Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 5963133, 10 pages
https://doi.org/10.1155/2022/5963133

Research Article

Urban Planning Design and Evaluation Based on GIS Information and Bayesian Network

Chunyan Li

College of Tourism and Planning, Pingdingshan University, Pingdingshan, Henan 467000, China

Correspondence should be addressed to Chunyan Li; 2835@pdsu.edu.cn

Received 23 May 2022; Revised 23 July 2022; Accepted 25 July 2022; Published 24 August 2022

Academic Editor: Zaoli Yang

In recent years, China's urban construction has set off a climax, with the rapid increase of the number of cities and towns, the increasingly perfect functions of cities and towns, the continuous improvement of the level of urbanization, and the urban landscape changing with each passing day. Under the influence of many factors, urban planning and assessment are facing unprecedented pressure, leading to the inconsistency between the compilation results of planning. Under the guidance of system analysis and system dynamics, this paper designs and develops an urban planning information management system based on GIS (Geographic Information System) and Bayesian network, and then the system is applied to the field of urban planning. In this system, all kinds of data generated by planning are stored in order to realize the standardization of data, and then the urban planning work is guided by the effective management of the result data so as to know the implementation status of urban planning in time and provide the basis for the future planning and implementation.

1. Introduction

With the deepening of reform and opening up, China's economy has experienced and is experiencing remarkable rapid growth and has achieved a series of fruitful results [1, 2]. After more than 30 years of development, China's GDP surpassed Japan in 2010 and became the second largest economy in the world after the United States. With the continuous development of the economy, China's urban construction and development have also made unprecedented achievements. In 1980, China's urbanization rate was only 19.39%. The urbanization rate increased to 36.22 percent. By 2012, China's urbanization rate has reached 52.57%, and it is predicted that by 2030, China's urbanization rate will reach 65% [3]. Under the huge wave of urbanization, the appearance of cities and towns in China has undergone earth-shaking changes: the number of cities and towns is increasing rapidly, the functions of cities and towns are becoming increasingly perfect, the level of urbanization is constantly improving, and the appearance of cities and towns is changing with each passing day [4, 5]. Under the trend of continuous urbanization development and urban economic construction and infrastructure construction, government departments must effectively plan and use limited land resources and promote the rapid and healthy development of the city [6, 7].

However, the rapid development of cities and towns brings great challenges to cities in the economy, environment, society, resources, ecology, housing, and other aspects. In the process of urban development, there are still many uncertain factors, such as economic marketization, social diversification, political democratization, and information network. Under the action of these factors, the compilation and implementation of urban planning work are facing unprecedented pressure [8]. And many of these factors do not exist in isolation [11]. In order to solve these problems, we must have a comprehensive and accurate grasp of the dynamic characteristics of the whole environment. This is because the performance of the CAD is more in support of the static properties, it is notable to provide a characterization of correlation degree between attribute data, and the user can only get the simple data but cannot see the implied correlation between data as well as the further numerical value correlation [12, 13]. Moreover, CAD software has poor

support for network data access. It was not until the end of the 1980s and the beginning of the 1990s that GIS was introduced into the field of urban planning in China, and it shone brilliantly in many fields and aspects.

Spatial geographic system can provide all kinds of things completely, and more importantly, it can also provide users with the related attributes of the dynamic conditions such as the mode of mutual influence and restriction. Users can classify, query, and analyze information quickly through the GIS system's special auxiliary decision-making ability, such as spatial analysis ability and virtual display ability. In addition, qualitative division of various planning schemes and results can be carried out, and quantitative analysis model establishment and result prediction can promote the scientific nature of planning decision-making so as to improve the quality and efficiency of planning management and design work more effectively. At present, according to the different application scenarios and the fields, the geographical systems can be divided into three types [14]:

(1) The blueprint for GIS planning application type. This type of planning focuses on the technical factors, and it describes the planning process and the mutual relationship of time.

(2) Application of GIS in process-based planning. Process-based planning focuses on social factors. When some behaviors are prone to cause different opinions or conflicts of interest and need to be coordinated and balanced at any time, process-based planning is more appropriate than blueprint-based planning.

(3) Advocacy planning GIS application. Advocacy planning originated in the west, and it mainly focuses on guiding and stimulating economic activity, with the independent social life of human activities to distribution, and slightly revised the urban development direction and goal; compared with the former two types, advocacy duration is longer and change per unit time is relatively slow. However, its change is corresponding to the level of human cognition; the less interference from the outside world, the less resistance encountered.

With the application of GIS in various fields, such as resources and environment, people gradually have a strong awareness of the proportion of spatial information in global information concentration, and various advantages of GIS gradually appear in front of people [15]. For example, GIS has a rich variety of software and application systems and has special features in the format, processing, and display of spatial data. In addition, the visualization function of GIS has special advantages for spatial data operation [16]. So, it is wise to use GIS technology to solve the problem of planning management [17]. This paper is to design GIS-based urban planning and design methods under this background. The purpose is to develop a set of thematic GIS system for urban planning, realize the digitalization of planning results and data, and improve the efficiency and level of planning information management, which can provide the correct idea for the reasonable planning of the city.

2. Related Work

The early 1960s was a period of gradual emergence of GIS ideas and exploration of technical methods [18, 19]. With the development of computer technology, computers were gradually used to collect data from various parties and finally output the final results. This produced the basic framework of the earliest GIS. During this period, many geographic information systems and spatial geographic systems have been invented and studied. At this time, the characteristics of these databases can be summarized as a large number, small capacity, and independent and independent state. During this period, the use and function of GIS in various countries were in the exploratory stage [20]. At the same time, some commercial companies have also seen the business opportunities provided by GIS and launched their own commercial GIS software. In the 1980s, GIS has made great progress in theory, method, and technology and entered the mature stage. From the 1990s to now, GIS has developed from the original single-function decentralized system into a comprehensive information system shared by multifunctional users [21].

