Environment, Resource and Ecology Journal (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/erej.2023.070610
ISSN 2616-3756 Vol. 7 Num. 6

Study on Carbon Emissions from Land Use Change in the Tarim River Basin

Du Jin

School of Public Administration, Xinjiang Agricultural University, Urumqi, Xinjiang, China

Keywords: Land use change; Carbon emission; Countermeasure suggestion

Abstract: Land use change is an important factor affecting carbon emissions, and this study takes the Tarim River Basin in China as the study area, and based on the five-period land use change data of the basin from 2000 to 2020, the IPCC inventory method and the carbon emission coefficient method are used to measure its land use carbon emissions.The results show that land use change in the Tarim River Basin is characterised by an increase in arable land and construction land, and a decrease in forest land, grassland, waters and unused land. Its land use carbon emissions increased from 679,400 tonnes at the beginning of the period to 24,912,900 tonnes at the end of the period, and the ratio of carbon sinks/carbon sources gradually decreased. Carbon emissions from construction land dominate among carbon sources, and forest land, watersheds and grasslands are the main carbon sequestration contributors among carbon sinks. Based on the results of the study, countermeasures including the protection of ecological land use, optimisation of arable land management measures, intensive use of construction land and low-carbon use of energy are proposed to help the Tarim River Basin achieve low-carbon development.

1. Introduction

The Special Report on Climate Change and Land published by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2019 states that irrational use of land resources will exacerbate climate change[1], and in 2023 the IPCC published data showing that the global surface temperature in 2011-2020 was higher than that in 1850-1900 by 1.1℃[2], global warming situation is grim, it is urgent for all countries to work together to reduce carbon emissions. In order to show the role of a big country, China clearly proposed in September 2020 to strive to achieve the "carbon peak by 2030, carbon neutral by 2060" dual-carbon goals, in this context, a wide range of scholars focus on the issue of carbon emissions from land use, to discuss how to achieve the development of low-carbon land use.

Land resources are the carriers of human life and production, and human activities make land use changes, including urban expansion, farmland development, and forest protection, which have direct and indirect impacts on carbon emissions[3]. This study deeply analyses the link between land use changes and carbon emissions in the Tarim River Basin, China, from 2000 to 2020, which is of great practical significance for the relevant departments in the basin to accurately formulate carbon emission reduction countermeasures for land use.

2. Methods

2.1 Studied Area

The study area selected for this investigation is the Tarim River Basin situated in the southern region of Xinjiang Uygur Autonomous Region in China (73°10′-94°05′E, 34°55′-43°48′N) , and is considered among the significant ecological regions in western China, characterized by both ecological sensitivity and fragility. Ecosystems in the Tarim River Basin play an important role in maintaining carbon balance and reducing carbon emissions, and ecosystems such as watersheds, grasslands, and forests are key to carbon storage. However, in the last two decades, there have been significant land-use changes in the basin, such as the expansion of land used for construction, the increase of agricultural activities, and the decrease of grasslands, and these land-use changes have had a significant impact on carbon emissions in the basin.

The study mainly sourced land use data for the Tarim River Basin from the Resource and Environment Science and Data Centre of the Chinese Academy of Sciences (CAS). For the years 2000, 2005, 2010, 2015, and 2020, five remote sensing images with a resolution of 30m×30m were chosen. The energy consumption data of the basin were obtained from the Xinjiang Statistical Yearbook.

2.2 Land use carbon emissions accounting and coefficient selection

Carbon emissions from land use are typically classified into direct and indirect measurements[4, 5]. Carbon emissions from arable land, forest land, grassland, waters, and unused land are directly measured using the carbon emission factor (CEF) technique. In this method, the product of land area and CEF for each land type quantifies carbon emissions for that particular land type. Indirect carbon emissions refer to carbon emissions from energy activities carried out on construction land, and are calculated by multiplying the amount of energy sources consumed on the land by the energy carbon emission factor. The formula for land use carbon emissions can therefore be expressed as:

$$\mathrm{LUC} = \sum \mathrm{S_i}\mu_\mathrm{i} + \sum \mathrm{E_j}\,\varphi_\mathrm{j}\tau_\mathrm{j} \qquad (1)$$

