# GIS METHODS FOR ANALYZING AND EVALUATING GREEN GAS EMISSIONS FROM URBAN LANDSCAPES

# ГИС МЕТОДЫ ДЛЯ АНАЛИЗА И ОЦЕНКИ ЭМИССИИ ПАРНИКОВЫХ ГАЗОВ С ТЕРРИТОРИИ ГОРОДСКИХ ЛАНДШАТОВ

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This research is devoted to exploring the impact of urban landscape on greenhouse gas emissions, and using geographic information system (GIS) to conduct in-depth analysis. The research process includes key steps such as data collection and others. The data, derived from publicly available data provided by the Environmental Protection Agency (EPA), covers real-time air quality information from more than 50,000 monitoring stations in 2,000 major cities in 132 countries around the world. Through the application of GIS technology, this study not only reveals the status of green gas emissions in different areas of the city, but also assesses the importance of landscape design for improving urban air quality and combating climate change. The research results aim to provide scientific basis and suggestions for urban planning, green construction and climate change adaptation strategies, and have important significance for theoretical research and practical application.

Исследование посвящено оценке воздействия городских ландшафтов на эмиссию парниковых газов и возможности использования методов географических информационных систем (ГИС) для проведения анализа. Исследование включает ряда этапов, в том числе сбор данных. Данные получены на открытом ресурсе Агентства по охране окружающей среды (АООС) где собрана информация по оценке качества воздуха из более чем 50 000 станций мониторинга, 2 000 городов и 132 стран. Применение ГИС технологий позволяет не только оценить объемы выбросов парниковых газов, но также и возможность влияния городского дизайна на качество воздуха и изменение климата. Цель исследования – создать научную основу для городского планирования и разработки стратегии адаптации к изменению климата. Результаты исследований имеют как теоретический, так и практический интерес.

*Keywords:* Greenhouse gases, Geographic Information System (GIS), Urban landscape, Air quality.

*Ключевые слова:* Парниковые газы, географические информационные системы (ГИС), городские ландшафты, качество воздуха.

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**Introduction.** In the global context of addressing climate change and promoting sustainable urban development, green gas emissions in urban landscapes have become an increasingly concerned issue. As a concentration of population and economic activities, the ecological footprint and environmental impact of cities have aroused a wide range of research interests. In particular, green vegetation in urban landscapes plays an integral role in mitigating urban heat island effects, improving air quality and promoting biodiversity. However, green vegetation is also an important part of the urban carbon cycle, which plays a dual role in the urban carbon balance through photosynthesis and respiration.

In this context, the accurate analysis and assessment of green gas emissions in urban landscape, especially the absorption and emission of carbon dioxide, is of great significance for formulating effective urban greening strategies and coping with climate change policies. Geographic Information System (GIS), as a powerful spatial analysis tool, provides the possibility to analyze the structure and function of urban landscape [1]. GIS methods can integrate spatial data from multiple sources, such as remote sensing images, topographic maps, and urban planning maps, to delineate the spatial pattern of the urban landscape in detail and evaluate its contribution to green gas emissions [2].

This research aims to explore how to use GIS technology to analyze and evaluate green gas emissions in urban landscape, with special attention to the impact of urban green space system on carbon cycle. Through the spatial analysis function of GIS, combined with ecological models and urban green space data, this study will evaluate the potential of different urban landscape types to mitigate climate change, and provide scientific basis for urban planning and environmental management. In addition, the study will also discuss the limitations and future development directions of GIS methods in urban green gas emission assessment, aiming to provide a more comprehensive perspective and methodological support for the formulation of urban sustainable development strategies.

Climate change with global warming as its main feature has become one of the most far-reaching global environmental problems in the world today. In 2007, the Fourth Assessment Report ($AR_4$) issued by the United Nations Intergovernmental Panel on Climate Change (IPCC) pointed out that some of the global warming phenomenon may be caused by the increase of greenhouse gases emitted by human activities. The warming caused by the increasing concentration of various greenhouse gases, mainly carbon dioxide, has greatly increased the frequency and intensity of extreme climate events. The grim reality prompts governments to work together to take effective measures to curb the further deterioration of the global climate. The 1992 United Nations Framework Convention on Climate Change (UNFCCC) aims to stabilize the concentration of greenhouse gases in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system.

In the current world primary energy composition, oil accounts for 36 %, coal accounts for 28 %, natural gas accounts for 24 %, and their sum accounts for 88 %. If future development continues on the high-carbon model, the Earth will be overwhelmed by the middle of the century. In recent years, with the rapid development of China's economy, energy use and carbon dioxide emissions have also increased sharply. Since 1750, the cumulative global emissions of 1.1 trillion tons of carbon dioxide, of which developed countries accounted for 80 %, the United States occupies the first place, reaching 26.9 %, and China since 2009, has surpassed the United States to become the world's largest carbon dioxide emissions. In terms of energy structure, fossil energy accounts for 90 % of China's primary energy structure, of which coal accounts for 69 %. Before 2000, China was an oil exporter, and imported oil accounted for 52 % of the total in 2009. Oil imports are concentrated in the Middle East, one of the world's most unstable regions. Therefore, how to improve the energy structure and improve energy efficiency will be related to China's energy security.

