International Journal of Sustainable Development & World Ecology

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tsdw20>

Comprehensive urban planning and management at multiple scales based on ecological principles: a case study in Beijing, China

Feng Li^a, Dan Hu^a, Xusheng Liu^b, Rusong Wang^a, Wenrui Yang^a & Juergen Paulussen^a

^a State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing

^b Chinese Academy of Forest Inventory and Planning, State Forestry Administration, Beijing
Published online: 08 Apr 2010.

To cite this article: Feng Li, Dan Hu, Xusheng Liu, Rusong Wang, Wenrui Yang & Juergen Paulussen (2008) Comprehensive urban planning and management at multiple scales based on ecological principles: a case study in Beijing, China, International Journal of Sustainable Development & World Ecology, 15:6, 524-533, DOI: [10.1080/13504500809469848](https://doi.org/10.1080/13504500809469848)

To link to this article: <http://dx.doi.org/10.1080/13504500809469848>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Comprehensive urban planning and management at multiple scales based on ecological principles: a case study in Beijing, China

Feng Li¹, Dan Hu¹, Xusheng Liu², Rusong Wang¹, Wenrui Yang¹ and Juergen Paulussen¹

¹State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing

²Chinese Academy of Forest Inventory and Planning, State Forestry Administration, Beijing

Key words: Urban planning, management, sustainable development, ecological principles

SUMMARY

Rapid urbanisation and serious environmental problems have led people worldwide to realise the significance of urban planning and management towards a sustainable environment. Beijing was used as a case study to develop a framework and strategies for sustainable development using ecological principles. At the regional level, Beijing-Tianjin agglomeration and Hebei Province are considered together. At the Beijing administrative level, some important measures are put forward for revision of the Beijing Urban Master Plan. At the Beijing plain level, the future spatial structure of Beijing city and the relationship between settlements, green space and transportation are considered, and three basic development patterns are proposed. At the inner district level, the ecological corridor system is suggested, based on ecosystem services. At the selected area level, a comprehensive strategy and key measures for conservation and renewal of old Beijing city core are provided. Once strategies for Beijing urban development are implemented step-by-step, a vision for future development can be achieved. This paper provides considerations for improvement of urban planning and management in China and other countries.

INTRODUCTION

The world is becoming an increasingly urban place and 65% of the world population is expected to be urban by 2025 (Schell and Ulijaszek 1999). Due to rapid urbanisation, natural ecosystems are increasingly being replaced by urban development (Pauleit and Duhme 2000; Pauleit *et al.* 2005). Urbanisation promotes the rapid development of society and economy, while bringing problems such as population centralisation, traffic congestion,

housing shortages, fewer resources, reduced biodiversity, heat island effects, and air, noise and water pollution (Savard *et al.* 2000; Herzele and Wiedemann 2003; Wang *et al.* 2004; Li *et al.* 2005a,b). People are increasingly realising the significance of urban sustainable development (Alexander *et al.* 2005; Shearer *et al.* 2006; Ericson 2006) as an important strategy (Costanza *et al.* 1997; Bolund and Hunhammar 1999; Wang *et al.* 2004).

Correspondence: Dan Hu, State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuangqing Road, Haidian District, Beijing 100085, China. Email: hudan@rcees.ac.cn; lifeng@rcees.ac.cn

A city is a social-economic-natural complex ecosystem (Ma and Wang 1984; Zhang *et al.* 2006), in which ecological security has already become an important component of national security (Axworthy *et al.* 2005; Timmer and Seymore 2005). The planning and management of a city is of significance to urban sustainable development (Landelma *et al.* 2000; Button 2002; Shearer *et al.* 2006; de Groot 2006) and can be based on ecological principles (Forman and Godron 1986; Forman 1995; Wu and Hobbs 2002; Leitão and Ahern 2002; Holden 2006).

