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DISSERTATION

MANAGEMENT OF SUSTAINABLE DEVELOPMENT OF REGIONAL TERRITORIAL COMMUNITIES IN PEOPLE'S REPUBLIC OF CHINA

Speciality 073 - Management
(Field of study 07 – Management and administration)

Submitted for a scientific degree of Doctor of philosophy

The dissertation contains the results of own research. The use of ideas, results and texts of other authors have references to the relevant source

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ABSTRACT

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The Dissertation substantiates theoretical-methodical and scientific-practical provisions regarding the management of sustainable development of regional territorial communities in the People's Republic of China.

The regional level is where the intersection and combination of ecological, economic, and social parameters of the socio-economic space take place. Therefore, ensuring the sustainable development of regions as complex spatial formations is organic and appears as the top priority of today's agenda. The investigation of regional development concepts shows the significant role of urbanisation in this process and the critical importance of urban settlements as the core elements of regional communities at their maturity stage. Therefore, in this thesis, regional territorial communities are considered regional complexes formed from one or two central cities and supplemented by several cities of different scales and types within a particular space, with labour specialisation and cooperation, complementary functions, and relationships. The role of cities in developing regional territorial communities is particularly significant in China, where the level of urbanisation is already more than 60%.

In this research, through the study of approaches for the development of urban areas, which should contribute to their sustainability (eco-city, compact city, green city, healthy city, knowledge city, smart city), it was established that the modern development of urban areas depends significantly on knowledge and information. In particular, the concepts of the knowledge city and the smart city, which have emerged recently, indicate that science, knowledge, technology, and innovation are the way to sustainable

development through technological solutions. The growing importance of science, knowledge and information is also associated with the need to implement management functions – due to the significant amount of data used in decision-making currently. On this basis, a five-dimensional vision of the smart city's functioning system was developed. It consists of understanding information as an essential component that integrates other elements of urban development (economy, society, technology and politics) and, simultaneously, is a source and means of building a proper urban governance system.

Since the three-aspect model of sustainable development is classical, considering the role of data and the coordination aspect of the management and functioning of territories of different levels is possible by placing science and technology as a particular component of sustainable development. This transforms the conceptual understanding of the main aspects (factors) of sustainable territorial development: sustainable economic growth, sustainable society, sustainable environment, sustainable technology and science as a source of sustainable innovations that can improve the functioning of all other spheres. This makes it possible to understand better the mechanisms of ensuring and supporting the sustainable development of territories in the conditions of digitalisation and to implement them in practice. A detailed analysis of the content of the proposed components made it possible to determine their role and significance, problems and main emphasis. Thus, the scientific understanding of sustainable urban development as a collaborative and lasting development of the urban economy, society, natural environment, science, and technology was emphasised. So, the city's sustainable development level is determined by the level of these elements' performance.

This research emphasises that one of the reasons that limit the ability of current urban management regimes in China to solve urbanisation problems is the dominance of traditional approaches to management (the vision of development through economic growth and physical expansion) and the limitations of the planned economic system. Therefore, it is essential to carry out reforms based on sustainable development and good governance. Three main elements of community development are defined: the government, which plays the leading role in the design, creation and management of communities – provides management (leadership); a market that represents the middle level and ensures the promotion of sustainable development through the implementation of government initiatives at the level of sectors and enterprises; population (micro level), whose primary role is active participation in the performance of these initiatives. Since the essential functions of the city are extensive and, at the same time, interconnected, the government should, through proper management, promote their best combination, integration, and implementation. At the same time, given the problems of traditional urban management in the People's Republic of China, it is indicated the need to strengthen the strategic context (taking into account the interdependence of the components of the design-creation-functioning cycle of urban infrastructure and its functional aspect) and preventive management in all spheres of city management (planning, construction, operational management). Since information and full-fledged knowledge about the urban system play a vital role in these processes, this research proposes an improved interpretation of the "knowledge-oriented" strategy of sustainable urban development, which is based on careful consideration of indicators characterising the natural environment, economy, society, development of science and technology as a system of interconnected factors, the result of which is the formation of driving forces for the sustainable development of cities and complex regional territorial communities. Knowledge-based strategic and preventive management of territorial development means the need to create and use in practice a holistic system of indices and an evaluation model, which is an essential component of the decision support system for urban development planning and impacts the overall process of sustainable urban development, increasing the ability of the management system to achieve the set goals.

According to the results of the review of methodical approaches to the assessment of the state urbanised territories development, the presence of a wide range of points of view regarding the main determinants of sustainable development was revealed: some evaluation systems concentrate on environmental aspects and levels social and economic ones; in others, attention is focused on a broader approach to the interpretation of capital and well-being (taking into account social and human capital), as well as on institutional aspects. Available methods generally characterise economic, ecological, and social aspects, considering their integration. Taking into account the importance of scientific and technological factors in ensuring the sustainable development of urban areas, an original index system was proposed. Unlike the existing system of indexes, the proposed method allows for measuring the level of sustainable development and the comprehensive effectiveness of economic, social, environmental, scientific and technological dimensions involved in the functioning and development of cities. Considering the methodological aspects of building a system of indices for assessing the sustainable development of communities, it was proposed to follow several vital principles: objectivity, completeness, sensitivity, reliability, dynamism, and coordination. This means the need to consider the specifics of sustainable urban development and the temporal aspects of data analysis (to demonstrate the dynamic nature of the state of sustainable development). The formed index system has a three-level structure: the level of the target indicator that is an integral indicator of sustainable urban development; indicators of the first level (estimates of four factors of sustainable development); indicators of the second level (20 indices – primary data on the parameters that characterise the components of sustainable development). Each index of the second level is given an attributive characteristic (a positive or negative value of dynamics is desirable).

In addition to defining the components of the sustainable development of the city and the indicators that can be used for their evaluation, it is also essential to choose an appropriate evaluation model that will consider the studied system's complexity and ensure the proper objectivity of the obtained results. The analysis of existing approaches to the construction of such comprehensive systems for evaluating the sustainable development of territories has proven several existing problems: the use of data that are difficult to measure, incompleteness of data, chaos, subjectivity, insufficient clarity and transparency in the selection of indicators and their weights (significance). In general, such approaches as "by functions" and "by variability" are used to determine the weights of the indices and the method of calculating the available indicator. The second approach ensures the objectivity of the assessment and weighting of indices and, therefore, the objectivity of the overall process of assessing sustainable development. This made it possible to improve the methodological approach to forming a scientifically based and "intelligent" system of evaluation and monitoring urban territories' development through entropy and TOPSIS methods. This approach makes it possible to assess the level of sustainable development of urban territories and the key factors influencing this process quantitatively and objectively through an assessment of the significance and fluctuations of each parameter. The entropy method estimates the weight of individual second-level indices in the proposed approach. The TOPSIS method measures the performance of sustainable development of particular researched objects. To assess the level of sustainability of regions, a scale is offered, which allows, based on the measurement results, to conclude about the territory's weak, average, good, and high-quality level of sustainable development.

The formed judgement scale was laid as the basis of an improved methodical approach to determining the main priorities of strategic management of sustainable development of regions. This approach is based on specific values of parameters and assessments of the level of sustainable development of territorial entities. It contributes to the formalisation of the decision-making process (which reduces the influence of the human factor and subjectivity when decision-making). Due to the substantive and structural-process aspects of strategic management of territories development, a scheme (algorithm) of actions based on measuring regions' level of sustainable development was proposed. According to the proposed scheme of the strategic decision-making process, the use of the developed measurement and evaluation system makes it possible to establish the main factors (drivers) of the territory's sustainable development and further assess the performance of individual regions. The identified drivers should be the main focus in developing sustainable development policies and strategies and, differentiated by region, allow for the formulation of measures that are a priority for one or regional territorial community.

An assessment of the factor’s influence in the general indicator of sustainable development for the entire general sample (31 provinces in the territory under the control of the Central Government of the People's Republic of China) showed that the component "science and technology" has the most significant impact (55.4%). The influence of economic growth (17.6%), social well-being (16.4%), and the environmental component (11.23%), on the other hand, is insignificant. Therefore, science and technology is the driving force of the sustainable development of territories in the PRC, and the role of this factor is increasing year by year: from 54.07% in 2016 to 54.56% in 2019. The analysis of the second-level indices showed that the most significant aspects of sustainable development are those belonging to the "Science and Technology" group (technology market turnover, the R&D involvement of the personnel of industrial enterprises, the number of patents, R&D funds of industrial enterprises, financial expenditures for science and technology). The least significant is the residential building area per capita (social group), electricity consumption per unit of GDP (economic component), level of centralised wastewater treatment and harmless level of waste processing technologies (environmental component), and water consumption per unit of GDP (economic part). The total impact of these indicators together is only about 5%. The obtained results reveal the fundamental factors of promoting the sustainable development of cities in the People's Republic of China: the development of talents, science and technology, capital and policy. At the same time, the obtained results also indicate that the sustainable development of cities is more related to the activity of business circles, while the government can significantly contribute to such action.

Therefore, the quantitative results from the proposed strategic decision-making algorithm made it possible to formulate the general principles of the strategy of the PRC in the direction of sustainable development. To improve the scientific and technological component of sustainable development, it is proposed to strengthen scientific and technical publicity, create a favourable environment for scientific and technological progress and independent innovation, and promote training and the introduction of talents. Regarding the economic subsystem, the primary efforts should be aimed at changing the regime of extensive economic growth, developing the tertiary industry, and establishing the industrial system in backward areas. When making strategic decisions on social issues, it is advisable to focus on the factors that affect the social stability of the community (infrastructure, access to public facilities, equality and justice) and to implement proper planning and leadership. From the point of view of environmental aspects of regional sustainable development, the most critical issues to be resolved are the effective use of land resources and the strengthening of the role and functions of environmental management.

Using the TOPSIS model, the sustainability performance of each of the studied 31 provinces was assessed, and their ranking was carried out. The territorial distribution pattern of the sustainability performance of the provinces grouped into four regions (coastal east, central, west and the urbanised agglomeration of Beijing-Tianjin-Hebei) is determined. In general, the level of development of provinces and territories is uneven, and the overall grade is relatively low. According to the results, the sustainable development of various regions of China is characterised by a weakening trend from the eastern coastal areas to the western inland parts. Considering this, the features of community development (economic structure, resource availability, socio-demographic situation, and development of science and technology) were characterised in detail. There were investigated reasons that restrict sustainable development and formulated strategic proposals for strengthening the potential of sustainable development for each regional territorial community. The obtained results testify to the practical significance and feasibility of using the provisions developed during this research in managing the regional territorial communities' sustainable development in the People's Republic of China.

Keywords: management, sustainable development, region, territorial communities, urbanisation, urban areas, strategic management, measurement, evaluation system, Entropy method, TOPSIS, People's Republic of China.

