0.1	0.7	2.5			5.3
O	3.3	2.1	3.2	60.4	1.3	1.4	1.7	0.6			13.6
UF											0
V	21.5	7.1	1.7	5.5	2.2	25.1	8.2	0.6	0.2		47
A	22	7.4	5.3	16.4	2.7	18.0	160.0	4.3	3.0	0.3	79.4
W	1.4	0.4	2.0	1.3		0.8	2.8	4.1			8.7
L	2.0	0.2	0.5	1.7	1.6	0.2	1.8		20.7		8
S	29.1	11.6	9.8	43.7	18.7	15.2	82.8	2.5	6.0	0.9	219.4
Incr total	86	28.8	22.6	72.5	28.3	36.5	98.3	10.5	9.2	0.3	

Buffer_30m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr. total
RC	63.0	5.2	4.3	8.1	3.3	2.6	3.1	2.7	1.1		30.4
MW	20.1	54.4	0.6	12.3	6.1	2.9	1.6				43.6
G	4.4	0.2	17.5	3.0	0.6	0.2	3.8	7.2	0.1	0.1	19.6
O	12.9	6.6	8.7	180.0	5.0	3.7	5.1	3.0			45
UF											0
V	75.0	23.2	4.4	12.6	7.1	87.0	22.4	2.0	0.6		147.3
A	65.8	23.6	19.3	38.1	10.5	47.0	513.4	12.7	8.6	1.2	226.8
W	4.4	1.6	6.0	3.2	0.3	2.0	10.1	13.6			27.6
L	5.1	0.3	0.6	3.9	5.8	1.1	2.7	0.2	73.0		19.7
S	72.0	26.4	30.1	80.4	57.3	33.1	210.5	5.0	11.8	2.9	526.6
Incr. total	259.7	87.1	74	161.6	96	92.6	259.3	32.8	22.2	1.3	

Buffer_100m (Ha)

	RC	MW	G	O	UF	V	A	W	L	S	Decr total
RC	299.2	24.2	14.8	30.9	14.8	12.0	12.4	6.4	3.8	0.3	119.6
MW	87.3	255.3	4.3	43.1	30.4	14.5	5.7		0.4	0.8	186.5
G	17.1	2.0	56.9	10.2	3.3	1.4	12.6	13.4	0.2	0.5	60.7
O	44.2	30.8	48.1	432.4	16.9	12.3	15.7	9.2	0.1	1.5	178.8
UF											0
V	274	85.3	9.9	35.6	21.5	261.3	63.0	4.1	1.5	1.4	496.3
A	227.6	78.8	50.8	89.0	41.3	107.4	1568.3	40.8	24.6	9.0	669.3
W	18.4	5.0	18.9	8.3	0.7	8.8	35.9	46.5	0.3		96.3
L	16.8	0.4	5.6	10.5	22.7	4.5	6.8	1.0	293.7		68.3
S	205.2	66.7	90.1	137.1	212.5	72.6	573.5	11.7	30.5	15.1	1399.9
Incr total	890.6	293.2	242.5	364.7	364.1	233.5	725.6	86.6	61.4	13.5	

Note: RC–Residential and Commercial; MS-Manufacturing and Storage; G-Green space; O-Other urban land use; UF- Urban transformation; V- Rural settlement; A- agricultural; W-Woodland; L-Lake; S-Shallow water

Incr. – Increase; Decr. – Decrease

Appendix F: Historical review of Dutch water management

The inter-relationship between human activities and the natural water systems in the Netherlands can be summarized into five stages according to van de Ven's book "Man-made Lowlands: History of Water Management and Land Reclamation in the Netherlands" (1993).

(1) Natural stage: before the year 800
People lacked the means to combat water effectively and only settled themselves in the places which could not be flooded. The natural landscape in the Netherlands had hardly been influenced by man.

(2) Defensive stage: From the year 800 to the year 1250
Land was taken into use and people started to build dikes to control water and protect themselves. The large scale reclamation of the soggy peat areas in the west started. The significant event in this period was the establishment of regional water boards whose responsibility was to construct and maintain hydraulic works and play an important role in water management in a certain area. Water boards are considered as the oldest democratic organizations in the Netherlands.