The development and application of GIS started late in China but developed rapidly. The development of GIS in China can be roughly divided into three stages:

(1) Preparation stage: public opinion preparation, formation of teams, and some exploratory work

(2) Initial stage: in this stage, theoretical exploration and regional experimental research on GIS are mainly carried out

(3) Development stage: as a key research topic, the research of GIS has been gradually combined with the national economic construction and has made great progress.

In addition, at this stage, the research and function of GIS have formed a systematic research plan [22]. On the other hand, a national general survey of natural resources and the environment will be carried out, and research on regional information systems for early warning and prevention and control of hydrological disasters in combination with environmental conservation will be carried out. The third aspect is the research and development of software system and expert diagnosis system and the completion of a batch of comprehensive regional and thematic geographic information system [23, 24].

With the rapid take-off of China's economy, the pace of urbanization is becoming more and more rapid. The capacity of urban population is also rapidly expanding, and the population pressure is increasing. In order to solve this problem, cities are constantly expanding outwards [25]. However, the urban area cannot be unlimitedly expanded because of the ensuing traffic, environment, resources, and other aspects. Therefore, it is a very effective solution at present to transform the original urban areas, change the existing places that are not suitable for reality, increase the residential capacity of the population, expand the water and electricity supply capacity, expand the public transportation capacity, and so on. The data volume of urban planning compilation results is increasing, and the data types are

extremely complex [26, 27]. However, the commonly used commercial software platform has many functions, and the management system is too complicated to operate. Therefore, aiming at the field of urban planning, it is an important development trend at present to customize a simple and effective applied GIS system to realize the integrated management of data and text of planning compilation results. Many existing researches have embedded some auxiliary strategies into the GIS system, such as the Bayesian network, as shown in Figure 1.

The urban development of foreign developed countries is very perfect, most of the urban construction has entered the maintenance stage, and the evaluation research of urban planning is more extensive and in-depth. In addition, urban planning in foreign countries has a high degree of informatization, convenient data sharing, and easy access to information [28]. Therefore, urban planning evaluation is relatively easy to carry out and mainly focuses on quantitative statistical analysis and evaluation. In China, government departments pay much more attention to urban development and construction than statistical evaluation. In recent years, due to some problems exposed in urban construction and a series of compulsory provisions of laws and regulations, urban planning statistical evaluation work gradually received the attention of relevant departments, and some theoretical research and practical work appeared successively. Reference [29] revealed the importance and difficulties of urban planning implementation evaluation research in China and introduced the basic ideas of carrying out planning evaluation with the results and process of planning implementation as the main evaluation content. Reference [30] believed that postimplementation evaluation of planning is mainly to investigate whether the phased implementation results and the content of planning compilation have been really implemented and to evaluate the role and influence of implementation results. Reference [31] compared the effect of the implementation of urban land-use planning in 1984 and 1995 in Tianjin. Reference [32] used qualitative and quantitative methods to evaluate the implementation of Yuyao's urban master plan by taking the public satisfaction evaluation of spatial organization and layout of the implementation of planning objectives as the evaluation index. Reference [33] evaluated the effectiveness of the master plan of Changsha by means of factor extraction, data collection, field investigation, statistical analysis, and other methods. Recently, [34, 35] evaluated the implementation of the overall plan of Changsha city from the implementation of various land uses with GIS technology.

Although the statistical evaluation of urban planning is carried out late in China, under the mandatory constraints of the Urban and Rural Planning Law of the People's Republic of China, various localities have carried out statistical analysis and evaluation of the implementation of urban planning in combination with the actual situation and achieved some results [36]. Data formats are inconsistent, and software is incompatible with data software functions having their own focus [37]. For urban planning, GIS is both toolbox and database. As a database, GIS can store spatial and attribute data and connect them organically through spatial model so that users can access, edit, and query orientation efficiently and quickly [38,39]. As a toolbox, GIS provides comprehensive geo-information processing power, such as spatial interpolation, linking, and caching. At present, the development direction of GIS mainly includes the following aspects: spatial data structure and data management technology, automatic data input technology, microcomputer miniaturization technology of GIS, the fusion technology of GIS and remote sensing, intelligent expert experience technology of GIS, and GIS application model development technology [40]. Based on the above discussions, the main contributions of this paper are as follows:

(1) Although the proposed method is not a new one, it solves a new problem in urban planning design and evaluation field

(2) This paper is the first time to combine GIS information with Bayesian network to solve urban planning design and evaluation problem

3. The Proposed Urban Planning, Design, and Evaluation Method

3.1. Principles of GIS Information System. GIS is a technical system that collects, stores, manages, analyzes, displays, and describes the geographical distribution data in the whole or part of the earth surface (including the atmosphere) space under the support of computer hardware and software system. Besides, GIS is mapping software that connects information about where you are with information about what it is. Unlike maps drawn on paper, a GIS map is associated with many different layers of information. Like paper maps, digital maps produced by GIS have pixels or dots for things like cities, lines for things like roads, and small chunks for things like lakes.

Unlike paper maps, the GIS information comes from a database, which stores information such as the location of a point, the length of a road, and even the area of a lake and is displayed only when the user chooses to display it. Each piece of information on the digital map sits on a layer that users can turn on or off as needed. One layer may contain information about all roads in an area while another may represent information about all lakes in the same area. Of course, there might be a layer that describes all the city information. Why is layering so important? The power of GIS over paper maps is that with GIS you can choose the information you want to see based on the purpose of your actions. The information displayed by merchants mapping customers for a particular city is, of course, very different from what municipal engineers want to see about the same city's water lines.

