Research article

Land use/cover change and influencing factors inside the urban development boundary of different level cities: A case study in Hubei Province, China

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ABSTRACT

Cities are divided into different levels around the world, which is manifested as cities are managed according to the urban administrative level system in China. Urban development boundary (UDB) has always been a spatial policy to limit the scope of urban sprawl. There is a lack of comparative studies on LUCC and influencing factors inside the UDBs of different level cities. Based on the methods of descriptive statistical analysis, transition matrix analysis, Pearson’s correlation analysis, and OLS regression, this paper takes Hubei Province, China as an example to study the statistical regularities of LUCC and its influencing factors within the UDBs of different level cities from 2006 to 2020. The results showed that LUCC is different within the UDBs of different level cities, economic and social factors are related to major types of LUCC at the level of PGHP city, correlations between economic and social factors and major types of LUCC is small at the level of PGPL city, and the influence of environmental governance on LUCC is increasing at the level of PGPL city. Differentiated control should be carried out according to the level of city in the process of formulating and implementing the policies of land use management.

1. Introduction

1.1. Research background

Cities are divided into different levels according to the size of population, economic and social activities (Armen, 1972; Turgel et al., 2020). In China, cities are managed according to the urban administrative level system of municipality directly under the central government, sub-provincial city, prefecture-level city, county-level city, and county, and there are differences in the allocation of resources and policies enjoyed by cities at different levels, which leads to the different of the development of different level cities; the most direct manifestation of these situations are differences in LUCC, which carries all human economic and social activities (Zhang et al., 2019, 2021). At the same time, urban development boundary is an important part of urban planning or land use planning in rapidly urbanising areas, and the land within the urban development boundary can be developed as urban construction land, while the land outside the urban development boundary cannot be developed, which has always been an important spatial policy to limit the scope of urban activities in order to effectively control urban sprawl at different level cities in some developing countries like China. Therefore, to carry out research on the temporal-spatial pattern evolution and influencing factors of LUCC within the UDBs of different-level cities can not only judge the control efficiency of UDBs on urban sprawl, but also identify the differences of the characteristics and influencing factors of urban sprawl in different-level cities, and provide decision-making reference for optimizing urban development policies at different levels.

1.2. Literature review and analytical framework

LUCC caused by rapid urbanization and industrialization has always been the focus of relevant research (Li et al., 2005; Peng et al., 2011; Zhang et al., 2014), which shows that LUCC are very strong in a specific single city or region in the process of urban development (Mundia and Aniya, 2005; Şen et al., 2018; Xiao et al., 2006). In addition, problems such as changes in urban ecosystem services (Hassan, 2017), surface temperature (Gohain et al., 2021; Ibrahim and Rasul, 2017; Tarawally et al., 2018), and carbon emissions (Chen et al., 2020) caused by changes in urban land use/cover are more prominent. At the same time, identifying LUCC resulting from urban development based on the images of

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high-resolution remote sensing (Chen et al., 2003; Gong et al., 2020; Zhang et al., 2014), and simulation and prediction of land use/cover change (Halmy et al., 2015; Veldkamp and Lambin, 2001) are also the important content of urban LUCC research.

On the other hand, a large number of scholars have carried out relevant research on the impact of urbanization, economic development, and population changes on LUCC by taking Ghana's oil city, Western Kenya as example respectively (Acheampong et al., 2018; Kogo et al., 2021), especially the change of construction land of LUCC, which is - the core content of research on urban sprawl or unlimited urban expansion (Hasse and Lathrop, 2003; Kuang et al., 2016). Some scholars have also begun to study the relationship between air quality and LUCC by taking Wuyishan City as a case, and found that land use types and the factors of air quality are closely related (Zhu et al., 2019).