Since 1978, Beijing has urbanized quickly, through rapid economic development, which presents a challenge to planning and management of the regional ecosystem, development of sustainable industries, ecological design and construction for urban dwellers while maintaining traditional culture. It is urgent for Beijing to learn from international experience in sustainable development, which will ensure fast economic and social development and provide clean and comfortable living conditions for residents.

In autumn 2002, the Beijing Municipal Institute of City Planning and Design asked the Research Center for Eco-Environmental Science and other institutes for scientific support to revise the current Beijing Urban Master plan. Our research team was commissioned to develop a comprehensive ecological planning proposal for Beijing. This paper presents Beijing urban planning at different scales, from the Greater Beijing regional zone to inner city level.

SITE DESCRIPTION

Beijing Province is in the north of China (39°38'–41°05'N, 115°25'–117°30'N) in the temperate climatic zone with a mean annual temperature of 12°C and precipitation of 640 mm per annum. It covers a total of 16808 km² and has a population of about 13.8 million, with an average population density of 821 persons/km² (Beijing Municipal Statistical Bureau 2005). Topography comprises mountains (62%) in the northwest and the Beijing Plain in the southeast (38%; elevation < 100 m), which is the main area of urban extension (Figure 1). The highest point in the province is 2303 m, and the lowest is 10 m. There are more than 200 rivers, mostly running from northwest to southeast through the city to join Bohai Bay in Tianjin. The

original natural vegetation was deciduous broad-leaf and evergreen coniferous forest, but most of this has disappeared.

The road network consists of ring roads and radial roads. There are currently six ring roads, with that around the Forbidden City being the first, the others radiating out from the centre (Figure 1). Before 1949, Beijing's development was confined to the old town, now marked by the 2nd ring road, but reform policies in the 1980s have led to rapid urbanisation and encroachment into the surrounding countryside. The developed area, as determined in the 1992 Urban Master Plan, has already been exceeded and has encroached into agricultural land, with new settlements around satellite towns mainly at the transition between the inner city and the suburbs. From 1992 to 2002, the settlement area increased by 25%, while agricultural land decreased by 32%, which has had a negative impact on ecosystem services (Thompson 2002; Kühn 2003). The main problems are irrational urban sprawl, population increases, traffic congestion, insufficient water supply and environmental pollution (Wang *et al.* 2004; Li *et al.* 2005a,b).

The Beijing-Tianjin region is one of the world's largest agglomerations, with a current population of more than 30 million. Including the surrounding cities and counties of Hebei Province, the population rises to about 60 million in the Greater Beijing regional economic zone (160729 km²) (Table 1; Figure 2), with an average urbanisation level of 45%, which is likely to increase by 20% or more until 2020, mainly through migration.

Figure 1 Map of Beijing province

Table 1 Area and population of Great Beijing regional economic zone

City	Province belonging to	Area (km ²)	Population (× 10 000)	Capita per km ²	Urbanisation level (%)
Beijing	Beijing	16808	1380	821	78%
Tianjin	Tianjin	11000	1011	919	72%
Baoding	Hebei	22159	1070	483	23%
Chengde	Hebei	39519	359	91	25%
Cangzhou	Hebei	13419	677	505	22%
Langfang	Hebei	6330	385	605	29%
Qinhuangdao	Hebei	7467	270	362	33%
Tangshan	Hebei	13206	703	532	32%
Zhangjiakou	Hebei	36829	449	122	29%
Total		160729	6347	381	45%

Source: Statistical Yearbook of China (2003); Statistical Yearbook of Hebei Province (2003). Urbanisation level refers to 2000 census data, published in 2001

Figure 2 Greater Beijing regional zone including Beijing, Tianjin and Hebei province

METHODS

Ecological principles for urban planning of Beijing

According to the analysis of the local situation, it was suggested that urban planning of Beijing should be based on landscape ecological principles and requirements (Table 2).

Temporal and spatial scale of urban planning

Three main steps are proposed over three time scales:

- By 2008: The Green Olympic City, with completion of the Olympic Park and other infrastructure in for the Olympic Games.
- By 2020: The Modern International City with distinctive characteristics.
- Longer term: The Sustainable City, with a green sustainable ecosystem, connecting green space, water and built-up areas.