3.2. Bayesian Network. Many problems in real life are probability problems, which are mutually influenced by multiple variables (factors and elements). However, if we want to use the Bayesian network to model them, we need to consider three problems:

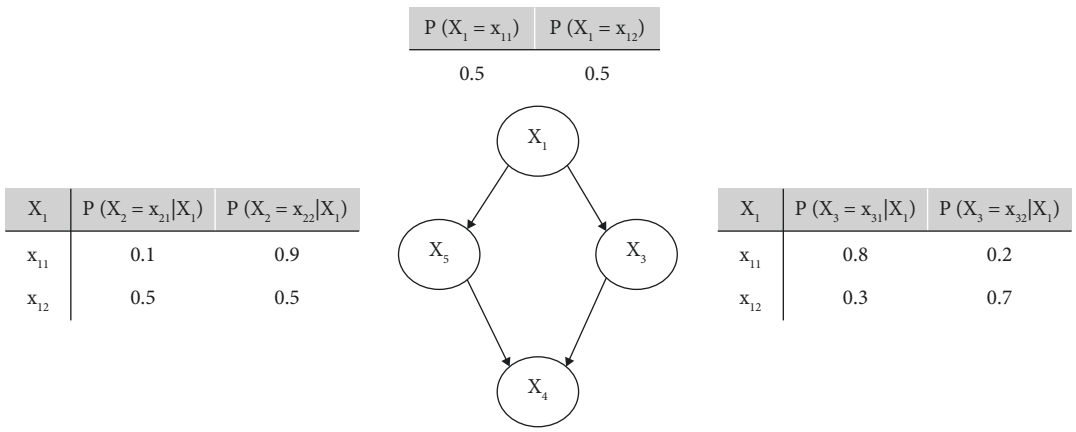

Figure 1: Schematic diagram of a Bayesian network.

(1) How to define nodes

(2) How to define the probability dependence between nodes

(3) How to express the joint probability distribution

Assuming that we now have N variables and each variable has K values, it can be modeled in the following form:

$$p(\mathbf{X}) = p(X_1, X_2, \ldots, X_N), \quad X_i \in \{1, 2, \ldots K\}. \tag{1}$$

Then, assuming that the variables are mutually independent, the joint probability distribution is greatly simplified to the following form. That means, equation (2) is a simplified form of formula (1).

$$p(\mathbf{X}) = p(X_1)p(X_2)\cdots p(X_N). \tag{2}$$

If the variables are not mutually independent, the joint probability distribution can be calculated by Kernel density estimation. However, the assumption that variables are independent of each other is too strong, so we can reduce the complexity of the model by taking advantage of the structure of graphs. A Bayesian network is a Directed Acyclic Graph (DAG) (Directed edges do not form a circle) represented by variable nodes and connections. Prior probability is used to express information without the parent node. Let G be a Bayesian network, then its joint probability distribution can be expressed as the product of the conditional probability distribution of each node:

$$p(X) = \prod_i p_i(X_i|\mathrm{Par}_G(X_i)). \tag{3}$$

Therefore, its joint probability distribution can be expressed in the following form:

$$p(D, I, G, S, L) = P(D)P(I)P(G|I, D)P(S|I)P(L|G). \tag{4}$$

If random variables X and Y are mutually independent, the following three equations will be satisfied:

$$P(X, Y) = P(X)P(Y), \tag{5}$$

$$P(X|Y) = P(X), \tag{6}$$

$$P(Y|X) = P(Y). \tag{7}$$

Random variables X and Y are conditionally independent under a given Z condition, if

$$P(X, Y|Z) = P(X|Z)P(Y|Z), \tag{8}$$

$$P(X, Y|Z) = P(X|Z), \tag{9}$$

$$P(Y, X|Z) = P(Y|Z). \tag{10}$$

Based on equations (1)–(10), Figure 2 gives the schematic diagram of urban planning, design, and evaluation procedure based on GIS information and the Bayesian network proposed in this paper. From the figure, we know that it mainly includes preparation, evaluation, and results.

4. Experimental Results and Analysis

4.1. Experimental Data Collection and Design. In the database table of software development and design, we divide it into static and dynamic data according to the characteristics of data use. Static data contain the user and spatial geographic information introduced in the previous chapter.