In order to effectively control the unlimited expansion of construction land, relevant scholars proposed to delimit urban development boundaries in various plans (Jiang et al., 2015, 2016), and studied the method of delimiting urban development boundaries (Chakraborti et al., 2018; Harig et al., 2021; Liu et al., 2017) and the control effect of construction land expansion (Gennaio et al., 2009; Hu et al., 2015) through typical case studies. Existing research believes that controlling the spread of urban construction land is the purpose of delimiting urban development boundaries, and in the land use planning (2006–2020) and urban-rural planning (2010–2020) from top to bottom drawn up by the governments at different levels in China delineate the urban development boundaries according to their expectation for the economic and social development, natural endowment environment, and range of urban activities.

Overall, Existing studies mostly focus on the analysis of land use/cover change caused by urban development in a specific city or region. There is a lack of comparative studies on LUCC in the development process of different level cities, and the differences in influencing factors are unclear. As a result, the analysis of the effects of different economic and social development policies and resource-environmental utilization policies are not enough. Meanwhile, in the study of LUCC caused by urban development, the differences in the constraint effect of urban development boundaries of different level cities on them are rarely considered.

According to the urban administrative level system of municipality directly under the central government, sub-provincial city, prefecture-level city, county-level city, and county, study area was selected and classification of cities was performed; LUCC within urban development boundaries of cities at different level were calculated through the methods of descriptive statistical analysis and transition matrix analysis. Based on the influencing factor system constructed from economic development, social development, population, and environmental governance, the influencing factors of LUCC and the main types of LUCC were analyzed based on Pearson’s correlation coefficient and OLS regression (Figure 1).

2. Materials and methods

2.1. Study area and classification of cities

Hubei Province is located at the middle of China, which is with a total area of 185,900 km². It has 1 sub-provincial city, 12 prefecture-level
cities, and 4 county-level cities that are governed by the People’s Government of Hubei Province, namely: Wuhan, Huangshi, Shiyan, Yichang, Xiangyang, Ezhou, Jingmen, Xiaogan, Jingzhou, Guangzhou, Xianning, Suizhou, Enshi, Xiantao, Qianjiang, Tianmen, and Shennongjia Forest District; and has 60 counties that are governed by the People’s Government of the prefecture-level cities. Liking other provinces in China, according to Urban System Planning of Hubei Province (2003–2020), cities can be divided into central city, sub-central city, regional central city, and general city in Hubei. Therefore, combined with the administrative level and management subject of cities in Hubei Province, this paper selects the central city of Hubei Province: Wuhan; 5 sub-central cities such as Yichang and so on; 11 regional central cities such as Jingmen and so on; and 60 general cities such as Fangxian county and so on as the research units, and analyze LUCC and their influencing factors inside the UDBs of different level cities (Figure 2).

2.2. Methods

2.2.1. Descriptive statistical analysis

Descriptive statistical analysis is a basic method used to summarize and express the overall situation of a set of data and the influence among the data. Simple statistical values can enable us to clearly grasp the overall picture of the data, and fully understand and identify the concentration or dispersion of the data. Therefore, this paper uses the descriptive statistical variables including arithmetic average ("Aver"), maximum ("Max"), minimum ("Min"), and sum ("Sum") to measure the changes of different types of land use/cover change inside the UDBs of different level cities from 2006 to 2020.

2.2.2. Transition matrix analysis of land use/cover change

Land use/cover transfer matrix is a two-dimensional matrix based on the relationship between land use/cover change in the same area of different time phases. By analyzing the resulting of land use/cover transfer matrix, it is possible to obtain 2 temporal phases with different land classes transformed into each other, describing land classes that change in different types of land use/cover in different years, as well as the locations and areas. It reflects not only the above static data on the area of each land class at a fixed time in a fixed area, but also the richer transfer of area from each land class at the beginning and the transfer of area to each land class at the end. Therefore, transition matrix of land use/cover change is selected to analyze the land use/cover change from 2006 to 2020 inside the UDBs of different level cities of Hubei province, and Sankey diagrams of different level cities are drawn to show the results of transition matrix from 2006 to 2020.

