Spatial-temporal variation analysis and prediction of carbon storage in urban ecosystems based on PLUS-InVEST model: A case study of Xuzhou

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Abstract

Taking Xuzhou City as the research area, this paper analyzes the land use changes from 2000 to 2020, and uses the PLUS model to predict the future spatial distribution pattern of land use under three scenarios of natural growth, urban development and ecological protection in 2030.Combined with the InVEST model, the carbon storage from 2000 to 2020 and the carbon storage in 2030 under three different scenarios were estimated and analyzed.Using the land use data in 2000 and 2010 and 13 influencing factors such as precipitation, temperature and elevation, the accuracy of the land use data in 2020 was 93.76%, and the Kappa coefficient was 87.21%, which verified the strong reliability of the PLUS model.In 2000, 2010 and 2020, the carbon storage was 1085.11×10^5Mg, 1066.32×10^5Mg, 1061.42×10^5Mg, respectively.The simulated carbon storage under natural development, urban development scenarios and ecological protection in 2030 was 1056.84×10^5 Mg, 1055.4×10^5Mg and 1059.26×10^5Mg, respectively.

Keyword: Land use/cover change(LUCC);PLUS model;InVEST model;Carbon stocks

Introduction

China announced: "China will adopt more vigorous policies and measures, strive to peak carbon dioxide emissions before 2030, and strive to achieve carbon neutrality before 2060." The carbon sequestration capacity of ecosystems is an important indicator of their climate regulation ability.

Terrestrial ecosystem carbon storage is an important part of global carbon stock,including carbon reservoirs of aboveground biomass, underground biomass,soil organic carbon and dead organic matter. Improving the carbon sink capacity of ecosystems, strengthening land spatial planning and use control, effectively giving play to the carbon sequestration role of forests, grasslands, wetlands, water areas and soils, and increasing the increase of ecosystem carbon sinks play a crucial role in alleviating global warming and approaching the "dual carbon" strategy.

Objective

- Adopt the PLUS model,predict the land use change in Xuzhou urban area in 2030 under different development scenarios such as natural development, ecological protection and economic development.
- Using the InVEST model,estimate the carbon storage of terrestrial ecosystems under different land cover types in Xuzhou urban area in 2000, 2010 and 2020 and analyze their change characteristics.Estimate the carbon storage in Xuzhou urban area in 2030 using the land use data under the three scenarios of 2030.
- Analyze the impact of land-use change on terrestrial ecosystem carbon stocks.