(3) Offensive stage: Between the year 1250 to the year 1800
This could be sub-divided further into two stages. Between the year 1250 and the year 1600, the improved technology (windmills) expanded people's capabilities to confront water to gain more and more land and the typical landscape, polder, appeared through reclamation. More regional water board were established and developed. Water board tax was levied. Thus the structure of water management reached full growth and the organization of the water boards became a constituent part of the government system in this period of time.
From 1600 to 1800, the economic and political golden age brought about great demand for land as well as huge prosperity, which made enough financial capabilities for reclamation. In the meantime, the available ample means due to technical innovation in drainage also made it possible to reclaim large amounts of land from the sea and from the lakes. While regional water management still stayed in the hands of private enterprises, the government was increasingly in charge of water management. Rijkswaterstaat (state water management agency) was established in 1798.

(4) Manipulative stage: after 1800 to the 1980s

The Netherlands entered into the era of modernization and industrialization. The upheavals happened in the field of demography, agriculture, industry (later the service industry), so did the construction of roads, bridges, dikes and waterways. The human influence on natural water system becomes tremendous and the land in this country was almost controlled artificially. Water management and land reclamation were gradually taken over by the government, which marked the new era to manipulate water and offered the possibility to realize large-scale hydraulic infrastructure. The three levels of governments for water management have been established, i.e. the state, the province and water boards.
During this period, the Netherlands has developed into a modern country with an advanced infrastructure systems of dikes, canals and waterways to control its water system. The technological and institutional achievement is great. Until now, the safety problem had been solved more or less depending on the 'pumping-drainage-dike raising' approach (Brugge et al., 2005). However, the other water-related problems, i.e. water pollution and water shortage had surfaced in the 1970s (van de Ven, 1993, p178). Some other environmental problems, such as desiccation were also recognized (van Ek et al., 2000). The realization of the conflicts calls for sustainable policy and integrated water management.

(5) Adaptive stage: After the 1980s
A new approach has sprang up since the beginning of the 1980s due to the other water-related problems (pollution, water shortage etc.) emerging. The focus of attention shifted more and more from the construction and maintenance of hard infrastructure to integrative water management policy. Such a shift becomes more and more fundamental due to the new challenges such as sea level rising, land subsidence, pressure of urban expansion, and scarcity in the natural resilience of the water system. It is realized that increase in height and size of the dunes and dikes is not sufficient to withstand the storm surges and river floods. Suppressing natural processes could actually lead to loss of control and worse losses at the end (RIZA, 1999). New water policy was presented and new approaches to water management were explored. In 2001, the Government and Parliament adopted the new water management policy for the 21st century entitled 'A Different Approach to Water' (NHV, 2004). Now the Netherlands is entering into the new era of 'accommodating water' (Drimmelen et al., 2005).

Summary

In the case of cities located in alluvial river plains, surface water systems are facing significant disturbances via reclamation, alteration and pollution due to the increasing pressures from urban expansion and urban land use change. In one way or another, many water related problems (e.g. flooding or drought disasters, and serious water pollution) are the outcome of disordered or ill-conceived land use development. However, the linkage between land and water resource management in the urban area has long been ignored. Under the circumstances of extensive urbanization and industrialization in China, many cities are experiencing the serious impacts of rapid urban land use expansion on surface water systems.

The central issues of this study are to explore the water-land relationship for spatial planning in both theory and practice, and to emphasize the need for better cooperation between spatial planning and water management in rapidly urbanizing regions. The main goal of the study is to examine and develop a spatial planning methodology that would enhance the sustainability of urban development by integrating the surface water system in the urban and regional planning process. Several research questions concerning the spatial concept of surface water systems in urban regions, the integration of surface water management and spatial planning, and information for planning support, have been examined. Extensive literature review, quantitative and qualitative analysis based on the primary and secondary data collection, and comparative analysis have been applied to answer these questions.

