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GIS BASED STUDY OF SUSTAINABLE URBAN DEVELOPMENT OF  
CENTER INNER MONGOLIA

# 基于 GIS 的蒙中经济区 城市可持续发展研究

李百岁 著



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## 序

“可持续发展”是20世纪80年代以来出现频率较高的术语之一。众所周知,城市作为我国行政区划中重要单元和区域经济活动的中心,城市经济、社会发展直接关系到城市综合发展水平。综观世界上诸多国家启动经济欠发达地区开发的经验,发挥中心城市经济核心作用,据点开发,以点带面,已成为一种可借鉴的模式。城市化发展是西部大开发的重要内容,它对西部大开发的成功起“牵引机”的关键作用,应该说西部大开发的最终成功表现为西部城市化水平的极大提高。但城市化过程所带来的一个突出问题就是城市扩张对周边地区以及城市内部生态环境造成巨大压力。如何协调城市发展与保护生态环境,合理利用有限的资源以达到城市可持续发展,既是目前世界各国多学科基础理论与应用研究的主题之一,又是西部大开发中亟待解决的首要问题。蒙中经济区作为内蒙古最重要经济区,是我国经济重心向北转移、农村经济发展和生态建设的重要阵地。虽然该地区并不具有现实的经济优势,但其三角状的城市群分布构成了黑色、有色金属工业中心(包头市)——区域综合中心(呼和浩特市)——煤炭生产中心(东胜市),这样发展重工业的绝佳区位配置,有发达的铁路交通体系,有利于钟摆式煤铁复合型经济区域的形成,这在整



序

个中国都为数不多的。另外,蒙中经济区有很好的经济基础和城市依托,某些产业优势突出,市场竞争力比较强,区位优势,内外联系方便,技术与人才有一定积累,发展潜力较大,应是内蒙古参与西部大开发的重要区域和依托据点。但所处的地理位置和过渡性的社会经济活动决定了区域生态环境的脆弱性,加之地方利益驱动长期资源的过度开发,草地退化、林木减少、荒漠化和水土流失等区域生态环境破坏加剧,近年来频繁出现的沙尘暴说明了这一点。基于上述背景,李百岁博士选择蒙中经济区为研究对象,在国内外学者的关于城市可持续发展研究的基础上,从系统和区域的角度出发,采用定性描述与定量分析相结合、理论与实践相结合的方法,对城市可持续发展进行综合研究。在理论评述主要以定性描述为主,在应用研究主要以定量分析为主。以 GIS 为技术支撑,从微观(城市 PRED 系统研究)和宏观(区域城镇体系研究)角度研究城市可持续发展相关理论、方法,研究结果不仅丰富可持续发展研究理论框架体系,同时对经济发展阶段和生态环境背景相似的、受惠于西部大开发优惠政策的广大西部欠发达地区的发展战略的选择具有很好的借鉴意义。

张楚  
2004年12月于上海

## 摘要



“可持续发展”是 80 年代以来出现频率较高的术语之一。可持续发展,作为一种理论,1980 年首次在《世界自然保护大纲》中出现;作为一种概念,1987 年前挪威首相布伦特兰在《我们共同的未来》报告中提出;作为一种发展战略,从 1992 年在世界环境与发展大会通过的《21 世纪议程》才开始实施。1987 年世界环境与发展委员会(WCED)提出的《我们共同的未来》报告中,对可持续发展概念作了如下解释:“可持续发展是这样一种发展,它既能满足当代人的各种需要,又不会使后代人满足他们自身需要的能力受到损害”。众所周知,城市作为我国行政区划中重要单元和区域经济活动的中心,城市经济、社会发展直接关系到城市综合发展水平,城市可持续发展在可持续发展中占有重要的战略地位。国家或区域的可持续发展首先表现为城市可持续发展。