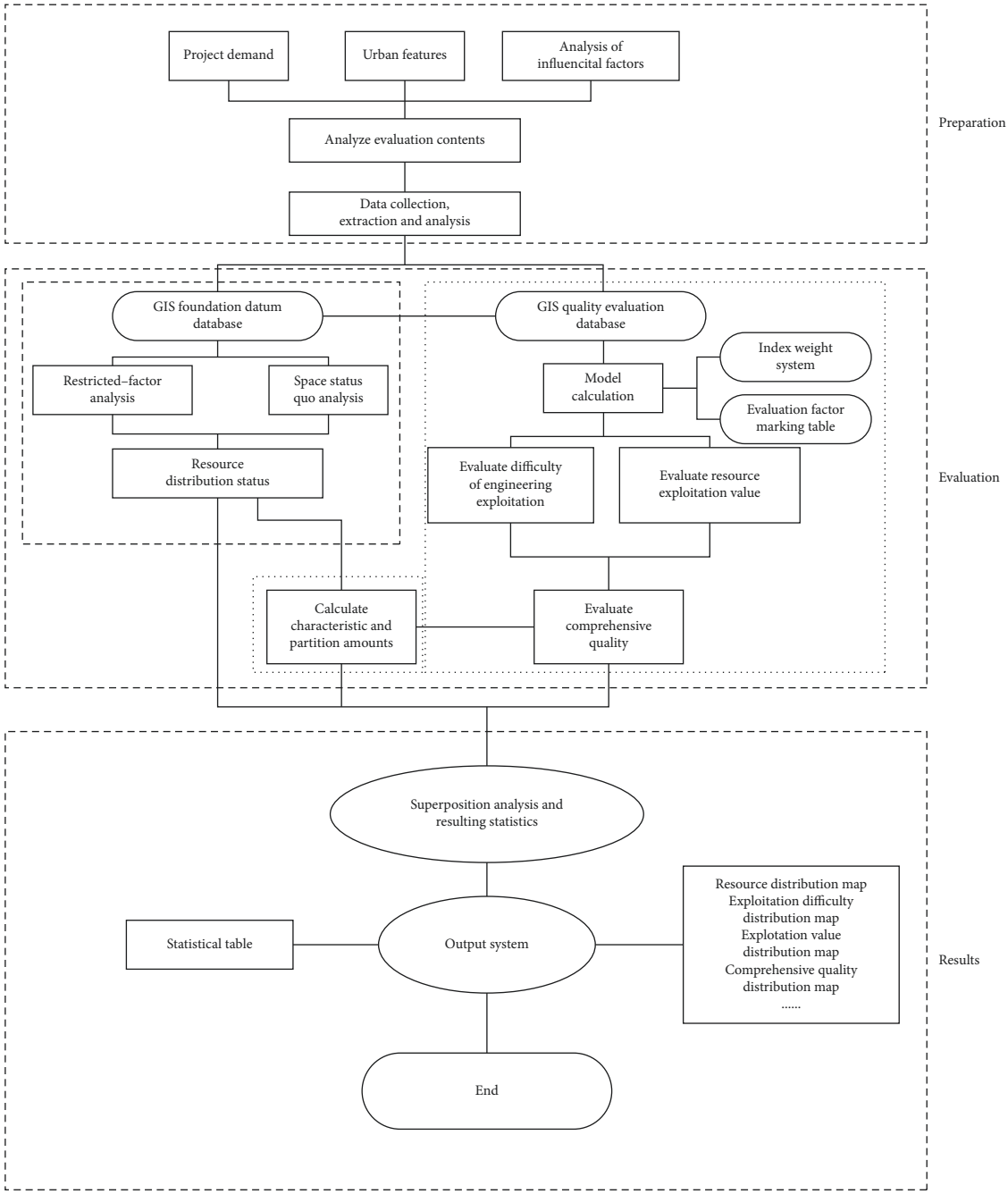

Figure 2: GIS information and Bayesian network-based urban planning method.

These data are fixed or the most terminal data, which can participate in data processing and operation but will not change themselves. Dynamic data are intermediate process data such as single data of message approval and weighted factor data, which can be different in different situations.

The user information management data sheet is used mainly in the login process and permission management process, and this type of database design has very mature steps and patterns. The login database is usually composed of several basic data tables. The first type of table stores the key data required by the login function, and the second stores the permission role resource relationship table. The third type of table holds auxiliary information, such as the system log information. The design of data table is not described in detail here; only the logical structure design of several database tables is given due to the limitation of page length.

4.2. Experimental Results. The most commonly used function of spatial data input and output is for further statistics and analysis. Therefore, this section only shows the function of spatial data input database.

In order to verify the validity of the proposed method in urban regulation, we compare the prediction accuracy of the

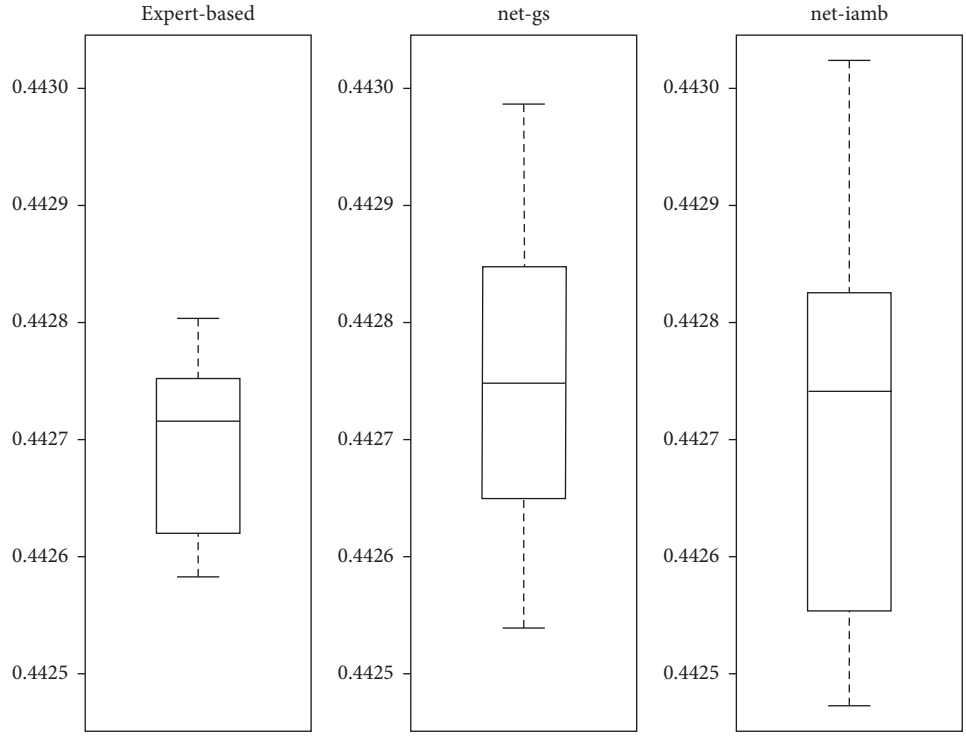

Figure 3: The prediction results of experts, net-iamb, and the model in this paper.