Based on the theoretical considerations, surface water systems possess three spatial forms, i.e. surface water bodies, riparian buffers and watersheds, all of which need to be integrated into spatial planning. The status of surface water bodies is closely related with the land use conditions of riparian buffer zones and watersheds. In order to mitigate the negative impacts and exert the positive ones, land use planning in watersheds must consider proper spatial organization and measures to integrate water as a determinant of good quality of space. Only through the cooperation between spatial planning and water management can these measures become effective. This study proposes that proactive-integrated policy and approaches need to be promoted in order to gain enough capacity to organize and preserve the space for water systems along with spatial requirement of urban development. Spatial requirements for water systems should be considered in advance and therefore it is important to have a paradigm shift both in water management and

spatial planning and design.

In the Chinese context, urban planning and water management are both undergoing a complex transformation process in concepts, contents, working approaches and institutionalization. The city of Wuhan is the main case study. It has abundant surface water bodies and is experiencing such a process. Wuhan urban development process presented in chapter 4 shows that the impacts on the surface water systems from urban activities have not been adequately reflected in the urban planning system. A multi-disciplinary approach to deal with the conflicts of water system protection and land use impacts in the urbanizing areas has not yet been fully developed. With the rapid urbanization and industrialization of recent decades, urban land use conversion has become faster than ever and this reality is reflected in planning's failure, to some extent, in protecting the natural environment and in regulating proper land use. A common spatial concept for surface water is not fully shared among urban planners and water managers, nor has a spatial policy framework for surface water systems been established. Even though since 2000, various policy efforts from urban planning and water management have gradually converged on environmental and ecological issues, institutional segmentation has brought about low efficiency of policy implementation.

Since the 1990s, Wuhan's urban expansion has massively encroached upon the water rich surroundings of the city. Because lakes and shallow water bodies occupy more than two-thirds of the total water surface area, the impacts from urban development and land use conversion on these water bodies and their riparian buffer zones based on quantitative spatial data analysis from 1993 to 2004 is examined. Imperviousness analysis on land use coverage is also done. The results show that urban development has had a significant impact on the surface water bodies and their riparian zones either by size reduction or complete reclamation. The process of water-to-land conversions for urban construction has been intensified under the pressure of the geographically outwardly expanding pattern and hierarchical-concentric urban form. The loss of surface water bodies and the increase of impervious areas are both contributing to qualitative and quantitative water problems in Wuhan. In the meantime, the time-lag between the two policy processes for water and urban development has made it difficult for urban planners and water managers to adopt effective measures to address the water-related problems in an integrated and coordinated manner. Water issues in Wuhan's urban region have so far not been tackled in an integrated way due to the lack of systematic policy arrangements at the strategic and local level, the lack of effective mechanism for institutional cooperation and the lack of approaches to incorporating water issues into spatial planning.

The case studies from the Netherlands are presented. These show how a cooperative approach in spatial planning and water management is helpful to link the water system with spatial issues. The experience of Dutch spatial planning and water management offers many valuable lessons not only in planning content, but also planning process for Wuhan or other cities in China. Some concepts in the national spatial water policy, i.e. 'space for nature', 'space for water', 'green-blue network', 'climate-proof city' may be a good practice for Chinese urban planners and water managers. Good horizontal and hierarchical cooperation is important for spatial planning and water management to work together to establish the spatial requirement for water systems. In the meantime, a positive implementation instrument, such as Water Assessment, was regarded as a useful tool to effectively stimulate the dialogue between water managers and spatial planners. These experiences show that integrating water issues in spatial planning could bring opportunities for making an attractive city with good quality of space.

The trend of urban development in Wuhan shows that the size of the urban expansion will be larger in the coming decades and the pressure on water systems from rapid economic development will remain high. Several new problems which may emerge on an even larger scale will make the situation more serious and complicated especially when an integrated solution of water-related problems has not been fully realized. Therefore it is urgent to have integrated planning options from the strategic level to the local action level. This is the key point of the conceptual model for integrated plan-making process for surface water systems presented in this study.