Method

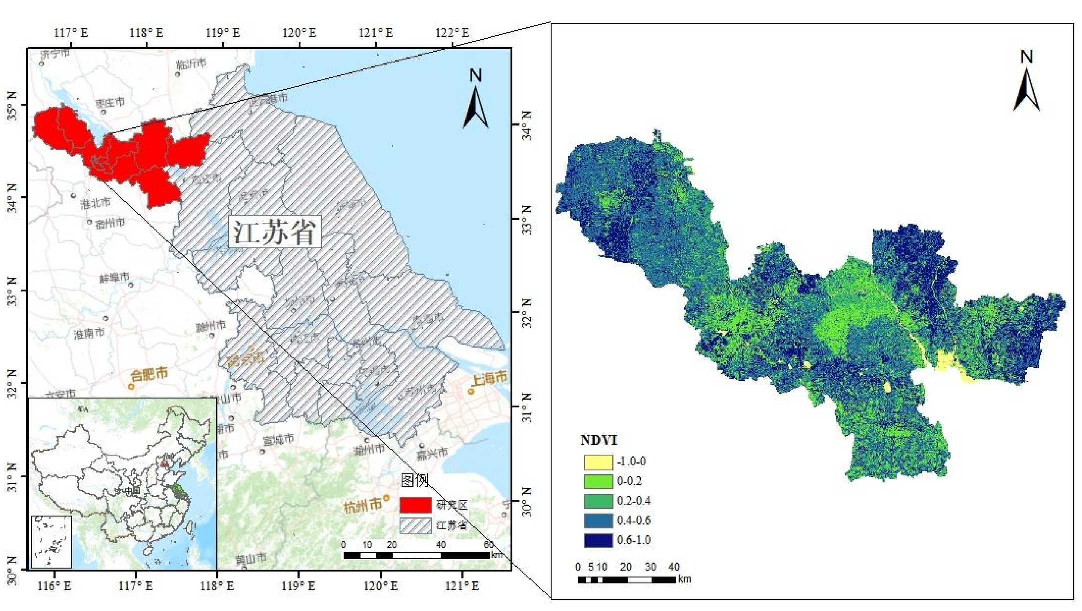

Figure 1 Research area

a)The PLUS model is a new and improved CA model built on the basis of the FLUS model, which is coupled with a new land use expansion analysis strategy and a CA model based on multi-class random plaque seeds.

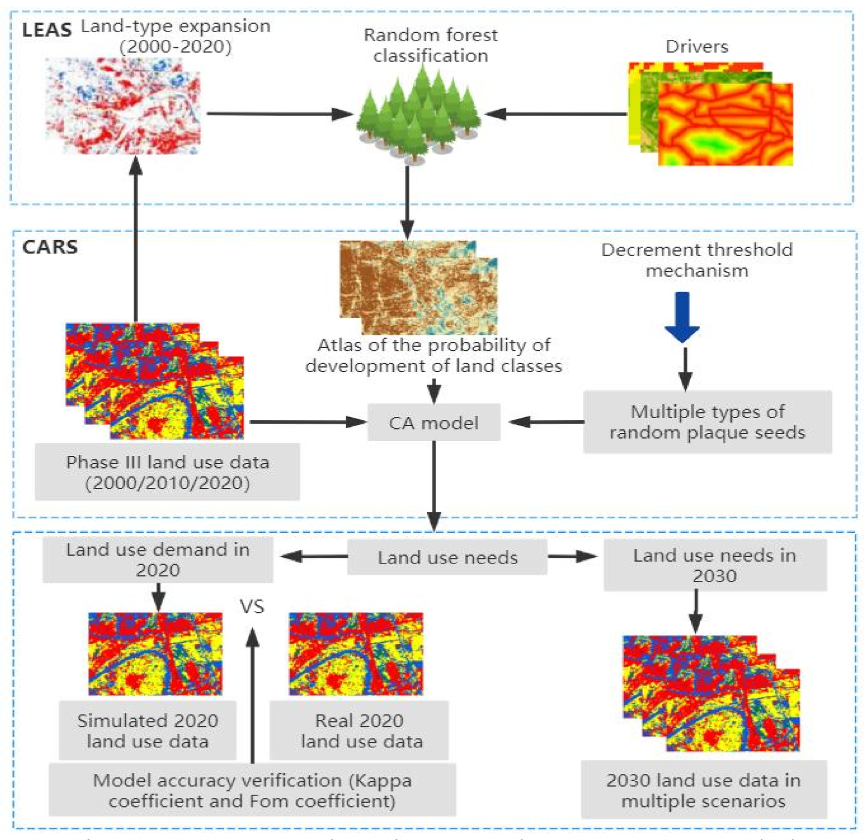

Figure 2 Introduction to the PLUS model

b)The InVEST model is a comprehensive assessment model for ecosystem services and trade-offs. In this paper, the carbon module in InVEST is used to calculate carbon storage by combining land use data and carbon density data, and the carbon storage in each carbon reservoir mainly includes four basic carbon pools: aboveground biomass, underground biomass, soil and dead organic matter.