LIST OF APPLICANT'S PUBLICATIONS

Scientific works reflecting the main scientific results of the dissertation:

1. **Hongyue Wang**, Inna I. Koblianska, Xiumin Yan. Research on Collaborative Innovation Path of Data Resources for Sustainable Development of Smart City. *International journal of ecology and development*. 2022. 37(1). C. 26–43. URL: http://www.ceser.in/ceserp/index.php/ijed/article/view/6851 **Web of Science** *(author proposes a concept of knowledge and informational-based management of urban development).*

2. **Hongyue, W.,** Koblianska, I., Zhengchuan, Zh., Xiumin, Y. Key Drivers of Urban Digital Economy Sustainable Development: The China Case. *Scientific Horizons*. 2022. Vol. 3. C. 76–84. 10.48077/scihor.25(3).2022.76-84 **Scopus.** *(author proposes the system to assess urban sustainability and presents the main calculations of research).*

3. **Hongyue Wang**, Koblianska Inna. Restructuring theoretical framework of urban sustainability from the health dimension. *Економіка та суспільство*. 2021. № 31. 10.32782/2524-0072/2021-31-13 *(author justifies the main elements of urban sustainability through health aspect).*

4. **Wang Hongyue**, Koblianska I.I. The concept of smart city to promote sustainable urban development. *Вісник СНАУ. Серія Економіка і менеджмент*. 2020. № 2 (84). С. 13-18. https://doi.org/10.32845/bsnau.2020.2.2 *(author explores the smart city concept of urban sustainability).*

5. **Hongyue W**., Koblianska I., Elaborating strategies for sustainable development in China regions: key principles. *International scientific journal "Internauka". Series: "Economic Sciences".* 2022. №9 (65). *https://doi.org/10.25313/2520-2294-2022-9-8305* *(author explores the main principles of management of sustainable development of regional territorial communities).*

Scientific works certifying the approval of the dissertation materials:

6. **Wang Hongyue**, Koblianska Inna. Evaluation of urban sustainable development in China based on the ENTROPY-TOPSIS method. Conference proceedings of 6th International Scientific Conference EMAN Economics & Management: *How to Cope with Disrupted Times* (March 24, 2022, Ljubljana, Slovenia). – Belgrade: UdEkoM Balkan, 2022. P. 199-206. ISSN 2683-4510 *(author summarises advantages of the ENTROPY-TOPSIS approach to assess the urban sustainable development).*

7. **Wang Hongyue**, Koblianska Inna. The Effective Path of Urban Knowledge Management in China from the World Perspective. Proceedings of 3rd Virtual International Conference *Path to a Knowledge Society-Managing Risks and Innovation* PaKSoM (November 15-16, 2021, Belgrade, Serbia). – Belgrade: Niš : Copy house, 2021. P. 71-74. *(author identifies main elements of knowledge management system in urban management).*

8. Koblianska I., **Hongyue W.** Artificial intelligence for urban sustainable development. *Технології XXI сторіччя*: Збірник тез за матеріалами 26-ої міжнародної науковопрактичної конференції (7-9 грудня 2020 р., м. Суми). Ч.2. – Суми: СНАУ, 2020. С. 47–48. *(author reveals the potential of artificial intelligence technologies for urban sustainable development management).*

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11. **Wang Hongyue**, Inna Koblianska. Research on urban spatial shape optimization based on low carbon orientation. *Економіко-управлінські та інформаційно-аналітичні новації в будівництві*: II Міжнародна науково-практична конференція (27 березня 2020 р., м. Київ). – Київ: Видавництво Ліра-К, 2020. С. 146–147. *(author generalizes main features of low-carbon orientation approach in urban development and management).*

12. **Wang Hongyue.** The compact ecological city: the new concept of urban sustainable development. *Економічний і соціальний розвиток України в XXI столітті: національна візія та виклики глобалізації*: збірник тез доповідей XVI Міжнародної науково-практичної конференції молодих вчених (9-10 квітня 2019 року, м. Тернопіль). Тернопіль: Вид-во ТНЕУ, 16-17.

АНОТАЦІЯ

Ван Хунює. Управління сталим розвитком регіональних територіальних громад в Китайській народній республіці.- Кваліфікаційна наукова праця на правах рукопису.

Дисертація на здобуття наукового ступеня доктора філософії за спеціальністю 073 – Менеджмент. – Сумський національний аграрний університет, Суми, 2022.

У дисертації обґрунтовано теоретико-методичні та науково-практичні положення щодо управління сталим розвитком регіональних територіальних громад в Китайській народній республіці.

Регіональний рівень є тим, де відбувається перетин та поєднання екологічних, економічних та соціальних параметрів соціо-економічного простору. Відтак, забезпечення сталого розвитку регіонів як комплексних просторових утворень є органічним та постає сьогодні першочерговим пріоритетом порядку денного. Дослідження концепцій розвитку регіонів показало значну роль урбанізації у цьому процесі та ключове значення міських поселень як основоположних суб'єктів регіональних утворень на стадії їх зрілості. Відтак, у роботі регіональні територіальні громади розглядаються як регіональні комплекси сформовані з одного чи двох центральних міст та доповнених декількома містами різного масштабу та типів в рамках певного простору, зі спеціалізацією праці та кооперацією, доповнюючими функціями та взаємозв'язками. Роль міст в розвитку регіональних територіальних громад особливо значима в Китаї, де рівень урбанізації вже становить більше 60%.

У роботі через вивчення ідей розвитку урбанізованих територій, що мають сприяти сталому розвитку міських поселень (еко-місто, компактне місто, зелене місто, здорове місто, знаннєве місто, розумне місто), встановлено, що сучасний розвиток урбанізованих територій значно залежить від знань та інформації. Зокрема, концепції знаннєвого міста та розумного міста, які виникли нещодавно,

свідчать про те, що саме наука, знання, технології та інновації є шляхом до сталого розвитку через технологічні рішення. Зростання значення науки, знань та інформації також пов'язано з необхідністю реалізувати функції управління – через значну кількість інформації, якою сьогодні оперують при прийнятті рішень. На цій основі було розвинуто п'ятиаспектне бачення системи функціонування розумних міст, що полягає у розумінні інформації як важливої складової, що інтегрує інші складові міського розвитку (економіку, суспільство, технологію та політику) та водночас є джерелом та засобом розбудови належної системи міського урядування.

Оскільки три-аспектна модель сталого розвитку є класичною, урахування ролі даних та координаційного аспекту управління та функціонування територій різного рівня є можливим через врахування науки та технологій як окремої складової сталого розвитку. Це трансформує концептуальне розуміння основних аспектів (факторів) сталого розвитку територій, якими є стале економічне зростання, стале суспільство, стале навколишнє середовище, сталі технології та наука як джерело сталих інновацій, які здатні поліпшити функціонування всіх інших сфер. Це дає можливість краще розуміти механізми забезпечення та підтримки сталого розвитку територіальних утворень в умовах цифровізації та реалізовувати їх на практиці. Детальний аналіз змісту складових дав можливість визначити їх роль та значення, проблеми і основні акценти. Таким чином, було підкреслено наукове розуміння сталого міського розвитку як скоординованого та тривалого розвитку міської економіки, соціуму, природного та науково-технологічного середовища. При цьому рівень сталого розвитку міста визначається рівнем розвитку цих елементів-факторів.

У роботі підкреслено, що однією з причин, яка обмежує можливості існуючих режимів управління містами в Китаї вирішити проблеми урбанізації, є панування традиційних підходів до управління (бачення розвитку через економічне зростання та фізичне розширення) та обмеження планової економічної системи. Тому важливим є проведення реформ відповідно до ідеї сталого розвитку та «гарного» управління. Визначено три основні елементи розвитку громад: уряд, що відіграє основну роль у дизайні, створенні та управлінні громадами – забезпечує керування (лідерство); ринок, що представляє серединний рівень та забезпечує сприяння сталому розвитку через реалізацію ініціатив уряду на рівні секторів та підприємств; населення (мікрорівень), основна роль якого – у активній участі в реалізації даних ініціатив. Оскільки базові функції міста є досить розгалуженими та, водночас, взаємопов'язаними, уряд має, через належний менеджмент, сприяти їх найкращому поєднанню та реалізації. При цьому, з урахуванням проблем традиційного управління містами в КНР, вказано на необхідність посилення стратегічного контексту в загальному процесі управління містами (ураховуючи взаємозалежність складових циклу дизайн-створення-функціонування міської інфраструктури та її функціональний аспект) та превентивного управління в усіх ланках міського управління (плануванні, будівництві, операційному управлінні). Оскільки інформація та повноцінні знання про міську систему відіграють ключову роль у цих процесах, у роботі було запропоновано вдосконалене трактування «знаннєво-орієнтованої» стратегії сталого розвитку міст, яка ґрунтується на комплексному розгляді та врахуванні показників, що характеризують природне середовище, економіку, суспільство, розвиток науки та технологій як систему взаємопов'язаних факторів, результатом яких є формування рушійних механізмів сталого розвитку міст та комплексних регіональних територіальних утворень. Засноване на знаннях стратегічне та превентивне управління розвитком територій означає необхідність створення та використання на практиці цілісної системи індексів та оціночної моделі, що є важливою складовою системи підтримки рішень щодо планування міського розвитку та відіграє роль в загальному процесі сталого розвитку міста, підвищуючи спроможність системи управління досягати поставлених цілей.

За результатами огляду методичних підходів до оцінки стану розвитку урбанізованих територій, виявлено наявність широкого кола точок зору стосовно основних визначників сталого розвитку: окремі системи оцінювання концентруються на екологічних аспектах та нівелюють соціальні та економічні; в інших – акцентовано увагу на більш широкому підході до трактування капіталу та добробуту (з урахуванням соціального та людського капіталів), а також на інституційних аспектах. Наявні методики загалом дозволяють охарактеризувати економічні, екологічні та соціальні аспекти, з урахуванням їх інтеграції. Ураховуючи значущість науково-технологічних факторів у забезпеченні сталого розвитку урбанізованих територій, було запропоновано індексну систему оцінки ефективності сталого розвитку міської території як складової регіонального комплексу, що, на відміну від існуючої системи індексів, дозволяє вимірювати рівень сталого розвитку та комплексну ефективність економічного, соціального, екологічного та науково-технологічного вимірів, задіяних у процесі функціонування та розвитку міст. Розглядаючи методичні аспекти побудови системи індексів для оцінки сталого розвитку громад, відповідно до запропонованого чотири аспектного підходу до розуміння факторів сталого розвитку, було виділено ряд важливих принципів: об'єктивності, повноти, чутливості, достовірності, динамічності та координації. Це означає необхідність врахування саме специфіки сталого розвитку міст, а також часових аспектів аналізу даних (в цілях демонстрації динамічного характеру стану сталого розвитку). Сформована система індексів має трирівневу структуру: рівень цільового показника – інтегральний показник сталого розвитку міста; показники першого рівня (оцінки чотирьох факторів сталого розвитку); показники другого рівня (20 показників – первинні дані щодо параметрів, які характеризують складові сталого розвитку). Кожному індикатору другого рівня надано атрибутивну характеристику (позитивне або негативне значення динаміки є бажаним).