In the framework of ecological planning of Beijing, the following spatial levels have been considered (Figure 3).

Table 2 Ecological principles and requirements for urban planning in Beijing Province

<i>Principles and requirements</i>	<i>Connotations</i>
Structure and function	Changes in urban structure can cause changes in its function. Fragmented and isolated green spaces and water systems should be integrated into a network.
Clarity and consistency of the urban landscape	An easily communicable long-term vision. An integrated landscape, divided into different units with special names and character.
Functional and ecological diversity	Landscape units and open spaces combine several ecological functions. Richness of visual experience.
Biodiversity and ecosystem services	Enhance ecosystem services to give high quality and diversity. Improve specific conditions for endangered species by reducing negative effects on their habitat (e.g. link fragmented habitats) and by adopting strict regulations for protection.
Accessibility for the public	Bridge separating elements such as road arteries, railroad tracks, rivers or drainage channels. Build a network of footpaths and bicycle routes. Interlink main attractions and recreation areas to high-quality public transport to avoid ecological deterioration of sensitive areas by cars and parking.
Distribution of green space	Public parks close to high-density residential areas. No pollution in fresh air zones and corridors. Noise protection.
Integration and transformation	Integration of existing elements: surface water, woods, small parks, and villages. Consider growth and change of plants.
Acceptance and implementation	Improve general acceptance of the concept by public participation. Publicise the concept through the media. Involve decision makers and the public as a strong driving force. Protect natural ecosystems not only by restricting over-development, but as an essential strategy for quality of life and enrichment of nature elements. Use the entire range of available legal and fiscal instruments to protect natural ecosystems against over-development.

URBAN PLANNING OF BEIJING PROVINCE AT DIFFERENT LEVELS

Level 1: Great Beijing regional economic zone

Major problems at the regional level

Beijing-Tianjin area is one of three large, fast-developing agglomeration areas of China's coastal zone and probably faces the most complex challenges and problems on its way to sustainability. Ongoing fast urbanisation has created disparities between urban and rural life, cultural differences, and differences in infrastructure and social structure between the main cities, suburban small towns and villages. There is a serious general shortage of water and energy, air quality is poor and urban sprawl prevails in many areas.

Requirements for urban planning at the regional level

To expand, a city requires the support of a much wider area in terms of water resources and energy. Furthermore, environmental and spatial problems do not halt at the city or province borders and require regional cooperation. Hence, communities cannot follow only their own interest, but have to face the facts of border-crossing effects. On the regional level, there is an urgent need for harmonization and balance of different interests to improve institutions and procedures dealing with the spatial problems at larger areas. The next necessary step is to constitute an administrative area, which covers the Greater Beijing regional economic zone.

The main tasks of regional ecological planning for this area are to balance development of Beijing-Tianjin area towards sustainability at the regional

Figure 3 Spatial levels of ecological planning for Beijing province

level by balancing and harmonising the interests of neighbouring cities and towns and industrial development through integrated planning departments and adoption of environmental precautionary principles that coordinate decisions on the location of new infrastructure, e.g. the location for a new international airport, and the establishment of regional green belts. This will reinforce the ecological and economic potential of the region and support specific regional development patterns, while protecting and developing free space and balanced urban-rural relationships that will enhance equality of living conditions.

Comprehensive strategy and key measures

Until the need for regional cooperation is widely recognized by all relevant decision makers, the next steps cannot be taken. During this process, it will be helpful to use international experience in organising complex urbanisation to enable government, planners and local level institutions to contribute to and cooperate in a future regional structure by:

- Establishing institutions responsible for the regional cooperation on key issues. In Germany, for example, the governments of Berlin and Brandenburg have a joint planning commission, which is responsible for the harmonization of all spatial relevant issues at the regional level.

- Reactivating and integrating existing institutions, e.g. watershed management groups.