2.2.3. Pearson’s correlation analysis

There may be a strong correlation among various types of LUCC and various influencing factors of LUCC, and the strength of the correlation needs quantiative verification. Based on the variable system of influencing factors on the LUCC and the area changes of different types of LUCC, Pearson’s correlation coefficient is introduced to calculate the possible correlation of each variable. Finally, the most representative variables are selected to depict the characteristics of LUCC and their influencing factors. Pearson’s correlation coefficient reflects the trend of the change of two linear data groups by dividing the covariance of two variables by the standard deviation of two variables. The specific formula of Pearson’s correlation coefficient is Eq. (1).

\[
r = \frac{\sum_{i=1}^{n} x_i y_i - \frac{\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n}}{\sqrt{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}}} \cdot \sqrt{\sum_{i=1}^{n} y_i^2 - \frac{\left(\sum_{i=1}^{n} y_i\right)^2}{n}}
\]

(1)

Figure 2. Study area and the classification system of cities.
2.2.4. OLS regression

Pearson’s correlation analysis can preliminarily determine the correlation variables and the degree of the correlation of the area changes of different types of LUCC and their possible influencing factors inside the UDBs of different level cities from 2006 to 2020. However, the influencing factors of cultivated land, water and construction land, which are closely related to human life, need to be measured by regression analysis. Therefore, this paper chose the model of OLS regression to analyze the influencing factors of cultivated land, water and construction land that are closely related to human life inside the UDBs of different level cities from 2006 to 2020. The specific formula is as Eq. (2).

\[ y_i = \alpha + \beta X_i + \epsilon_i \]  

Among them, \( y_i \) represents the area change of the main types of LUCC, \( X_i \) represents the main explanatory variables, and \( \epsilon_i \) represents the random error term.

2.3. Selection of influencing factors

Existing studies have shown that economic development, social development, and the growth of population significantly affects the structure of land use/cover (Li and Wang, 2016; Merlotto et al., 2012; Sun et al., 2016). Therefore, the possible influencing factors of LUCC inside the UDBs of different level cities are selected respectively from the perspectives of economic development and social development. On the other hand, the environmental governance in China is becoming more and more stringent, and has led to the changes of the scope and types of human activities, which may indirectly affect the changes in the LUCC, but existing research is rarely involved. Therefore, the indicator system of this paper includes the change of environmental governance (Table 1).

2.4. Data description

The data involved in this paper include vector data and statistical data. Vector data include the UDBs of different level cities in the planning from 2006 to 2020, the data of land use/cover in 2006 and 2020, and the data of environmental governance in 2006 and 2020. The UDBs of different level cities in the period from 2006 to 2020 come from Land Use Planning of Hubei Province (2006–2020); the data of LUCC in 2006 and 2020 are from Landsat-derived annual land cover product of China (CLUC) from 1985 to 2020, which collected the training samples by combining stable samples extracted from China’s Land-Use/Cover Datasets (CLUD), and were constructed via all available Landsat data and fed to the random forest classifier to obtain classification results (Yang and Huang, 2021); the data of environmental governance is from the China-High-Air-Pollutants (CHAP) dataset, which refers to the long-term, full-coverage, high-resolution, and high-quality near-surface air pollutants in China (Wei et al., 2019, 2021). The statistical data come from Hubei Statistical Yearbook (2006–2020) and China City Statistical Yearbook (2006–2020).

3. Results

3.1. LUCC in the UDBs of different level cities

3.1.1. Descriptive statistical analysis of LUCC

Based on the method of descriptive statistical analysis and classification system of Urban System Planning of Hubei Province, LUCC in the UDBs of different level cities in Hubei Province from 2006 to 2020 was measured. Wuhan is the unique central city of Hubei Province, and the value of the aver, the sum, the max, and the min of the area of different types of LUCC are the same separately. The area of cultivated land, water, wetland, forest, and unused land change within the UDB of the central city have been greatly reduced from 2006 to 2020, but the construction land and pasture land are increasing greatly from 2006 to 2020.

Hubei Province has 5 sub-central cities, the sum of the area of forest land, cultivated land, and wetland change within the UDBs of the sub-central city have decreased, and the sum of the area of other land use/cover change have increased. Except for construction land, the minimum values of other types of LUCC are negative, and except for wetland, the maximum values of other types of LUCC are positive. The aver of the area of forest land, cultivated land, and wetland change are negative, which show that the area of these types of LUCC in the sub-central cities have decreased; and the aver of the area of construction land, water, pasture land, and unused land change are positive, which show that the area of these types of LUCC have increased.