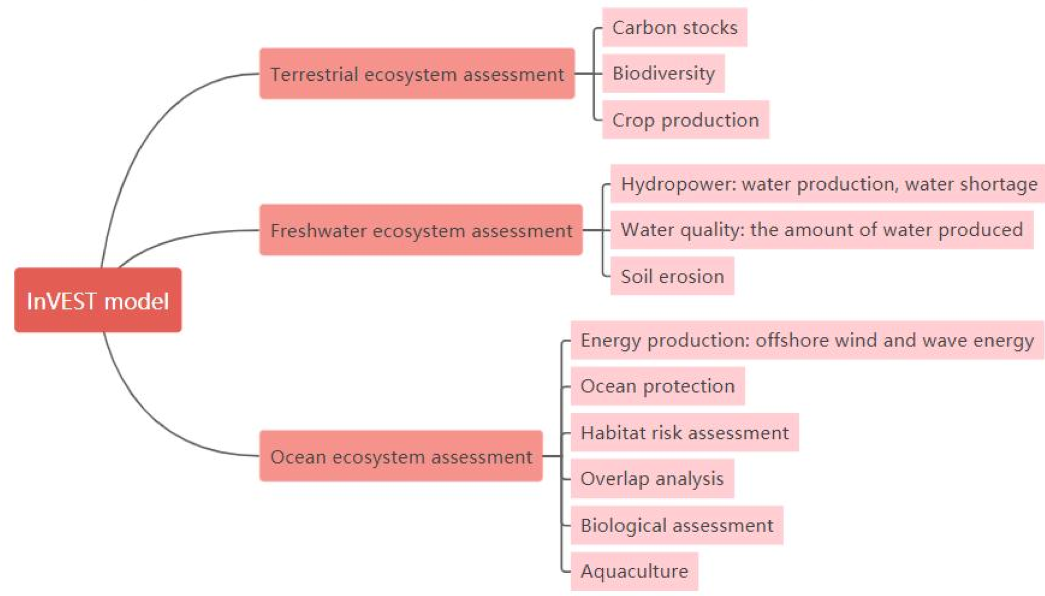

Figure 3 ntroduction to the InVEST model

Result

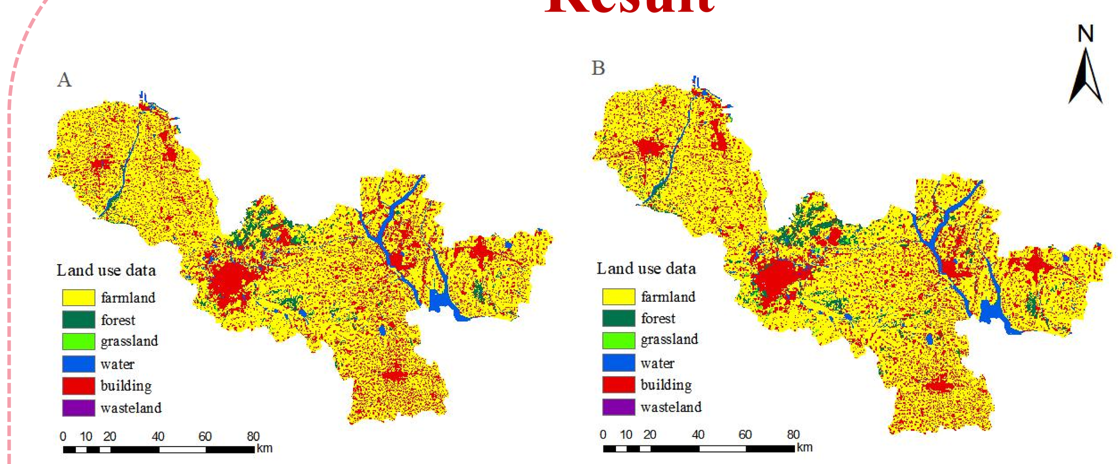

Figure 4 Forecast 2020 vs. real 2020 land use data(A: Forecast map of land use data for 2020; B: True land use data map for 2020)