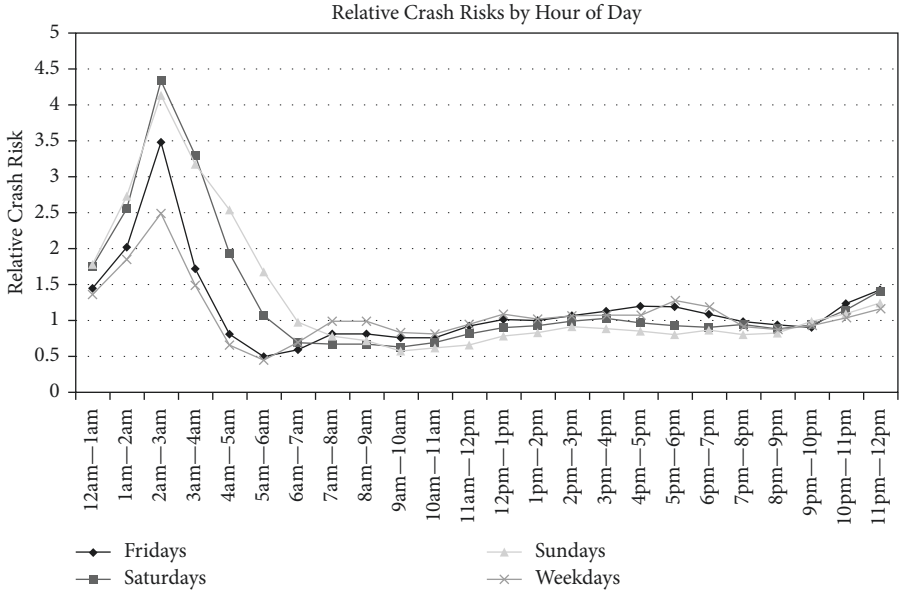

Figure 4: City's relative crash risk by the hour.

cumulative impact nodes of all three BN (Bayesian network) model structures. The boxplot in Figure 3 shows the average loss of prediction error of three different models. It can be seen from the figure that the prediction accuracy of the proposed method is better than that of the comparison algorithms, thus proving the effectiveness and practicability of the proposed method.

Besides, Figure 4 shows the hourly curve of the relative crash risk in cities. It can be seen from the graph that although different types of vehicles and vehicle mileage are distributed differently, the trend of red dust is very similar. In general, the risk is highest in the early morning (1 am to 4 am), with weekends being less safe than weekdays. The highest risk (over 4.0) was found between 2 am and 3 am on Sunday and Saturday, and the relative risk was also above 1 for all categories between 10 pm and 4 am. Factors could include a lack of good lighting, tired drivers, or even drunk driving. Although morning and afternoon vehicle mileage

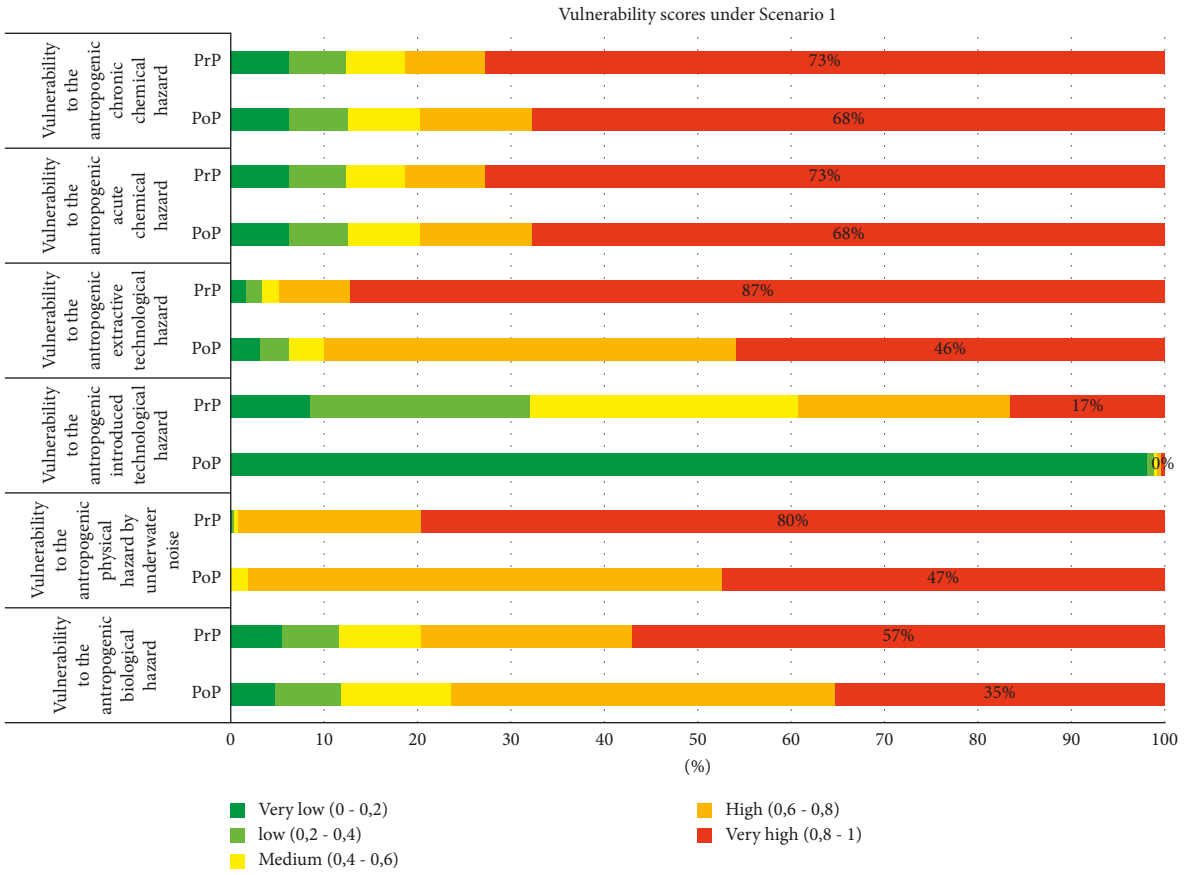

Figure 5: Vulnerability probability distribution of urban planning and design under different disasters.