Hubei Province has 11 regional central cities, the sum of the change of the area of construction land and pasture land within the UDBs of 11 regional central cities have increased, and the sum of the area of other types of LUCC have decreased. The maximum values of all types of LUCC within the UDBs of 11 regional central cities are positive or zero. However, except for the change of the area of construction land, the minimum values of all types of LUCC are negative. On the other hand, and the aver of the change of the area of construction land and pasture land are positive, which show that these types of LUCC in the regional central cities have increased.

Within the UDBs of the 60 general cities, the sum of the area of construction land change is positive, and the sum of the area of all other types of LUCC are negative. The maximum of the area of all types of LUCC are positive. Except for the value of the minimum of construction land change is zero, the minimum of the area of all types of land use/cover change from 2006 to 2020 are negative. On the other hand, the aver of the change of the area of construction land is positive, and the aver of the area of all other types of land use/cover change are negative (Table 2).

3.1.2. Transition matrix analysis of LUCC

The results of transition matrix analysis of LUCC show that a large amount of cultivated land and water within the UDBs of central city of Hubei province from 2006 to 2020 have been converted into construction land, and some water has been converted into cultivated land. A large amount of forest land within the UDBs of the sub-central cities is converted into cultivated land and construction land from 2006 to 2020, and a large amount of cultivated land is converted into construction land at the same time. Within the UDBs of regional central cities, a large amount of cultivated land and forest land has been converted into construction land, while a large amount of forest land, wetland and part of construction land have been converted into cultivated land. Within the UDBs of general cities, a large amount of cultivated land and part of forest

| Classification                      | Variables                          | Unit             |
|------------------------------------|------------------------------------|------------------|
| Environmental governance           | NO₂                                | µg/m³/yr         |
|                                    | SO₂                                | µg/m³/yr         |
|                                    | PM₂.₅                              | µg/m³/yr         |
|                                    | PM₁₀                               | µg/m³/yr         |
|                                    | PM₁                               | µg/m³/yr         |
| Economic development               | Investment in fixed assets (IFA)   | (10,000 yuan)    |
|                                    | Gross domestic product of primary  | 10 billion yuan  |
|                                    | industry (GDPPI)                   |                  |
|                                    | Gross domestic product of secondary | 10 billion yuan  |
|                                    | industry (GDPSI)                   |                  |
|                                    | Gross domestic product of tertiary  | 10 billion yuan  |
|                                    | industry (GDPTI)                   |                  |
| Social development                 | The number of county and district (|                  |
|                                    | Population of permanent residents  | 10,000 people    |
|                                    | (PPR)                              |                  |
|                                    | Persons employed in urban units at  |                  |
|                                    | year-end (PEUUY)                   | person           |
|                                    | Local general public budget revenue| 10,000 yuan      |
land are converted into construction land, and a large amount of forest land, part of wetland and construction land are converted into cultivated land (Figure 3).

3.1.3. Restraint effects of the UDBs of different level cities

Based on the descriptive statistical analysis of LUCC, the analysis of the restraint effects of the UDBs of different level cities on the expansion of urban construction land is carried out. The results show that the construction land of different level of cities continues to sprawl within the planned UDBs from 2006 to 2020, and the proportion of the area of the construction land is increasing rapidly; the highest increase occurred at the level of general city, reaching 57.459%, and the least increase also occurred at the level of general city, the proportion of the area of the construction land is reduced by -1.181%. However, central city has the highest average of the D-value of the proportion of the area of construction land at different level cities, regional central city and general city have the similar average of the D-value of the proportion of the area of construction land, and sub-central city has the lowest average (Table 3).

