IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS)
ISSN (P): 2347–4580; ISSN (E): 2321–8851
Vol. 10, Issue 8, Aug 2022, 25–40

THE ANALYSIS ON ENVIRONMENTAL EFFECTS OF LAND USE AND LAND COVER CHANGE IN LIUXI RIVER BASIN OF GUANGZHOU

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Received: 08 Aug 2022 **Accepted:** 12 Aug 2022 **Published:** 13 Aug 2022

ABSTRACT

This study aims to realize that the relationship between Land Use/ Cover Change (LUCC), human activities, and natural environment in Liuxi River Basin, thus the causes of current ecological problems are analyzed. In this paper, hence, the Landsat 8 Remote Sensing (RS) images of Guangzhou from 2013 to 2021 were collected and processed, then the LUCC maps of 2013, 2019 and 2021 were obtained. Based on the above purpose, the Land Use Transfer Matrix (LUTM) and Land Use Degree Analysis (LUDA) were used for analysis. Final, studies have shown that LUCC in the basin changed significantly from 2013 to 2021, specifically, the construction land increased significantly, with an increase of 7.16 %. LUCC not only changed the natural landscape of the basin, but also affected the four environmental factors, specifically in the atmosphere, water, soil and biology. Based on the analysis this study can provide a reference for the ecological environmental protection of the Liuxi River Basin.

KEYWORDS: *Liuxi River Basin; Land Use/Cover Change (LUCC); Land Use Transfer Matrix (LUTM); Environmental Effect; Guangzhou*

INTRODUCTION

With the continuous expansion and deepening of human activities, nature is undergoing significant changes. The people and natural environment are coexisting, a part of the change in nature will bring the corresponding changes to human production and life, and this two-way impact has both advantages and disadvantages. Generally, this kind of environmental impact and change caused by human activities is called Environmental Effect, which has both positive and negative effects. According to the formation reason, it can be divided into natural environmental effects, environmental chemical effects and environmental physical effects. Most of them have comprehensive effects. For example, a large amount of industrial wastewater directly discharged into rivers, lakes and oceans can change the physical, chemical and biological conditions of the water, cause changes in the species and population of aquatic organisms, and have an impact on human beings.

In order to further realize this relationship of interest and how to better transform nature to serve the human itself, hence Land Use/Cover Change (LUCC) research arises at the historic moment is an important realms of global change research (Yu and Yang, 2002; Liu et al.,2009; Sodango et al., 2017), it is also increasingly becoming a hotspot issue. Since the 1990s, LUCC research has been paid more and more attention, and it has become an important project of environmental change research (Li, 1996). Due to LUCC having a significant impact on the global environment, human beings through the transformation of the earth's surface, not only is causing the local and domestic environmental change, but even involving the whole world.

In terms of LUCC research, foreign countries started earlier than China, such as Sweden's monitoring of desertification and vegetation in Africa, the project has carried out long-term research since 1972 (Shi, 2012). In1995, the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) jointly proposed “Land-Use and Land-Cover Change (LUCC)” research plan (Turner II et al., 1995). After 30 years of development, LUCC research has made remarkable achievements.

In China, the main research directions of LUCC can be roughly divided into the following categories: Firstly, it is to analyze the LUCC of the watershed, that is, by studying the land use in a certain period of time and analyzing its changes. Secondly, it is to analyze the driving factors of the change based on the LUCC of the watershed. Thirdly, it is to analyze the environmental effect of one side caused by the change of land use/erosion in the watershed. In summary, despite the rapid development of LUCC research, and in the above aspects have made remarkable achievements, but for now, for a watershed land use/cover change analysis, and further study of its overall environmental effect is still relatively rare. Meanwhile, some achievements have been made in the research on the ecological environment change caused by urban LUCC, and the research mainly focuses on the regional and local scales (Lu et al., 2006).

Guangzhou is one of the most economically developed and the fastest urbanized cities in Guangdong Province. The Liuxi River runs through Guangzhou and is the primary river of Guangzhou. However, there is little research on the river and its adjacent areas. Thus, the study is helpful to analyze the reasons for the thorny problems such as the deterioration of water quality and the reduction of biodiversity in recent years, and guiding the direction for the construction of green cities in Guangzhou.

In recent years, with the continuous development of urbanization in Guangzhou City, the urban population has surged, and the industrial scale of both sides of the river basin has also been expanding. The form of people changing the earth's surface is becoming more and more diversified, and the changing depth is further increased. For instance, the water quality of the Liuxi River Basin is deteriorating, the river discharge capacity is reduced, and the biodiversity is damaged. Thus, a series of ecological and environmental problems such as agricultural non-point source pollution hinders the healthy development of the city (Zhang, 2018). Thus, this study by studying the LUCC in Liuxi River Basin, the spatial change of land use in the basin is revealed, and a series of impacts on various aspects of regional development are analyzed. Meanwhile, the relationship between LUCC and the interaction and restriction of ecological environment is also analyzed (Du et al., 2011). The effect of land use on four environmental factors, including atmosphere, water, soil and biologyis studied, in order to construct the mechanism of land use on ecological environment and provide a theoretical basis for the future planning and development of cities.

The significance of this study lies in as fellows, firstly, Liuxi River is the Pearl River Delta river network, abundant in water resources, that plays an important role in coastal regional economic development, which is one of the important drinking water sources in Guangzhou City. The study of LUCC in Liuxi River Basin is helpful to reveal the thorny ecological problems and Environmental Effects such as water pollution and biodiversity reduction in rivers in recent years, and provide direction guidance for solving these problems and better guarantee the safety of drinking water sources. Meanwhile, the current research on Liuxi River is scarce, and the updated data is not in time. Also, this study is helpful to fill the gaps in the study of land use change and its Environmental Effects in Liuxi River Basin of Guangzhou City, and to enrich and update the research database of LUCC in Guangzhou City. Secondly, through the analysis of LUCC data, the trend of land use in Liuxi River Basin in the future can be further predicted by establishing a model, which provides a

reference for the future planning and management of the basin, and promotes the sustainable development of Guangzhou's economy and ecology while realizing the harmonious coexistence between man and nature.

