WEP Warwick Evans Publishing

International Journal of Natural Resources and Environmental Studies

ISSN: 3006-2012 (Print), ISSN: 3006-0834 (Online) | Volume 3, Number 1, Year 2024
DOI: https://doi.org/10.62051/ijnres.v3n1.03
Journal homepage: https://wepub.org/index.php/IJNRES/index

Progress in The Study of Land Use Landscape Patterns

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ABSTRACT

Landscape pattern refers to the spatial distribution and configuration of heterogeneous geographic units composed of different ecosystems, i.e., landscape elements, and is usually determined by the type, number, scale, shape and spatial distribution pattern of landscape elements. The formation of landscape patterns is mostly the result of complex interactions among physical, biological and socio-economic factors. Land use change (LUCC) is one of the key factors affecting the structure, function and dynamics of landscapes, and LUCC can not only objectively reflect the use of natural resources such as land and potential ecological risks by human activities, but also reveal the mechanisms of interaction between human activities and the ecological environment.

KEYWORDS

Landscape pattern; Land use, Landscape ecology.

1. INTRODUCTION

Research on land-use landscape patterns appeared in the 1830s, and at that time, most studies used qualitative methods to describe their characteristics. Since Troll, a German ecologist, first proposed the concept of "landscape ecology" in 1939, the research methods of ecology and geography have been integrated to study the structure and function of landscape in multiple dimensions. In particular, the "matrix-patch-corridor" model proposed by Forman in 1981 had a profound impact on the study of land use landscape patterns, which were then classified into four different types, i.e., finger landscape, checkerboard landscape, network landscape and patchy landscape, and focused on the spatial patterns and dynamics of landscape elements and ecosystems. It also focused on the spatial pattern of landscape elements and ecosystems and their dynamic changes. Until the 1970s, spatial statistical analysis methods were widely used in the quantitative analysis of land use landscape pattern. Until the 1980s, landscape pattern index analysis was applied by a large number of scholars in the study of land use landscape pattern and its changes, and became the most mainstream tool. For example, O'Neill and Krumme et al. used indices such as dominance, dimensionality and spread to describe the characteristics of land use landscape pattern in the eastern region of the U.S. In the late 1980s, Zonneveld further delineated the hierarchical structure of the landscape system and analysed its composition and relationship. Compared with other countries, scholars in China only began to pay attention to the study of land use landscape pattern in the early 1990s.

2. LANDSCAPE ECOLOGICAL PATTERNS

After the first National Landscape Ecology Symposium was held in 1989, the study of land use landscape pattern began to be widely concerned and a large number of researches were carried out, including the introduction of relevant basic theories, the discussion of methods for analysing the land landscape pattern, the quantitative study of landscape pattern and its application, etc. The objects of the research also covered various regions such as cities, villages, farmlands, wetlands, grasslands and deserts. Since 2000, the objects and scope of research on land use landscape pattern have been further expanded, and most of the studies have focused on watersheds, cities, rural areas and forests, but they have also begun to pay attention to the land use landscape pattern of urban wetlands, urban greenlands, scenic areas, nature reserves and mining areas, etc. The research methods have become more diversified, and most of the research methods, apart from qualitative description and spatial statistical analysis, have adopted the landscape pattern index method to characterise the land use landscape pattern, and the landscape pattern index method is used to characterise the land use landscape pattern of the land. In addition to qualitative description and spatial statistical analysis methods, most of them adopt the landscape pattern index method to characterise the land use landscape pattern, and the landscape pattern analysis model has also begun to be popularised and applied. In recent years, with the development of technology, the number of landscape pattern studies integrating multiple analysis methods has increased rapidly. The ultimate goal of land use landscape pattern research is to explore a specific ecological process under the premise of identifying a specific problem, and to combine it with landscape structure analysis, so as to reveal and analyse the process and its driving mechanism. However, so far, most landscape pattern analyses have been limited to the characterisation of land use landscape patterns and the analysis of their driving forces, but the integration with practical problems is still far from being sufficient.

2.1. Phase I

Based on the continuous development of remote sensing technology and classification methods, basic data on land use/land cover and its evolution have been constructed and improved with different resolutions covering the whole world, including: UMD data (University of Maryland, USA), IGBP DISCover data (USGS), MODIS data (Boston University, USA), GlobCover data and CCI-LC (Climate Change Initiative-Land Cover) data (European Space Agency). CCI-LC (Climate Change Initiative-Land Cover) data (European Space Agency). The development and construction of these data have provided strong data support for the study of land use landscape pattern and its evolution process, and greatly improved the accuracy of the research results[1].

2.2. Phase Ⅱ

Drivers of land use/land cover evolution, including natural and socio-economic factors. The evolution of land use/land cover is the result of a combination of natural, social and economic factors. Natural factors are mainly temperature, rainfall and soil. Socio-economic drivers include direct and indirect drivers, with direct drivers being explored mainly in terms of the degree of human interference, the degree of land intensification, the demand for land products, and land policies, etc. Indirect drivers include population growth, economic development, political systems and economic policies, etc. In general, over short time scales, land use/land cover evolution is the result of a combination of natural and economic factors. Generally speaking, the driving effect of socio-economic factors is more significant in short time scales, while the cumulative effect of natural factors is more significant in long time scales[2].