Окрім визначення складових сталого розвитку міста та показників, що можуть бути використані для їх оцінювання, важливим є й вибір належної оціночної моделі, що дозволить врахувати комплексність досліджуваної системи, забезпечить належну об'єктивність отриманих результатів. Аналіз існуючих підходів до побудови подібних комплексних систем оцінювання сталого розвитку територій засвідчив ряд наявних проблем: використання даних, які складно виміряти, неповнота даних, хаотичність, суб'єктивність, недостатня чіткість та прозорість у виборі показників та їх ваг (значущості). Загалом, для визначення ваг індексів та методики обчислення загального показника застосовуються такі підходи як "за функціями" та "за варіативністю". Саме другий підхід дозволяє забезпечити об’єктивність оцінювання та зважування індексів, а отже – й об’єктивність загального процесу оцінювання сталого розвитку. Це дало змогу вдосконалити методичний підхід до формування науково-обґрунтованої та «розумної» системи оцінки та моніторингу управління міськими територіями через застосування комбінації методів ентропії та TOPSIS. Такий підхід дозволяє кількісно та об’єктивно оцінити рівень сталого розвитку територій та ключові фактори впливу на цей процес через кількісну оцінку значущості та коливань впливу кожного індивідуального параметра. Зрештою, за запропонованим підходом, метод ентропії використовується для оцінки ваги окремих індексів другого рівня, а метод TOPSIS – для вимірювання «ступеня досягнення» сталого розвитку окремих досліджуваних об’єктів відносно їх потенціалу. Для оцінки рівня сталості регіонів запропоновано шкалу, що дозволяє, за результатами вимірювання, зробити висновок про слабкий, середній, гарний та високоякісний рівень сталого розвитку території.

Сформована оціночна шкала була покладена в основу вдосконаленого методичного підходу до визначення основних пріоритетів стратегічного управління сталим розвитком регіонів, який ґрунтується на конкретних значеннях параметрів та оцінках рівня сталого розвитку територіальних утворень та сприяє формалізації процесу прийняття рішень (що знижує вплив людського чинника та суб’єктивності при прийнятті рішень). Враховуючи змістовні та структурно-процесні аспекти процесу стратегічного управління розвитком територій, була запропонована схема (алгоритм) дій, заснованих на результатах вимірювання рівня сталого розвитку територій. Відповідно до запропонованої схеми процесу прийняття стратегічних рішень, застосування розробленої системи вимірювання та оцінки дає змогу встановити основні фактори (драйвери) сталого розвитку території і далі – оцінити ступінь розвитку окремих регіонів через аналіз «ступеня досягнення» загального показника. Визначені драйвери мають становити основний фокус при виробленні політики та стратегії сталого розвитку та, диференційовані за регіонами, дозволяють сформулювати заходи, що є пріоритетними для тієї чи іншої регіональної територіальної громади.

Здійснена оцінка значущості окремих складових у загальному показнику рівня сталого розвитку для всієї генеральної сукупності досліджених об'єктів (31 провінція на території, підконтрольній Центральному уряду КНР) показала, що найбільший вплив справляє складова «наука та технології» (55.4%). Вплив економічного зростання (17.6%), соціального добробуту (16.4%), та екологічної складової (11.23%) натомість є незначним. Отже, наука та технології є рушійною силою сталого розвитку територій в КНР, а роль цього фактора зростає з року в рік: з 54.07% у 2016 до 54.56% у 2019. Аналіз індексів другого рівня показав, що найбільш значущими факторами сталого розвитку є ті, що належать до групи «Наука та технології» (оборот ринку технологій, залученість персоналу виробничих підприємств до досліджень та розробок, кількість патентів, фонди досліджень та розробок виробничих підприємств, фінансові витрати на науку та технології), а найменш значущими є житлова площа на одну особу (соціальна група), споживання електроенергії на одиницю ВВП (економічна складова), рівень централізованої переробки стічних вод та рівень забрудненості технологій переробки відходів (екологічна складова), та споживання води на одиницю ВВП (економічна складова). Загальний вплив цих показників разом становить лише близько 5%. Отримані результати викривають фундаментальні чинники сприяння сталому розвитку міст в КНР: розвиток талантів, науки та технологій, капіталу та політики. При цьому, отримані результати також свідчать про те, що сталий розвиток міст більшою мірою пов'язаний із активністю бізнес-кіл, тоді як уряд може значною мірою сприяти такій активності.

Тож отримані кількісні результати, відповідно до запропонованого алгоритму прийняття стратегічних рішень, дали змогу сформулювати загальні принципи стратегії КНР у напрямку сталого розвитку. Для покращення науково-технологічної складової сталого розвитку пропонується акцентувати увагу на зміцненні наукової та технологічної публічності, створенні сприятливого середовища для науковотехнічного прогресу та незалежних інновацій, а також сприянні навчанню та впровадженню талантів. Відносно економічної підсистеми, основні зусилля мають бути спрямовані на зміну режиму екстенсивного економічного зростання, розвиток третинної промисловості та налагодження промислової системи у відсталих районах. Приймаючи стратегічні рішення щодо соціальних питань, доцільно зосередитися на факторах, що впливають на соціальну стабільність громади (інфраструктура, доступ до громадських об'єктів, рівність і справедливість), а також здійснити належне планування та керівництво. З точки зору екологічних аспектів регіонального сталого розвитку, найважливішими питаннями, які необхідно вирішити, є ефективне використання земельних ресурсів та посилення ролі та функцій екологічного управління.

З використанням моделі TOPSIS було оцінено рівень досягнення сталості кожної з досліджених 31 провінцій та проведено їх ранжування. Визначено характер територіального розподілу стану сталого розвитку провінцій, згрупованих у чотири регіони (прибережний східний, центральний, західний та урбанізована агломерація Беньжи-Тяньжи-Хебей (Beijing-Tianjin-Hebei). Загалом, рівень розвитку провінцій та регіонів є нерівномірним, а загальний – відносно низький. Згідно з результатами, сталий розвиток різних регіонів Китаю характеризується тенденцією ослаблення від східних прибережних районів до західних внутрішніх районів. З урахуванням цього було детально охарактеризовано особливості розвитку громад (економічна структура, забезпеченість ресурсами, соціально-демографічна ситуація, розвиток науки та технологій), причини, що перешкоджають сталому розвитку, а також сформульовано стратегічні пропозиції щодо посилення потенціалу сталого розвитку для кожної регіональної територіальної громади. Отримані результати засвідчують практичну значущість та доцільність використання в управлінському процесі розроблених під час дослідження положень.

Ключові слова: менеджмент, сталий розвиток, регіон, територіальні громади, урбанізація, міські території, стратегічне управління, вимірювання, система оцінювання, метод ентропії, TOPSIS, Китайська народна республіка.

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3. **Hongyue Wang**, Koblianska Inna. Restructuring theoretical framework of urban sustainability from the health dimension. *Економіка та суспільство*. 2021. № 31. 10.32782/2524-0072/2021-31-13 *(автору належить теоретичне обґрунтування складових концепту сталості розвитку міських територій через аспект здоров'я).*

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12. **Wang Hongyue**. (2019). The compact ecological city: the new concept of urban sustainable development. *Економічний і соціальний розвиток України в XXI столітті: національна візія та виклики глобалізації*: збірник тез доповідей XVI Міжнародної науково-практичної конференції молодих вчених (9-10 квітня 2019 року, м. Тернопіль). Тернопіль: Вид-во ТНЕУ, 16-17.

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LIST OF SYMBOLS

AHP	-	Analytic Hierarchy Process
EU	-	European Union
HDI	-	Human Development Indicator
IUCN	-	International Union for Conservation of Nature
OECD	-	Organization for Economic Cooperation and Development
PESTD	-	Policy, Economy, Society, Technology, Data
PRC	-	People's Republic of China
PRED	-	Population, Resources, Environment and Development
TOPSIS	-	Technique for Order Preference by Similarity to an Ideal Solution
UNCSD	-	United Nations Commission for Sustainable Development
UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
WB	-	World Bank
WCED	-	World Commission on Environment and Development
WHO	-	World Health Organization

INTRODUCTION

Relevance of the topic. With the acceleration of China's urban development and urbanisation process, problems such as energy and resource crisis, ecological environment deterioration and weak scientific and technological innovation incubation ability have gradually emerged and greatly restricted the sustainable development of China's regional territorial communities. Ensuring an adequate level of people's well-being in the long term against the background of the ever-increasing load on the environment, global climate changes, and the spread of destructive natural phenomena and processes through the search for adequate mechanisms and models of management decision-making regarding territorial organisation and structure is the main priority of current society and the subject of scientific research. Fully understanding the main factors affecting regional territorial communities' sustainability is of great significance for comprehensively improving management capacities towards sustainability. The ability to promote sustainable development is determined by the degree of clarity and comprehensibility of the conceptual content of sustainable development of territorial entities, the methodological basis for making relevant decisions and the identification of priority areas for taking measures. From these positions, the development of an appropriate theoretical and methodological foundation to support the process of effective management of the sustainable development of regional territorial communities, in particular, in the People’s Republic of China, where urbanisation processes are carried out without proper justification of spatial and structural solutions have already led to catastrophic consequences for the environment and population health, appears as an actual and essential research problem.

This is an important research topic to which more and more studies are being devoted now. In particular, the following scholars have investigated the theoretical and methodological aspects of managing the sustainable development of territorial communities of various scales in recent studies: M. Ala-Uddin (2019), R. Bali Swain & F. Yang-Wallentin (2020), D. Blanco et al. (2021), Yu. Danko et al. (2019, 2020), S. Da

Silva Neiva et al. (2021), J. Gao et al. (2021), C. Gu et al. (2017), G. Fang et al. (2020), M. Larsson (2021), I. Lozynska et al. (2021), I. Lytvynchuk et al. (2020), 2021), G. Monastyrskyi & M. Volosiuk (2021), M. Mortoja & T. Yigitcanlar (2021), S. Lu et al. (2021), N. Stoyanets et al. (2020) van Meeteren (2021), J. Uitto (2019), J. Wang, (2021), C. Wong et al. (2021). However, issues related to the identification of the main factors of sustainable development, especially in the conditions of digitisation and exponential growth of knowledge, measurement of their significance and impacts, and formalisation of these processes in the decision-making system to simplify their use in management practice, require further study and deepening.

Connection of work with scientific programs, plans, and topics. The dissertation was completed by the directions of research work of the Department of Economics and Entrepreneurship named after I.M. Bryukhovetskyi: "Formation of an effective toolkit for the functioning of the socio-economic mechanism of entrepreneurial activity in the agrarian sector of the economy" (state registration number 0121U107709, 2021-2022). The author defines the main principles and priorities that should be considered when developing strategies for the sustainable development of regions in the People's Republic of China and, particularly, promoting entrepreneurship in the innovative sphere.

The purpose of the work. The dissertation aims to develop theoretical and methodological principles and formulate practical recommendations to support the effective management of the sustainable development of territorial communities of the regions. To achieve the goal, **the following main tasks were set and solved**:

- to investigate and clarify the elements and scientific content of the concept of sustainable development of regional territorial communities;

- to study existing methodical approaches in the field of management and measurement of sustainable development of territorial communities;

- to explore the indicators for assessing the sustainability of territorial communities and the proper evaluation methodology;

- to investigate the level of efficiency of sustainable development based on panel data of Chinese (PRC) cities and provinces;

- to define and clarify the driving factors and mechanisms for stimulating the sustainable development of regional communities in the People's Republic of China;

- to develop recommendations for transforming management mechanisms to ensure the sustainable development of territorial communities in the regions of the People's Republic of China and strategies for their implementation.

Research object – the organisational and economic interrelations existing while planning, making, and implementing regional territorial communities' sustainable development decisions.