At the strategic level, proactive land use planning for urban development should consider water issues at the initial stage before negative impacts occur. Clear lines of responsibility between different departments should be demarcated so as to harmonize the fragmented and dispersed local efforts dealing with the water-land related problems regionally and locally. Public participation is encouraged during the process in order to achieve consensus among the different stakeholders. At the local level, an on-site water-sensitive design approach should be advocated so as to eliminate the negative cumulative effect by local incremental construction. The measures of zoning to control construction and land use in and around the surface water bodies can be used but should reflect the consensus of views from various agents such as urban planners, water managers and the public at large. Useful information and knowledge is crucial during this process and therefore spatial data infrastructure is urgent to be promoted.

Samenvatting

Voor veel steden die in alluviale rivierdalen liggen hebben de stelsels van oppervlaktewater te maken met sterke verstoring als gevolg van landaanwinning, verandering van waterlopen en verontreiniging. De verstoring hangt samen met stedelijke uitbreidingen en wijzigingen van grondgebruik. Veel waterproblemen (zoals overstromingen, watertekorten en ernstige watervervuiling) zijn het gevolg van slecht geplande en gereguleerde stedelijke ontwikkeling. Het verband tussen het beheer van de hulpbronnen land en water is echter lang over het hoofd gezien. In een situatie waarbij sprake is van snelle urbanisering en industrialisering, zoals in China, krijgen dan ook veel steden te maken met de ernstige gevolgen van de uitbreiding van stedelijk grondgebruik op de stelsels van oppervlaktewater.

De centrale thema's van deze studie zijn het verkennen van de water-land relatie voor de ruimtelijke ordening in zowel theoretische als praktische zin en het benadrukken van de samenwerking tussen ruimtelijke planning en waterbeheer in snel urbaniserende regio's. Het belangrijkste doel van het onderzoek is de ontwikkeling van een methodologie van ruimtelijke en regionale planning die het duurzame karakter van stedelijke ontwikkeling kan verbeteren. Hiervoor is het noodzakelijk dat waterbeheer een geïntegreerd deel gaat uitmaken van het planningsproces. Verschillende onderzoeksvragen komen aan de orde: het ruimtelijke concept van stedelijke watersystemen, de integratie van ruimtelijke ordening en waterbeheer en de noodzakelijke informatie voor de ondersteuning van de planning. Uitgebreid literatuuronderzoek, kwantitatieve en kwalitatieve analyses gebaseerd op primaire en secundaire ruimtelijke gegevens en vergelijkend onderzoek zijn als methoden aangewend om de vragen te kunnen beantwoorden.

Vanuit een theoretisch gezichtspunt hebben stelsels van oppervlaktewater drie ruimtelijke vormen: waterlichamen, oeverstroken en stroomgebieden. Met al deze drie vormen dient in de ruimtelijke planning rekening gehouden te worden. De status van de waterlichamen hangt nauw samen met de het grondgebruik langs de oevers en met de waterstromen. Om negatieve effecten tegen te gaan en positieve te bevorderen moeten een ruimtelijke organisatie gerealiseerd beleidsmaatregelen genomen worden waardoor water een onderdeel wordt van goede ruimtelijke kwaliteit. Alleen door samenwerking tussen ruimtelijke planning en waterbeheer kan zo'n aanpak effectief worden. In deze studie wordt een proactief en geïntegreerd beleid voorgestaan teneinde genoeg capaciteit te kunnen organiseren om de ruimte voor water te veilig te stellen

binnen de ruimte-eisen voor stedelijke ontwikkeling. Die ruimtelijke eisen voor water moeten van te voren in ogenschouw genomen worden en daarom is het belangrijk dat er een paradigmawisseling komt bij zowel het waterbeheer als bij de ruimtelijke ordening en de stedenbouw.