In the formula: LUC represents land use carbon emissions, $\sum \mathrm{S_i}\mu_\mathrm{i}$ represents direct carbon emissions, S_i represents the area of the i th land use type, and u_i represents the carbon emission coefficient of the i th land use type ; $\sum \mathrm{E_j}\varphi_\mathrm{j}\tau_\mathrm{j}$ represents indirect carbon emissions, where j represents the type of energy, E_j represents the consumption of the jth energy, φ_j represents the carbon emission coefficient of the jth energy, and τ_j represents the standard coal coefficient of the jth energy. According to the energy statistics of various cities in the Tarim River Basin, the main energy consumed is raw coal, coke, liquefied petroleum gas, crude oil, gasoline, diesel oil, natural gas and electricity. The conversion coefficient of standard coal and the corresponding carbon emission coefficient of various fossil energy refer to ' China Energy Statistics Yearbook ' and ' IPCC Guidelines for National Greenhouse Gas Emission Inventories ', respectively, as shown in Table 1.

In this study, the carbon emission coefficients were assembled and collated to obtain Table 2 by collecting research results on land use carbon emission accounting in Xinjiang region. After consulting with a panel of experts in the field, it was deemed appropriate to use the regional weighting method to determine the carbon emission factors for each type of land use in the Tarim River Basin. It was determined that the weightage of the carbon emission factors for the research conducted in the Xinjiang region was 60%, while the research conducted in other regions carried a weightage of 40%. After weighting, this study establishes the carbon emission coefficients for different types of land, including arable land, forest land, grassland, waters, and unused land, to be 0.0457, -0.0621, -0.030, -0.0250, and -0.0005kg/(m^{2}a), respectively.

Table 1: Conversion coefficient of main energy standard coal

Energy type	Raw coal	Coke	Liquefied petroleum gas	Crude oil	Gasoline	Diesel oil	Natural gas	Electric power
Conversion standard coal coefficient	0.7140 (tce/t)	0.9714 (tce/t)	1.7143 (tce/t)	1.4826 (tce/t)	1.4714 (tce/t)	1.4571 (tce/t)	1.2143 (kgce/m^3)	0.1229 (kgce/kw•h)
carbon emission coefficient	0.7559 (t/tce)	0.8550 (t/tce)	0.5042 (t/tce)	0.5930 (t/tce)	0.5538 (t/tce)	0.5921 (t/tce)	0.4483 (kg/kgce)	0.2132 (kg/kgce)

Table 2: Carbon emission coefficient table of different land use types

types of land	carbon emission coefficient kg/(m^2•a)	field of quotient of research	types of land	carbon emission coefficient kg/(m^2•a)	field of quotient of research
arable land	0.0422[6]	China	grassland	-0.0021[13]	Guangyuan City, Sichuan Province
	0.0372[7]	duolun county of inner mongolia		-0.0021[8]	urumqi city xinjiang
	0.0497[8]	urumqi city xinjiang	waters	-0.0252[6]	China
	0.0497[9]	Xinjiang Uygur Autonomous Region		-0.0253[14]	Xinjiang Uygur Autonomous Region
forest land	-0.0644[10]	Inner Mongolia Autonomous Region		-0.0248[9]	Xinjiang Uygur Autonomous Region
	-0.0644[11]	Central Yangtze River Delta		-0.0245[15]	Xinjiang Uygur Autonomous Region
	-0.0581[8]	urumqi city xinjiang	unused land	-0.0005[6]	China
	-0.0628[9]	Xinjiang Uygur Autonomous Region		-0.0005[14]	Xinjiang Uygur Autonomous Region
grassland	-0.0039[12]	changsha-zhuzhou-xiangtan urban agglomeration		-0.0005[9]	Xinjiang Uygur Autonomous Region
	-0.0039[9]	Xinjiang Uygur Autonomous Region		-0.0005[15]	Xinjiang Uygur Autonomous Region

3. Result

3.1 Results of land use change

Through the statistics of the area, proportion and rate of change of each category in the Tarim River Basin during the five periods (Table 3), it is found that the land use change in the Tarim River Basin during the period of 2000-2020 shows the characteristics of "the area of arable land and construction land is increasing, and the area of forest land, grassland, waters, and unused land is decreasing", which is as follows:

Arable land area has shown an increasing trend at all stages, from 17,144km^2 in 2000 to 27,362km^2 in 2020, an increase of 59.60%, and the proportion of arable land area in the total land area has also increased from 1.58% to 2.52%. The increase in arable land is mainly driven by the fact that arable land is protected by policies, government encouragement to open up land, and improved agricultural technology, which has greatly encouraged farmers to develop arable land. At the same time, the quantity and quality of arable land has also improved in recent years as the

Government has carried out land improvement and high-standard farmland construction work.