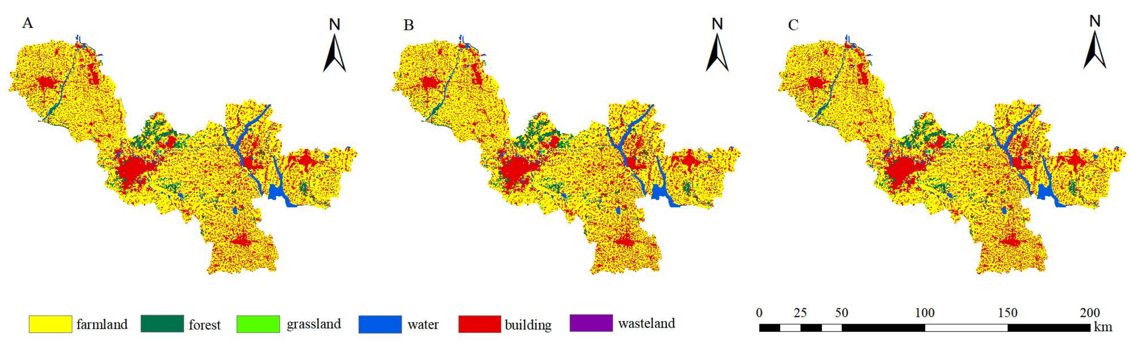

Figure 5 Land use data for three scenarios projected for 2030(A: Under natural development scenarios; B: Under the scenario of urban development; C: Under the scenario of ecological protection)

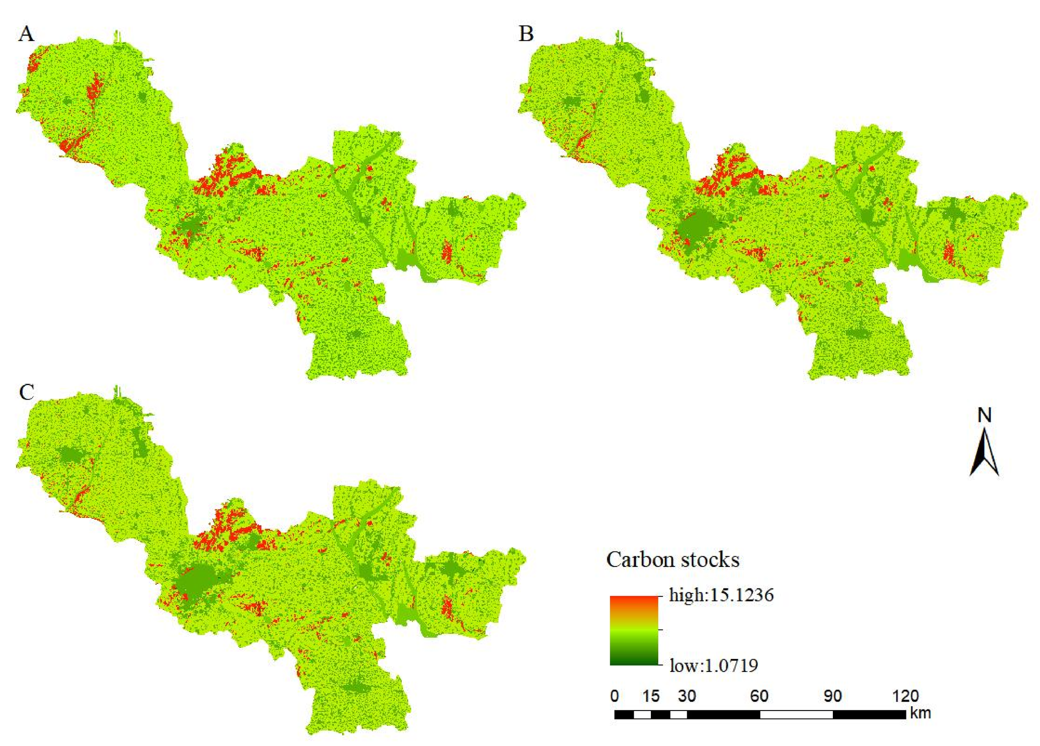

Figure 6 Distribution of carbon stocks in Xuzhou from 2000 to 2020(A: 2000; B: 2010; C: 2020)