Research subject – a set of theoretical and methodological foundations describing the organisational and economic interrelations existing while managing regional territorial communities' sustainable development.

Research methods. This study comprehensively uses the literature research method, theoretical deduction method, and the combination of qualitative, quantitative, and multidisciplinary research methods to explore the academic background of regional territorial communities and urban sustainability. When investigating the knowledge accumulated concerning the management and measurement of territories' sustainability, the following methods were applied: literature research method, theoretical derivation method, Interdisciplinary research methods, and the combination of qualitative and quantitative research. First, by searching and sorting out the literature related to this study's keywords, subject, and theme, adhering to the principles of timeliness, frontier, authority, and relevance of literature research, in-depth reading and analysis were carried out to lay a theoretical foundation. The deductive theory method involves obtaining derivative concepts and laws through promoting, derivation, and inferring the original concepts and rules. This study uses this method to deeply analyse the research results of the evaluation system and evaluation method of regional sustainability in China and abroad, to understand the system structure, function, and coordination mechanism of sustainable regional action, to grasp the interrelationship among the internal elements of the four subsystems of regional sustainable development. According to the fields and characteristics of the research content, in the process of theoretical analysis and empirical analysis, the use of interdisciplinary research methods such as management, economics, sociology, and so on allowed expanding and deepening of the research content and revealing the essence of the research object. This study defined the relevant concepts of sustainable development through qualitative analysis. This research conducted a macro analysis of the current situation of sustainable urban development in China (PRC) to find the relevant problems. The entropy-TOPSIS methods were used to determine each index's weight, clarify the driving factors of the sustainable development of provinces and cities, and evaluate the sustainability performance.

The information base of the study. This research is based on a solid literature review involving English-language scientific papers from all over the world and papers authored by Chinese scholars. Additionally, some analytical documents, laws, and regulations were used. The empirical data was sourced from statistical yearbooks of the People's Republic of China.

The scientific novelty of the obtained results lies in the deepening of the theoretical and methodological basis of supporting the effective management of the sustainable development of regional territorial communities in the People's Republic of China. The main provisions of scientific novelty are as follows:

Improved:

- a conceptual understanding of the main aspects (factors) of the sustainable development of territories, which, unlike the existing ones, integrates the economy, society, the natural environment, and science and technology components, providing an opportunity to understand better the mechanisms of ensuring and supporting the sustainable development of territorial entities in conditions of digitalisation and science exponential growth;

- a methodical approach to the interpretation of the concept of a "knowledge-oriented" strategy for sustainable development of cities, which regards the natural environment, economy, society, and science and technology as a system of interrelated factors and presupposes careful consideration and choice of indicators to determine driving mechanisms and parameters of the action promoting regional territorial communities' sustainability;

- an index system for assessing the efficiency of sustainable development of urban areas as components of the regional complex, which, unlike the existing approaches, allows measuring the level of sustainable development and comprehensive efficiency in all economic, social, technological and environmental aspects influencing urban development.

To be further developed:

- a methodical approach to define the smart city's functioning system, which, unlike the existing ones, proposes a five-dimensional PESTD vision and regards data as an essential component that integrates other elements of cities' development (economy, society, technology, and policy) and, at the same time, is a source and means of building a proper urban management system;

- a methodical approach to the formation of a scientifically based and intelligent system of evaluation and monitoring of urban sustainability, which, unlike the existing ones, allows objective assess the level of sustainable development and critical influencing factors through a quantitative evaluation of the significance and fluctuations of each key parameter;

- a methodical approach to determining the main priorities of strategic management of the sustainable development of regional communities, which, unlike the existing ones, is based on specific assessments and parameters of the sustainable development performance and allows for the formalisation of the decision-making procedure;

- put forward scientific and reasonable suggestions for sustainable development of regional territorial communities' strategies, which, unlike the existing ones, are based on results of evaluating the main drivers of sustainability, including the science and technology sphere.

The scientific and practical significance of the dissertation. The scientific and practical importance of the research made lies in the development of a complex of scientifically based provisions and conclusions regarding the solution of the scientific task – the formation of a theoretical and methodological basis for ensuring the support of the process of effective management of the sustainable development of regional territorial communities in the People's Republic of China. The regional sustainable development laws and strategies suggestions proposed in this study can make comprehensive, coordinated, and sustainable development come true and provide an accurate direction for practising the scientific idea of sustainable development. The entropy-weight TOPSIS evaluation model constructed offers a yardstick for measuring the level of the environmental, economic, social and technological sustainability performance of 31 provinces and cities in China, which promotes the relevant departments to carry out the work of promoting sustainable urban development in a more efficient and targeted way. Based on quantitative empirical analysis, the driving factors and incentive mechanisms of sustainable urban development in China (PRC) have been identified: talent, technology, capital, and policy. And based on the empirical results, it condenses scientific and universal sustainable development countermeasures and suggestions. This way, it is convenient for relevant departments to find problems promptly, summarise the experience, grasp the principal contradiction, avoid blind development, and ensure that all cities in China (PRC) achieve sustainability targets.

The results of the research, conclusions and recommendations contained in the thesis can be taken into account and used in the activities of various organisations that, in one way or another, are involved in the process of managing regional territorial communities: authorities, non-governmental public organisations, individuals, and representatives from experts pool. The obtained results and formulated conclusions can form the basis for decision-making in these organisations.

Personal contribution of the acquirer. Dissertation research is an independent scientific work of the author. The author obtained scientific results, conclusions, and proposals submitted for defence.

Approbation of the results of the dissertation. The main provisions and results of the dissertation research were made public by the author at conferences, seminars, meetings, among which the most important were "Economic and social development of

Ukraine in the 21st century: national vision and challenges of globalization" (April 9-10, 2019, Ternopil), "Economic-management and information-analytical innovations in construction" (March 27, 2020, Kyiv), 26th and 27th International scientific and practical conferences "Technologies of the 21st century" (November 24-26, 2021; December 7-9, 2020, Sumy), "Modern managerial and socio-economic aspects of the development of the state, regions and economic entities in the conditions of the transformation of public administration" (November 11, 2021, Odesa), 3rd Virtual International Conference "Path to a Knowledge Society-Managing Risks and Innovation" (November 15-16, 2021, Belgrade, Serbia), 6th International Scientific Conference EMAN Economics & Management "How to Cope with Disrupted Times" (March 24, 2022, Ljubljana, Slovenia).

Publication of obtained results. The results of the author's theoretical and experimental research, the leading scientific propositions and the conclusions of the dissertation are sufficiently covered in 12 scientific papers, including three publications in professional journals of Ukraine; 2 publications in scientific publications indexed by Scopus (1), Web of science (1) databases; 7 abstracts of reports at scientific conferences. The total volume of publications is 4.5 prints—sheets, of which 4.08 are printed. The sheet belongs to the author personally.

Scope and structure of the dissertation. The dissertation consists of an introduction, the main content, three chapters, general conclusions, and a list of used literary sources with 171 items and appendices. The work's main content is laid out on 138 pages of main text, including 13 tables and 35 figures.

SECTION 1. THE CONCEPT OF SUSTAINABLE DEVELOPMENT OF REGIONAL TERRITORIAL COMMUNITIES

1.1 Sustainable development of regional territorial communities in view of the urbanisation

The formation of sustainable development theory has undergone a long historical evolution. Before 1960, it was hard to see words related to environmental protection in newspapers, books, and periodicals (Popkova et al., 2022). At that time, most people took "conquering nature" as the ultimate goal. Since the '60s, further economic growth, followed by a population explosion and resource mining, the effects of urbanisation, environmental problems are becoming more and more to be reckoned with, and so on, generating a series of problems. Hence, people gradually began to realise the importance of environmental protection and recognised some gap between environmental issues and economic development. Following this, a series of studies was carried out globally. In 1972, the United Nations held the Human Environment Conference in Stockholm, the capital of Sweden, which was an epoch-making event (Shi et al., 2019). It was the first-time governments of all countries gathered to discuss environmental problems. The Conference called on governments and people of all nations to work together to preserve and improve the human environment for the benefit of all people and future generations (Yang et al., 2020). In 1987, the chairman of the World Commission on Environment and Development pointed out that the current environmental problems are worsening and have a severe negative impact on the sustainable development of human beings. Therefore, a new way of human development needs to be explored, that is, a way of sustainable development that takes into account the protection of resources and the environment and the development of the economy and society (Ruggerio, 2021). In 1992, the United Nations Conference on Environment and Development was held in Rio de Janeiro, Brazil. Although the conference was only 20 years away from the 1972 Conference, an obvious fact is that during these 20 years, the international community's focus has shifted from simply focusing on environmental protection to the significant issues of the environment and development. The Adoption of the Rio De Janeiro Declaration on Environment and Development and the Global Agenda 21 by the General Assembly for the first time moved sustainable development from theory and concept to action (Brown & Quiblier, 1994). In 1992, China declared that it would implement a sustainable development strategy. In 1994, to fulfil the commitments made at the United Nations Conference on Environment and Development, China formulated and adopted China's Agenda 21, which serves as a guiding document for China to implement its sustainable development strategy for the 21st century (Steblyanskaya et al., 2021). In 1995, the strategy of sustainable development was officially identified as one of the basic strategies of China.

As for the meaning of sustainable development, in 1980, the International Union for Conservation of Nature (IUCN) published the World Nature Conservation Strategy, which first proposed the concept of sustainable development. "Sustainable development emphasises the management of mankind's use of the biosphere so that the biosphere meets the maximum continuing interests of the present while protecting its potential for the needs and desires of future generations," the document states (*cited according to* (Dong et al., 2021).

The definition of sustainable development generally accepted by the international community is divided into two levels: one is the simple definition of sustainable development, and another is a specific one. The former is defined by the World Commission on Environment and Development in “Our Common Future” in 1987: "Sustainable development refers to development that meets the needs of the present without jeopardising the ability of future generations to meet their needs" (*cited according to* (Topal et al., 2021). The latter is the definition given by the Governing Council of the United Nations Environment Programme in 1989 in the Statement on Sustainable Development: sustainable development refers to the development that meets the needs of the present without weakening the ability of future generations to meet their needs, and in no way implies the infringement of national sovereignty (Ligorio et al., 2022). The United Nations Environment Programme (UNEP) Council believes that to achieve sustainable development, domestic cooperation and international balance are involved, including assistance to developing countries with the priorities and development goals of their national development plans (Dzator et al., 2022). In addition, sustainable development implies a supportive international economic environment leading to sustainable economic growth and development in all countries, particularly in developing countries, which is highly important for sound environmental management. Sustainable development also means maintaining, rationally using, and enhancing the natural resource base that underpins ecological resilience and economic growth.

Moreover, sustainable development implies incorporating environmental concerns and considerations into development plans and policies. It does not represent a new form of conditionality in aid or development financing (Liu et al., 2022). So far, the environmental protection and social development issue has been widely concerned and valued by governments and the media.

Since the concept of sustainable development was put forward in 1980, the discussion on sustainable development on a global scale has formed bursts of upsurge. Economists, sociologists, and natural scientists have expounded on sustainable development from their disciplines' perspective, creating four main research directions, namely, the direction of economics, sociology, ecology, and system science.