城市可持续发展是西部大开发和数字城市战略的重要内容,反过来,西部大开发和数字城市为城市可持续发展提供了宏观环境和技术支撑。综观世界上诸多国家启动经济欠发达地区开发的经验,发挥中心城市经济核心作用,据点开发,以点带面,已成为一种可借鉴的模式。城市化发展是西部大开发的重要内容,它对西部大开发的成功起“牵引机”的关键作用,应该说西部大开发的最终成功表现为西部城市化水平的极大提高。但城市化过程所带来的一个突出问题就是城市扩张对周边地区以及城市内部生态环境造成巨大压力。如何协调城市发展与保护生态环境,合理利用有限的资源以达到城市可持续发展,既是目前世界各国多学科基础理论与应用研究的主题之一,又是西部大开发中亟待解决的首要问题。因此,西部大开发迫切要求作为区



域增长极的城市走可持续发展之路。另一方面,数字城市和可持续发展是在世界范围内已成为最受瞩目的两个领域,两个领域互相渗透、相互作用,通过实体城市紧密联系在一起。数字城市为可持续发展提供了大量的有关自然资源和环境变化方面的系统的、可靠的和现实的信息,特别是城市可持续发展信息系统和网络的建立及其利用,更有利于对城市可持续发展现状的深入理解,以及对城市发展模式和发展趋势的模拟、分析和判别,从而为城市可持续发展决策提供科学依据。

蒙中经济区作为内蒙古最重要经济区,是我国经济重心向北转移、农村经济发展和生态建设的重要阵地。虽然该地区并不具有现实的经济优势,但其三角状的城市群分布构成了黑色、有色金属工业中心(包头)——区域综合中心(呼和浩特)——煤炭生产中心(东胜),这样发展重工业的绝佳区位配置,有发达的铁路交通体系,有利于钟摆式煤铁复合型经济区域的形成,这在整个中国都为数不多的。另外,蒙中经济区有很好的经济基础和城市依托,某些产业优势突出,市场竞争力比较强,区位优势,内外联系方便,技术与人才有一定积累,发展潜力较大,应是西部大开发的重要区域和依托据点。但所处的地理位置和过渡性的社会经济活动决定了区域生态环境的脆弱性,加之地方利益驱动长期资源的过度开发,草地退化、林木减少、荒漠化和水土流失等区域生态环境破坏加剧,近年来频繁出现的沙尘暴说明了这一点。同时以脆弱的自然环境系统和紧张的人地关系,在全球变化及区域可持续发展研究中成为理想区域。

基于上述背景,本文选择蒙中经济区为研究对象,探讨城市可持续发展理论框架、研究方法及实践。具体内容有:

第一章导论,阐明了蒙中经济区在西部大开发、内蒙古现代化中的战略地位和中心城市对西部大开发的拉动、示范、辐射、推动和窗口作用,并介绍论文选题背景、研究思路、意义以及创新点。第二章评述城市可持续发展基础理论,主要对城市可持续发展的提出、概念的界定、内涵以及国内外研究最新进展等基础理论进行了系统地分析。第三章城市空间数据库、模型与GIS空间分析,主要介绍城市空间数据库现状、存储模式、与城市可持续发展相关的专业模型和GIS空间分析的城市可持续发展中用途。本章的目的