STUDY AREA

Liuxi River Basin is located in the north of Guangzhou, covering Conghua District, Huadu District and Baiyun District. The Liuxi River is one of the North River tributaries of the Pearl River. It originates from the Guifeng Mountain to the Dalingtou area at the junction of Lutian Town and Longmen County in Conghua District. Its main stream passes through the Pearl River Delta river network and finally enters the South China Sea. Liuxi River is the first river developed and utilized in Guangzhou, and it is also an important drinking water source protection area and green barrier in the city, shown as Figure 1 and Figure 2.

The river basin ranges from 23° 12 ′ 30 ″ ~23° 57 ′ 36 ″ N, 113° 10 ′ 12 ″~114° 2 ′ 00 ″ E. The river is 156 km long and covers an area of 2300 km^2, accounting for 80.2 % of the total land area in Guangzhou. The whole basin presents a narrow shape in the northeast-southwest direction. The terrain is high in northeast and low in southwest, and the fluctuation is large. The Liuxi River flows through Guangzhou from north to south. The main tributaries of Liuxi River pass through three administrative districts including Conghua, Huadu and Baiyun,which flows through 15 townships in Guangzhou with about 300,000 people in the basin.

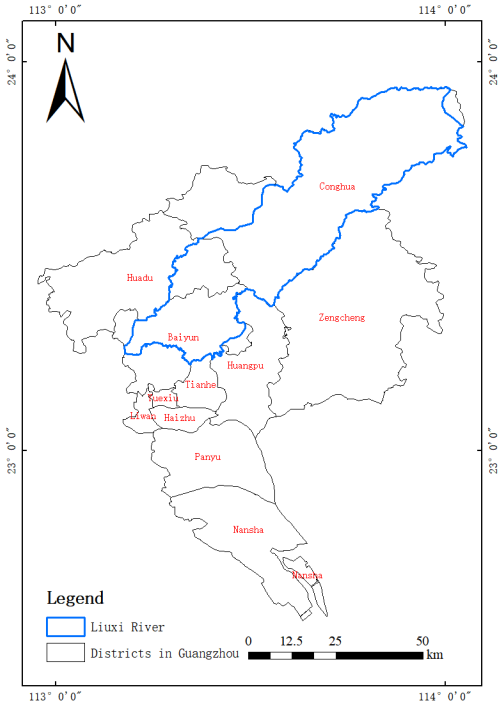


Figure 1. The Distribution area of Liuxi River Basin in Guangzhou.

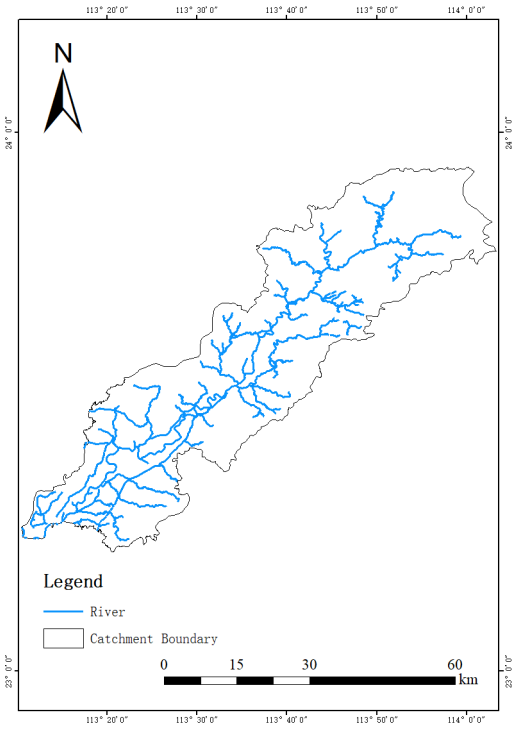


Figure 2.The water distribution map of Liuxi River Basin.

METHODOLOGY

Data Source and Processing

In this study, the Remote Sensing (RS) and Geographic Information System (GIS) technology is used (Wang et al., 2022) for the analysis pre-processing. Thus, the land use data of Liuxi River Basin in Guangzhou City from 2013 to 2021 that is

using the RS image data, and which is derived from the Geospatial Data Cloud(GDC) platform (http://www.gscloud.cn/). The data collected is mainly the original RS images of Landsat 8 in Guangzhou City from 2013 to 2021, including the data of 2013, 2019 and 2021. The township administrative division data of Guangdong Province is obtained from the Gaode vector data, and the data year is 2015. The classification standard of land use is based on the standard of the Chinese Academy of Sciences (CAS), which is divided into six types of land use, namely forests, grassland, cultivated land, water, construction and unused land.

In addition, the data of population, social economy and climate factors in Guangzhou are derived from the statistical data of Guangzhou Statistics Bureau (SONBSG, 2020), as well as the statistical data of Conghua District, Baiyun District and Huadu District in the basin over the years, including the concentration of common pollutants, atmospheric environment-related indicators, monthly average temperature (°C), city (urban section) water supply, industrial solid waste and other data. The intensity of urban heat island originates from the "Guangzhou Urban Heat Island Monitoring Bulletin 2021" issued by Guangzhou Municipal Meteorological Bureau (GMMB), the data of water quality and soil pollution are derived from the environmental bulletin of Guangzhou Municipal Ecological Environment Bureau (GMEEB) in 2021 and the list of key monitoring units of soil pollution in 2021.