The area of forest land and grassland all showed a decreasing trend, and the decreasing trend first expanded and then became smaller during the study period. Among them, the area of forest land decreases from 23,418km^2 in 2000 to 22,488km^2 in 2020, with a decrease of 930km^2 during the period, with a decrease of 3.97%; whereas, the area of grassland is similar to the change of the area of forest land, with a decrease of 4,521km^2 during the period, with a decrease of 1.62%, and the proportion of the total area decreased from 25.80% at the beginning of the period to 25.38%. The area of forest land and grassland decreased mainly during the period 2005-2015, during which time China's Western Development Strategy allowed for the rapid development of the Tarim River Basin, and large-scale infrastructure development including transportation, industrial zones, and urbanisation may have led to the use of forest land and grassland for development and construction. During this period, forest land and grassland also shifted significantly to arable land, while the water demand from population growth, industrial development and expansion of arable land made it impossible for the limited water resources to fully satisfy the growth demand of the original forest land and grassland area, which led to the degradation of forest land and grassland. However, during the period 2015-2020, the trend of decreasing the area of forest land and grassland declined, which is due to the fact that ecological protection has received national attention in recent years, and ecological land, such as forest land and grassland, has been protected.

Table 3: Changes in the land areas of each type in the Tarim River Basin from 2000 to 2020.

land use type		arable land	forest land	grassland	waters	construction land	unused land
2000	area(km^2)	17,144	23,418	279,861	40,896	1,437	721,944
	proportion(%)	1.581%	2.159%	25.801%	3.770%	0.132%	66.557%
2005	area(km^2)	18,456	23,221	279,213	40,732	1,572	721,506
	proportion(%)	1.702%	2.141%	25.741%	3.755%	0.145%	66.516%
2010	area(km^2)	20,882	22,979	277,856	40,463	1,699	720,821
	proportion(%)	1.925%	2.118%	25.616%	3.730%	0.157%	66.453%
2015	area(km^2)	23,891	22,553	276,542	39,619	2,235	719,860
	proportion(%)	2.203%	2.079%	25.495%	3.653%	0.206%	66.365%
2020	area(km^2)	27,362	22,488	275,340	38,379	2,807	719,291
	proportion(%)	2.523%	2.073%	25.384%	3.538%	0.259%	66.223%
2000-2020	area variation(km^2)	10,218	-930	-4,521	-2,517	1,370	-2,653
	rate of change(%)	59.601%	-3.971%	-1.615%	-6.155%	95.338%	-0.367%

The water area showed a decreasing trend, but the decreasing trend gradually became larger. The water area decreased from 40,896km^2 at the beginning of the period to 38,379km^2 at the end of the period, a decrease of 6.16%, and the proportion of water area in the total land area decreased from 3.77% at the beginning of the period to 3.54%. The Tarim River is crucial to the socio-economic development of Xinjiang in the arid zone. With the rapid development in recent years, the water resources of the Tarim River Basin have been heavily used for agricultural irrigation, industry and urban water supply, which has reduced the amount of water in the rivers and lakes, and secondly, due to the frequency of droughts and the reduction of precipitation, the water level of the rivers and lakes has declined, which accelerated the decrease of the watershed area.

The area of construction land shows an increasing trend. Its area increased from 1,437km^2 in 2000 to 2,807km^2 in 2020, with an increase of 95.34 % during the period. Its change range is the largest among all land types. At the end of the period, the construction land area accounted for 0.26 % of the total land area. The expansion of construction land has been prompted by rapid urbanisation, infrastructure construction, and related factors, resulting in the conversion of previously arable, unused, and grassland into construction sites.

The amount of unused land in the Tarim River Basin has exhibited a decline, with the area falling from 721,944km^2 in 2000 to 719,291km^2 in 2020, resulting in a 0.37% decrease. Unused land represents the most extensive type of land in the region, and by 2020, it accounted for 66.22% of the entire land area. During the study period, there was a decrease in unused land due to the reclamation of such land to supplement cultivated land, grassland, forest land, construction land, and other types of land.

3.2 Results of land use carbon emission effect

3.2.1 Results of total land use carbon emissions

The determined coefficients were substituted into the land-use carbon emission accounting model to estimate the land-use carbon emissions, carbon emissions by sources and carbon sequestration by sinks in the Tarim River Basin for the five periods from 2000 to 2020. Carbon emissions from carbon sources refer to carbon emissions from arable land and construction land, and carbon sequestration by carbon sinks refers to carbon sequestration from forest land, grassland, water and unused land. The results are shown in Table 4.