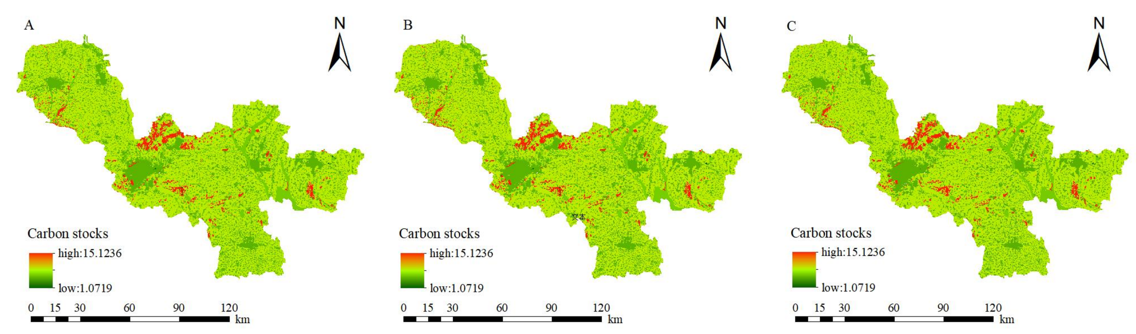

Figure 7 Distribution of carbon storage in Xuzhou under three scenarios(A: Under natural development scenarios; B: Under the scenario of urban development; C: Under the scenario of ecological protection)

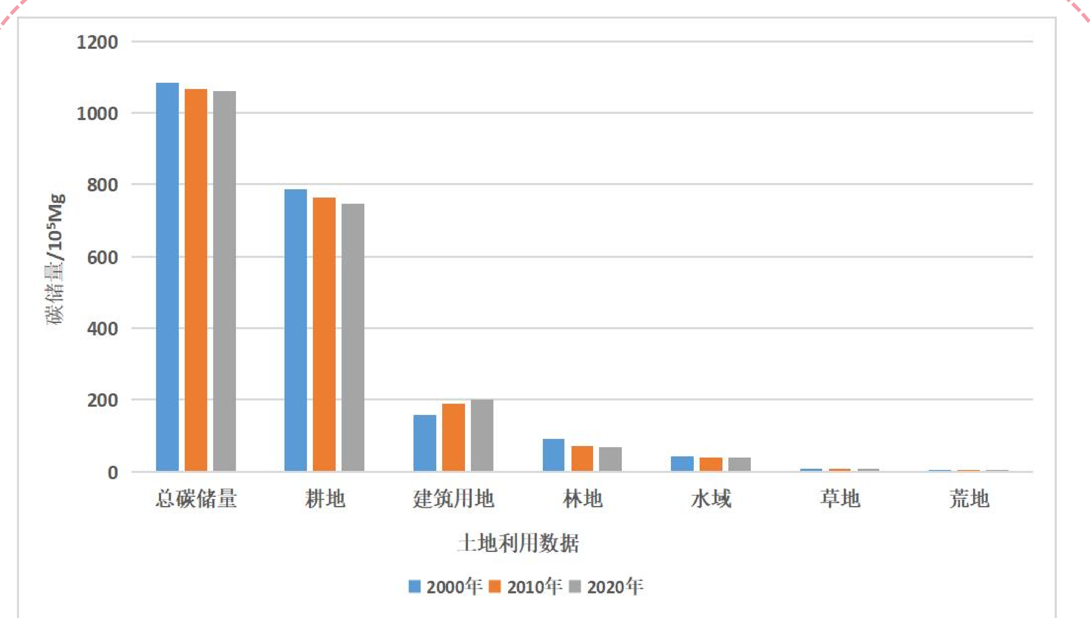

Figure 8 Histogram of total carbon storage and distribution of carbon storage in various features in Xuzhou from 2000 to 2020