By collecting the RS image data of Landsat 8 in Guangzhou from 2013 to 2021 in 2013, 2019 and 2021, ENVI 5.3 software and ArcGIS 10.1 software were used to analyze the land use situation, and then the LUTM method and LUDA method were used to analyze the transformation of land use types and the change of utilization degree in the basin. On this basis, through literature comparative analysis, combined with the actual Liuxi River Basin, the impact of LUCC on four environmental factors of atmospheric, water, soil and biological in the basin and its surrounding areas is analyzed, and then the conclusion is drawn. The processing framework of this study is shown in Figure 3.

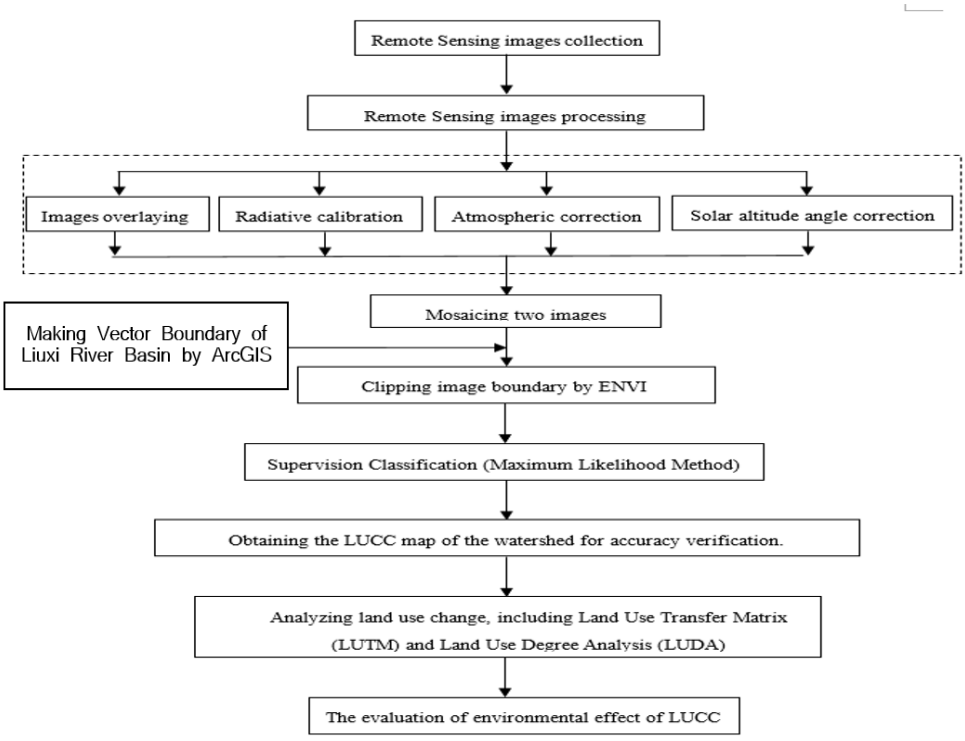


Figure 3: The Framework of this Study.

Theoretical Basis

Land Use and Land Cover Change (LUCC)

Since the 1990s, LUCC research has been paid more and more attention, and it is an important project for environmental change research (Li, 1996). Land cover refers to vegetation on the surface and artificial buildings, such as woodland, housing, bare ground, etc., which belong to one of the specific forms of land cover (FAO, 1994).Land use includes the purpose of changing the way of land use and producing this way of use (Turner II et al., 1995), such as animal husbandry, returning farmland to forest and so on. Thus, LUCC has an important impact on the global environment. Land use reflects the active role of human transformation of nature. Land cover is the result of land use, and its change leads to global environmental problems.

Environmental Effect

The earliest study on the relationship between LUCC and the environment was in 1865. Marsh and Lowenthal (1965) systematically expounded the relationship between land use and ecological environment in the book “Man and Nature”. Which refers to the LUCC affects environmental factors in the region such as atmosphere, water, soil, and biology. There is a complex relationship between these factors, and their cumulative effect can lead to corresponding changes in the ecosystem (Lu et al., 2006).

Land Use Transfer Matrix (LUTM)

The LUTM (Liuand Zhu, 2010; Lu and Wang, 2022; Chen and Wang, 2022; Liu and Wang, 2022) is a specific way of using Markov model in land use change. By using this model, it is helpful to quantitatively analyze the land use transformation in the region and the transformation of different types of land use. The expression form is shown as Table 1.

Table 1: Land Use Transfer Matrix (LUTM)

		T_2						
		A_1	**A_2**	**...**	**A_i**	**...**	**A_n**	
T_1	A_1	—	S_{12}	...	S_{1i}	...	S_{1n}	S_1
	A_2	S_{21}	—	...	S_{2i}	...	S_{2n}	S_2
	...	...	...	...	...	...	...	...
	A_j	S_{j1}	S_{j2}	...	S_{ji}	...	S_{jn}	S_j
	...	...	...	...	...	...	...	...
	A_n	S_{nl}	S_{n2}	...	S_{ml}	...	—	S_n
		S_1	S_2	...	S_i	...	S_n	S_T

The row represents the land use type in T_1 period, and the column represents the land use type in T_2. In the above table, A_i and A_j represent different land types, S_{ji} represents the area of land type J transformed into land type i, S_i represents the area of land type A_i transformed from T_1 to T_2, S_j represents the area of land type A_j transformed from T_1 to T_2, and S generally represents all land types that have been transformed. This method can quantitatively analyze the transfer state of land use and reflect the temporal and spatial change process of LUCC (Wu et al., 2014).The mathematical expression is:

$$S_{ij} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ S_{n1} & S_{n2} & \cdots & S_{nn} \end{bmatrix} \quad (1)$$

Land Use Degree Analysis (LUDA)