The economic direction of sustainable development theory is based on regional development, distribution of productive forces, optimisation of economic structure, the balance of supply and demand of material and energy, etc. A focus of this direction is to try to "scientific and technological progress contribution offset or overcome the marginal benefit decline rate of investment" as an essential indicator and primary means to measure sustainable development (Chaiechi, 2022). The research in this direction is represented by the World Bank's World Development Report and the Sustainable Economic Development (Shi et al., 2019).

The sociology direction of sustainable development theory is based on social fairness, social development, social distribution, and interests balance. A focus of this direction is to "achieve a reasonable balance between economic efficiency and social equity" as an essential indicator and primary means of sustainable development

(Spiliotopoulou & Roseland, 2020). Research in this direction is mainly represented by the Human Development Report and the Human Development Index of the United Nations Development Programme (UNDP).

The ecological direction of sustainable development theory is based on ecological balance, natural protection, sustainable utilisation of resources, and environmental governance. A focus of this direction is to strive for "a reasonable balance between environmental protection and economic development" as an essential indicator and primary means of sustainable development (Mirgholami & Rahimian, 2020). The research in this direction is mainly represented by the UNEP.

The systematics direction of sustainable development theory research is to explore the origin and evolution law of sustainable development with the view of comprehensive coordination, to take the logic and intersection maximisation of development degree, coordination degree, and sustainability degree as the centre, and to deduce the relationship of space-time coupling, mutual restriction, and interaction of sustainable development system in an orderly way. The basis and identification rules of a unified interpretation of relations between humans and nature. The Sustainable Development Strategy Research Group of The Chinese Academy of Sciences has continuously published the annual China Sustainable Development Strategy Report (from 1999 to 2007), which is representative of a series of research and thoughts of Chinese scholars on sustainable development system theory.

According to the concept’s content, sustainable development is the organic unity and coordinated balance of ecological, economic, and social pillars. A sustainable ecological environment is a spatial basis, economic development is the leading, and social sustainability is the guarantee. As it was mentioned above, sustainable economic development is based on regional development, determined by productive forces, economic structure and supply and demand relations. However, there is evidence of the dependence of productive forces maturity from a social structure having regional features, as well as the impact of the regional natural environment on economic structure and industries’ patterns. Thus, the regional socio-economic spaces – integrating economic, social, and environmental parameters – shape the state of sustainability and can serve as a unit of analysis.

The concept of regional territorial communities originated from "Garden City". In 1898, Howard, a famous British urbanist, first put forward the idea of a "Garden City", namely, to establish an urban agglomeration" composed of the central city combined with several surrounding "Garden Cities" to achieve the purpose of reasonably promoting the spatial expansion of big cities and the integration of urban and rural areas (Blanco, 2021). Later, in the process of studying the suburbanisation of London, American scholar Unwin proposed to establish some suburban residential areas or satellite cities around the central city further to develop the rural town into a satellite city, realise the organic development of the major city, and improve the town function (Treude, 2021). In 1918, Finnish scholar Saarinen emphasised that the city is an organic whole and that the city's concentration should move from disorder to order. He proposed the theory of organic expansion and elaborated on it in detail (Zhang et al., 2021).

In the early 20th century, with the acceleration of industrialisation, the urban density and economic scale of some regions in Western European countries increased significantly, and the embryonic form of urban agglomeration began to appear, such as the Ruhr mining area in Germany and West Midland in Britain. In 1915, Geddes, a British regionalist, believed that cities would expand rapidly under the forces of industrialisation, industrial agglomeration, and urbanisation and that the spatial form would gradually form a “City Region” and then a “Conurbation” and then evolved into a “World City”**,** which emphasises that regional territorial communities are the product of urban expansion to the advanced stage (Blanco, 2021). In the 1920s, thanks to the development of cars and communication technology, urbanisation in the United States showed a rapid spread from big cities to suburbs. The suburbs gradually developed into new towns closely connected to the central city. This closely connected and collaborative area between the central city and suburban towns is called a metropolitan area, while neighbouring large cities expand in a corresponding direction. In 1957, Gottmann observed that the area along the Atlantic coast of the United States was a belt region formed by several metropolitan areas in series, with a highly dense and continuous urban distribution. After a series of exploration and analysis, he named this area “Megalopolis” and put forward the theory of Megalopolis (Da Silva Neiva et al., 2021). Since the 1970s, urbanisation in developing countries has taken on some characteristics that are different from those in developed countries. In 1991, Mc Gee, a Canadian scholar, studied many dense urban areas in developing countries and found that the boundary between urban and rural areas had become blurred, so he proposed the concept of "Desakota" (Gao et al., 2021). The research in this period mainly studied the image and characteristics of the "City-Region" formed in the expansion of big cities from the perspective of space.

The urbanisation-driven nature of regional territorial communities’ performance in China is especially significant. The concept of regional territorial communities was introduced in China around the 1980s. Since that, scholars have discussed the nature and factors driving regional development in China. The most comprehensive is the position of Yao defining regional territorial communities through in-depth research on the development mechanism, evolution process, and development trend of urban agglomeration. He believes that regional territorial communities are a regional complex composed of one or two central cities as the core and several cities of different scales, types, and natures within a particular spatial scope, with the division of labour and cooperation, complementary functions and interconnection. The academic community has widely accepted Yao's definition of regional territorial communities. Reviewing the process of putting forward the concept of regional territorial communities, it can be found that scholars focus on the generation and development process of urban agglomeration from the perspective of space and believe that urban agglomeration is a stage product of urbanisation to a certain degree (Yao, 2021), which has the dual attributes of space and economy and is a complex system.

Scholars divide the evolution stages of regional territorial communities differently. Still, there is the following consensus: the evolution process of urban agglomerations is characterised by the transition from low-level to high-level, the urban system from imperfect to perfect, and the continuous improvement of structure and function. The academic community has widely recognised Chen Qunyuan's division of the evolution stage of regional territorial communities. Drawing on the life-cycle theory, he believes that the development of regional territorial communities conforms to the S-shaped curve and divides the development of urban agglomeration into four stages, which are as follows: embryonic, rapid, tending to the mature, and mature development stages.

Embryonic development stage. The embryonic development stage of regional territorial communities refers to cities' relatively discrete and closed development within the urban agglomeration. It begins to produce internal links – the initial development stage of urban agglomeration. The characteristics of this stage are the following: the scale of regional territorial communities is small, the level of urbanisation is low (the urbanisation rate is about 30%), and the development is slow. The growth path is dominated by extension development; the density of cities and towns is low, and the urban system is highly imperfect (Wong et al., 2021). The agglomeration effect of central towns is limited; the internal links of cities in urban agglomeration are weak, the division of labour system has not yet formed, the spatial structure is loose, and the infrastructure is imperfect.

Rapid development stage. The fast development stage of urban agglomeration is when urban agglomeration begins to pay attention to connotative growth and develops rapidly, which is the critical stage of urban agglomeration development. The characteristics of this stage are as follows: the scale of urban agglomeration is expanding rapidly, and the level of urbanisation is increasing rapidly (the urbanisation rate is about 30% to 50%). The growth path is still dominated by extensional development but gradually turns to connotative growth. The density of cities and towns has increased, and the development of the urban system has accelerated but is still imperfect. The agglomeration effect of central cities is noticeable, and the diffusion effect is gradually strengthened. The internal links of cities within urban agglomerations have to be maintained, the division of the labour system has begun to take shape, the spatial structure is closer, and infrastructure construction has increased rapidly (Mortoja & Yigitcanlar, 2021). At this stage, urban agglomerations are mainly distributed in relatively low economic and social development levels but with a solid financial foundation, obvious location advantages and rapid development.

Tending to the mature stage. The mature set of regional territorial communities refers to the higher stage of urban agglomeration development, which is the transition from extensional de conjunctive development. This stage of development is characterised by a relatively large scale of urban agglomerations, a relatively high level of urbanisation (urbanisation rate of about 50% to 70%), and relatively stable development. Urbanisation continues to increase, and the urban system tends to improve. Central cities' aggregation and diffusion are prominent and tend to be balanced. The internal links of cities within regional territorial communities are more intense, the division of the labour system tends to be reasonable, and the infrastructure is more perfect.

Mature development stage. The mature development stage of regional territorial communities refers to the advanced stage of urban agglomeration development, which is dominated by connotative development and plays a significant role. The mature development stage is characterised by large-scale urban agglomerations, a high-level of urbanisation (urbanisation rate of about 70% or more), and dynamic and balanced development within the region. The urban density tends to be stable, and the urban system is relatively well-developed (Larsson, 2021). The diffusion effect of the central city is slightly dominant. The inner connection to each town in the regional territorial communities is very close, and the division of labour system and infrastructure is pretty perfect. In the middle and late stages of the development of regional territorial communities, it shows the morphological characteristics of the metropolitan belt in regional spatial forms, such as the Boston-Washington urban agglomeration in the United States, Tokyo urban agglomeration in Japan and other highly mature world-class urban agglomeration.

Urban areas constitute a significant part of Chinese regional territorial communities. The urbanisation rate amounts to more than 60%. As China is a developing country with the largest population in the world, the development of urban areas significantly impacts the overall development of regional territorial communities, determining the quality and level of the overall country's performance.

After 1970, many countries in the world have put forward many ideas of urban development according to the problems facing urban development and the needs of the times (Fig. 1.1). These urban development concepts can better guide urban development, on the one hand, they can alleviate the external pressure faced by urban development while reducing the impact of urban development on the external environment. On the other hand, they can improve the city's sustainable development under the current and future economic, social, and environmental conditions.

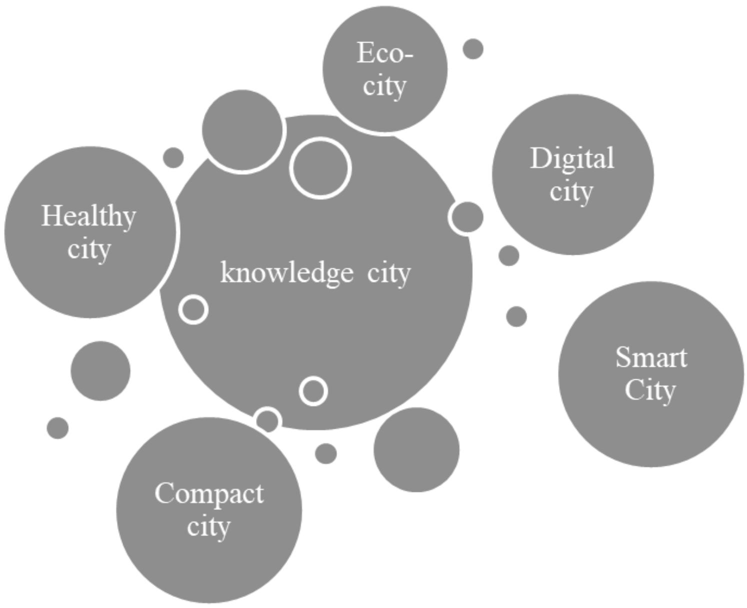


Figure 1.1 – Urban development concept

Source: author's development

Eco-city. With the rapid development of cities, urban ecological crises occur frequently, and the urban natural environment is damaged. In 1971, eco-city became a way to optimise urban development. The characteristics of an eco-city are urban ecology, an excellent urban natural environment, harmonious social evolution, and healthy economic development. Urban space, economics, and socially equal human development are integrated (Larsson, 2021). The construction of an ecological city needs to take the realisation of sustainable development as the core task of urban development to build a healthy economic, social, and natural environment of the city.

