



Research Status and Prospect of Intelligent Computing in Urban Expansion and Land Use Change

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Abstract

With the improvement of urbanization level, the scale of cities continues to expand. The prominent urban problems such as urban heat island effect, loss of agricultural land, and adjustment and adaptation of urban functional zones make the research on the relationship between urban expansion and land use types particularly important. This paper reviews the relationship between urban expansion and land driving forces based on intelligent computing, using bibliometric and literature analysis, the application of land driving force calculation methods and land use driving forces in predicting urban expansion, land cover change trends, urban environment and climate change. It is believed that considering the comprehensive influence of multiple factors, revealing the trends, causes and mechanisms of land use and land cover changes will become a new direction for applying intelligent computing to study urban expansion and land use changes.

Keywords: Urbanization; Urban Expansion; Land Use Change; Driving Force; LUCC

Introduction

With the rapid development of the world economy, the process of urbanization has intensified (Figure 1) [1]. The continuous expansion of the city scale is accompanied by a sharp increase in the demand for urban construction land, and the ecological environment problems brought by a large number of emerging cities also play a role in the sustainable development of the city. Studying urban sprawl and obtaining land use and land cover change (LUCC) has become a new research focus of Earth system science. Summarizing the current research directions of LUCC in various countries, it can be seen that the main research contents of LUCC include the driving force of land use, the temporal and spatial changes of land use, and the environmental impact of land use on urban air and

soil quality [2]. With the acceleration of the urbanization process, the study of the impact of human activities on land change, the environmental effects of LUCC and the study of sustainable land use have gradually become the hot and difficult research points. This paper mainly reviews the effects of land use and land cover change (LUCC) driving factors on land expansion.

Research Methods

Based on intelligent computing, this study applied the method of land driving force calculation and land use driving force to predict the relationship between land expansion, land cover change trend, urban environment and climate change. The specific methods are as follows: Firstly, the research problems and objectives are established; Then, the existing literatures were retrieved on the ba-

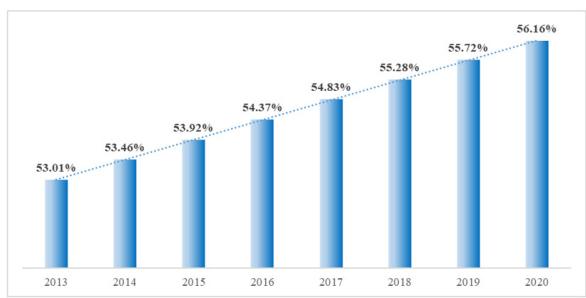


Figure 1: The level of urbanization in the world from 2013 to 2020 [1].

sis of Google Scholar and Science Network database, and bilometric analysis and keyword co-occurrence analysis were carried out based on Web of science database and Citespace tool, and literature screening and reading were carried out at the same time. Finally, based on the above literature and keywords, the main points of the literature are extracted and analyzed, and the conclusions and prospects of the research field are put forward (Figure 2).

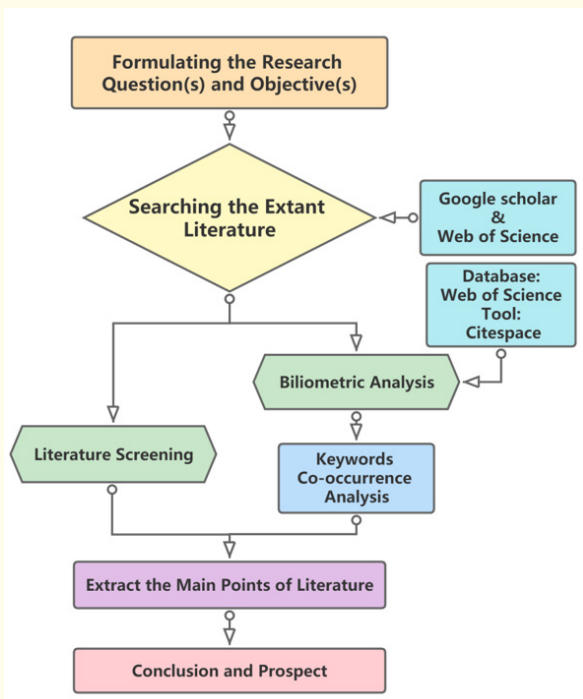


Figure 2: The flow chart of the research.

Based on Web of Science database, we searched urban expansion and found 855 papers in total. Through the statistical analysis of the publication year of the papers, it is found that the related papers have been increasing year by year since 2008, as shown in figure 3. It shows that the research on this topic has received increasing attention. Based on the above, hot issues are analyzed and the results show that: urbanization (283), growth (261), city (187), pattern (141), impact (137), land use Change (134), the dynamics (119), sprawl (106), China (104), model (74). Therefore, urban expansion is closely related to urbanization level, and the research focus on land use change, as shown in figure 4.