Table 4: Carbon emissions of land use in Tarim River Basin

particular year		**2000**	**2005**	**2010**	**2015**	**2020**
net carbon emission	Total (ten thousand tons)	67.94	392.56	743.40	1,685.78	2,491.29
	Stage increment		324.62	350.84	942.38	805.51
	Stage increase		477.82%	89.37%	126.77%	47.78%
Carbon source carbon emissions	Total (ten thousand tons)	480.30	814.27	1,156.12	2,104.58	2,911.68
	Stage increment		322.76	348.23	937.18	801.57
	Stage increase		74.09%	45.92%	84.69%	39.22%
Carbon sink carbon absorption	Total (ten thousand tons)	367.72	365.86	363.25	358.06	354.12
	Stage increment		-1.86	-2.61	-5.20	-3.94
	Stage increase		-0.51%	-0.71%	-1.43%	-1.10%
Carbon sink / carbon source ratio		84.41%	48.24%	32.83%	17.52%	12.45%

Table 4 shows that the land use carbon emissions in the Tarim River Basin have been rising year by year from 2000 to 2020, from 679,400 tonnes of net carbon emissions in 2000 to 249,129,900 tonnes of net carbon emissions in 2020, and the net carbon emissions have increased by 24,233,500 tonnes during the past 20 years, an increase of 3567.04%, mainly due to the substantial increase of carbon emissions from carbon sources (an increase of 24,097,500 tonnes during 20 years, an increase of 553.13%), while the carbon absorption by carbon sinks has been decreasing (an increase of -136,100 tonnes during 20 years, a decrease of 370%). The main reason is that the carbon emissions from carbon sources have increased greatly (24.0975 million tonnes in 20 years, an increase of 553.13%), while the carbon absorption by sinks has been decreasing (an increase of -136.1 thousand tonnes in 20 years, a drop of 3.70%), and the ratio of carbon absorption by sinks to carbon emissions by sources has dropped from 84.41% at the beginning of the period to 12.45%, which indicates that the rapid growth of carbon emissions by sources in the Tarim Basin has made it possible to achieve "Carbon Sinks" by relying on the natural carbon sink function only. This indicates that the rapid growth of carbon emissions from the Tarim River Basin's carbon sources has significantly reduced the potential to achieve the goal of "carbon peak and carbon neutrality" by relying only on the natural function of carbon sinks.

From the viewpoint of each stage, the stages with larger increments of carbon emissions from carbon sources in the Tarim River Basin are 9,371,800 tonnes in 2010-2015 and 8,015,700 tonnes in 2015-2020, which indicates that the Tarim River Basin had a larger expansion of land for construction and arable land as well as a drastic energy consumption activity in the period of 2010-2020. The phase decline in carbon sequestration by sinks gradually increases, with a phase decline of 1.43% from 2015 to 2020, which is closely related to the drastic reduction of waters and degradation of forests and grasslands in the Tarim Basin in these five years.

3.2.2 Results of land use carbon emissions composition

According to Table 5, it can be seen that in terms of land use carbon sources in the Tarim River Basin, carbon emissions from construction land dominate and show a rapid upward trend during the study period. It grows from 3,573,100 tonnes to 27,203,600 tonnes, and its share of carbon emissions from carbon sources increases from 82.02% in 2000 to 95.61% in 2020. Carbon emissions from arable land have increased year by year, from 783,500 tonnes at the beginning of the period to 1,250,400 tonnes. However, its share in carbon emissions from carbon sources has been decreasing year by year, because its growth is not as large as the growth of carbon emissions from construction land. Therefore, the growth of carbon emissions from construction land largely determines the growth of carbon emissions from carbon sources.