Compact cities. Urban development demands more urban space, and urban sprawl appears. The orderly expansion of the city seriously affects the convenience of urban residents' life and increases the cost pressure of various production activities in the city. In 1973, the concept of a compact city was put forward. The characteristics of a compact city are a high level of comprehensive development and utilisation of urban land, reduced impact on the natural environment of the surrounding areas of the city, rational urban spatial layout, and a high degree of urban convenience (Hongyue et al., 2019). The construction of a compact city needs to increase the density of urban development and construction, rationally design the layout of urban residents' production and life, optimise the urban structure and scale, perfect the urban function, improve the urban convenience, reduce the negative impact of urban expansion in the process of urban development, and maintain the orderly development of urban scale.

Green city. In 1990, the maintenance and development of the urban ecological environment attracted attention. The concept of a green city was put forward in the face of the urban energy crisis and the pressure of urban ecological environment construction in developed countries. Green cities pay attention to the harmony between man and nature, have higher energy and resource utilisation efficiency and can effectively control all kinds of pollution caused by urban development (Zhu et al., 2021). The construction of a green city needs to realise green economic growth, reduce the damage to the urban ecological environment caused by urban development, and improve residents' awareness of green environmental protection to achieve green social results. The main tasks for authorities aimed to perform the green city involve the following: to get the cost of green growth, to maintain the stable state of the urban ecosystem, and reduce pollution emissions and urban energy use.

Healthy city. In 1842, Professor Chadwick first put forward the concept of a healthy city and promoted the birth of the British Healthy City Association (Ma et al., 2021). He believes a healthy city is an organic combination of healthy people, a healthy environment, and a healthy society, which can improve the urban environment, expand urban resources, and make the urban situation support each other to maximise its potential (Wang & Koblianska, 2021). In 1988, the World Health Organisation (WHO) defined a healthy city as a city that continuously improves the natural and social environment so that people can enjoy life, give full play to their potential, and support each other; by 2009, WHO again proposed that the construction of healthy cities is an active process of providing innovative and creative solutions to new and old public health problems (Xia et al., 2020). The concept of a healthy city is put forward to promote the formation of health intervention mode and improve the city's status and residents' health by improving residents' understanding of health and appropriate influencing factors (Fig. 1.2).

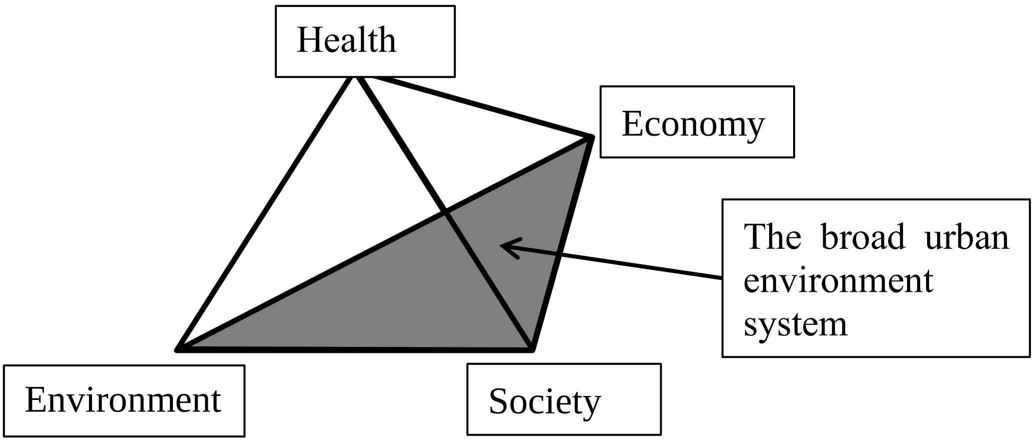


Figure 1.2 – Theoretical framework for healthy cities

Source: author's development

Knowledge City. In the new century, the development of cities is more dependent on knowledge (Fig. 1.3), and countries pay more attention to the role of expertise in international competition and global economic development strategy. Due to this, knowledge city became one of the urban development concepts in 2002. Knowledge city attaches great importance to investment in scientific and technological research and development, is committed to enhancing the ability of technological innovation, and the town's vital intelligence and creativity (Hongyue et al., 2021; Wang & Koblianska, 2021).

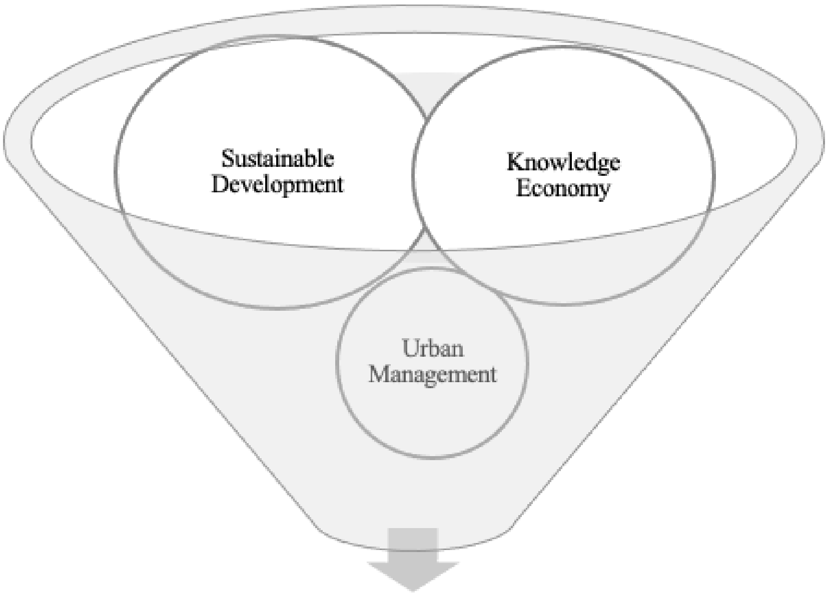


Figure 1.3 – "Knowledge City" concept driving forces

Source: author's development based on Sørup et al. (2020)

On the one hand, the construction of a knowledge city needs to improve the knowledge and cultural literacy of urban residents and consolidate the foundation of urban development; on the other hand, it needs to rely on high and new technology, develop urban functions and services, build urban intelligent management and operation system, optimise the layout of urban environment, social, and economic development, and improve the efficiency of urban management (Fig. 1.4).

Smart city. The development of information technology in urban development surges the amount of urban information. Therefore, to realise the city's sustainable development, all data generated in the urban development process must be processed at a higher level to meet the needs of efficient and lean urban operation and management. In 2008, the urban development concept of a smart city was proposed to better cope with these issues. The smart city carries out innovative operations and management of the city (Hongyue et al., 2021; Wang & Koblianska, 2021), makes the production and life of urban residents efficient and convenient, ensuring the overall harmonious and sustainable growth of the city (Fig. 1.5).

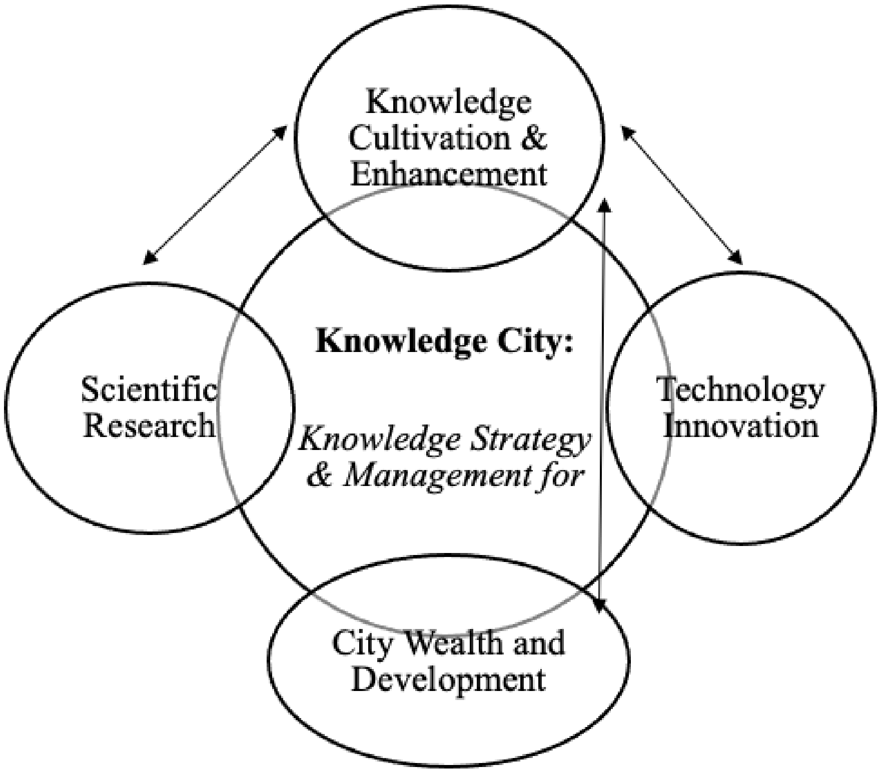


Figure 1.4 – "Knowledge City" concept core elements

Source: author's development based on Simon & Masters (2021)

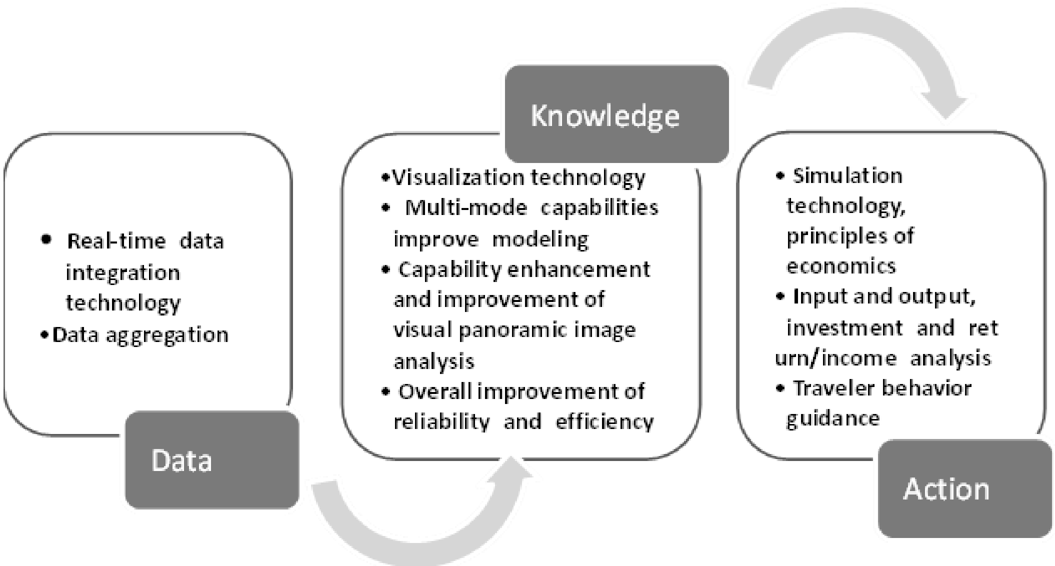


Figure 1.5 – Smart city big data application technology system design concept

Source: Internet of Things Reporting Center, http://www.wlwbgzx.com/newsdetail/313

A smart city is an applicable urban development concept in the era of the information explosion. To build a smart city, we are optimising urban information and digital infrastructure building, creating a three-dimensional information technology network based on the Internet of Things, 3S (GIS/GPS/RS) technology and cloud computing. The smart city concept allows for efficient realising of the mode of urban operation and management according to the way of urban production and life and moving toward interconnected city. Due to this, governments have put forward digital continuity projects, which require digital information to be maintained in a digital manner, unaffected by changes in digital technology, and always intact, accessible and usable. In general, national digital continuity projects aim to improve the responsiveness of data and information, balance the allocation and supply of data and information, and stimulate the innovative use of data and information (Hongyue et al., 2022). To achieve digital continuity, governments manage data and information as assets and support corresponding technical safeguards and business rules. The data, as the centre of the five-dimension development path construction in smart city construction, can cooperate with other dimensions for innovation and development (Fig. 1.6).

