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Editorial: Meta-scenario computation for social-geographical sustainability

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Editorial on the Research Topic
Meta-scenario computation for social-geographical sustainability

Introduction

A socio-geographical system is a highly complex, coupled, open, and giant system (Pickett et al., 2011; Cui et al., 2019). In this system, both the space of human economic production and social life activities and the space of the natural environment form a diverse flow-based network of elements and system structures through material, information, capital, and value flows (Luo et al., 2021). With the development of information technology, especially in the context of rapid development of industrialization, urbanization, and digitalization, the organization of material circulation, energy consumption, and information flow of the social-geographic system also undergo different degrees of changes (Cui, 2022; Su et al., 2022), and the multi-dimensional, multi-structural, multi-level, and multi-element relationships within and among the system become more complex (Moore et al., 2022). The social geographic system exhibited a high level of complexity in both space and time, and the dynamics of its changes and mutations reveal non-linear behavior (Moroni and Cozzolino, 2019; Zhang et al., 2022). These changes and mutations could further impact the geographical setting, which serves as the foundation for economic and production activities (Magalhães et al., 2023). Similarly, the organizational form, strategic path, and goal vision of industrial activities react to the operation and performance of the social-geographical system, which brings about a series of socioeconomic and environmental effects that extend across time and space scales, and they have a profound impact on the government decision-making process and the efficiency with which it operates (Gambarotto et al., 2022; Wang et al., 2022). For example, the trend of urbanization leads to the loss of agriculture and ecological land, which creates danger for both the preservation of ecosystems and the ability to ensure adequate food supplies (Qiao and Huang, 2022; Shi et al., 2022).

Today, understanding the interactive coupling between social systems dominated by human activities and geographical systems dominated by environmental and ecological evolution is a key scientific component for advancing and achieving sustainable development (Mackinnon et al., 2019). Therefore, sustainable development in the perspective of complex social geographic systems requires the promotion of cross-innovation and integration research of multidisciplinary technological approaches in the context of new and changing times (He et al., 2022). In particular, we need to conduct interdisciplinary and method integration research based on data-driven technologies, so as to promote integrated system development of disciplinary knowledge and decision support (Kim et al., 2022; Liu et al., 2023). For example, to build a new knowledge system that is based on spatio-temporal big data, with computational science as the core, combined with new technologies such as geographic cloud, artificial intelligence, deep learning, and digital twinning, and is compatible with cross-disciplinary methods such as information science, and industrial ecology (Stratigea et al., 2015; Ahad et al., 2020; Said and Tolba, 2021). In addition, there is also an urgent need to carry out case experience summaries and refine new development directions to promote the cognitive and adaptive management of the complexity of social geographic systems and support the construction of a community for a shared future of humanity (Xue et al., 2020; Aigwi et al., 2023).

Therefore, we organized the Research Topic "Meta-Scenario Computation for Social-Geographical Sustainability", under which a total of 59 articles from 248 authors were published and have received more than 47 k views till 10 Jan 2023, which shows the broad interest of scholars and readers in this Research Topic. In the following section, we will summarize the key contributions of this Research Topic, and then present the conclusions and outlook.

Contributions and highlights

Data mining, modeling, and methodology development in new data contexts

The continuous development of digital technology and information technology provides new possibilities to re-observe and better understand the socio-geographical system (Xue et al., 2022), therefore, the development of new data sets, the development of new models, and the innovation and development of new methodologies in the new data context is a fundamental and critical area of socio-geographical system research. Under this research theme, we find more than ten valuable and interesting research papers. For example, Zhang et al. develop the first comprehensive dataset of known brownfield sites and their distributions in China, which contains 816 georeferenced brownfield records from 255 cities. Lu et al. use the new data generated from the nighttime light images to identify the spatial structure and evolutionary trends of the resource-based cities, which provides a fresh viewpoint on the stages of urban life cycle development. Yang et al. propose a mapping relationship between the POI data (points of interest) and commercial gentrification and then explain the development process and spatial correlations of commercial gentrification in Chengdu, Sichuan Province. In terms of modeling studies, Meng et al. propose a GM(1,1|sin) power model-based prediction approach for predicting sea surface temperature in conjunction with the genetic algorithm and the least-squares method; Pan et al. establish the two two-order linear quantitative models between Landsat8-derived normalized difference vegetation index and Sentinel-1A interferometric coherence in co- and cross-polarization, which solves the problem that Sentinel-1A decorrelation in the vegetated area is difficult to estimate prior to single-look complex interference. Chen et al. develop the grassland quality index (GQI) and map the grassland quality of the flooded plain based on Jilin-01 images with a red-edge spectral band, and this study is of practical significance for the timely and accurate monitoring of grassland growth, which is beneficial for the development of livestock husbandry and the protection of the ecological environment in northern China. Other interesting research was done by Zang et al. , they establish a remote-sensing estimation model for withered AGB (the aboveground biomass) in the dry-grass season, which could contribute to rapidly acquiring the amount of withered-grass biomass and improve the fire-warning efficiency. While Hou et al.'s study focus on aquatic vegetation models of lakes, they establish an improved CA-Markov model to reconstruct the historical potential distribution of aquatic vegetation in the two typical lakes in Northeast China during 1950s to 1960s. Machine learning is an important tool for data analysis in the new era, herein, Song et al. propose a machine learning-based automatic classification and dynamic prediction method of the surrounding rocks of the tunnel face using the data monitored by a computerized rock drilling trolley based on the intelligent mechanized construction process for drilling and blasting tunnels. Through a summary analysis of this theme, we find that with the new technology support, the analysis data of the social geographic system is more diversified, but also needs innovative and integrated analysis methods, and further form a new series of methodological analysis systems. Although there are many data analysis methods at present, the integrated analysis methods for complex systems still need to be further developed and improved at the application level.