Level 2: Beijing administrative area

Major problems at the administrative level

From the viewpoint of spatial and ecological planning, the main problems in the Beijing administrative area are: over-centralization, unbalanced development between north and south, increasing discrepancies in economic, social, ecological and institutional aspects, and large-scale spatial conflicts between urban development and non built-up areas.

The traditional planning instruments of the Beijing Urban Master Plan and Sectoral Plans are not sufficient for the spatial development of Beijing. They should be supplemented by specific instruments like a comprehensive environmental strategy, planning green areas and a water system in the context of the surrounding region; sectoral planning for specific parts of the city that respond to population development and migration, and a new concept for public urban transport.

Important measures for ecological planning at the administrative level

The main goal is to provide a scientific basis for revision of the Urban Master Plan through the following steps:

1. Analyse *status quo* in terms of the state of the environment, obvious problems and current measures for environmental protection and improvement.
2. Estimate development of Beijing environment in 5, 10 and 20 years using available research, which allows insight into the future.
3. Identify ecological issues (restrictive factors) that influence the Urban Master Plan.
4. Confirm space-related and non space-related problems and measures.
5. Determine appropriate spatial level for action or unit size for space-related issues.
6. Identify cross-border problems that can only be solved in close cooperation with neighbouring communities and other administrations.
7. Identify areas for urgent action.

- 8. Confirm strict protection areas.
- 9. Provide a draft plan for the three key issues: carrying capacity, boundary of strict non-built-up area and recommended built-up area, and integration of eco-aspects into the Urban Master Plan.

It will be necessary for a large area like Beijing region to concentrate first on issues that are a) currently most urgent and b) likely to become serious in future. For this, it might be helpful for decision makers and planners to focus and to ‘calm’ some other issues. Often, very important issues are neglected because they are hidden, while others are overestimated because they are currently urgent but will become less important in the near future. The task of researchers is to support decision makers and help them to avoid mistakes.

Level 3: Beijing plain area

Major problems at the plain level

Major problems at the level of Beijing plain are: population growth and urban sprawl; the spatial development pattern of the ‘rings’; serious ecological deterioration of urban and peri-urban fringes; increasing individual motorised traffic while the urban public transport system lags behind settlement development in terms of quality and capacity; lack of harmonization between settlement development, transportation pattern and green space.

Three basic patterns of Beijing plain development

Considering the future spatial structure of Beijing urban agglomeration and the relationship between

settlements, green space and transportation, three basic development patterns are proposed:

- **The rectangular grid of the inner urban area**, which is the basic pattern of Beijing’s inner urban area. In the grid, all modes of passenger transport should be balanced, and car transport plays a minor role. Introduction of linear elements like riverside walks, connecting isolated parks; improving convenient minor routes for pedestrians and bicycles inside the major blocks; and regulating parking and car use.
- **Tang Hu Lu or Settlement axis pattern of the suburban area**. Tang Hu Lu is a popular Chinese sweet made of ball-shaped red fruits on a stick. It can be used as a pattern to organise Beijing’s sub-urban and peri-urban development, to create a settlement axis along high quality public transport systems (Wang and Xu 2005), such as rail, light rail, metro, and express bus systems. Private car use along the axis should be reduced. Gateways to the inner city should regulate car inflow in the morning to prevent or limit traffic congestion in the inner city. The green buffer zones between settlements would provide green landscape recreation areas, connected by public transport systems.
- **Grape pattern of the rural areas**, where the end of a developed area meets natural landscape areas with a low population density. The appropriate modes for passenger transport are bus, taxi, private cars and bicycles.

The proposed combination of settlement and green structure in Beijing is shown in Figure 4, with one urban centre from which several traffic lines radiate and settlements follow these traffic lines.

Figure 4 Combining traffic lines with settlement nodes and the green system to develop a basic spatial scheme for urban sustainable development

The green space is composed of two greenbelts, several green wedges, some parks and corridors located between the traffic axes and connected with greenbelts to form an ecological network of parks, greenways, farmland, rivers and wetland (Figure 4).