The comprehensive intensity index of land use (Zhuang and Liu, 1997; Liu and Wang, 2022) can reflect the land use degree of people in a region, which can be manifested in two aspects: breadth and depth. This paper will use this method to analyze the degree of land use change in Liuxi River Basin. Referring to the research results of scholars, six first-class land types can be divided into four land use levels. Among them, the index of unused land is 1, the index of grassland, forest land and water area is 2, the index of cultivated land is 3, and the index of construction land is 4. Its mathematical expression is:

$$L = 100 \times \sum_{i=1}^{n} B_i \times D_i \quad L \in [100,\ 400] \tag{2}$$

In the formula, L represents the comprehensive degree index of land use in the study area, the higher the value of L is, the greater the intensity is. B_i represents the classification index of the i-level land class in the region, D_i represents the percentage of the area corresponding to the i-level land class, and n represents the fractional order.

ANALYSIS AND RESULT

Analysis of Land Use Change Characteristics in Liuxi River Basin

According to the division of the upper, middle and lower reaches of Liuxi River Basin, it can be seen from Figure 4 that from 2013 to 2021, the LUCC of Liuxi River Basin in Guangzhou City changed significantly. On the whole, the area of water, forests land and cultivated land decreased, the area of grassland decreased to a certain extent, and the unused land showed a stable state of change. While the urban construction land increased significantly, it was mainly concentrated in the middle and lower reaches of the basin. Indicating that the human development activities of forest vegetation in the upper reaches were less, and the appropriate development and utilization activities were mainly based on natural ecological protection. The middle reaches are affected by the development of urbanization in urban areas, the increase of population and the increase of land demand, and the land use shows obvious changes in construction land. As a concentrated area of human activities, the lower reaches of the river have early human activities. With the advancement of industrialization, human beings have deeper transformation of the underlying surface of the surface.

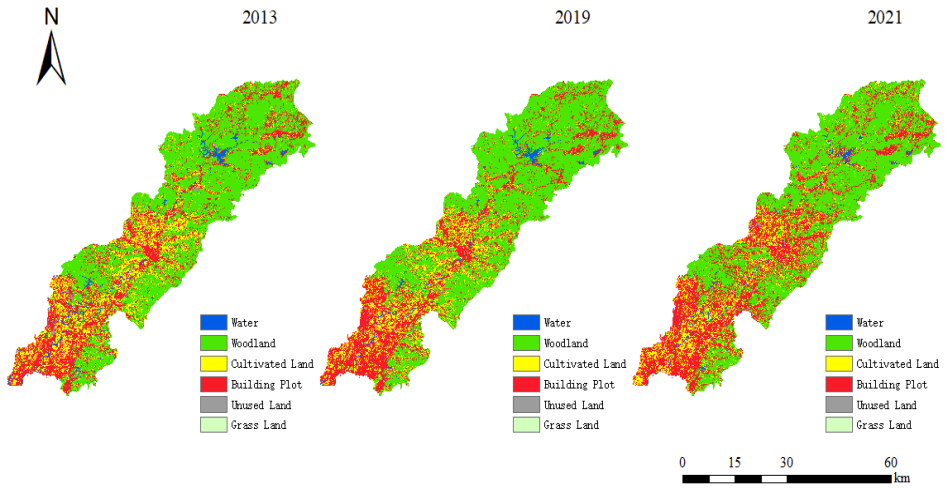


Figure 4: Land Use Map of Liuxi River Basin in 2013, 2019 and 2021.

Transformation of Land Use Types

In this paper, the LUCC map and change data of Liuxi River Basin are processed by ENVI 5.3 software, and the data of different years are processed by ArcGIS 10.1software. The transfer of land use types in each year of the basin is obtained, and then the area of each conversion is calculated. Further data collation is carried out to obtain the LUTM of Liuxi River Basin in Guangzhou from 2013 to 2019 and from 2019 to 2021, respectively, as shown in Table 2 and Table 3.

On the whole, since 2013, the water area, cultivated land and grassland area in Liuxi River Basin have decreased, and these land types are mainly transferred to construction land, forests and unused land. Among them, the area transferred to construction land is the largest, which can reflect the increase of land demand for urban development to a certain extent.

From 2013 to 2021, the construction of land in the basin increased significantly. The reason is that transfer from a large number of cultivated land and forests land, as well as some water and unused land. The transfer area of these land types from 2013 to 2019 was 90.75 km^2, 59.62 km^2, 13.38 km^2 and 19.32 km^2, respectively. The transfer area from 2019 to 2021 was 126.5 km^2, 134.36 km^2, 4.05 km^2 and 12.49 km^2, respectively.

Table 2: LUTM of the Basin from 2013 to 2019 (Unit: km^2)

Year	Land Type	2019						
		Grass Land	Cultivated Land	Construction	Forests	Water	Unused Land	Total
2013	Grass Land	0.04	0.12	0.52	0.00	0.31	0.02	1.00
	Cultivated Land	0.03	163.02	90.75	77.20	0.23	4.15	335.38
	Construction	0.18	64.57	408.15	79.85	2.79	10.48	566.01
	Forests	0.01	46.14	59.62	1147.51	0.22	4.15	1257.64
	Water	0.08	1.71	13.38	3.58	32.71	0.48	51.93
	Unused Land	0.00	1.27	19.32	0.47	0.05	2.77	23.88
	Total	0.30	113.69	591.73	1308.60	36.30	22.04	2235.84

Table 3: LUTM of the Basin from 2019 to 2021 (Unit: km^2)