Table 5: Carbon emission composition of land use in the Tahe River Basin

particular year			2000	2005	2010	2015	2020
Carbon source carbon emission composition	arable land	Carbon emissions (ten thousand tons)	78.35	84.34	95.43	109.18	125.04
		proportion	17.98%	11.12%	8.62%	5.34%	4.39%
	construction land	Carbon emissions (ten thousand tons)	357.31	674.08	1,011.22	1,934.65	2,720.36
		proportion	82.02%	88.88%	91.38%	94.66%	95.61%
Carbon sink carbon absorption composition	forest land	Carbon emissions (ten thousand tons)	145.43	144.20	142.70	140.05	139.65
		proportion	39.55%	39.41%	39.28%	39.12%	39.44%
	grassland	Carbon emissions (ten thousand tons)	83.96	83.75	83.36	82.96	82.60
		proportion	22.83%	22.89%	22.95%	23.17%	23.33%
	waters	Carbon emissions (ten thousand tons)	102.24	101.83	101.16	99.05	95.95
		proportion	27.80%	27.83%	27.85%	27.66%	27.09%
	unused land	Carbon emissions (ten thousand tons)	36.10	36.08	36.04	35.99	35.92
		proportion	9.82%	9.86%	9.92%	10.05%	10.14%

In terms of land-use carbon sinks in the Tarim River Basin, the largest contributor to carbon sequestration is forest land, followed by watersheds and grasslands. Carbon sequestration in forest land showed a rapid downward trend from 2000 to 2015, from 1,454,300 tonnes of carbon sequestration in 2000 to 1,965,500 tonnes of carbon sequestration in 2015, and carbon sequestration in forest land in 2020 is almost at the same level as in 2015. Carbon sequestration in watersheds showed a slow downward trend during the period 2000-2015, but declined rapidly during the period 2015-2020, falling from 990,500 tonnes of carbon sequestration in 2015 to 959,500 tonnes, and the proportion of carbon sequestration in carbon sinks decreased from 27.66% to 27.09%. Grassland carbon uptake was overall in a state of gradual decline during the study period, with grassland carbon uptake decreasing from 839,600 tonnes at the beginning of the period to 826,600 tonnes at the end of the period. Although the carbon sequestration coefficient of the unused land is very small, the carbon sequestration of the unused land should not be neglected because the total amount of the unused land in the Tarim River Basin is huge, and the carbon sequestration of the unused land in the Tarim River Basin has been stable in the range of 359,200-3,610,000 tonnes, which accounted for the carbon sequestration by carbon sinks in the range of 9.82%-10.14% in the study period.

4. Conclusion and Suggestions

4.1 Conclusion

This study analyses the land use change characteristics of the Tarim River Basin based on the land use data from 2000 to 2020, and then adopts the IPCC inventory method and the carbon emission coefficient method to measure the land use carbon emissions in the basin, and obtains the main conclusions as follows:

(1) Land use changes in the Tarim River Basin during the study period were generally characterised by an increase in arable land and construction land, and a decrease in forest land, grassland, waters and unused land. Influenced by the protection of arable land policy, the area of arable land increased by 59.60% during the study period. Construction land is the land category with the largest change of all land categories, with an increase of 95.34% over the period. The area of forest land, grassland and unused land has been decreasing. The waters have been decreasing due to the increase in water demand for agriculture, industry and rapid urban development, as well as the impact of extreme arid climate, and the trend may be expanding, which requires urgent attention.

(2) The upward trend of total land use carbon emissions in the Tarim River Basin is significant, the ratio of carbon sinks/carbon sources gradually decreases, and the carbon emission effect of land use changes increases. Carbon emissions from land use in the basin rose from 679,400 tonnes at the beginning of the period to 24,912,900 tonnes at the end of the period. The large increase in carbon sources and the decrease in carbon sinks led to a decrease in the ratio of carbon sinks to carbon sources from 84.41% at the beginning of the period to 12.45% at the end of the period. It shows that the pressure of carbon emission is obvious. In terms of the composition of carbon emissions, carbon emissions from construction land dominated among carbon sources; forest land, waters and grasslands were the main contributors to carbon sequestration among carbon sinks.

4.2 Suggestions

(1) Protecting the green hills and mountains and enhancing the ecological carbon sink capacity of watersheds. Environmental protection departments should accurately improve the quality of forests in watersheds and promote afforestation and forest conservation on suitable land. At the same time, grassland ecosystems should be maintained and grassland degradation problems should be improved. We need to optimise the grazing system, improve the grass-animal balance management system, build low-carbon pastures, and reduce the problem of grassland degradation caused by overgrazing. The Government should coordinate planning for the rational use of water resources, improve water resource management and explore the implementation of a water rights system to protect water resources.

(2) Farmers should optimise arable land management measures to achieve low-carbon production on arable land. Agricultural departments should encourage farmers to adopt appropriate arable land management measures, such as crop rotation fallow and culm return to the field, which can effectively reduce the carbon source of arable land. The government and enterprises should vigorously promote conservation tillage techniques such as diversified composite cropping systems and integrated nutrient management systems in order to increase the carbon sequestration space of conservation tillage techniques. At the same time, farmers should be encouraged to reduce the use of traditional chemical fertilisers to lower agricultural carbon emissions and promote the application of organic fertilisers.