In China zijn stedelijke planning en waterbeheer onderhevig aan een complex hervormingsproces wat betreft concepten, inhoud, benaderingswijzen en instituties. De stad Wuhan, de voornaamste gevalstudie, ligt in een waterrijk gebied en ondergaat ook de genoemde hervormingen. In hoofdstuk vier is het ontwikkelingsproces van Wuhan beschreven en wordt duidelijk gemaakt dat de impact van stedelijke activiteiten op het oppervlaktewater niet adequaat is opgepakt binnen het stedelijke planningsstelsel. Een multidisciplinaire benadering om te kunnen omgaan met conflicten rond de bescherming van water is nog onvoldoende ontwikkeld. Door de snelle urbanisering en industrialisering in de afgelopen decennia is de omzetting naar stedelijk grondgebruik sneller dan ooit verlopen en deze realiteit uit zich in het feit dat de planning niet in staat is geweest de natuurlijke omgeving te beschermen en een goede regulering van het grondgebruik te realiseren. Er wordt geen gemeenschappelijk planningsconcept voor oppervlaktewater gebruikt door stedelijke planners en waterbeheerders en ook is geen ruimtelijk beleidskader voor oppervlaktewatersystemen aanwezig. Sinds 2000 zijn verschillende beleidsinitiatieven ontwikkeld vanuit de stedelijke planning en het waterbeheer die hebben geleid tot samenwerking op het gebied van milieu en ecologie, maar de heersende institutionele segmentatie verhindert een doelgerichte beleidsimplementatie.

De laatste twee decennia is de stedelijke expansie opgerukt tot in de waterrijke omgeving van de stad. De meren en ondiepe wateren maken meer dan tweederde van het locale wateroppervlak uit. Daarom zijn de gevolgen van de stedelijke ontwikkelingen en de veranderingen in grondgebruik bij en in de waterlichamen en de oevergebieden onderzocht voor de periode 1993-2004. Er is gebruik gemaakt van grondgebruiksgegeven en GIS-analyses. Ook is een analyse uitgevoerd naar de toename van het bebouwde grondgebruik. De uitkomsten tonen aan dat de stedelijke groei een grote impact heeft gehad op de waterlichamen en de oeverstroken zowel als gevolg van verkleining als van volledige droogmaking van die wateroppervlakken. Het transformatieproces van water naar land door stedelijke bebouwing is versterkt door het proces van voortdurende buitenwaartse aangroei van het stedelijke gebied bij een blijvend hiërarchisch-concentrisch urbaan patroon. Zowel het verlies van wateroppervlak als de toename van bebouwd gebied hebben bijgedragen aan de huidige kwantitatieve en kwalitatieve waterproblemen van Wuhan. Met name het tijdsinterval tussen het beleid voor ruimtelijk-stedelijke ontwikkeling en dat voor waterbeheer hebben het voor de stadsplanners en de watermanagers lastig gemaakt om effectieve maatregelen te nemen waarmee de watergerelateerde problemen op een geïntegreerde en gecoördineerde wijze aangepakt kunnen worden. Deze situatie wordt vooral veroorzaakt door een gebrek aan systematische beleidsarrangementen op zowel strategisch als locaal-uitvoerend niveau, door gebrek aan een werkzame institutionele samenwerking en doordat te weinig rekening wordt gehouden met waterkwesties binnen de ruimtelijke planning.

Als vergelijking is ook de aanpak in Nederland van de waterproblemen in de ruimtelijke ordening bestudeerd. Deze deelstudie laat zien hoe een gezamenlijke benadering van ruimtelijke en waterplanning behulpzaam is om het watersysteem te verbinden met ruimtelijke vraagstukken. Van de ervaringen van de ruimtelijke ordening en het waterbeheer in Nederland kunnen, voor Wuhan en andere Chinese steden, waardevolle lessen geleerd worden, niet alleen wat de inhoud van het beleid betreft maar ook ten aanzien van het planningsproces. Een aantal beleidsconcepten in het nationale waterbeleid, zoals `ruimte voor natuur', `ruimte voor water', `groen-blauwe netwerken' en `klimaatbestendige steden' zijn een goed voorbeeld voor de stedelijke planners en watermanagers in China. Goede horizontale en hiërarchische samenwerking is belangrijk voor de ruimtelijke ordening en het waterbeheer om samen de ruimtelijke vereisten voor watersystemen te bepalen. Maar ook een positief invoeringsinstrument zoals een watertoets, is een nuttig hulpmiddel om de dialoog tussen ruimtelijke en waterspecialisten effectief te bevorderen. Deze ervaringen tonen aan dat het integreren van waterthema's in de ruimtelijke planning kansen creëert voor het werken aan een aantrekkelijke stad met goede ruimtelijke kwaliteit.