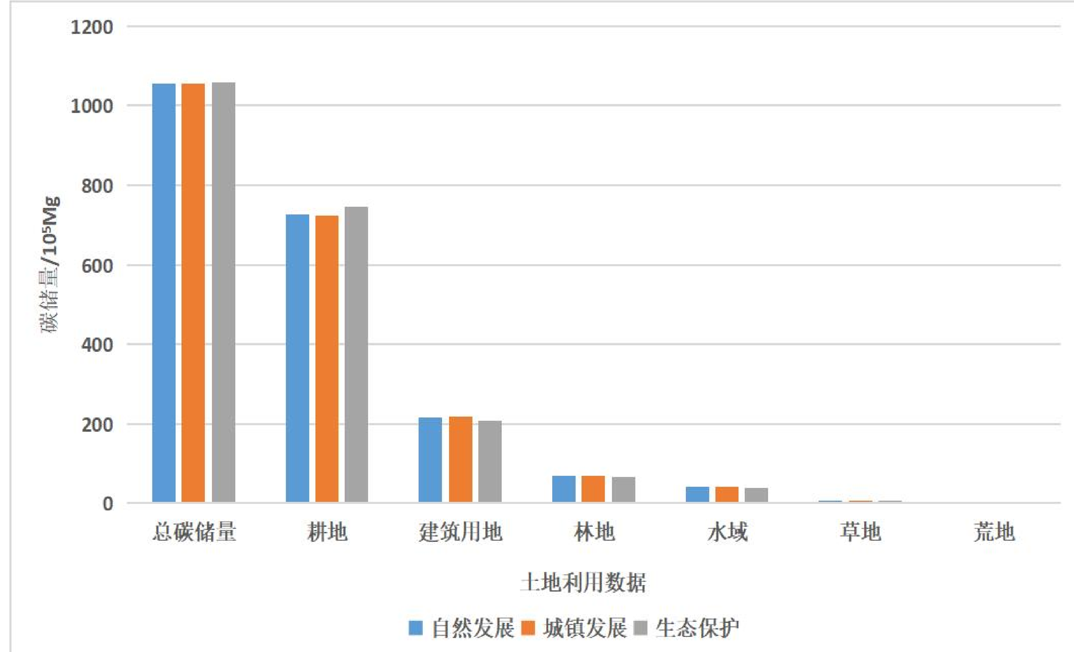

Figure 9 Histogram of total carbon storage and distribution of carbon storage in various features in Xuzhou under three scenarios

Discussion and Conclusion

The change of carbon storage from 2000 to 2020 showed a downward trend, and the carbon storage in 2020 decreased by 23.69×10^5Mg compared with 2000. The land use data of Xuzhou City in 2000, 2010 and 2020 were superimposed on the InVEST model and ArGIS to obtain the spatial distribution map of carbon storage in each year, and the carbon storage distribution map was analyzed and concluded that the high-density carbon storage was mainly distributed in forest areas.Arable land has a lower carbon sequestration capacity than forests; Carbon storage is lower in areas where building land is concentrated. It can be seen that the large expansion of cities has led to a large-scale reduction of vegetation types such as forest land and arable land, which has led to a decrease in the overall carbon sequestration capacity of ecosystems.Compared with the carbon storage in 2020, the carbon storage under the simulated natural development, urban development and ecological protection scenarios in 2030 decreased by 4.58×10^5 Mg, 6.02×10^5 Mg and 2.16×10^5 Mg, respectively, and the carbon storage in the simulated 2030 ecological protection scenario was 2.42×10^5 Mg more than that under the natural development scenario, and the carbon storage under the urban development scenario was 3.86×10^5Mg more. It shows that a certain degree of ecological protection measures will help to slow down the decline trend of regional carbon stocks, scientifically and rationally plan the spatial distribution pattern of land use, help to increase the increase of ecosystem carbon sink, and play a crucial role in alleviating global warming and promoting the "dual carbon" strategy.

Reference

- FAN Xiao-cao,ZHANG Lin.Inter-provincial carbon emission intensity factor analysis and carbon intensity projection calculation in China[J].Ecological Economy,2022,18(04):242-260.
- Hong T ,Miao-miao Z ,Li-min F , et al.Research on quality changes and influencing factors of groundwater in the Guanzhong Basin[J].Journal of Groundwater Science and Engineering,2017,5(03):296-302.DOI:10.19637/j.cnki.2305-7068.2017.03.009.
- XiaoQian L ,Tao P ,ChengHu Z , et al.A systems dynamic model of a coal-based city with multiple adaptive scenarios: A case study of Ordos, China[J].Science China(Earth Sciences),2018,61(03):302-316.
- Jun Yang ,Peng Xie ,Jianchao Xi ,Quansheng Ge ,Xueming Li ,MA Zhandong.Land Use Change Simulation Based on Cellular Automata Model: A Case Study of Dalian Economic and Technological Development Zone[J].Journal of Geography,2015,70(03):461-475.
- Chaoqun Liu ,Shucun Sun.Overview of studies on carbon density patterns in terrestrial ecosystems[J].Chinese Journal of Plant Ecology,2004(05):692-703.