是为后面研究提供方法论,对整个论文起技术支撑。第四章城市可持续发展决策支持系统,在分析研制背景和意义的基础上,设计出城市可持续发展决策支持系统总体框架,并选择 MapX 为 GIS 开发工具,Visual Basic 为开发主语言来实现了一般 GIS 系统的功能(放大、缩小、漫游等),并结合研究需要,还实现了对某地区的基础信息的查询与显示、基础信息的统计图表显示以及 AHP 模型、综合评价模型等城市可持续发展专业模型和其计算结果专题地图的显示功能。第五章城市可持续发展能力定量评价,城市可持续发展需要进行定量分析,研究成果有据可依,即便是定性分析,也要建立在确实的定量分析基础之上。然而,定量评价分析却一直是城市可持续发展研究的薄弱环节。本章在系统分析城市可持续发展要素的基础上,根据涉及到基本要素建立评价指标体系,然后确定指标体系相对应的权重,建立综合评价模型,对城市可持续发展进行时间序列和空间层面的评价,从而揭示城市可持续发展轨迹和空间分布差异特征。第六章蒙中经济区城镇体系可持续发展,运用城镇体系规划理论和方法,从总人口和城市化水平预测、城市规模、城市空间结构、水资源、基础设施、生态环境建设及城乡一体化的角度对蒙中经济区城镇体系规划进行了讨论。第七章城市 PRED 系统动态模拟与调控研究,阐述系统动力学(SD)与城市可持续发展研究的关系,以商都县为例,运用 SD 对城市 PRED 系统进行动态模拟与调控,经过调试和参数调整,得出趋势型、重种植业型、重牧业型和协调发展型四种方案,并对其结果进行定性分析。然后,利用模糊综合判别方法对四种方案进行判别,结果顺序是协调发展型、重牧业型、重种植业型、趋势型。很显然,协调发展型预测结果是最好。第八章产业结构调整与城市可持续发展,主要从产业结构现状、产业内部结构演变、主导产业群选择及培育等角度说明产业结构与城市可持续发展互动关系,认为产业结构调整是城市可持续发展的重要动力。第九章城市可持续发展动力机制与调控策略,着重阐述城市可持续发展中政府、生态工业园、科技进步、基础设施、信息化及 WTO 等动力因素,鉴于此动力机制,“对症下药”地提出了战略性调控策略。第十章结束语,总结城市可持续发展的关键问题,建议各学科应携手合作、交流,扬长避短,推动城

市可持续发展研究。

本文在国内外学者的关于城市可持续发展研究的基础上,从系统和区域的角度出发,采用定性描述与定量分析相结合、理论与实践相结合的方法,对城市可持续发展进行综合研究。在理论评述主要以定性描述为主,在应用研究主要以定量分析为主。以 GIS 为技术支撑,从微观(城市 PRED 系统研究)和宏观(区域城镇体系研究)角度研究城市可持续发展相关理论、方法,并以蒙中经济区城镇体系为例进行实践研究,研究结果具有理论和实践意义。首先,内蒙古是我国北方重要的生态防线,系统研究内蒙古(尤为蒙中经济区)可持续发展和城市化方面尚属空白;其二,本文从区域的角度去研究城市可持续发展,认为城市可持续发展是城市地域系统 PRED 问题的解决与协调发展,这有别于目前其他领域研究城市可持续发展角度(如环境、经济、社会等);其三,本文以城市可持续发展决策支持系统为切入点,有益地尝试地理信息系统(GIS)在城市可持续发展研究中的应用,从而丰富可持续发展研究理论框架体系;其四,研究成果为内蒙古在西部大开发的定位、参与方式及发展战略方面提供了思路。同时,经济发展阶段和生态环境背景相似的、受惠于西部大开发优惠政策的广大西部欠发达地区的发展战略的选择具有很好的借鉴意义。



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# Abstract



“Sustainable Development” is one of the terms that have appeared frequently in academic and policy literature since 1980s. It is regarded as a theory for the first time in Guideline for World Nature Protection of 1980. It is presented as a concept in the speech of Norwegian former president Brundtlan Our Common World. It is confirmed as a developmental policy in Agency of Twenty-first Century which is passed though in the World Environment and Development Conference in 1992 and executed from then on. World Environment and Development committee made a definition for the term Sustainable Development in the report of Our Common World in 1987, that is, sustainable development is a development which meets the need of the current generation and doesn't damage the capacity of next generation to fulfill their need. As we know, city is a key unit in our canton, and the center of region activities. Its economy and social development have a close relationship with civic integrated development level and sustainable urban development occupies a strategic position in sustainable development. So sustainable national or regional development can be regarded to be sustainable urban development firstly.