Land use and change, land functions and their influencing factors and responses

The study of land use and its associated systems has been a traditional yet new topic in social geography systems, and it is not only an important scientific topic, but also a topic that involves development decisions, spatial planning, and other practical issues (Foley et al., 2005; Song et al., 2021). Under this research theme, our Research Topic has also attracted a large number of intriguing articles with diverse discussions based on various research viewpoints, spatial dimensions, and research methodologies. For instance, concerning urban land use and its related issues, Yang et al. quantitatively analyze the landscape ecological effects under the expansion of built-up land in the Yellow River basin based on multi-period Landsat satellite image data, and their study emphasizes the importance of spatial heterogeneity at different zoning scales in identifying the dynamic relationships between land expansion in built-up areas and ecological security, scientific planning of land resources, and mitigation of ecological and environmental crises. Ning et al. use remote sensing images combined with statistical methods to analyze the spatial and temporal patterns and quality levels of construction land expansion at different scales, taking the middle reaches of the Yangtze River urban agglomeration as the research object. Fu and Zhang focus on the main urban area of Anshan city of Liaoning province, where mining areas are concentrated, and map the land use in 2008, 2014, and 2020 by using the Landsat TM/OLI surface reflectance data from the Google Earth Engine (GEE) platform and the random forest algorithm. One of the important values of their study is that the GEE-based random forest algorithm is found to exhibit high accuracy in land use classification; in contrast, Wu et al. study the change characteristics of carbon emissions from land use in Chengdu from 1990 to 2020 and then develop four low-carbon land use scenarios based on multi-objective linear programming and the future land use simulation model. In recent years, rural land systems have also gradually become a hot topic, especially in the context of rural revitalization as well as reverse urbanization (Trenberth, 2004; Gawith and Hodge, 2019). Under our Research Topic, we also received several valuable contributions concerning either land use in rural areas or arable land issues. Wang et al. evaluate the arable land expansion trajectories of three urban agglomerations in the Yangtze River Economic Zone and their impact on arable land fragmentation, emphasizing that arable land protection policies should pay attention to arable land expansion trajectories rather than just requiring the total arable land area to be in dynamic equilibrium. Using 75 townships in Yuxi City, Yunnan Province as an example, Wu et al. use an integrated land use/land cover change evaluation model and related analysis methods to analyze the changes in land use patterns in mountainous areas and basins during 1995–2018 and reveal the spatial differences and their influencing factors. Of course, there are also studies that focus on ecological land use or land structure and changes in natural systems. For example, to fully comprehend the dynamic dynamics of land use, Ma quantifies the spatiotemporal pattern of land use change and estimated trade-offs and synergies between dominant and recessive morphologies. Jin et al. use multi-source land use data and Google remote sensing data to explore land use change, spatial-temporal evolution of habitat quality, and driving variables impacting habitat quality change in Sanjiang Plain from 1985 to 2017. In summary, we would like to point out that the study of regional spillover effects and coupling relationships of different land use transformations should be strengthened in the future. Existing studies still focus more on single systems, such as urban systems, rural systems, or natural ecosystems, while the issue of cross-system land-use transitions and functions needs to be further strengthened.