3.2. Correlations of influencing factors and LUCC

Economic and social activities are carried out under the guidance of the government. Therefore, in the process of analyzing the influencing factors of LUCC, cities are classified according to the difference between the management subjects, namely cities that are governed by the People’s Government of Hubei Province (PGHP city) and cities that are governed by the People’s Government of the prefecture-level city (PGPL city). The results of Pearson’s correlation analysis show that change of the area of construction land, water, wetland and cultivated land are closely related to the change of GDPPI, GDPSI, GDPTI, NCD, PPR, PEUUY and LGPBR in the level of cities that are governed by PGHP city, and have significant characteristics of correlation. At the same time, there is correlation between the change of SO2 and change of the area of cultivated land and construction land, and the area of all types of LUCC have the least correlation with the indicators of environmental governance (Table 4).

The results of the Pearson’s correlation analysis at the level of cities that are governed by PGPL city are significantly different with the results of the Pearson’s correlation analysis at the level of cities that are governed by PGHP city. The change of construction land and most of the indicators of environmental governance, economic development and social development show significant characteristics of correlation. Changes of water, wetland and cultivated land and a small number of indicators of environmental governance, economic development and social development show significant correlations (Table 5).

3.3. Main types of LUCC and their influencing factors

Based on Pearson’s correlation analysis, this paper analyzes the influencing factors of the change of the three types of cultivated land, water and construction land from 2006 to 2020 in the UDBs that are more important to human life. At the same time, the research eliminates the influence of heteroscedasticity based on the method of Robust’s standard error regression.
R² of the regression model of the factors affecting the change of construction land at the level of PGHP city is 0.984, which means all influencing factors can explain 98.36% of the reasons for the change of construction land. When the F test is performed on the model, it is found that the model passes the F test (F = 1201.766, p = 0.000 < 0.05), which means that at least one of the influencing factors will have an impact on

![Figure 3. Sankey diagrams of land use/cover transition from 2006 to 2020 in the UDBs of different level cities of Hubei Province.](image)

| Table 3. Descriptive statistics of restraint effects inside the UDBs of different level cities. |
|---------------------------------------------------------------|-----------------------------------------------|
| The level of city Variables | Proportion of the area of construction land | D-value of the proportion of the area of construction land |
| | 2006 | 2020 | 2006 | 2020 |
| Central city-Sub-center city-Regional central city-General city | Max 36.910% | 70.554% | 33.643% | 37.989% | 88.909% | 50.929% | 24.926% | 70.538% | 54.635% | 36.768% | 79.538% | 57.459% |
| Min 36.910% | 70.554% | 33.643% | 4.736% | 15.132% | 8.557% | 5.234% | 26.928% | 11.953% | 0.298% | 1.841% | -1.181% |
| Aver 36.910% | 70.554% | 33.643% | 16.852% | 41.258% | 24.406% | 17.201% | 46.372% | 29.171% | 13.744% | 40.127% | 26.383% |
the regression coefficient of the change of construction land. The final specific analysis shows that: the regression coefficients of GDPP, GDPSI, GDPTI, NCD, PEUUY are -1.279, 6.474, -7.935, -0.506, 1.038, and they are significant at the level of 0.01. Therefore, GDPSI and PEUUY have a significant positive impact on the change of construction land, and GDPP, GDPTI, and NCD have a significant negative impact on the change of construction land. However, NO2, SO2, PM2.5, PM1, IFA, PPR, LGPBR do not affect the change of construction land.

From the perspective of the change of construction land within the UDBs of the level of PGHP city, the R2 of the regression model is 0.532, which means all influencing factors can explain 53.15% of the reasons for the change of construction land. When the F test is performed on the model, it is found that the model passes the F test (F = 7.358, p = 0.001 < 0.05), which means that at least one of influencing factors have an impact on the change of construction land. The final specific analysis shows that: the regression coefficients of NO2, SO2, is 0.484, -0.330, and they are significant at the level of 0.01, which shows that NO2 will have a significant positive impact on the change of construction land, and SO2 has a significant negative impact on the change of construction land.