Volgens de trend van de stedelijke ontwikkeling van Wuhan kan verwacht worden dat de omvang van de stedelijke uitbreiding nog zal toenemen in de komende decennia en dat de druk op de watersystemen als gevolg van snelle economische groei hoog zal blijven. Verschillende nieuwe problemen kunnen zich daarbij aandienen, zelfs op een grotere schaal dan in het verleden. Dit zal de situatie nog ernstiger en ingewikkelder maken, tenzij een geïntegreerde oplossing voor de watergerelateerde problemen wordt gerealiseerd. Het is daarom belangrijk geïntegreerde planningsoplossingen te hebben van het strategische en regionale tot het praktische locale niveau. Dit is dan ook het voornaamste aspect van het conceptuele model voor geïntegreerde planontwikkeling voor oppervlaktewater dat in deze studie wordt gepresenteerd.

Op strategisch niveau moet een proactieve grondgebruikplanning waterkwesties beoordelen in de beginfase van het proces, voordat negatieve gevolgen ontstaan. De verantwoordelijkheden van de diverse diensten en afdelingen moeten zodanig afgebakend zijn dat de gefragmenteerde en gespreide inspanningen op het gebied van `water en land'-thema's geharmoniseerd worden. Zowel het regionale als het locale niveau zijn daarbij van belang. Interactieve vormen van planning moeten aangemoedigd worden om consensus tussen de verschillende belanghebbenden te bereiken. Op het locale niveau moeten watergevoelige ruimtelijke ontwerpen geïntroduceerd worden om zodoende het cumulatieve effect van incrementele stedelijke aangroei te beteugelen. Zonering kan gebruikt worden om bouwactiviteiten en grondgebruik in en rond de wateroppervlakken te beheersen, maar dergelijke controlesystemen zullen gebaseerd moeten zijn op consensus tussen planners, waterbeheerders en de burgers. Om dat te bereiken zijn een goed kennisniveau van de problematiek en een adequate informatievoorziening cruciaal en die kunnen niet bereikt worden zonder een geëigende infrastructuur voor geoinformatie.

中文摘要（Summary in Chinese）

对于位于河流冲积平原的城市， 地表水系统常面临着被蚕食、改变和污染的危险，这些危险来自城市扩张和城市土地利用的压力，从很大程度上说，许多与水相关的问题（即洪涝、干旱、水污染）是不良土地开发的结果。 然而在城市地区水、土资源统一进行管理的必要性常被忽视。在中国快速城市化和工业化的背景下，许多城市正经历着城市土地扩张对地表水带来的负面影响。

本研究的宗旨拟从理论和实践方面探讨空间规划中的水-土关系，并强调快速城市化地区加强空间规划和水资源管理部门通力合作的迫切性。主要的研究目标是检验和发展一套空间规划方法，使其在城市与区域规划过程中将地表水系统纳入规划体系，从而促进城市的可持续发展。相关的研究问题涉及城市地区地表水系统的空间内涵、空间规划与水管理的一体化策略以及相应的信息支持系统。该研究采用了广泛的文献查阅、对第一手和第二手资料的定性定量分析、以及比较分析等方法。

理论上，地表水系统一般拥有三种空间形态：地表水体、水体周边缓冲区以及集水区，地表水体的状况与缓冲区和集水区内地土地利用状况紧密相关。为了减少负面影响，土地利用在空间组织中必须将水作为一个创造良好空间质量的因素进行考虑，相关的措施亦如此，同时只有通过空间规划部门和水管理部门的合作，这些措施才会发挥效益。本研究提出一套前摄性的一体化发展策略和方法，目的是将水系统的空间安排和保护与城市发展的空间要求结合起来，将水系统的空间发展要求事前考虑，研究提出现有的水管理和空间规划的范式转变尤为必要。