Year	Land Type	2021						
		Grass Land	Cultivated Land	Construction	Forests	Water	Unused Land	Total
2019	Grass Land	0.00	0.23	0.11	0.00	0.00	0.01	0.34
	Cultivated Land	0.08	114.50	126.5	30.65	0.06	4.97	276.76
	Construction	0.09	103.04	448.43	24.74	1.26	13.83	591.40
	Forests	0.00	42.86	134.36	1127.39	0.15	3.34	1308.10
	Water	0.01	8.86	4.05	0.28	22.91	0.18	36.29
	Unused Land	0.00	2.75	12.49	0.11	0.05	6.64	22.03
	Total	0.19	272.23	725.93	1183.17	24.43	28.96	2234.91

Analysis of Land Use Intensity

By using the land use data of Liuxi River Basin in Guangzhou and the vector boundary of the intercepted villages and towns in the basin, ArcGIS 10.1 was used to process the data. According to the four land use levels (the index of unused land is 1, the index of grassland, forests and water area is 2, the index of cultivated land is 3, and the index of construction land is 4), the comprehensive intensity index of land use in each village and town was calculated by using the calculation formula, and then the map was producing, shown as Figure 5.

It can be seen from the comprehensive intensity distribution map that whether in 2013, 2019 or 2021, the land use intensity of Liuxi River Basin in Guangzhou was low in the upper reaches, medium in the middle reaches, and showed an increasing trend. The utilization of the lower reaches was the highest, and the intensity index was higher than that in 2013 and 2019. In Figure 5, it can be observed that the comprehensive utilization intensity of the upper reaches in 2013 and 2019 is more prominent than that in the corresponding years, mainly due to the increase of human activities, such as the increase of residential areas and the implementation of river development and construction projects, which makes the comprehensive intensity index of land use of some areas in the upper reaches of the two years higher.

From the specific values, in 2013, the average comprehensive strength index of the upstream region was 232.06, that of the middle region was 277.79, and that of the downstream region was 314.89. In 2019, the average comprehensive strength index of the upstream region was 229.71, that of the middle region was 272.62, and that of the downstream region was 326.86. In 2021, the average comprehensive strength index was 237.72 in the upper reaches, 291.75 in the middle reaches and 327.54 in the lower reaches. It can be speculated that the land use intensity in the next few years will continue to be basically stable in the upper reaches, rapid growth in the middle reaches, stable development in the lower reaches, and deepening intensity and high index value.

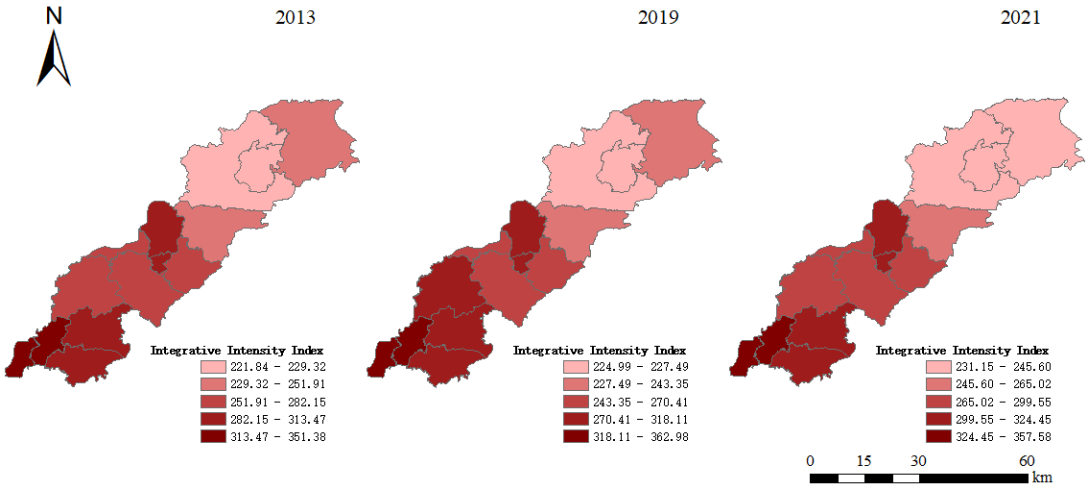


Figure 5: Distribution Map of Comprehensive Land Use Intensity of Watershed from 2013 to 2021.

Analysis of Environmental Effects of LUCC in Watershed

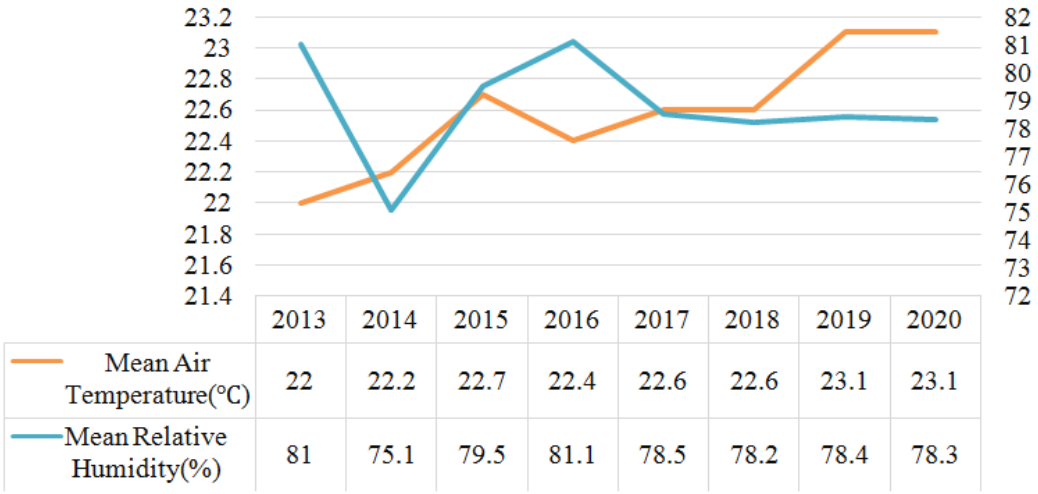
Through the analysis of land use in Liuxi River Basin, it can be seen that in the short eight years from 2013 to 2021, land use in the basin has changed significantly. From the perspective of the whole environmental system, the land use of the watershed and the land cover change caused by it will not only bring significant indigenous changes to the natural surface environment, but also affect the land productivity and people's daily working and living conditions in the region. Human production and living activities will also affect the watershed LUCC and constitute its driving factors, which constitutes a complete LUCC Environmental Effect mechanism (Wan et al., 2017). Based on the four environmental factors of atmosphere, water, soil and biology, this paper analyzes the Environmental Effects caused by LUCC in Liuxi River Basin of Guangzhou.