Level 4: Inner districts of Beijing

Major problems at the inner district level

The inner urban area between the 2nd and 4th ring roads is already almost completely built up, leading to fragmentation of inner city green space, unbalance between building and open space, heat island effects, old city restoration and overcrowding.

Ecological corridor system for the inner city

By analysing the physical structure, main wind direction, water flow and other space-related aspects of Beijing, a specific direction can be identified as typical: a northwest-southeast direction, also called the main Eco-direction or Main eco-axis. Ecological corridors support the urban ecosystem services in many ways (Bolund and Hunhammar 1999). In the high-density built-up inner city area of Beijing, a diverse system of ecological corridors should be implemented northwest-southeast outside the 4th ring road, adjusted to the historic rectangular grid inside the 2nd ring road in the former old city. The ecological corridors would follow the natural direction as much as possible, and be adjusted to the already fixed rectangular grid between the 2nd and 4th ring road.

Level 5: The former old city inside the 2nd ring road

Major problems of the old city

There is a serious loss of cultural conservation sites and patterns because of a high population density in overcrowded areas, transportation problems and poor air quality and climate. Due to the dramatic loss of historic buildings, an immediate restoration of the inner city and urban renewal is urgent for cultural conservation (Qing and Ming Dynasty) as part of the cultural heritage of Beijing.

Urban conservation and renewal of old Beijing city core

A comprehensive strategy and key measures should be undertaken for urban conservation and renewal

of old Beijing city core by regenerating the city's canal and river system; reducing the impact of motorised private transport and main roads; improving the quantity and quality of public areas for pedestrians, bicyclists, children and older people; improving living conditions in remaining old quarters; providing parking space outside the 2nd ring road; and rebuilding sections of the old city wall. This should include large-scale demolition of entire quarters, and protecting monuments of outstanding importance (even ordinary old residential buildings) to save the unique and outstanding urban housing culture of ancient Beijing.

DISCUSSION

This paper develops a comprehensive ecological planning framework at multiple levels for Beijing province. Compared with other work (Diamantini and Zanon 2000; Fang *et al.* 2005; Repetti and Desthieux 2006), the proposal is more conceptual and multidimensional. It is planned at the Greater Beijing region, administrative area, plain area, inner city and selected areas levels. Regarding urbanisation, industrial structure and GDP per capita still lag far behind Western countries (Attwell 2000; Kühn 2003). Even the differences between cities and rural areas of the Beijing region are much larger than in Western countries. Other key aspects, like environmental quality, infrastructure, and quality of life, must keep pace not only in the city centre, but also in the region.

During recent decades, many different strategies of preservation, restoration and urban renewal of historic quarters, particularly in the centre of cities and towns in Europe and other continents (Attwell 2000; Lütz and Bastian 2002; Kühn 2003; Fang *et al.* 2005), have been implemented. Such ancient areas have their own urban quality that cannot, in most cases, be replaced by new structures, functions and dimensions. For Beijing, an immediate memorandum and revision of the renewal policy for the old city is necessary. Restoration and integration of new functions into existing historic structures should be considered. Demolition of the important heritage areas must be stopped. At the same time, revising and correcting problems in the general structural layout of Beijing city is required in the long term.

A long-term strategy of environmental improvement is indispensable, particularly at the city administrative level, and linked to general long-term

development strategies of cities and counties (Diamantini and Zanon 2000; Cheng *et al.* 2006). Current policy and processes like China's Agenda 21 and scientific research have achieved a lot, but there is still space for improvement (Wang *et al.* 2004). In the next step, traditional urban planning will be improved and adapted to the new needs of urban development.

After completion of this study in 2005, we discussed the results with politicians and planners from the Beijing Municipal Institute of City Planning and Design and the Beijing People's Government. There was agreement that this strategy would help to meet the challenges of future urban development in Beijing, and it is intended to implement it step-by-step. Public views have been gauged in a survey and are reflected in newspapers, Internet discussions, conferences and meetings attended by decision makers, real estate developers and researchers. Most proposals have already been adopted in the new Beijing Urban Master Plan (2004–2020). However, our ecological planning is conceptual and was not elaborated in detail. The proposals still need to be studied and designed in the next research step. Ecological planning not only needs qualitative explanation, but also quantitative indicator evaluation in future research (Huang *et al.* 1998; Riley 2001; Ong 2003).