R2 of the regression analysis of the change of cultivated land within the UDBs of the level of PGHP city is 0.911, which means all influencing factors can explain 91.09% of the reasons of the change of cultivated land. When the F test is performed on the model, it is found that the model passes the F test (F = 44.659, p = 0.001 < 0.05), which means that at least one of influencing factors affect the change of cultivated land. The summary analysis shows that SO2, GDPP, GDPTI, and NCD have a significant positive impact on the change of cultivated land, and GDPSI, LGPBR have a significant negative impact on the change of cultivated land. However, NO2, PM2.5, PM1, IFA, PPR, LGPBR do not affect the change of cultivated land.

From the perspective of the change of cultivated land within the UDBs of the level of PGPL city, the R2 of the regression model is 0.532, which means all influencing factors can explain 53.15% of the reasons for the change of construction land. When the F test is performed on the model, it is found that the model passes the F test (F = 7.358, p = 0.001 < 0.05), which means that at least one of influencing factors have an impact on the change of construction land. The final specific analysis shows that: the regression coefficients of NO2, SO2, is 0.484, -0.330, and they are significant at the level of 0.01, which shows that NO2 will have a significant positive impact on the change of construction land, and SO2 has a significant negative impact on the change of construction land.

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Table 6. Estimates of OLS regression model on LUCC and influencing factors inside the UDBs of different level cities.

| Different level cities | City level-coefficients | County level-coefficients |
|------------------------|-------------------------|---------------------------|
| Types of land use/cover | Construction land | Cultivated land | Water |
| NO2 | -0.082 (-0.681) | 0.484***(3.484) | 0.151 (0.451) | -0.172 (-1.393) | -0.083 (-0.607) | -0.192 (-1.028) |
| SO2 | 0.016 (0.221) | -0.330*** (-2.666) | 0.409** (2.096) | 0.210 (1.529) | 0.174** (2.657) | 0.039 (0.333) |
| PM2.5 | -0.071 (-0.482) | 0.007 (0.134) | 0.055 (0.220) | 0.082 (1.084) | -0.026 (-0.231) | 0.067 (0.627) |
| PM1 | 0.008 (0.088) | 0.202** (1.744) | 0.277 (1.360) | 0.179 (0.709) | 0.146 (1.323) | -0.039 (-0.281) |
| IFA | 0.178* (1.791) | 0.128 (0.764) | 0.335 (0.783) | 0.093 (0.576) | -0.028 (-0.180) | -0.417 (1.455) |
| GDPTI | -1.277** (-3.141) | 0.219 (0.764) | 2.313** (2.236) | -0.009 (0.050) | -0.472 (-0.979) | -0.639 (1.455) |
| GDPSI | 7.913*** (4.432) | -0.044 (0.994) | -9.699*** (-3.819) | 0.341 (0.612) | 4.169** (2.086) | -0.484 (-0.770) |
| NCD | -0.506*** (-3.496) | -0.119 (-0.568) | 1.277** (2.192) | -0.331 (-1.382) | -0.052 (-0.204) | 0.119 (0.391) |
| PPR | -0.240 (-0.436) | 0.334 (0.731) | 0.579 (0.572) | 0.602 (1.290) | 0.539 (0.997) | -0.479 (-0.624) |
| PEUUY | 1.038*** (5.152) | -0.175 (-0.475) | 0.090 (0.151) | -0.365 (-1.400) | 0.652*** (2.660) | 0.397 (0.736) |
| LGPBR | 3.084 (1.572) | -0.388 (-1.310) | -12.058** (-2.131) | -0.296 (-0.557) | -3.678* (-1.882) | 0.053 (0.023) |
| R² | 0.984 | 0.532 | 0.911 | 0.218 | 0.976 | 0.417 |
| Adj. R² | 0.934 | 0.38 | 0.644 | -0.035 | 0.903 | 0.228 |
| F-statistic | F (12,4) = 1201.766, p < 0.000 | F | F | F | F |
| D-W statistic | 2.181 | 1.804 | 2.299 | 1.995 | 2.452 | 2.700 |

* p < 0.1 ** p < 0.05 *** p < 0.01 **** p < 0.001 t statistics in parentheses

R² of the regression analysis of the change of water within the UDBs of the level of PGHP city is 0.976, which means that all influencing factors can explain 97.59% of the reasons of the change of water. When the F test is performed on the model, it is found that the overall level of the F test (F = 744.684, p = 0.000 < 0.05), which means that at least one of influencing factors have an impact on the change of water. The summary analysis shows that SO2, GDPSI, PEUUY have a significant impact on the change of water. However, NO2, PM2.5, PM1, IFA, GDPTI, NCD, PPR, PEUUY, LGPBR do not affect the change of water.