The Environmental Effects of LUCC on the atmosphere in Liuxi River Basin are described as follows. Firstly, in the regional climate change, according to the data collected by Guangzhou Statistics Bureau (SONBSG,2020), with the " ambient air quality standard " (GB3095 - 2012) as the standard, the single factor index method is used to evaluate the four indicators including SO_2, NO_2, inhalable particles and PM2.5, shown as Table 4. The results showed that the single factor index of each common pollutant decreased year by year from 2013 to 2020, and the concentration of SO_2 reached the first-level standard since 2014. The single factor index value was lower than 1, indicating that the pollutant did not exceed the standard. The first-level standard of NO_2 was not exceeded for the first time in 2020. The concentration of inhalable particles remained below the second-level standard since 2014, and the single factor index value decreased year by year, but there was still a certain distance from the first-level standard. This overall reflected that the air environment in Guangzhou was generally improving, but it was worth noting that the concentration of PM2.5 had not yet reached the second-level standard. Therefore, attention must be paid to improving air quality in the future.

Table 4: Single Factor Index of Common Pollutant Concentrations

Year	Index			
	SO_2	NO_2	Inhalable Particles	PM2.5
2013	1.00	1.30	1.03	1.51
2014	0.85	1.20	0.96	1.40
2015	0.65	1.18	0.84	1.11
2016	0.60	1.15	0.80	1.60
2017	0.60	1.30	0.80	1.60
2018	0.50	1.25	0.77	1.54
2019	0.35	1.13	0.76	1.51
2020	0.35	0.90	0.61	1.23

Secondly, in terms of Urban Heat Island Effect, combined with LUCC in Liuxi River Basin from 2013 to 2021, the urban construction land in the basin increased significantly, while the water area, forest land and cultivated land that can improve the microclimate decreased relatively, making the temperature in densely populated and building concentrated areas higher than that in suburbs. According to the monthly average temperature report of Guangzhou Statistics Bureau from 2013 to 2020 (SONBSG, 2020), shown as Figure 6, the monthly average temperature of Guangzhou shows a relatively obvious upward trend, especially the change of urban area. Both reflect the temperature change of Guangzhou, which is consistent with its urbanization process. According to the "Guangzhou City Heat Island Monitoring Bulletin 2021" issued by the Guangzhou Meteorological Bureau, the urban heat island intensity of Guangzhou in 2021 was 1.3 °C, which was 0.2 °C higher than last year. In terms of spatial distribution, the western Baiyun District, the central and southern Huadu District and the central Conghua District were rated as areas with strong heat island intensity.



	2013	2014	2015	2016	2017	2018	2019	2020
Mean Air Temperature(°C)	22	22.2	22.7	22.4	22.6	22.6	23.1	23.1
Mean Relative Humidity(%)	81	75.1	79.5	81.1	78.5	78.2	78.4	78.3

Figure 6: Average Temperature (°C) and Relative Humidity (%) in Guangzhou from 2013 to 2020.

The Environmental Effects of LUCC on the water body in Liuxi River Basin are shown as follows. Firstly, in terms of water area change, combined with the LUCC in Liuxi River Basin from 2013 to 2021, it can be seen that the water area within the basin shows a downward trend. The main reason is that more water land use types are transferred to construction land, which is closely related to human activities. According to the statistical data of Guangzhou Statistics Bureau (SONBSG, 2020), shown as Figure 7, during the eight years from 2013 to 2021, the urban water supply in Guangzhou showed a trend of substantial increase year by year, and the growth rate was amazing. It is preliminarily expected that the water consumption of the city will reach a higher value in the future. Due to urban development promoting the increase of water demand in all walks of life in people's lives and industrial production activities. While increasing the pressure of urban water supply and water production, it also reduces the amount of water in river basins.

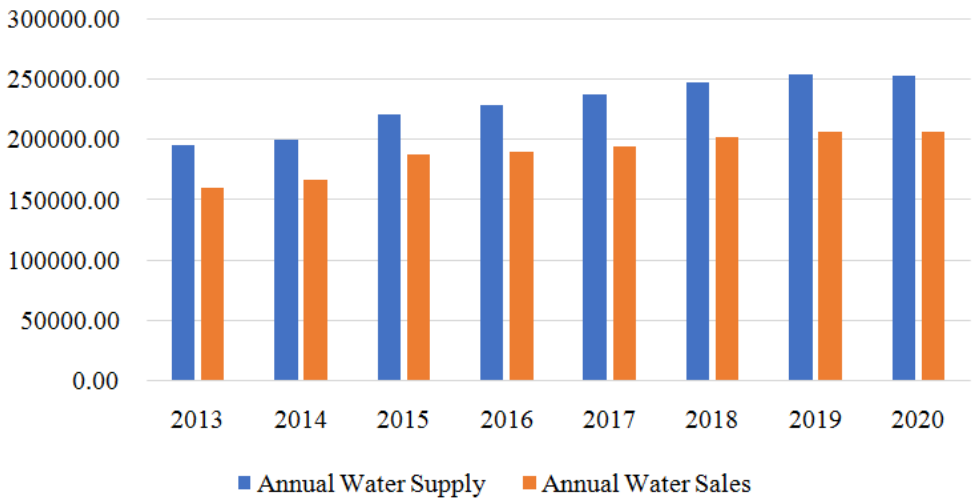


Figure 7: Urban Water Supply in Guangzhou from 2013 to 2020 (Unit: 10000 m^3).