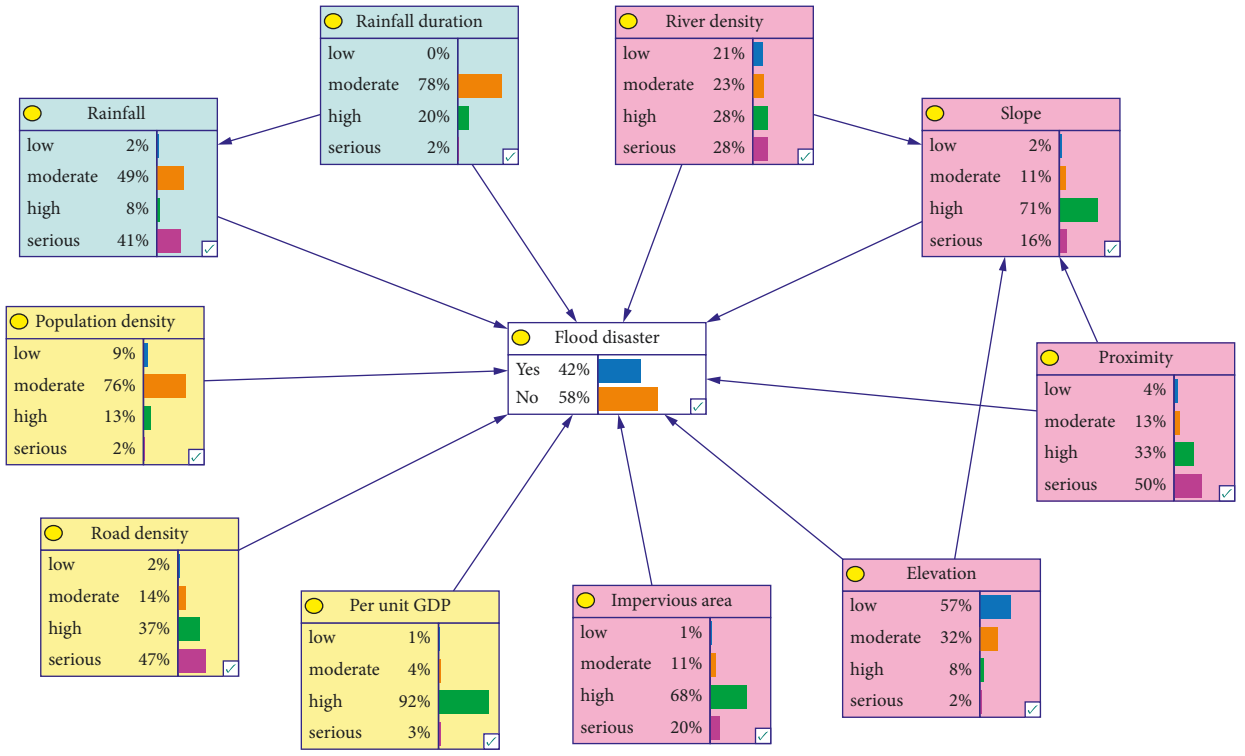

Figure 6: The results of flood risk assessment by the proposed method.

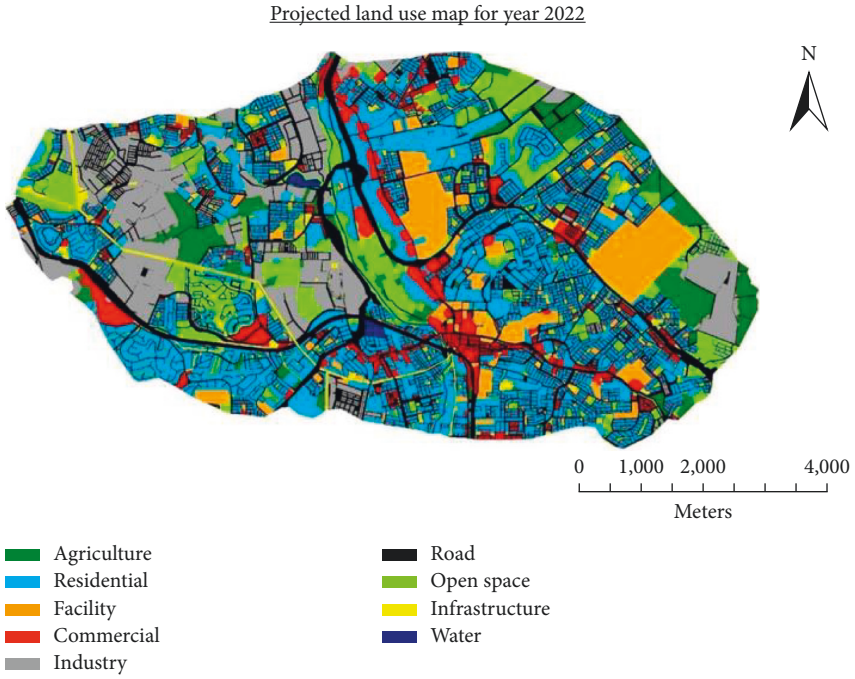

Figure 7: The land-use prediction results 2022 by the proposed method.

are almost the same from Monday to Friday, the time of lowest risk is 5 am to 6 am.