Sustainable urban development is an important part of the stratagems of Western China Development and digital city. In turn, they provide sustainable urban development with macro social environment and technical support. Make a comprehensive view of the ways that the developed countries start up their development in are-



as whose economic level is lower than other parts of the country, and it is obvious that the patterns are similar with each other, namely, construct a key city as the kernel of an economic region and then develop other areas around the kernel through the influence of the key city. So successful is the pattern that it almost becomes a model. In terms of the pattern Western China Development should focus on the urbanization of the western cities of China firstly, because it will be a "traction engine" of development of western China. It can be say that the great improvement of urbanization level of western cities is a remarkable symbol of Western China Development. However, with growing urbanization, there comes a series of environmental problems that bring pressure to bear on city. It becomes a principal research project in academic study and Western China Development. So it is urgent for those cities to make the plan of sustainable development and start up the project as soon as possible. On the other hand, digital city as well as sustainable development becomes the most remarkable field in the world. The two fields react each other and are closely linked through the entity of city. Digital city offers a large amount of systematic, dependable and realistic information for sustainable urban development on natural resources and environmental change. Especially, the construction of sustainable urban development information system and its net will offer us an opportunity to make a further comprehension about the current situation of sustainable urban development, to simulate the pattern of urban development, to analyze and judge the direction of urban development, to support the decision-making of sustainable urban development.

Economic District of Center Inner Mongolia is one of the most important parts of Inner Mongolia. Meanwhile it is also a significant base in the process of transferring economic barycenter from the South to the North, and a crucial zone for rural economic devel-



opment and ecologic construction. Though the region's economic level is not very high, it still has its exclusive advantage. Three cities of colored metal industrial center (Baotou), region integrated center (Huhehaote) and coal manufacture center (Dongsheng) constitute a triangle city group which is a kind of superexcellent configuration for heavy industry. It also owns convenient railway communication system. All these are useful to form a pendulum-style coal-iron-compound-type economic region that is fairly rare in China. In addition, Economic District of Center Inner Mongolia has a strong economic foundation and city support, and some of its industries are so prominent that they own strong competition capacity in according to those in southeast China. Besides, it has accumulated rich human resources and a certain technology that manifest a potential power of fast development. These advantages make the region play a key role in Western China Development. However, its disadvantages are obvious too. Its geographic position and transitional social activities lead to frangibility of regional ecologic environment. There exist long-term immoderate development, pasture degeneration, forest decrease, desertation and water and soil losing, and these phenomenon show that natural environment is deteriorating, which is demonstrated by more and more sand-dust devil. These fragile natural environment system and intense human-earth relationship let Economic District of Center Inner Mongolia be a perfect region in the research of global change and sustainable region development. The dissertation is based on this background. This paper chooses Economic District of Center Inner Mongolia as the research object, outlines the theory framework of sustainable urban development, and discusses the research methods and the practice of sustainable urban development. The paper is made up of ten chapters. The following are main idea of each chapter.

Chapter One is a brief introduction. It reviews the strategic po-



sition of Economic District of Center Inner Mongolia in the process of Western China Development and Inner Mongolia's industrialization. Construction of key cities is emphasized because of its significant meaning. They contribute to Western China Development by acting as a "traction engine", an example and a window of development. They will accelerate Western China Development. After the reviews several questions are listed, including research background, study methods, research meaning and the originality of the paper. Chapter Two lists out the theory base of sustainable urban development. The chapter focuses on the definition of sustainable urban development, its emergence, its meaning and the latest research finding of relative fields in the world, and systematically analyzes these questions in detail. Chapter Three is about urban spatial database, GIS-based urban models and GIS spatial analysis. An introduction of current situation of urban spatial database and the patterns of data storing and retrieving is given out at the beginning of the chapter. Then the author discusses several kinds of professional models that is relative to sustainable urban development and emphasizes that GIS spatial analysis plays an important role in sustainable urban development. Content of Chapter Three offers methodology for the following research, and is a technological support for the whole paper. Chapter Four evaluates the ability of sustainable urban development in a quantitative way. The author argues that sustainable urban development needs quantitative analysis to make the research finding more accurate and more persuasive. Even though the research is based on qualitative analysis, it is necessary for the research to contain a large amount of accurate factual data. It is obvious that poor data quantitative analysis imposes constraints on research of sustainable urban development, and is a "bottle neck" to further the research. The chapter systematically analyzes the factors that have effects on sustainable urban development, and con-