(3) Intensive and efficient use of construction land and control of carbon emission sources. The red line for ecological protection and urban development boundaries will be drawn and implemented in a coordinated manner, and efforts will be made to build a new pattern of green and

low-carbon territorial spatial development and protection in the Tarim River Basin. We will strengthen the detailed management and efficiency of construction land use, further improve the mechanism of intensive and efficient construction land use.

(4) Strictly controlling the total amount of fossil energy and accelerating the low-carbon transformation of energy sources. The government should strengthen the management of the energy market, formulate fossil energy consumption plans in advance, and strictly control the total amount of fossil energy consumption. The energy sector should establish fossil energy consumption measurement standards and charging mechanisms to limit the total amount of fossil energy consumed by enterprises and increase the proportion of renewable and clean energy used.

References

[1] Huang L, Wang C, Chao Q. Interpretation of IPCC special report on climate change and land[J].Climate Change Research Progress, 2020,16 (01): 1-8.

[2] IPCC. Synthesisreport of the IPCC sixth assessment report [R].2023, https://www.ipcc.ch/report/ar6/syr/.

[3] Wu M, Ren L, Chen Y. Simulation of Urban Land Use Carbon Emission System based on a System Dynamic Model: Take Wuhan as an Example [J]. China Land Science, 2017, 31 (2): 29-39.

[4] Li Y, Qin Y, Yang L, Li Z, Lu L. Estimation and analysis of carbon emissions from the large-and medium-sized reservoirs in the upper reaches of Changjiang River: On the basis of the IPCC National Greenhouse Gas Inventory[J].Lake Science, 2023,35 (01): 131-145.

[5] Fang L, Li C, Li H, Liu Y. Spatio-temporal effects and driving forces of land use carbon emissions in the Yangtze River Economic Belt[J].Prataculture Science, 2022,39 (12): 2539-2553.

[6] Sun H, Liang H, Chang X, Cui Q, Tao Y. Land Use Patterns on Carbon Emission and Spatial Association in China[J].Economic Geography, 2015,35 (3): 154-162.

[7] Aruhan, Mu D, Sudesurige, Asina. Analysis on land use carbon emissions and influencing factors in Duolun county, Inner Mongolia [J]. Resources and Environment in Arid Areas, 2019, 33 (4): 17-22.

[8] Meng M, Cui X, Wang Z. Correlation between Land Use Structure and Carbon Emission in Urumqi City. Soil and Water Conservation Bulletin [J], 2018, 38 (2): 178-182, 188.

[9] Zhang R, Li P, Xu L. Effects of urbanization on carbon emission from land use in Xinjiang and their coupling relationship [J]. Ecology, 2022, 42 (13): 5226-5242.

[10] Li C, Su M, Yang X J L T. Carbon sink industry development potential in Inner Mongolia [J]. Resources and Environment in Arid Areas, 2012, 26 (5): 162-168.

[11] Qin Y, Yu R, Yu Z, Lu P, Li L, Gui Z, Song Z. Spatial and temporal characteristics of land use carbon emission intensity in the central area of Yangtze River Delta from 2000 to 2018[J]. Journal of Henan Agricultural University, 2021, 55 (1): 132-140.

[12] Li J, Mao D, Jiang Z, Li K. Research on Factors Decomposition and Decoupling Effects of Land Use Carbon Emissions in Chang-Zhu-Tan Urban Agglomeration[J]. Eco-economy, 2019, 35 (8): 28-34, 66.

[13] Shi H, Mu X, Zhang Y, Lv M. Effects of Different Land Use Patterns on Carbon Emission in Guangyuan City of Sichuan Province[J].Soil and Water Conservation Bulletin, 2012,32 (3): 101-106.

[14] Zheng Y, Liu X, Xiong M, Li F, Fu Y, Zhang Z, Lai M. Spatial-temporal characteristics of ecological-living-productive land and its carbon emissions in Xinjiang from 1990 to 2018[J]. Pratacultural Science, 2022, 39 (12): 2565-2577.

[15] Tang H, Ma H, Su Y, Xin C, Wang J. Carbon Emissions and Carbon Absorptions of Different Land Use Types in Xinjiang [J].Research on arid areas, 2016,33 (03): 486-492.