在中国，城市规划和水管理模式正在经历一个复杂的转变过程，其中包括理念、内容、工作方式和管理体制，武汉作为实例验证了这一过程。武汉拥有大量的地表水，其城市发展的过程显示城市活动空间带给地表水系统的影响还没能充分地体现在城市规划系统中，目前扔缺乏多学科融合解决城市化地区土地利用与水系统保护的矛盾的方法。最近十几年快速城市化和工业化使城市用地的转变大大加快，并反映出城市规划应对自然空间环境保护的失败。就地表水来说，地表水的空间含义并没有被规划师和水管理专家充分认识到，当然更谈不上地表水系统空间政策框架的构建。虽然 2000 年后，许多规划政策将环境和生态问题提到了很高的高度，然而现有体制的分割状态使政策实施大打折扣。

武汉城市扩张在 1990 年代进入高峰期，相应地对水系统的影响也是巨大的。因为湖泊和沼泽地占据武汉地表水面积的 2/3，故本研究主要选择了该两种水体进行城市发展和土地利用对水体影响的空间定量分析，基于数据，分析时限定为 1993 至 2004。研究还分析了建成区内的不透水率状况。研究结果表明，城市发展及其土地利用通过蚕食和面积消减对地表水体和水体缓冲区有重大影响，由城市建设造成的用地转变在城市形态摊大饼式的圈层发展模式下而更加恶化。水体的丧失和不透水率的提高又带来了相关的水环境恶化问题。水管理和空间规划部门政策颁布和实施的时间间隔使规划师和水管理专家难以对水问题的一体化解决采取有效措施。武汉城市区域水问题的解决目前尚缺乏战略性和实施性的系统化政策安排、缺乏水问题的空间规划方法以及部门合作的有效机制。

荷兰的实例研究表明空间规划和水管理的合作模式可以有助于将水系统和空间议题联系起来。荷兰空间规划和水管理的经验为武汉以及中国其他城市提供了有益的经验，包括规划内容和程序。一些国家层面的水空间概念，如“为自然留出空间”、“为水留出空间”、“绿带-蓝带网络”、“防风雨城市”等，对中国城市规划师和水管理专家均有启迪意义。荷兰良好的部门间纵向和横向的合作机制有助于其将空间规划部门和水管理部门纳入到共同合作的领域，为水系统创建空间需求框架。同时积极的实施手段，如‘水评估’工具，被认为是有效地促进了规划师和水管理师的对话与合作。这些经验显示，在空间规划中整合水事务可以为创造具有良好空间质量的、有吸引力的城市提供难得的机会。

武汉的城市发展趋势表明，未来十年由于经济的快速发展，城市的扩张规模将较以前更甚，其对水系统带来的压力将更大。一些新问题将会由于缺乏一体化的水系统保护方式而在更大的空间范围内蔓延。因此现在迫切地需要战略性和实施性相结合的一体化规划方法。本研究针对此，提出了一体化规划编制程序的概念模型。

在战略宏观层面，前摄式的土地利用规划对城市发展的考虑应将水事务纳入规划过程的初期，以避免问题的产生。在解决水-土相关问题时整合分散的职能部门的力量，明确目标，分清职责，鼓励公众参与。在微观实施层面，倡导水敏感设计方法，利用区划工具控制对水体及其周边的用地开发、控制集水区调蓄用地的保留。同时用地界限的划分应充分征求专家和公众的意见。最后令人满意的实用信息和知识的提供将在这一规划过程中发挥重要作用，因此空间数据基础设施的建设显得尤为紧迫。

Curriculum Vitae

Ningrui Du was born in Zhenning, China, on 3 May 1966. After high school (Anshun No. High School) in 1984, she commenced her study in urban and regional planning at Nanjing University and obtained her Bachelor's degree in 1988. She joined and worked as lecturer in Wuhan Technical University of Surveying and Mapping (WTUSM), now merged in Wuhan University. From 1995 to 1997, she came to ITC to pursue her higher education and finished her MSc. Degree on Human Settlement Analysis. After returning WTUSM, she continued her teaching and research work and has been involved more than ten planning projects till now.

ITC Dissertation List

http://www.itc.nl/Pub/Research/Graduate-programme/Graduate-programme-PhD_Graduates.html