Secondly, on the impact of water quality, Liuxi River Basin in 2013 - 2021 LUCC shows that urban construction land continues to increase, along with the reduction of water quantity in Liuxi River Basin, hence increasing human activities have a certain impact on the water quality of the river. According to the Environmental Quality Bulletin of 2021 issued by GMEEB, although the data show that since 2011, the water quality of urban centralized drinking water sources in Guangzhou has reached the standard rate of 100 %. Nevertheless, the water quality of the main rivers on the surface shows

that class II water quality accounts for 42.8 %, class III water quality accounts for 37.5 %, and class IV water quality accounts for 18.7 %. Class II water quality has decreased, and the water quality of the upper reaches of the Liuxi River is better. Meanwhile, the middle reaches of the Liuxi River show slight pollution to some improvement. The water quality of the upper and middle reaches of the Liuxi River is evaluated as excellent, and the water quality of the downstream reaches such as Bainihekou is still polluted. According to the existing research results, specifically, the water pollution degree in the upper reaches of Liuxi River Basin is low, and the water pollution degree in the middle and lower reaches is high (Jia et al., 2018).

The Environmental Effects of LUCC on soil in Liuxi River Basin are shown as follows. Firstly, in terms of soil pollution, combined with the LUCC in Liuxi River Basin from 2013 to 2021, it shows that with the deepening of human activities and the expansion of urban land demand, the area of cultivated land, water area and forest land has decreased. From the GMEEB, it is known that the list of key monitoring units of soil pollution in Guangzhou in 2021 (including 29 companies), Baiyun District accounted for 5 companies, Huadu District accounted for 5 companies, and Conghua District accounted for 4 companies. The main business products of these companies are chemical industry, cement, environmental protection energy, automobile accessories, leather, and hardware and so on. These companies in the range of Liuxi River Basin accounted for nearly half, and the situation is worrying. The data obtained from Guangzhou Statistics Bureau (2000) show that the production of general industrial solid waste in Guangzhou from 2013 to 2021 shows a downward and then upward trend, while the overall utilization rate is relatively stable. Except for 81.10 % in 2018, the other years are all above 94 %, as shown in Figure 8. In terms of the production of hazardous waste, the overall performance is a steady growth state, shown as Figure 9, related research (Dankoub et al., 2012) shows that human activities have increased the accumulation of heavy metals in soil. Therefore, Guangzhou needs to continue to improve the ability of solid waste treatment and comprehensive utilization, in order to better cope with the increasing industrial emissions in the future.

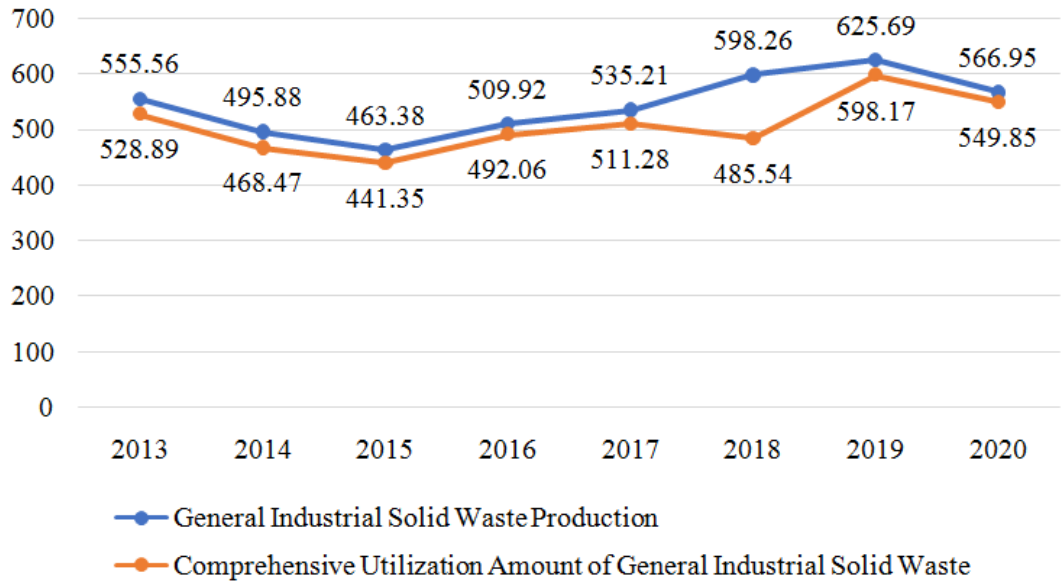


Figure 8: General Solid Waste Production and Comprehensive Utilization in Guangzhou from 2013 to 2020 (Unit: 10000t).