2.3. Phase Ⅲ

Modelling is an important tool for the study of land-use landscape evolution at this stage, which is an important tool for better analysing the process of land-use landscape evolution and its driving forces, predicting the future trend of landscape evolution and formulating relevant support. Spatial and non-spatial models, as well as comprehensive models, are the main models established at this stage. Among them, spatial models mainly characterize the spatial features of land-use landscape evolution and focus on expressing human behaviours or environmental suitability and constraints in the "human-environment" system, including common Agent-based Model (ABM), Cellular Automata (CAM), and other models. These include the common Agent-based Model (ABM), Cellular Automata (CA) models, etc. Non-spatial models mainly include Markov Model and System Dynamics Model, etc., which mainly focus on the quantitative analysis of the rate of change and quantitative characteristics of land use/land cover. The integrated model is a kind of model that uses spatial and non-spatial models to simulate at multiple scales. Usually, the CLUE-S model and LUSD model are generally used to determine the overall rate of land use/cover change and its quantitative characteristics at the macro-scale, and then gradually configure the spatial geographic units at the next level of scale. There are also scholars who use the SAMBA model to model the behaviour and processes of land use decision makers at a specific scale from a small scale, and then use scale deductions to express the characteristics of land use landscapes at a macro scale[3].

3. EVOLUTION OF LAND USE LANDSCAPE PATTERNS

In the second phase (2005-2013), domestic and international researchers focused on the impacts of the evolution of land use and landscape patterns on natural habitats and their biodiversity, atmosphere, soil and water resources, etc. Some scholars and experts also tried to apply 3S technology to monitor the dynamics of land use/cover change. In summary, the main research contents at this stage include:

3.1. Phase I

Impacts of evolving land-use landscape patterns on biodiversity and habitats. Most scholars generally use the degree of habitat loss, degradation and fragmentation to characterise the impacts of land-use landscape pattern changes on habitats. Most studies have shown that changes in land-use landscape patterns are the most direct cause of changes in habitat types or habitat fragmentation or even loss, with statistics showing that globally, about two fifths of terrestrial natural habitats have been replaced by agricultural land and urban built-up land, and about two fifths of terrestrial natural habitats have been degraded or fragmented. At the same time, habitat fragmentation or degradation caused by land-use change contributes to the loss of biodiversity. It has been shown that 20-35 per cent of mammals, reptiles and amphibians are at risk of extinction as a result of habitat degradation and loss. It is even predicted that by 2070, 1700 species may be at risk of extinction due to the reduction of suitable habitats caused by land use change. Furthermore, the evolution of land-use landscape patterns will have immeasurable negative impacts on terrestrial ecosystems in terms of biodiversity, climate change and carbon emissions[4].

3.2. Phase Ⅱ

Impacts of land-use landscape pattern evolution on regional climate and regional atmospheric quality. Changes in land-use landscape patterns can change regional climate by affecting net radiation and precipitation distribution processes. For example, land use changes in the tropics generally affect regional climate by changing the water balance, while land use changes in temperate regions mainly affect regional climate by changing surface radiation. To a certain extent, changes in land-use landscape patterns have even more impacts on climate than greenhouse gases, especially the impacts of rapid urbanisation processes on regional climate, as shown by Kim et al. Rapid urbanisation in

South Korea over a period of 54 years since 1954 has caused dramatic changes in land-use landscape patterns, which have had an impact on the regional temperature increase and significantly outweighed the greenhouse effect; The results of Kishtawal et al. show that the rate of urbanisation has a significant impact on regional climate, especially on the frequency of precipitation events, and that precipitation rates are higher in urbanised areas compared to non-urbanised areas. In addition to influencing regional climate, the evolution of land-use landscape patterns may also affect atmospheric quality, mainly through changes in gas emissions and atmospheric conditions (e.g., reaction rates and transport and deposition) [5].

3.3. Phase Ⅲ

Impact of land use landscape pattern evolution on soil productivity. It has been shown that the evolution of land use landscape pattern can not only change the physicochemical properties and soil composition, but also affect its quality and fertility, and ultimately lead to changes in land productivity. For example, the transfer of forested land to cropland will cause a decrease in above-ground biomass and a reduction in soil carbon input [69]. At the same time, changes in land use types can also change the content of soil nutrients such as nitrogen, phosphorus and potassium, thus affecting soil fertility. For example, the expansion of agricultural activities intensifies the development of agricultural land, and the use of large amounts of pesticides and chemical fertilisers ultimately leads to changes in soil structure and functional degradation. In addition, the evolution of land use landscape pattern may accelerate the decline of soil conservation capacity and desertification. The loess plateau in China, after a long period of reclamation and utilisation, has suffered extremely serious damage to the vegetation cover, with the area of soil erosion exceeding 50% of the plateau, and the amount of sediment entering the Yellow River due to large-scale soil erosion has remained high for a long period of time[6].

4. CONCLUSION

In conclusion, the research on land use landscape pattern is a cutting-edge and hot area, which has attracted great attention from scholars all over the world in the face of global changes and ecological crises. It has become a hot topic and a challenge to better serve the national spatial planning through the innovation of research frameworks and new technologies, and how to integrate the research on land use landscape pattern with multidisciplinary cross-disciplinary research, so as to serve the building of a beautiful China and the implementation of the strategic goal of ecological civilisation.

ACKNOWLEDGEMENTS

This research was funded by Shaanxi Provincial Land Engineering Construction Group fund (DJNY2024-26, DJNY2024-36).

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