Climate change is an environmental issue, a resource issue, and ultimately a development issue. The transformation of the extensive, high-carbon traditional economic development mode and the realization of the low-carbon development mode with low energy consumption, low emissions and low pollution as the basic characteristics is another major civilization progress characterized by ecological civilization after the primitive civilization, agricultural civilization and industrial civilization. Low-carbon development is the only way for sustainable urban development. In January 2008, China's first Harmonious City Forum opened, pointing out that "low-carbon economy is the only way to achieve sustainable urban development", "low-carbon city" became the theme of the domestic conference for the first time. In the same month, China's National Development and Reform Commission and the World Wide Fund for Nature (WWF) jointly selected Shanghai and Baoding as pilot low-carbon urban development projects. In 2010, China's National Development and Reform Commission identified eight cities in five provinces, including Nanchang, to carry out low-carbon pilot work; In 2012, China's National Development and Reform Commission identified the second batch of national pilot provinces and cities. In this way, cities will become the leaders of China's low-carbon future and will become the pioneers of China's sustainable development.

Traditional approaches to controlling greenhouse gas emissions include energy efficiency, clean and renewable energy, forest management and afforestation, waste disposal and recycling, industrial emission control, policy legislation, and public education and awareness raising. Together, these measures constitute a comprehensive strategy to address the challenge of climate change by optimizing energy use, promoting sustainable resource management, promoting cleaner production technologies, and strengthening laws and regulations and public participation. Practice has shown that these methods can effectively reduce greenhouse gas emissions and mitigate the trend of global warming, but their successful implementation requires extensive cooperation and sustained efforts of the international community.

As a comprehensive platform that integrates principles, methods and tools for visualizing, analyzing and modeling human activities and the environment, geospatial information systems (GIS) offer great potential for improving sustainability in the construction sector compared to traditional methods. This is particularly important in the context of renewable energy applications in buildings that aim to achieve the goal of net zero energy consumption, which requires minimizing energy consumption, improving efficiency, and prioritizing renewable energy sources. The complexity of these processes, including aspects such as data availability, scalability, and integrability, highlights the challenges of implementing effective GIS based solutions. A practical example of GIS application was observed in New Zealand's practice of monitoring greenhouse gas emissions and land use change to comply with the Kyoto Protocol. The Land Use and Carbon Analysis System (LUCAS) developed on ESRI's ArcGIS software exemplifies how GIS can support complex carbon sequestration calculations by leveraging validated land use and land use change data. The system is capable of assessing carbon stocks and changes, helps meet national and international reporting requirements, and highlights the critical role of GIS in environmental monitoring and policy compliance. These highlight the importance of GIS in promoting sustainable development in the construction sector, facilitating the identification of emission hotspots, optimizing the energy mix and implementing renewable energy technologies. However, the realization of these benefits depends on addressing the challenges associated with data management, technology integration, and the development of a clear, applicable framework for the application of GIS in green gas emission analysis.

**Methodology.** The purpose of this study is to analyze and evaluate the contribution and impact of urban landscape to green gas emissions by geographic information system (GIS), in order to provide scientific basis for urban planning and environmental management. The research questions focus on how to quantitatively assess the contribution of different urban landscape types (e.g., green Spaces, built-up areas, water bodies, etc.) to greenhouse gas emissions and explore possible strategies to reduce these emissions [3]. This study assumes that different landscape types in the city have significantly different impacts on green gas emissions, and the overall emissions can be effectively reduced by optimizing

urban landscape design. The scope of the study focuses on specific cities or urban clusters, taking into account the feasibility of data acquisition and the precision of the analysis, while clarifying the limitations of time

In this research, we focused on air quality monitoring data from around the world, which is derived from the outstanding contributions of the World Environmental Protection Agency (EPA). In particular, the agency coordinates an extensive network covering 2,000 major cities in 132 countries, which includes more than 50,000 air quality monitoring sites that provide us with real-time air quality information. This vast monitoring network covers the globe and provides a unique and valuable data resource for our research.

To ensure a high degree of consistency and comparability of the analysis results, the study only used data from monitoring sites that publish readings of particulate matter (PM2.5 and PM10). Particulate matter is widely recognized as one of the key pollutants affecting air quality and human health, so its monitoring data is critical for assessing green gas emissions in urban landscapes and their potential health impacts. In addition, the Air Quality Index (AQI) published by each monitoring site is based on the U.S. Environmental Protection Agency's (EPA) Instant-Cast standard, which provides a scientifically rigorous and uniform methodological framework for assessing and reporting air quality internationally [4]. By using this criterion, the study was able to ensure a high degree of data consistency across different regions and countries, making cross-regional comparative analysis possible. Figure 1 shows the distribution of data sampling.


*Figure 1 – The distribution of data sampling*

As pointed out by Gintamo T et al., the adoption of GIS technology is very effective [5]. The application of GIS technology in this study includes data collection, spatial data processing and analysis. Here are the steps, as shown in Figure 2.