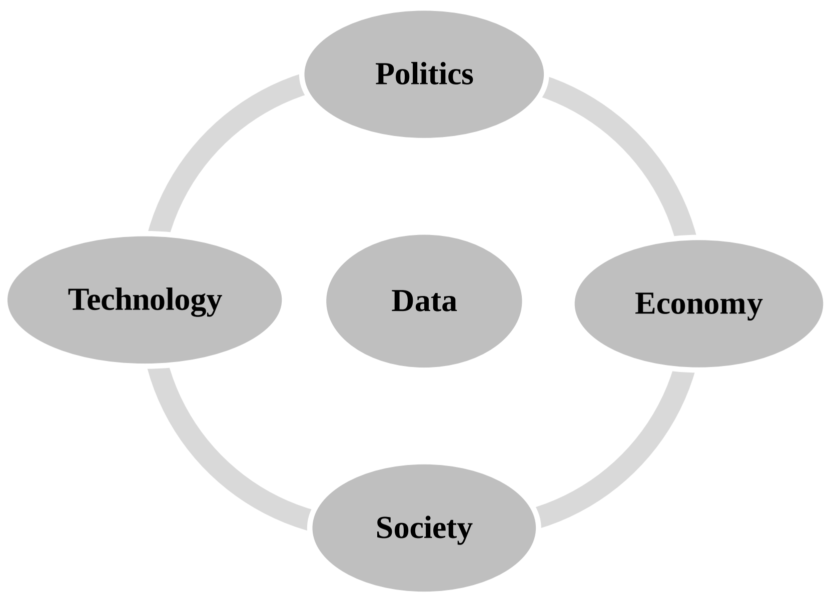


Figure 1.6 – PESTD: five dimensions collaborative innovation and development of smart city construction path

Source: author's development

The creation of management mode and the precision of urban governance are based on the application practice of big data to realise the integrated application, cross-border integration and interconnection of data resources. The sustainable development of economic development and ecological system construction takes data sharing as the path and innovation as the driving force to realise the innovative application environmental model of the Internet. The people-oriented and participatory smart city construction encourages multiple stakeholders to participate and obtain data information and feedback from different stakeholders to achieve a dynamic, humanistic and inclusive innovative social-ecological system. Based on the construction of intelligent cities in technology, the technical system design of "data-knowledge-action" is constructed, which fully reflects that data, as the centre of five-dimension collaborative development, can help the construction of sustainable development of smart cities. So, a smart city is a new type of urban form based on the new generation of information technology; through the dynamic monitoring, analysis, integration and utilisation of the data of various parts of the city to achieve a thorough perception of the urban living environment, the comprehensive regulation and control of urban resources, the coordination of multiple parts of the city, the convenient operation of all aspects of the urban, and the harmonious win-win between people and the town (Camero & Alba, 2019). Mining urban data resources, realising data resource collaboration and interconnection, and constructing a data integration system are the foundation of learning intelligent city construction and the core content throughout the whole process of smart city construction.

Therefore, the sustainable management and utilisation of urban data resources should be improved from the following three main aspects. First, innovate the awareness of data asset management, enhance the ability of digital control, and promote collaboration, co-governance and innovation. Second, innovate the data resource utilisation system, and build open mass innovation space in urban areas. Third, innovate the data decision-making analysis methods, improve the level of digital governance, and promote precision, accuracy and efficiency. New ways of urban management should be constructed to realise scientific decision-making based on data, improve the pertinence and effectiveness of urban governance, and help the city run efficiently.

Although there are many concepts of urban development, the core is to improve the level of sustainable urban development and make up for the shortcomings in urban construction and development. Applying various concepts in urban development can restore and protect the urban natural ecosystem and improve its quality. This also makes it possible to improve the utilisation rate of urban space and land, avoid urban sprawl problems, support rational layout and planning, and improve the convenience of urban production and life. Another critical issue is the ability to optimise urban energy resources to alleviate the urban energy crisis. Finally is the capacity to enrich the tools of urban management and operation, improve the efficiency of urban governance, and apply the concept of sustainable urban development in practice so that cities can provide sustainable and high-quality services for urban residents.

Urban sustainable development is of the less critical content economic and social development of various countries and regions. The scarcity, value and imitability of urban resources are the criteria to judge whether a city has sustainable development. A series of achievements have been made in the theoretical research of sustainable urban development (Table 1.1).

Table 1.1 – The major theories of sustainable urban development

Theory	Main points
1	2
Multi-objective synergy theory	Urban sustainable development is a comprehensive system characterized by multi-objectives and multi-levels. It is a multi-objective mode aiming at the coordinated development of economic development, social progress, sustainable support of resources and environment, and cultivation of sustainable development ability
Urban PRED system theory.	A city is a complex giant system of nature, society and economy, it is composed of PRED, and the population is its core. The external condition to maintain the dissipative structure of the urban PRED system is the interaction between the system and the environment. The formation of the orderly structure of the urban PRED system is driven by synergy, and the characteristics and laws of the system phase transition are also determined by the synergy, thereby promoting the realization of the system's self-organization

Continue of Table 1.1

1	2
Urban development cybernetics	The urban development process is a dynamic and controllable process with people as the main body. The most active and basic element in the process of urban development is information. Information is an essential element to regulate and control the sustainable development of the city, and to better coordinate and control the process of urban development. The basic method to realize urban development control is information feedback, and the orderly, stable and balanced sustainable development direction is the goal of control
Degree of sustainable development	A system or system elements that are in harmony with each other is an important guarantee for the implementation of sustainable development strategies, and the index to measure the degree of harmony and consistency is the degree of urban sustainable development. The development level of the urban economic, social and natural complex system is represented by the development degree, which is an important indicator to measure the degree of urban development, and the weighting of multiple indicators can quantify it
Theory of urban ecology	A city is a typical social-economic-natural complex ecosystem, with openness as its basic feature and people as the centre. Following the principles and laws of ecology is the premise for a city to achieve sustainable development. The metabolism of a city needs to be maintained through continuous material flow, energy flow and information flow. The basic theories of ecology such as ecosystem theory, niche theory, minimum factor theory and ecological base area theory constitute the urban ecological theory system
Theory of man-land relationship	The core of urban sustainable development research is the research on the comprehensive optimization and regulation of the human-earth system. The role of humans and the geographical environment is mutual: on the one hand, human beings deeply transform and utilize the geographical environment to enhance their ability to adapt to the geographical environment to meet the needs of survival; on the other hand, the geographical environment also has a profound impact on human activities
Circular economy theory	A linear economic model characterized by high exploitation, low utilization, and high emissions (the so-called two highs and one low) since the industrialization movement. The future of human society should establish a circular economy characterized by the closed-loop flow of materials, to realize the environmental and economic win-win required for sustainable development without degrading or even improving the resource environment

Source: prepared by the author based on J. Wang, (2021)

Urban PRED system theory. PRED refers to Urban, Population, Resources, Environment, and Development; coordinated development of these elements is an integral part of the sustainable urban development (Pumain, 2018). Systematicity and coordination are the two core thoughts of urban PRED development. The proposal of this theory reflects that people's understanding of the relationship between human beings and the natural environment is changing. It believes that human development should be limited to the allowable range of the earth's life support system (Aiken et al., 1987).

Furthermore, the population, resource consumption, and environmental pollution should be controlled, and the economic development model should be carefully and rationally selected. To maintain a certain level of economic development and quality of life, human society can achieve sustainable growth by adjusting various aspects. Integrity, dynamic, and controllability are the main characteristics of the urban PRED system (J. Wang, 2021). Each subsystem and its constituent elements or links should be placed in the whole system for comprehensive research, and local problems cannot be solved in isolation. Still, they should be solved in a coordinated manner in the overall situation, which is the characteristic of the whole. Over time, the problems of population growth, resource exhaustion, environmental deterioration, and economic development occur and change constantly, so the four subsystems of PRED are also in the dynamic change process all the time; they interweave each other, promote the evolution and transformation of the whole system together – this is the dynamic characteristic (Lobo et al., 2020). National and local policies have a significant impact on the PRED complex system. When some policies change, the parameters with higher policy sensitivity will also change. The improvement of the overall function of the PRED complex system can be achieved by actively regulating these parameters with higher sensitivity, which is the regulable characteristic (van Meeteren, 2021).

Urban development cybernetics. The cybernetics of urban development points out that population, resources, environment, social, and economic growth factors interact and restrict each other to form a unified whole of the urban development system (Thill, 2020a). The four subsystems of human, resources, environment, and economy constantly interact and influence each other, which makes the overall system evolve and transform in dynamic changes (Fang et al., 2020). Therefore, dynamic controllability is an essential feature of urban development. In addition, the most active and critical element in the process of urban development is information, which is a vital element for regulating and controlling the sustainable development of cities, that is, using different forms and different carriers of urban development information to better coordinate and manage the process of urban development activities. From the perspective of urban system control theory, urban development can be transformed into an urban control problem, mainly involving three aspects: controlled object, control mechanism, and external environment. It belongs to complex, comprehensive control and requires the support of various urban development control theories.

Theory of urban ecology. Taking the whole system as the starting point to examine the research object is an essential requirement of ecological science. The interconnected subsystems – the biosphere (and its organisational characteristics and structure) and system dynamics (and its evolution and change processes) – together constitute the entire system (Thill, 2020b). Ecology sees cities as unique ecosystems. The "Man and the Biosphere" program was initiated by United Nations Educational, Scientific and Cultural Organization (UNESCO), in which the concept of "Eco-city" was first proposed (Lu et al., 2021). With the development of the concept idea of eco-city, it has become an essential concept of urban development. The main characteristics of an "eco-city" are sustainable, in line with ecological laws and suitable for their ecological aspects (Lu et al., 2021). The original ecological city theory is limited to applying ecological principles to cities. With the deepening of the research, the current ecological city theory has developed into a set of comprehensive ecological city theories, including urban natural, economic, social-ecological, and composite ecological views. The development of ecological city principles includes: the repair of degraded land, urban development and regional coordination equilibrium development, maintaining the balance of the urban development and land-bearing capacity, putting an end to the spread of cities, optimising energy structure, the protection of historical and cultural heritage, cultivating colourful cultural landscape, correcting the destruction of the biosphere, etc. (Azamat & Rukhshona, 2021).