A city is a complex ecosystem composed of natural, social, economic and scientific subsystems (Ma and Wang 1984; Wang *et al.* 2004). In addition to natural factors, social, economic and scientific aspects play an important role in urban planning and management (Shafer 1999; Landelma *et al.* 2000). In facing the ecological problems and challenges of the urbanisation process, a range of policy instruments should be applied and harmonized: legal and financial instruments as well as environmental planning, environmental protection

initiative by enterprises, participation and individual initiatives. Stakeholders and the public play significant roles in the decision-making process on how a city should be planned and managed. Improving the participation of all stakeholders, and better co-ordination of planning institutions is crucial for success (Landelma *et al.* 2000; Ericson 2006).

In order to realise this planning, much work needs to be done for successful management of the urban ecosystem in terms of administrative, legal, economic and technical guarantees in urban planning. Measures to protect historic buildings require particular attention. Urban green spaces, water, traffic, housing and infrastructure should be planned and designed as an integrated system. Furthermore, urban planning and management and the wider landscape of Beijing must proceed hand-in-hand with surrounding regional land-use planning of Tianjin and Hebei Province. This paper provides suggestions for improvement of the urban planning and management in China and other countries.

ACKNOWLEDGEMENTS

This research was financially supported by the National Natural Science Foundation of China (70803050, 70433001), the Knowledge Innovation Project of the Chinese Academy of Sciences (KZCX2-YW-324, KZCX2-YW-422), and the Key Supporting Project of the Ministry of Science and Technology of China (2007BAC28B04). We are grateful to colleagues in our research group and the Beijing Municipal Institute of City Planning and Design for providing information on urban planning and development. Finally, we thank Stephan Pauleit for his constructive suggestions for revising the manuscript.

REFERENCES

- Alexander D, Seymore NK, Babicki D and Ferguson J. *The capable city*. International Centre for Sustainable Cities; 2005:42–51
- Attwell K. Urban land resource and urban planning – case studies from Denmark. *Landscape and Urban Planning* 2000;52:145–63
- Axworthy L, Fallick AL and Ross K. *The secure city*. Liu Institute for Global Issues, University of British Columbia; 2005:19–28
- Beijing Municipal Statistical Bureau. *Beijing statistical yearbook*. Beijing: China Statistics Press; 2005:11–24 (in Chinese)