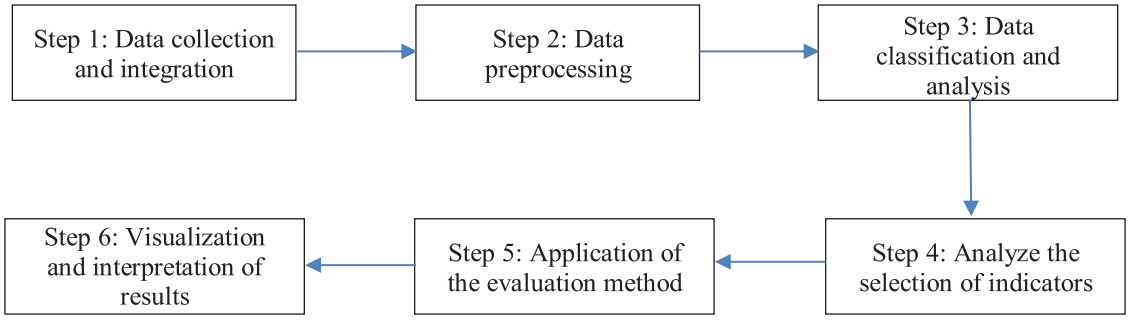


*Figure 2 – GIS method steps*

**Result and analysis.** In the results presentation section of this study, we will present the results obtained through GIS analysis and model evaluation in detail. The results will be presented in the form of maps, charts and statistics to visually reveal the impact of different landscape types on green gas emissions in the city. The map will show the spatial distribution of green gas emissions, highlighting hot spots; The chart will reveal the relationship between different landscape types and gas emissions; Statistical data provide quantitative analysis results to support subsequent discussions and conclusions. In the results interpretation section, we will delve into the patterns and trends revealed by GIS analysis. In particular, we will analyze how different landscape types in cities, such as parks, water bodies, residential areas, industrial areas and roads, affect green gas emissions, and examine how the distribution, size and configuration of these landscape elements are related to gas emissions. In addition, we will discuss the potential impact of changes in landscape structure, such as increased green space, changes in building density, or adjustments in traffic patterns, on reducing gas emissions, and what these changes mean for urban sustainability strategies. Where possible, the study will also include one or more case studies showing

how the methods presented in the study can be applied to practical analysis through specific urban examples. These case studies will describe the research process in detail, including steps such as data collection, GIS analysis execution, model application, and results interpretation. Through the results and enlightenment of case analysis, we will demonstrate the application value of GIS methods in actual urban environmental management and planning, and how to effectively reduce green gas emissions and promote urban environmental sustainability by optimizing urban landscape design.

**Conclusion.** In this research, we analyzed and evaluated the impact of urban landscape on green gas emissions by GIS method, and revealed the complex relationship between different urban landscape types and green gas emissions. Through the presentation of results in the form of maps, charts and statistical data, this study not only quantitatively assesses emissions from different areas of the city, but also explores the potential impact of landscape structural changes on gas emissions. Compared with the existing literature, the innovation of this study lies in the adoption of advanced GIS technology and methods to improve the accuracy and spatial resolution of the analysis of the relationship between urban landscape and green gas emissions. Based on the results of this research, we put forward a series of policy recommendations and practical significance. It is suggested that urban planners should consider the impact of landscape types on gas emissions in urban design and planning, and reduce urban green gas emissions through measures such as increasing green space, optimizing building layout and improving transportation system, so as to cope with climate change. In addition, this study emphasizes the importance of green construction and sustainable urban design, which provides a scientific basis for realizing the sustainable development of urban environment.

Looking forward to the future, the research can be further expanded from the following directions: first, improve and optimize GIS analysis methods to improve the accuracy and efficiency of analysis; The second is to expand the scope of the study to include more cities and regions to increase the universality and representativeness of the study; Third, explore new research topics, such as assessing the contribution of urban green infrastructure to climate change mitigation. Through the exploration of these future research directions, we can gain a deeper understanding of the interaction between urban landscape and environment, and provide support for achieving more sustainable urban development goals. In conclusion, this research effectively analyzes the relationship between urban landscape and green gas emissions through GIS, providing a new perspective and tool for urban planning and environmental management. This study not only answers the research questions, but also highlights its important contributions in theory and practice.

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# СОКРАЩЕНИЕ ЧИСЛЕННОСТИ НАЗЕМНЫХ НАСЕКОМЫХ КАК СЛЕДСТВИЕ ЭКОЛОГИЧЕСКОГО КРИЗИСА

# DECLINE IN THE NUMBER OF TERRESTRIAL INSECTS AS A CONSEQUENCE OF THE ENVIRONMENTAL CRISIS

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Изучили данные о численности насекомых, выявили источники загрязнения, проанализировав научные исследования, новостные статьи, показали значимость вопроса о последствиях сокращения насекомых. Научная работа посвящена вопросу изучения факторов сокращения численности насекомых и необходимости решения данной проблемы. В работе освящаются причины уменьшения популяции насекомых. Также рассматриваются последствия сокращения численности насекомых для экосистем и биоразнообразия на Земле.