Ecosystem, ecological resilience, and ecosystem-economic system interactions and relationships

Ecosystem services are a key reliance for sustainable human development, and the relationship between ecosystems and economic systems forms one of the cognitive foundations of the socio-geographic system (Sonter et al., 2020; Mandle et al., 2021). Within this research theme, Duo et al. explain the complex dynamic evolutionary mechanism of urban ecosystem resilience and develop a framework for quantitative measurement of urban ecological resilience in three dimensions (resistance, resilience, and vitality) which aims to provide a comprehensive evaluation of urban ecosystem resilience. Hu et al. construct a PCA-MGWR (principal component analysis - multi-scale geographically weighted regression) model to explore the temporal and spatial patterns of ecosystem services in the Sichuan Basin from 2000 to 2015 and explore the spatial variability of the driving factors. Trade-offs between ecosystem services are measures of the degree to which the differences between individual ecosystem services are changing (Bennett et al., 2009). Thus, Jia et al. investigate the spatiotemporal changes and determinants of ecosystem service trade-offs in various forest types after the implementation of the natural forest conservation project, using the Greater Khingan Mountains as an example. Ecological compensation is an important tool for optimizing ecosystem management from an economic policy perspective and an important tool for situational governance of socio-geographic systems (Wei et al., 2022; Xing et al., 2022). With this in mind, Wang et al. design a decision-making framework of ecological compensation by combining spatial planning and ecosystem service value accounting, which includes “Subject choice, Value accounting, Priority evaluation, Policy supply”, and they select 32 counties (districts) in the Yangtze River Delta region to test the framework and find that the implementation of ecological compensation slows down the urbanization process and promotes the increase of ecological space. However, given that the period-oriented comparative evaluation of biodiversity conservation success is the primary foundation for executing the transfer payment policy of ecological compensation (Gantioler et al., 2014; Hayes et al., 2022). Chen et al. propose a method to construct the period conservation effectiveness index and apply it to the spatial comparative assessment of Chinese biodiversity conservation effectiveness in three periods from 1990 to 2015. Such a study could provide a reference for global large-scale ecological compensation. In addition to this, we have received some studies on the evolution of natural ecosystems and climate systems. For example, Yan et al., analyze the characteristics of a backflow blizzard in Liaoning, China, and reveal the reasons behind the spatial heterogeneity of snowstorm intensity and duration. Zhou et al. uncover the dynamic change of vegetation index and its influencing factors in Alxa League in the Arid Area. It is worth mentioning that we have an article discussing the spatial and temporal variation of human pressures faced by key biodiversity areas; Zeng et al. analyze the spatiotemporal variation of human pressure on key biodiversity areas from 1990 to 2017 and compare it with the human pressure on national natural reserves through a case study of the Qinghai–Tibet Plateau, and the findings are expected to serve as a reference to formulate policies for the improvement of the effectiveness of conservation.

Built environment, habitat, and the mechanisms on human health, ecosystems, and climate change

The built environment and habitat system are the core dominant forces of the socio-geographic system and have the most complex system composition (Liu et al., 2022). Within this research theme, we collected several interesting an d inspired articles which combine detailed and reliable technical analysis with decision-support applicability. For example, Zhang et al. explore the spatiotemporal evolution characteristics of the climate comfort of the urban human settlement environment in China from 2000 to 2015, based on a three-level time scale of a year, a month, and a day using the temperature and humidity index and wind efficiency index, and their findings imply that the population density in the country is generally concentrated in the climate comfort areas. Xin et al. assess the seasonal differences in surface UHI (urban heating island), normalized differences in vegetation index, built-up index, and water index and their relationships in Dalian City, Northeast China, and their findings could facilitate the rational layout of cities. Further, Dai and Liu establish an appraisal system to assess how and to what extent UHIs affect resident health, by taking Tianjin during 2006–2020 as an example, and their findings offer some decision-making guidance for the planning of healthy cities. A study done by Huang et al. shows us the spatiotemporal pattern of temperature's impact on residents' irritability using data from summer high-temperature measurements and an emotional health survey in Beijing, combined with remote sensing images and statistical yearbooks, while Li et al. evaluate the performance of different thermal indices on quantifying outdoor thermal sensation in humid subtropical residential areas of China. The authors argue that it is necessary to establish the thermal sensation ranges of humid subtropical areas of China. Zhou et al. investigate the spatiotemporal evolution and factors of climate comfort for urban human settlements in the Guangdong–Hong Kong–Macau Greater Bay Area, which provide data-driven guidelines for improving the climate comfort of urban human settlements, while Ao et al. focus on the rural built environment, performing a scientometrics literature review to understand the state-of-the-art interplay between the rural built environment and travel behaviors and to identify future research directions. We also include several articles that discuss microclimate and ecosystem or health responses. For example, Cheng et al. demonstrate the positive impact of water bodies on improving the thermal environment of a village and regulating its microclimate by quantifying the impact of morphological elements of the settlement on its microclimate, while Tang et al. uncover the spatial impact of urban expansion on lake surface water temperature base on the perspective of watershed scale, and Liu et al. explore the cooling effect of urban parks based on the ECOSTRESS (ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station) land surface temperature data. We also note that there are other studies that focus on urban green spaces, the built environment, and their relationship to vitality. For example, Zhou et al. conduct a thermal analysis of crowd activities, service pressure analysis, and demand evaluation for the layout of green park space in the central urban area of Yuxi City in Yunnan province, Yu et al. study the spatial-temporal impacts of the built environment on vibrancy, and Luo et al. uncover the spatially varying impacts of the built environment on physical activity from a human-scale view by using the street view data. The above studies not only provide good intellectual contributions and discussion on their topics but also, it is particularly important to note that they have tried to introduce new data systems, such as POI big data, to enrich their studies, which reflects the new trend of current research (Xue et al., 2023).