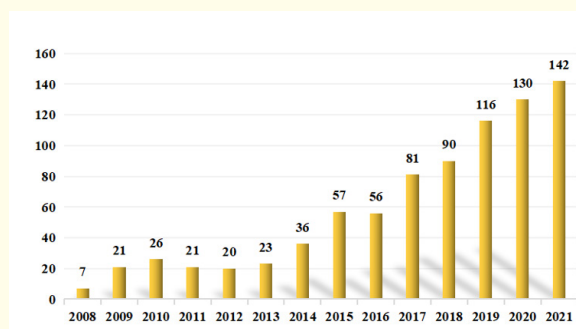


Figure 3: The number of papers with The topic of "Urban Expansion" in 2008-2021.

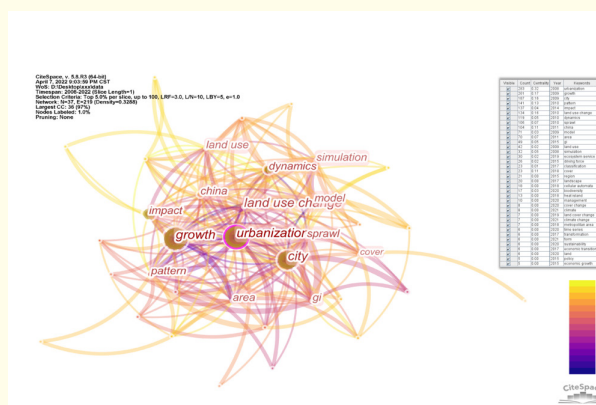


Figure 4: Keywords co-occurrence analysis of the article on "urban expansion. (Font size is positively correlated with the number of occurrences).

Urban expansion and driving forces of land use

The study on urban expansion was first started in the 1960s. As the expansion of urban scale limited the continuous development of social politics, economy and urban functions, the earliest study on urban expansion mainly focused on how to establish a complete location choice model for urban residents to optimize their choice by considering the marginal benefit and cost of the region. Since then, location choice model has become the research paradigm of urban expansion. Alonso [3] established a complete residential location selection model for urban residents, and selected residential areas based on the comparison of marginal revenue and marginal cost of residential locations. This model became the standard paradigm for studying urban sprawl. As urban scale and expansion are directly subject to the level of socio-economic development and urban function, Wheaton [4] incorporated income as one of the evaluation factors into the residential selection model to consider the role of residents' income in location selection. Wright, *et al.* [5] further analyzed the urban expansion model by taking commercial location and public service as factors. Cho [5,6] took the above factors as comfort level to analyze the influence of residents' location choice and urban expansion, and reflected the decision factor of urban residents' residence choice by the degree of labor market decentralization. Yong Liu [7], a Chinese scholar, explored the impact of policies on land use and proposed a conceptual framework to prove the impact of land fiscal incentives on urban expansion. Gao Caihong, *et al.* [8] explored the impact of government policies and economic profitability on land use. Hou Ying, *et al.* [9] took Beijing as the research area to reveal the impact of impervious surface and explore risk control strategies, so as to show the spatial and temporal dynamics of regional ecological land use. Abbas, *et al.* [10] constructed a model based on landscape fragments, and set up a framework based on land use distribution analysis, and further estimated land use distribution by economic model based on spatial Lentz curve and Gini index. Therefore, population and national economic policies play a direct role in the change of cultivated land and urban land, and the analysis of the mechanisms and functions of various driving forces is a good reference for the formulation of agricultural land, especially cultivated land policy and the study of landscape change in hot spots.

Calculation method of driving force of land use

By analyzing the effects of land use at different scales, such as economically developed areas, high-density population areas,

rapid urbanization areas and fragile ecological environment areas, etc. [11]. Build a driver weighting model (e.g., Markov chain) to reveal the time series characteristics of driving force [12]; Natural and socio-economic indicators were selected to calculate the driving force index [13]; Multiple regression method was used to quantitatively analyze the impact of policy and economic driving factors on land use [14]; A land change model was constructed to simulate the dimension reduction of agricultural LUCC. The application oriented application object-oriented approach focuses on the impact of community participation and ownership of natural resources [15]; Multi-temporal and multi-resolution land use data were obtained with the technical support of remote sensing and geographic remote sensing information system, and the driving forces of land change pattern under GIS spatial analysis module were studied [16]; Mondal, *et al.* used 20 climate models and 5 comprehensive assessment models (IAM) to study the urban flood risk caused by extreme precipitation under the four combination scenarios of coupling models comparing the shared socio-economic path and representative concentrated path in the sixth stage of the project [17]; Ali Maroof, *et al.* used the supervised maximum likelihood classification algorithm in ARCGIS 10.1 to process temporal satellite images, so as to explain the information about land use or land cover change and study the change of relevant pasture and forest coverage rate [18]; Zhong Sheng, *et al.* analyzed the impact of land financing on urban green space utilization efficiency based on the global Malmquist-Lemberg index and spatial economic model based on the directional distance function superefficiency model [19]; Abbas, *et al.* constructed a model based on landscape fragments, and set up a framework based on land use distribution analysis, and further estimated land use distribution by economic model based on spatial Lentz curve and Gini index [20].