Conversion of cultivated land into construction land is a common feature in the development process of different level cities, which is consistent with the related research on the process of construction land (Acheampong et al., 2018; Estoque and Murayama, 2012; Yu et al., 2011). However, different from central cities and sub-central cities, there are more construction land and forest land converted into cultivated land in regional central cities and general cities, which shows that the country’s strict policy of “Cultivated Land Requisition-compensation Balance” is better implemented in the level of regional central cities and general cities, and it has slowed down the trend of continuous encroachment of cultivated land by construction land. Which should be pointed out that this is only the situation in the UDBs, and it should be more obvious in the urban region.

The cities with the best restraint effects of UDBs on the control of construction land expansion exist in the level of general city, and the cities with the worst restraint effects of UDBs on the control of construction land expansion also exist in the level of general city. However, based on the average, the restraint effects of UDBs on central cities, sub-central cities, regional central cities and general cities are similar. Therefore, in the process of formulating UDBs, it is necessary to strengthen the formulation and implementation of UDBs in some general cities.

There are huge differences between the influencing factors on LUCC inside the UDBs at the level of cities that are governed by the People’s Government of Hubei Province (PGHP city) and cities that are governed by the People’s Government of the prefecture-level city (PGPL city). At the level of cities that are governed by PGHP city, economic and social factors are more major types of LUCC such as construction land; but at the level of cities that are governed by PGPL city, the correlations between economic and social factors and most types of LUCC is small, and the influence of environmental governance factors on LUCC is increasing. The influence of economic and social factors on the expansion of urban construction land has been covered in previous studies (Liu et al., 2014; Reid et al., 2000), but it did not effectively identify the differences between different level of cities.

The results of OLS regression model indicated that change in construction land at the level of cities that are governed by PGHP city are significantly affected by factors such as the primary, secondary, and tertiary industries, but change in construction land at the level of cities that are governed by PGPL city are more significantly affected by the change of NO2, SO2. The change of cultivated land at the level of cities that are governed by PGHP city is significantly affected by factors such as...
the primary, secondary, and tertiary industries, but the change of cultivated land at the level of cities that are governed by PGPL city is not significantly affected by different factors. The water area is less affected by various factors at the level of cities that are governed by PGHP city and cities that are governed by PGPL city. This proves that there are huge differences in the factors affecting LUCC in different level cities.

5. Conclusions

Within the UDBs of different level cities, land use/cover is undergoing tremendous change from 2006 to 2020, and there are also huge differences in the conversion of different types of land use/cover in different level cities, and the reasons are the differentiated land use control policies of different level cities and the influence of the types of the original land use/cover. On the other hand, different level cities have the common characteristics that a large number of natural landscape land converted into construction land, and the restrictive role played by UDBs is very limited, which has also led to the continuous reduction of urban functional land and the increasing risk of urban functional imbalance, and the risks are more obvious at the level of central city and regional central city.

Economic and social factors are importantly related to major types of LUCC such as construction land at the level of PGPH city, the correlations between economic and social factors and most types of LUCC is small at the level of PGPL city. However, the influence of environmental governance on LUCC is increasing at the level of PGPL city, this shows that strictly environmental governance policies have had a significant impact on human activities in PGPL cities where the pressure of construction land expansion is relatively small. On the other hand, the formulation and implementation of UDBs should take the statistical characteristics of land use/cover change within the UDBs at different level cities over time into account.

Declarations

Author contribution statement

Hongwei Zhang: Conceived and designed the experiments; Wrote the paper.
Zhanqi Wang: Performed the experiments; Analyzed and interpreted the data.
Ji Chai: Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest’s statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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