- Bolund P and Hunhammar S. Ecosystem services in urban areas. *Ecological Economics* 1999;29:293–301
- Button K. City management and urban environmental indicators. *Ecological Economics* 2002;40:217–33
- Cheng JQ, Turkstra J, Peng MJ, Du NR and Ho P. Urban land administration and planning in China: opportunities and constraints of spatial data models. *Land Use Policy* 2006;23:604–16
- Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Laskin R, Sutton P and van den Belt M. The value of the world's ecosystem services and natural capital. *Nature* 1997;387(15):253–60
- de Groot R. Function analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning* 2006;75:175–86
- Diamantini C and Zanon B. Planning the urban sustainable development the case of the plan for the province of Trento, Italy. *Environment Impact Assessment Review* 2000;20:299–310
- Ericson JA. Participatory approach to conservation in the Calakmul Biosphere Reserve, Campeche, Mexico. *Landscape and Urban Planning* 2006;74:242–66
- Fang S, Gertner GZ, Sun Z and Anderson AA. The impact of interactions in spatial simulation of the dynamics of urban sprawl. *Landscape and Urban Planning* 2005;73:294–306
- Forman RTT. *Land mosaics: the ecology of landscapes and regions*. 2nd edition. London: Cambridge University Press; 1995
- Forman RTT and Godron M. *Landscape Ecology*. New York: Wiley; 1986
- Herzele AV and Wiedemann T. A monitoring tool for the provision of accessible and attractive urban green spaces. *Landscape and Urban Planning* 2003;63:109–26
- Holden M. Urban indicators and the integrative ideals of cities. *Cities* 2006;23(3):170–83
- Huang SL, Wong JH and Chen TC. A framework of indicator system for measuring Taipei's urban sustainability. *Landscape and Urban Planning* 1998;42:15–27
- Kühn M. Greenbelt and green heart: separating and integrating landscapes in European city regions. *Landscape and Urban Planning* 2003;64:19–27
- Landelma R, Salminen P and Hokkanen J. Using multicriteria methods in environmental planning and management. *Environmental Management* 2000;26(6):595–605
- Leitão AB and Ahern J. Applying landscape ecological concepts and metrics in sustainable landscape planning. *Landscape and Urban Planning* 2002;59:65–93
- Li F, Wang RS, Liu XS and Zhang XL. Urban forest in China: development patterns, influencing factors and research prospects. *The International Journal of Sustainable Development and World Ecology* 2005a;12:197–204
- Li F, Wang RS, Paulussen J and Liu XS. Comprehensive concept planning of urban greening based on ecological principles: a case study in Beijing, China. *Landscape and Urban Planning* 2005b;72:325–36
- Lütz M and Bastian O. Implementation of landscape planning and nature conservation in the agricultural landscape—a case study from Saxony. *Agriculture, Ecosystems and Environment* 2002;92:159–70
- Ma S and Wang RS. Social-economic-natural complex ecosystem. *Acta Ecologica Sinica* 1984;4(1):1–9 (in Chinese)
- Ong BL. Green plot ratio: an ecological measure for architecture and urban planning. *Landscape and Urban Planning* 2003;63:197–211
- Pauleit S, Ennos R and Golding Y. Modeling the environmental impacts of urban land use and land cover change—a study in Merseyside, UK. *Landscape and Urban Planning* 2005;71:295–310
- Pauleit S and Duhme F. Assessing the environmental performance of land cover types for urban planning. *Landscape and Urban Planning* 2000;52:1–20
- Repetti A and Desthieux G. A relational indicator set model for urban land-use planning and management: methodological approach and application in two case studies. *Landscape and Urban Planning* 2006;77:196–215
- Riley J. Indicator quality for assessment of impact of multidisciplinary systems. *Agriculture, Ecosystems and Environment* 2001;87:121–8
- Savard J-PL, Clergeau P and Mennechez G. Biodiversity concepts and urban ecosystem. *Landscape and Urban Planning* 2000;48:131–42
- Schell LM and Ulijaszek SJ. *Urbanism, health and human biology in industrialized countries*. London: Cambridge University Press; 1999:59–60
- Shafer C. US National park buffer zones: historical, scientific, social, and legal aspects. *Environmental Management* 1999;23(1):49–73
- Shearer AW, Mouat DA, Bassett SD, Binford MW, Johnson CW and Saarinen JA. Examining development-related uncertainties for environmental management: Strategic planning scenarios in Southern California. *Landscape and Urban Planning* 2006;77:359–81
- Thompson CW. Urban open space in the 21st century. *Landscape and Urban Planning* 2002;60:59–72
- Timmer V and Seymore NK. *The livable city*. The International Centre for Sustainable Cities; 2005:31–8

- Wang RS and Xu HX. *A comprehensive approach for Yangzhou eco-city development*. Beijing: China Science and Technology Press; 2005:3–20 (in Chinese)
- Wang RS, Wang XR, Hu D and Tang LJ. *Eco-services of urban survival and development*. Beijing: China Meteorological Press; 2004:50–60 (in Chinese)
- Wu JG and Hobbs R. Key issues and research priorities in landscape ecology: An idiosyncratic synthesis. *Landscape Ecology* 2002;17:355–65
- Zhang Y, Yang ZF and Yu XY. Measurement and evaluation of interactions in complex urban ecosystem. *Ecological Modeling* 2006;196:77–89