Applications of land use drivers

Land use drivers are often used to predict urban sprawl, land cover trends, urban environment and climate change.

Urban expansion and land cover change trends

Wei Liu, *et al.* conducted quantitative analysis of historical changes of land use in the context of urban expansion to better understand the relationship between ecological services and land use, and found that hydrological regulation, climate regulation, soil formation and conservation have the greatest contribution value in terms of ecological services [21]. Yuan Yang, *et al.* studied the spa-

tial expansion model of the study area by analyzing the landscape pattern and urban land area of the study area in the past 28 years and based on GIS buffer analysis, and found that the combination of landscape matrix of practice sequence in the study area presents a typical spatial pattern and the overall trend of urban expansion [22]. Isabelle Duvernoy, *et al.* in the study area near the city of agricultural and urban sprawl, quantitatively investigation related to study area in the study area of urban sprawl and agricultural land use types between the relationship between the space and the function of potential, the results show that the urban expansion effect suburb farm characteristics, changing farmers' economic scale, crop production and social characteristics [23]; Wei ChunZhu using remote sensing images, such as using general single-channel algorithm combined quantitative inversion guangzhou land surface temperature of the MNF of principal component analysis and support vector machine (SVM) for opaque surface distribution pattern, using the object-oriented classification method to obtain the land use cover, focuses on the opaque surface in guangzhou, land cover and vegetation index and quantitative relation of urban thermal environment, The results show that the average urban surface temperature is positively correlated with the impervious water surface area, and negatively correlated with the urban vegetation index and bare soil index [24]. Then, a cellular automata land expansion model optimized by BP neural network and genetic neural network algorithm is established to simulate and analyze the urban expansion in Guangzhou from 2009 to 2011. The results show that this method is feasible for urban expansion simulation [25]; Yuan Lei selected 17 impact factors from the three dimensions of social carrying capacity, economic carrying capacity and ecological carrying capacity to construct the evaluation system, adopted the mean square deviation decision weighting method to construct the CLCC evaluation model, combined with Markov model and geographic information system spatial analysis method to analyze the spatio-temporal evolution characteristics of the study area [26]; Wang Qingbo, *et al.* based on morphological spatial pattern analysis and patch importance index, used binary autocorrelation analysis and three-dimensional surface to reveal related land changes in the Yellow River Basin on the Tibetan Plateau [27].

Urban environment and climate change

Shi Yuyue, *et al.* analyzed the relationship between NDVI, temperature and precipitation changes in Wujiang River Basin in August from 2001 to 2015, and obtained the spatio-temporal variation

law of vegetation change, which provided reference for ecological protection of Wujiang River Basin [28]. Then, based on the DATA of GLDAS, MODIS/NDVU and TRMM3B43, First, the trend analysis method was used to analyze the change trend of NDVI in the past 12 years, and the relationship between vegetation cover change and surface water (including snow water equivalent, soil water and surface runoff) was obtained by simple correlation and partial correlation analysis. The research results showed that human activities played a leading role in vegetation cover change in the study area [29]; Xiaolu Li, *et al.* analyzed infiltration and retention capacity of various land use types and regional total retention storage capacity based on landsat TM satellite images of Beijing and New York City in 2011 [30]; Zhou Huailai, *et al.* improved the existing signal-to-noise separation technology of seismic data based on the compromise processing method of soft and hard thresholds combining CurVelet transform and KL transform to reduce noise interference and conduct geological structure analysis [31]; Li Bo, *et al.* used relevant data to study the morphological characteristics and temporal and spatial distribution of microplastics in urban lake sediments. The results showed that urban expansion and economic growth played a crucial role in accelerating the accumulation of microplastics [32].

Conclusion and Prospect

At present, land use change has become a global issue. Based on the summary of relevant researches on land use change and urban expansion, it has become a hotspot to study the development and change of a certain area and its future development trend through historical urban expansion change and spatial change of various land use types, combined with relevant driving factors or influencing factors. With the continuous development of cities, more and more influencing factors or driving factors such as economy, natural geographical environment, urban transportation construction, residential location selection, policy and planning will affect the future development trend of a certain aspect. The interaction of land use has evolved from a horizontal dynamic change to an external vertical change of the land use system, and some new factors have been derived, which are increasingly uncertain. The analysis and research on the driving force factors and mechanisms of land use change also have higher requirements. Therefore, how to comprehensively consider the influence of these factors or elements, reveal the causes, internal mechanisms, and basic processes of land use and land cover changes, conduct quantitative and in-

ternal mechanism exploration, and formulate corresponding countermeasures, will be the direction to be explored in the future. In addition, with the development of artificial intelligence and remote sensing technology, computers will be more widely used in the analysis and prediction of urban expansion and land use.

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