Figure 5 shows a significant reduction in the overall vulnerability of the surveyed marine areas to related hazards. To be more specific, through the analysis of vulnerability to man-made technological disasters, the probability of vulnerability in high or medium state in the reference scenario is about 0 70% (i.e., the normalized vulnerability score ranges from 0.4 to 1). As expected, 98% of the cases were at the low level of vulnerability (i.e., the standardized vulnerability score was in the range of 0.2). It shows that the city planning method proposed in this paper has strong reliability.

The most core part of GIS is the analysis and processing of spatial data information. The basic means adopted include spatial information calculation, spatial information classification, and spatial information statistics. This is the difference between GIS and CAD in the basic level, which is also the main function of GIS in this software system.

As can be seen from Figure 6, the influence degree of different factors on urban planning flood can be quantitatively described, which provides method support and theoretical reference for designers.

Figure 7 depicts the forecast results of urban land utilization in 2022. As can be seen from the figure, commercial land along major roads, especially around railway stations, is growing significantly. New industrial buildings are springing up near former industrial sites in the Midwest. On the contrary, the industrial plots in the north of the city also gradually increased, which may be caused by the internal and external effects of industry. The same is true for residential land across the city, growing near existing residential land. It follows that the loss of agriculture and the natural environment in and around cities cannot be completely stopped by the growth of urban settlements.

5. Conclusions

As we all know, urban planning is by no means a pure technical science, which contains a large number of humanities and knowledge. It is a challenge for GIS in urban planning application that GIS tools and urban planning are connected and integrated scientifically and may play their role to the maximum extent in practical work.

The purpose of this study is to develop a GIS-based Bayesian approach for link-based relative collision risk analysis at the inner-city level. The research method is aimed at the spatio-temporal pattern of urban norms, which can guide the subsequent urban planning work effectively. The results of the proposed method can be used to determine the dangerous environment and potential disasters that need attention, which has both theoretical and practical significance. Although the opinions in this paper have achieved good results, some work still needs to be further studied:

(1) When it comes to big data scenarios, the current shallow network is often ineffective, and the deep learning model is worth studying and exploring.

(2) Whether the planning model is scalable between different cities is also an important aspect to measure the practicality of the method.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

References

[1] G. Lobaccaro, S. Croce, C. Lindkvist et al., "A cross-country perspective on solar energy in urban planning: l," *Renewable and Sustainable Energy Reviews*, vol. 108, pp. 209–237, 2019.

[2] A. Czachura, J. Kanters, N. Gentile, and M Wall, "Solar performance metrics in urban planning: a review and taxonomy," *Buildings*, vol. 12, no. 4, p. 393, 2022.

[3] Z. Cai, Q. Liu, and S. Cao, "'Real estate supports rapid development of China's urbanization," *Land Use Policy*, vol. 95, Article ID 104582, 2020.

[4] S. Ali, "Historic centres of Syrian towns ruined by the war: restoration through urban planning," *Vestnik MGSU*, vol. 15, no. 5, pp. 632–640, 2020.

[5] M. Goliński, "On the problem of the size of trading complexes in medieval towns and cities of central europe," *Acta Poloniae Historica*, vol. 119, 2019.

[6] L. Sturiale and A. Scuderi, "The role of green infrastructures in urban planning for climate change adaptation," *Climate*, vol. 7, no. 10, p. 119, 2019.

[7] L. Rossi, M. E. Menconi, D. Grohmann, A. Brunori, and D. J. Nowak, "Urban planning insights from tree inventories and their regulating ecosystem services assessment," *Sustainability*, vol. 14, no. 3, p. 1684, 2022.

[8] D. Mauree, S. Coccolo, A. T. D. Perera, V. Nik, J. L. Scartezzini, and E. Naboni, "A new framework to evaluate urban design using urban microclimatic modeling in future climatic conditions," *Sustainability*, vol. 10, no. 4, p. 1134, 2018.

[9] O. Fioretos and E. C. Heldt, "Legacies and innovations in global economic governance since Bretton Woods," *Review of International Political Economy*, vol. 26, no. 6, pp. 1089–1111, 2019.

[10] C. F. Bergsten, "China and the United States: the contest for global economic leadership," *China and World Economy*, vol. 26, no. 5, pp. 12–37, 2018.

[11] K. Grunewald, O. Bastian, J. Louda et al., "Lessons learned from implementing the ecosystem services concept in urban planning," *Ecosystem Services*, vol. 49, Article ID 101273, 2021.

[12] J. Mueller, H. Lu, A. Chirkin, B. Klein, and G. Schmitt, "Citizen Design Science: a strategy for crowd-creative urban design," *Cities*, vol. 72, pp. 181–188, 2018.

[13] Y. Ma, Y. Jiang, and S. Swallow, "'China's sponge city development for urban water resilience and sustainability: a policy discussion," *Science of the Total Environment*, vol. 729, Article ID 139078, 2020.

[14] M. Sánchez-Sepúlveda, D. Fonseca, X. Calvo et al., "Innovation in urban design education," in *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality*, pp. 729–736, Salamanca, Spain, October 2018.

[15] E. Gebetsroither-Geringer, R. Stollnberger, and J. Peters-Anders, "Interactive spatialweb-applications as newmeans of support for urban decision-making processes," *ISPRS annals of photogrammetry, Remote Sensing & Spatial Information Sciences*, vol. 4, 2018.

[16] W. Huang and W. M. Wey, "Green urbanism embedded in TOD for urban built environment planning and design," *Sustainability*, vol. 11, no. 19, p. 5293, 2019.