Human activities, socio-cultural and environmental impacts and their sustainable development mechanisms

Human activities are the core dominant force of socio-geographical systems, and culture is an important driving force influencing the evolution of socio-geographical systems (Campari and Frank, 1995). At the same time, we also note that it remains an important research proposition to quantify the environmental and climate impacts of human socio-economic activities under socio-geographical systems. As the only article with archaeological ideas under this research theme, Liu et al. investigate the spatial distribution and evolution of ancient settlements from the Neolithic to the Bronze Age in the Dalian area, --China, and they find that such spatial distribution and evolution are influenced by the contemporary climate. Gao et al. study the dynamic evolution and synergistic relationship between urbanization and eco-efficiency through the selection of 76 agricultural counties and districts in Liaoning province as research units. In contrast, Wu et al. investigate the eco-environmental constraints, economic incentives, and spatiotemporal variations of construction land use efficiency in the Yangtze River Delta, China between 2000 and 2020, and they argue that proper policies should be tailored to specific places to coordinate construction land use, economic growth, and eco-environmental sustainability. We also received two valuable articles that discuss educational inequality and equity using multiple sources of data. One of them was done by Zhang et al., who discuss education equality and its influencing factors for migrant children in the compulsory education stage by taking Dalian City as a case study, and they call for attention to be paid to the spatial balance of educational resource allocation. Another article, done by Liu et al., discusses the spatiotemporal heterogeneity of primary and secondary school student distribution in Liaoning Province, China from 2010 to 2020, which provides important insights into the population and educational geography. We also received articles focusing on themes such as urban transportation, innovation networks, digital economy, industrial ecology, and regional culture. They either focus on methodological innovation or are problem-oriented and present some valuable conclusions and recommendations. For example, Mao et al. analyze the impact of rapid transit development on the urban economic growth of 220 cities in 19 urban agglomerations in China from 2008 to 2019 and examined the heterogeneity of the difference in market integration capability in promoting urban economic growth, Ma et al. constructed a theoretical analytical framework for intercity innovation network resilience and conducted a case study of 338 prefecture-level cities in China from 2017–2019, finding that the systemic resilience of Chinese urban innovation networks exhibits relatively low hierarchical and decreasing mismatch characteristics year by year. Zhou et al. propose a framework to discuss the impact of China's digital economic development on the population and find that the digital economy has a bidirectional influence on the population, and the digital economy can indirectly affect the spatial layout of the population attributes by giving digital connotations to regional elements. Xiu and Li summarize the internal relationship and mechanism of industrialization, business culture, and higher education that affect the development of modern industrial and commercial culture, and they argued that it is necessary to continue cultural construction, adapt to the requirements of the highest level of openness and realize the healthy development of the Hainan Free Trade Port. Furthermore, Qin et al. study the spatial correlation and drivers of industrial agglomeration and pollution discharge in the Yellow River basin. In contrast, Xia et al. investigate the energy consumption connection of the industrial sector based on the industrial link theory. In general, we find that the research on social subsystems is still not particularly adequate, and existing studies still focus on the economic-environmental system, while research on the socio-cultural system and its interaction with the geographical-environmental system is obviously lacking, and the data accumulation and research in this area should be strengthened in the future.

Conclusion and outlook

Under this Research Topic, more than 59 articles have been published, ranging from technical articles on data methods and modeling studies to thematic articles focusing on land use, ecosystems, built environment, and society and culture, which fully illustrates the frontier and topicality of this research theme. However, we also note that there are still many challenges and difficulties to be overcome in the future, including but not limited to 1) strengthening data and methodological research, further developing new data systems with modern technical support, and creating more advanced analytical methodologies to achieve visualization and modeling interpretation of research processes and results; 2) strengthening research on the integration of socio-cultural themes with environmental-geographic themes, establishing a comprehensive analysis system for different time scales, different spatial scales, and different organizational scales of professional research system comprehensive analysis system, to realize the collaborative innovation research under the socio-geographic system and 3) strengthening using international case studies and promotion. The authors in this Research Topic are predominately Chinese authors, which reflects the popularity of this research theme in China, but international cooperation should be strengthened in the future to establish a broader academic community and jointly promote academic development.

Author contributions

BX, YX, and JY wrote the first version of this editorial. All the editors contributed to the final version of this editorial.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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