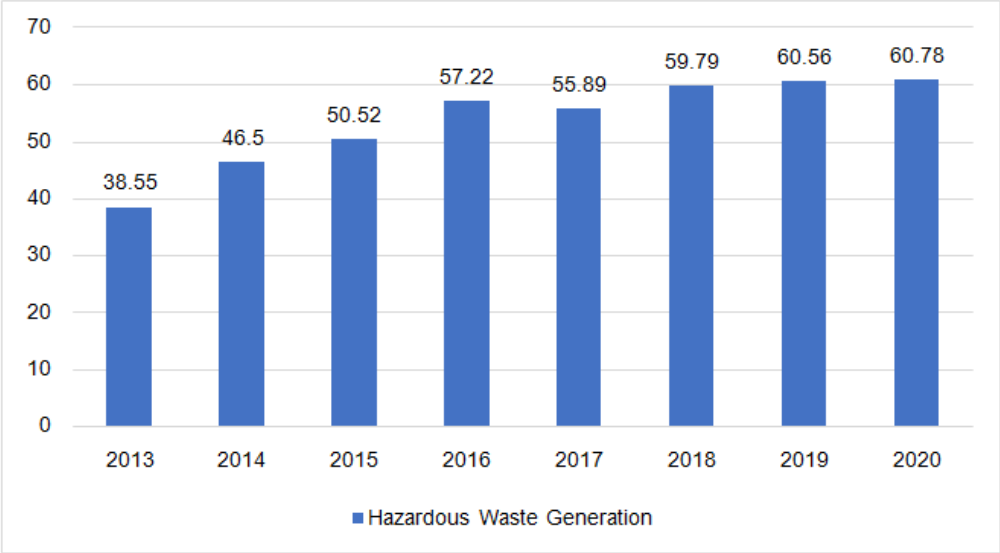


Figure 9: Production of Hazardous Waste in Guangzhou from 2013 to 2020 (Unit: 10000t).

Secondly, in terms of soil degradation, the LUCC of Liuxi River Basin from 2013 to 2021 shows that the area of cultivated land and forest land shows a downward trend, while the increasing and intensive artificial buildings may make the soil erosion within the basin more serious. Liuxi River Basin is located in the humid region of southern China, especially in the upper and middle reaches. The mountainous and hilly areas are wide, while most of the mountains belong to relatively barren latosol with a thin soil layer. In the season of concentrated rainfall, the surface soil is easy to lose with water, thereby aggravating or causing soil degradation (Shi et al., 2000). Soil degradation refers to the decrease of land quality, which is manifested in the decrease of agricultural production or the decrease of agricultural product quality. The direct reason for soil degradation is the loss of surface soil, the reduction of soil quantity, quality and ecological function. Facts have proved that among the factors that cause soil degradation, the human factor is the most obvious and main one. Human production and living activities continue to exert pressure on land, so that the fragile ecological environment is destroyed, and then adverse changes occur.

The Environmental Effect of LUCC on organisms in Liuxi River Basin is manifested in the following aspects. The change of land use / grassland directly affects the natural appearance of the regional surface, which will have a corresponding impact on the survival and reproduction of organisms in the region. On the one hand, with the expansion of urban land use, humans occupy and transform a large number of original natural surfaces, making the biodiversity and richness of regions with intensive human activities less than those with sparse human activities, and unreasonable land use patterns have a serious adverse impact on biodiversity (Li, 2007). On the other hand, human activities have an impact on the transformation of habitats and the environment. Its cumulative effect not only makes the regional natural landscape change significantly, but also affects the structure and function of the ecosystem.

Combined with the LUCC situation of Liuxi River Basin from 2013 to 2021, it can be seen that with the progress of human science and technology, the ability to transform nature has been continuously improved, and artificial buildings continue to expand outward, making many organisms dependent on the natural ecological environment move to a more suitable living space far from human beings, reducing the regional biodiversity and species richness. Among them, Liuxihe National Forest Park is worthy of attention, that total area of the park is 8813km^2, which has rich animals and plant resources, and the coverage rate of forests is 86 % (Fu, 2006). It integrates ecotourism, sightseeing, scientific research,

popular science education and other functions, and provides 60% of drinking water for Guangzhou. Therefore, we should adhere to the policy of "giving priority to protection and supplemented by development ", make rational use of and give full play to its maximum ecological function, and maintain a good habitat for organisms in the basin.

CONCLUSION

In general, this study's analysis result indicated that the LUCC of Liuxi River Basin changed significantly from 2013 to 2021. On the whole, the water area, forest land and cultivated land is decreased, and the grassland area also decreased to a certain extent. The unused land showed a stable state of change, while the urban construction land increased significantly and was mainly concentrated in the middle and lower reaches of the basin. Meanwhile, the intensity of land use in the study period was low in the upper reaches, medium in the middle reaches, and showed an increasing trend. The utilization in the lower reaches was the highest, and the intensity index was high. The main reason was that the breadth and depth of human activities were more obvious in the lower reaches.

In terms of the Environmental Effects of LUCC in the watershed, LUCC has a profound impact on the four environmental factors of atmosphere, water, soil and biology in the watershed. It can be divided into the following four aspects:

- In the aspect of atmosphere, it mainly displays in causing regional climate change, changing the chemical composition and concentration of the atmosphere, causing regional air pollution and urban heat island effect.
- In terms of water, mainly in two aspects of water quantity and water quality, one is the increasing demand for water intensifies the pressure of river water supply; second, surface pollutants enter the river through the water cycle, thereby affecting the river water quality.
- In terms of soil, it mainly causes soil pollution and soil degradation. Human activities aggravate the accumulation of heavy metals in soil, which is easy to cause soil pollution. The increasing number and density of artificial buildings may make soil erosion more serious in the basin.
- In terms of biology, it mainly adversely changes biodiversity and species richness, and affects the ecosystem.

Overall, this paper is of great significance to the analysis of the complex relationship between LUCC and environment, and there is still much research and development space for this topic. The study of LUCC and its Environmental Effects is of constructive significance for guiding more scientific urban planning and urban sustainable development.

ACKNOWLEDGEMENTS

The author is grateful for the research grants given to Ruei-Yuan Wang from GDUPT Talents Recruitment (No.2019rc098), Peoples R China under Grant No.702-519208, and Academic Affairs in GDUPT for Goal Problem-Oriented Teaching Innovation and Practice Project Grant No.701-234660.

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