[17] K. Mouratidis, "Urban planning and quality of life: a review of pathways linking the built environment to subjective well-being," *Cities*, vol. 115, Article ID 103229, 2021.

[18] N. Šprah and M. Košir, "Daylight provision requirements according to EN 17037 as a restriction for sustainable urban planning of residential developments," *Sustainability*, vol. 12, no. 1, p. 315, 2019.

[19] V. Ferretti and R. Grosso, "Designing successful urban regeneration strategies through a behavioral decision aiding approach," *Cities*, vol. 95, Article ID 102386, 2019.

[20] Q. Hao and L. Qin, "The design of intelligent transportation video processing system in big data environment," *IEEE Access*, vol. 8, pp. 13769–13780, 2020.

[21] M. B. Tobey, R. B. Binder, S. Chang, T. Yoshida, Y. Yamagata, and P. P. J. Yang, "Urban systems design: a conceptual framework for planning smart communities," *Smart Cities*, vol. 2, no. 4, pp. 522–537, 2019.

[22] J. Zhang, L. Xu, V. Shabunko et al., "Impact of urban block typology on building solar potential and energy use efficiency in tropical high-density city," *Applied Energy*, vol. 240, pp. 513–533, 2019.

[23] G. Brown, J. Rhodes, and M. Dade, "An evaluation of participatory mapping methods to assess urban park benefits," *Landscape and Urban Planning*, vol. 178, pp. 18–31, 2018.

[24] M. O. van Schaik, S. Sucu, H. J. Cappon et al., "Mathematically formulated key performance indicators for design and evaluation of treatment trains for resource recovery from urban wastewater," *Journal of Environmental Management*, vol. 282, Article ID 111916, 2021.

[25] J. Natanian, O. Aleksandrowicz, and T. Auer, "A parametric approach to optimizing urban form, energy balance and environmental quality: the case of Mediterranean districts," *Applied Energy*, vol. 254, Article ID 113637, 2019.

[26] M. Haklay, P. Jankowski, and Z. Zwoliński, "Selected modern methods and tools for public participation in urban planning – a review," *Quaestiones Geographicae*, vol. 37, no. 3, pp. 127–149, 2018.

[27] Y. Chen, T. A. Daamen, E. W. T. M. Heurkens, and W. J Verheul, "Interdisciplinary and experiential learning in urban development management education," *International Journal of Technology and Design Education*, vol. 30, no. 5, pp. 919–936, 2020.

[28] L. Jiang, M. Masullo, L. Maffei, F. Meng, and M Vorlander, "A demonstrator tool of web-based virtual reality for participatory evaluation of urban sound environment," *Landscape and Urban Planning*, vol. 170, pp. 276–282, 2018.

[29] J. Peng and F. L. Peng, "A GIS-based evaluation method of underground space resources for urban spatial planning: Part 2 application," *Tunnelling and Underground Space Technology*, vol. 77, pp. 142–165, 2018.

[30] F. Ali-Toudert, L. Ji, L. Fährmann, and S Czempik, "Comprehensive assessment method for sustainable urban development (camsud) - a new multi-criteria system for planning, evaluation and decision-making," *Progress in Planning*, vol. 140, Article ID 100430, 2020.

[31] J. Xiao, L. Lavia, and J. Kang, "Towards an agile participatory urban soundscape planning framework," *Journal of Environmental Planning and Management*, vol. 61, no. 4, pp. 677–698, 2018.

[32] R. Fox-Kämper, A. Wesener, D. Münderlein, M. Sondermann, W. McWilliam, and N Kirk, "Urban community gardens: an evaluation of governance approaches and related enablers and barriers at different development stages," *Landscape and Urban Planning*, vol. 170, pp. 59–68, 2018.

[33] M. Cetin, F. Adiguzel, S. Gungor, E. Kaya, and M. C Sancar, "Evaluation of thermal climatic region areas in terms of building density in urban management and planning for Burdur, Turkey," *Air Quality, Atmosphere & Health*, vol. 12, no. 9, pp. 1103–1112, 2019.

[34] N. Trushkina, "Development of the information economy under the conditions of global economic transformations: features, factors and prospects," *Virtual Economics*, vol. 2, no. 4, pp. 7–25, 2019.

[35] J. Fu, Y. Wang, D. Zhou, and S. J Cao, "Impact of urban park design on microclimate in cold regions using newly developped prediction method," *Sustainable Cities and Society*, vol. 80, Article ID 103781, 2022.

[36] Z. Shao, H. Fu, D. Li, O. Altan, and T Cheng, "Remote sensing monitoring of multi-scale watersheds impermeability for urban hydrological evaluation," *Remote Sensing of Environment*, vol. 232, Article ID 111338, 2019.

[37] M. Kahila-Tani, M. Kytta, and S. Geertman, "Does mapping improve public participation? Exploring the pros and cons of using public participation GIS in urban planning practices," *Landscape and Urban Planning*, vol. 186, pp. 45–55, 2019.

[38] B. Madonsela, S. Koop, K. Van Leeuwen, and K. Carden, "Evaluation of water governance processes required to transition towards water sensitive urban design—an indicator assessment approach for the City of Cape Town," *Water*, vol. 11, no. 2, p. 292, 2019.

[39] D. Zhou, X. Li, Q. Wang et al., "GIS-based urban underground space resources evaluation toward three-dimensional land planning: a case study in Nantong, China," *Tunnelling and Underground Space Technology*, vol. 84, pp. 1–10, 2019.

[40] S. Cajot and N. Schüler, "Urban Energy System Planning: Overview and Main challenges," *Urban Energy Systems for Low-Carbon Cities*, pp. 19–49, 2019.