struct an evaluating guideline system based on elementary factors. Then the weight of each factor included in the evaluating system is worked out. By doing that the author develops an integrated evaluating model to estimate the degree of sustainable urban development from a multi-dimensional perspective of time and space. The integrated evaluating model not only espouses users to tracing the contrail of sustainable urban development but also allows users to find out the distinction of spatial distribution. Chapter five is about sustainable urban development of Economic District of Center Inner Mongolia. Based on theories and methods of urban system planning, the author discusses the urban system planning of Economic District of Center Inner Mongolia, urban scale, urban space structure, water resource, city infrastructure, ecological environment construction and urban and rural integration. Main idea of Chapter Six is about urban PRED system dynamic simulation and adjusting and controlling research. The relationship of systematical dynamics and sustainable urban development is discussed firstly. Through a case study of Shangdu County, the author simulates the urban PRED system dynamically. After adjusted and parameters' controlled, four schemes are given out. They are trend pattern scheme, planting-inclined pattern scheme, stockbreeding-inclined pattern scheme and corresponding pattern scheme. The result of each scheme is analyzed quantitatively. Then the author makes a adjustment to the four schemes by using blurry integrated judgment and finds out the sequence of the four is corresponding pattern scheme, stockbreeding-inclined pattern scheme, planting-inclined pattern scheme and trend pattern scheme. It is obvious that corresponding pattern scheme is best. Chapter Seven is about industrial structure adjustment and sustainable urban development. By analyzing current situation of industrial structure, inner evolvement of structure, key industrial group s selection and cultivation, the



chapter illustrates the interoperation relationship between industrial structure and sustainable urban development. The author contends that industrial structure adjustment is a strong force to impel sustainable urban development. Based on the research background and its significant meaning, the author designs the frame of decision-making support system of sustainable urban development which is based on MapX and Visual Basic. The system includes the basic functions of Geographic Information System, such as zoom in, zoom out, pan. More importantly, the system develops some special functions to meet the need of research. It can select regional basic information according to users' need and display the result in the map. It can also view the basic information in the way of statistics chart. Besides, the system owns professional models of sustainable urban development such as AHP model, integrated evaluating model, and display results of the models in thematic map. Chapter Nine is about the forces of sustainable urban development and its adjusting and controlling stratagems. The author argues that the government, ecological industrial areas, science and technology, infrastructure, informatization and WTO are factors that impel sustainable urban development. And then a series of adjusting and controlling stratagems are given out according to each factor. Chapter Ten is a brief summary. It summarizes and induces the key problems of sustainable urban development, and makes a suggestion that each academic subject should cooperate and exchange with each other and promote the sustainable urban development.

This paper based on the research of sustainable urban development by the scholars both here and abroad, started at the point of system and region view, integrated applied the methods of both the descriptive qualifier and the quantitative analysis, and the way of theory related with practice, synthetically studied the sustainable urban development. The descriptive qualifier method was mostly

used in the theoretic expatiating, and the quantitative analysis in the application research. GIS was used as the technical support in this paper, and some theories and methods of sustainable urban development were studied both in the micro phenomenon, the Urban PRED System, and in the macro phenomenon, the Region Town Architecture. The town architecture of Economic District of Center Inner Mongolia was studied as a research sample, and the final results possess academic and practical significances. Firstly, Inner Mongolia is the important ecological line of defense in Northern China, there was still blank in the study of the Inner Mongolia sustainable development and urbanization, especially of the Economic District of Center Inner Mongolia; Secondly, the sustainable urban development in the region system was studied, the view of that the sustainable urban development should be the key solution to the problems of PRED and development in phase of the urban district System was prompted, which is different than other researches on Urban Sustainable Development in the fields of Environmental, Economic and Social etc; Thirdly, the Decision-making Support System of Sustainable Urban Development was built as the research cut-in point, and the rewarding attempt of GIS was used in the study of Sustainable Urban Development, thereby, the research theoretic architecture of the sustainable development was extended; Fourthly, the results of this research offered the ideas about the location, the practical mode and the development strategy of Inner Mongolia in Western China Development; Finally, this research could be used for reference of the development strategy choice in other undeveloped Western regions, the environment and background of which are similar with Inner Mongolia.





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