Goal synergy theory. Multi-objective and multi-level are essential features of sustainable urban development. Market regulation through economic actions can achieve environmental sustainability. However, these regulations should be coordinated with other goals to control the smooth operation of the market, based on ensuring the realisation of social and ecological goals (Ala-Uddin, 2019). Sustainable urban development should result from the interaction between social, economic, and environmental systems. Given this, solving environmental problems in isolation is often restricted by economic and social factors. Therefore, it is necessary to link the environment with the socioeconomic system for comprehensive analysis.

Degree of sustainable development. Evaluating a sustainable development degree is an integral part of the research on sustainable resource utilisation. Single index, compound index, and systematic index are three types of sustainable development index system (Bali Swain & Yang-Wallentin, 2020). Each of these three indicators has its advantages and disadvantages. Although the single index system cannot fully reflect the complex context of sustainable development, it is relatively simple and has good operability. The primary content of sustainable development can be reflected more comprehensively through the composite index system, and the data collection and related calculations are relatively simple. It is widely used in research and practical applications at this stage. It is the purpose of a systematic index system to analyse the essential characteristics of sustainable development from the theoretical level. However, its research is limited by complex operations and more restricted index content, so it is not widely used. In the current process of constructing the index system of sustainable development, the constant pursuit of the logic gradation causes some apparent gradation index subordination problems; the continuous search of the comprehensive index content produced many data, causing the deterioration of it to reflect the expressive ability. In addition, the lack of integration objectively exists, and there are few studies on the complex ecosystem.

Theory of man-land relationship. In the view of the human-land relationship, coordination is a comprehensive strategic goal. The coordination theory believes that social and economic development is necessary. However, the index system of social and economic development should include the improvement of ecological conditions, the rational use of natural resources, the progress of environmental quality, and the ecological and social indicators involved (Trusina & Jermolajeva, 2021). The purpose is to establish a comprehensive development strategy goal composed of multiple indicators. It is a consistent proposition of the coordination theory to make economic development and ecological environment construction parallel, putting forward new requirements for the dialectical relationship between economic development and ecological environment construction. Economic development is the leading factor because the funds and technologies to improve and renovate the natural environment and the ability to protect the environment should be based on the economy's rapid, healthy, and steady development. Providing a solid material foundation for the construction of the ecological environment should be found on the premise of the economic start (Monkelbaan, 2019). Only reasonable development can fully and sustainably utilise urban natural resources. According to the theory of modern man-land relationship coordination, the protection of resources and productive forces are consistent. The particularity of natural resources of different natures must be considered in economic development. The development and utilisation methods should be beneficial to maintaining the overall use value of natural resources and create conditions for their reproduction. Renewable and non-renewable resources must be used rationally. Combined with local characteristics, the resources can be used sustainably. The theory of coordination holds that the connotation of coordinated development is harmonious, efficient, optimised, and orderly. The essence is to fully promote and utilise the positive relationship while weakening and eliminating the negative relationship and influence between economic and social development and resources and environment to realise the virtuous circle among the four (Uitto, 2019).

Circular economy theory. Circular economy refers to the reconstruction of an economic system according to the law of the material cycle and energy flow of the natural ecosystem. It is the integration of the financial system into the process of material and energy recycling of the natural ecosystem to form an eco-friendly economic development form, whose main characteristics are clean production, recycling of resources, and efficient recovery of waste (Vayona & Demetriou, 2020). The sustainable development of ecology, economy, and society is the focus of the circular economy theory. The economic system's closed-loop flow of material and energy is the fundamental guarantee of achieving this goal. At present, hybrid system theory, natural capital theory, environmental capacity theory, and three production theories constitute the theoretical basis of the circular economy and guide and enrich the idea of the circular economy. The hybrid system theory proposes the concept of sustainable development and the development goals of the circular economy. The theory of natural capital emphasises the importance and scarcity of natural resources and ecosystem elements, which holds that establishing a circular economic development mode is necessary to ensure resource utilisation's sustainability and puts forward specific measures to develop a circular economy. The theory of environmental capacity holds that when the ecological load exceeds its carrying capacity limit, there will be consequences such as failure of the ecological self-repair mechanism and imbalance of the ecosystem, so economic development cannot exceed the carrying capacity of the environment (Hao et al., 2020). The three production theories put forward the harmonious requirements between material production, human production, and environmental production, which is the extension of sustainable development theory and guides the establishment of a circular economy system.

The above theories of urban development take the economy, environment, society, people and environment, urban organism, urban function, and urban competitiveness as the breakthrough points, respectively, and expound the influence of each factor on urban development.

1.2 Managing the urban development towards sustainability

In 1987, the World Commission on Environment and Development published the report Our Common Future, which impacts the world. In addition to clearly putting forward the theory of sustainable development, it also made clear that the theoretical framework of sustainable development is composed of three elements: society, economy and environment (Sanders, 2018). Therefore, the three-dimensional system is the classic paradigm composed of the theoretical framework of sustainable development. With the rapid growth of economic globalisation and global informatisation, science and technology are increasingly integrated with economic and social development. Technological innovation plays an increasingly prominent role in urban economic construction, social progress, resources, and the environment. In this regard, the four-dimensional framework consisting of economy, society, ecology, and science and technology can help us understand and practice the theory of sustainable urban development more clearly. This study takes the whole system as the observation point and starts from the multi-dimensional framework of sustainable urban development and divides the specific manifestations of sustainable urban development into four dimensions: sustainable ecological environment, sustainable economic growth, sustainable social well-being, and sustainable scientific and technological innovation (Fig. 1.7).

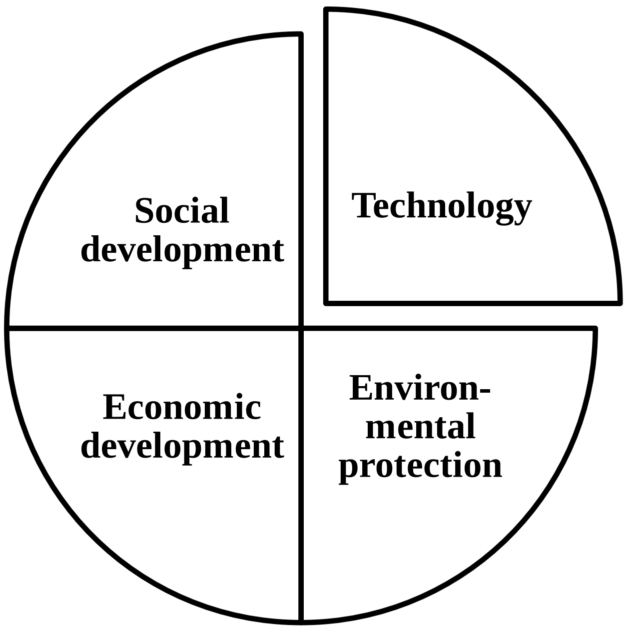


Figure 1.7 – The four-dimensional paradigm of urban sustainable development

Source: author's development

The ecological environment dimension is the most critical because urban environmental sustainability is the premise of sustainable development of the human economy and society and is the basis and goal of the development of science and technology (Vysochyna et al., 2020). Urban sustainable development means that economic and social development must be coordinated with the carrying capacity of the ecological environment; that is to say, urban construction and development should be ranked after the protection of the environmental sphere (Liu et al., 2021). The practice of human society has proved more than once that the high cost of "pollution first, treatment later", irreversible damage and other fouling diseases, and the economic, social, and scientific development that does not take the protection and improvement of the ecological environment as the premise, mostly must compensate for the cost several times higher than the immediate vested interests. Therefore, both the use of natural resources and the use of the ecological environment should be controlled within the environmental carrying capacity of our Earth.

The economic development dimension is the most challenging because to achieve sustainable development of the urban economy; it is necessary to change the mode of economic growth, adjust the industrial structure, and reduce the negative impact of economic development on the urban environment through social investment or technological innovation (Akimova et al., 2020). In western developed countries, the market mechanism for ecological resources utilisation has been established and gradually improved, thus forming a united front of sustainable development from the government to the ordinary people, thus promoting the sustainable use of natural capital in developed countries and also playing a substantial role in curbing the consumption of non-renewable resources, environmental pollution, and other undesirable phenomena (Kwon et al., 2021). As the largest developing country, China still relies mainly on the government's macro-control to promote the sustainable development of the urban economy, such as the government's green investment projects, preferential and policy intervention to promote green industry and ecological industry, etc. (Kühner et al., 2021).

From the perspective of the realisation of sustainable urban development, the broad participation of the public is a necessary guarantee for the realisation of comprehensive and coordinated sustainable development (Lytvynchuk et al., 2021). Therefore, the social dimension is the top priority of sustainable urban development capacity building (Carley & Spapens, 2017). When the government or other decision-makers set specific goals for sustainable urban development, they need to rely on individuals in society – human beings – to achieve them. The precondition for these social people to actively participate in the action of promoting sustainable urban development is their cognition and recognition of the goal. People also need to supervise the specific decision-making and rule implementation process of sustainable development. The participation of the people, social groups and organisations, the degree of involvement and even the way of participation can determine the process and effect of realising sustainable development goals to a certain extent. In addition, sustainable urban development in society must overcome obstacles and social justice issues and problems, such as the gap between rich and poor. Today's global economy grows rapidly, but not all people enjoy the world of wealth: only 1% of the world's population has 40% of the world's wealth. They only need to pay a minimum cost to enjoy wild natural resources.

On the contrary, the poor people, who account for 50% of the total number of people in the world, only share less than 1% of the global wealth. At the same time, the environment and resources they depend on for survival have been enjoyed and consumed by the rich, and they cannot get due compensation (Atkinson, 1992). The severity of this disparity between the rich and the poor and social injustice is proportional to the degree of poverty in the country (Tambovceva et al., 2020); that is, the more impoverished the country's government or developing country, the more serious this situation is, so it is urgent to achieve the sustainable development of society.

The dimension of science and technology is a new dimension with the rapid development of the urban environment, economy, and society. However, as the first productive force, the development of science and technology cannot be underestimated in promoting or hindering sustainable urban development. The industrialisation process of the world for more than 200 years is only for the modernisation of developed countries with a population of about 1 billion. Still, the limited natural resources and ecology have paid a painful price (Robinson, 1993). Therefore, as a country that has not fully realised modernisation, including China, it must not continue the mode of economic growth and development adopted by developed countries in the past. Urban social civilisation, economic development, and environmental protection need new scientific and technological forces. Urban culture must rely on scientific and technological innovation to achieve sustainable development, create a mode of production with less input and output, and perform a consumption mode with fewer emissions and more utilisation. Scientific and technological innovation promotes the realisation of sustainable urban development. From the economic point of view, scientific and technological innovation and breakthroughs enable the adjustment of economic structure and provide a new engine for urban economic growth (Lozynska et al., 2021).

Moreover, self-reliance and self-improvement in science and technology are the only way to grasp the initiative of development (Echegaray et al., 2021). Science and technological innovation support achieving sustainable urban environmental development. All countries in the world attach great importance to developing new energy science and technology and pay attention to the scientific and technological revolution and innovation based on green and low-carbon standards (Ksonzhyk et al., 2021).

The four elements of the urban development system, namely, ecological environment, economic development, social residents, and technological innovation, combine and interact differently. Society is the primary subject of this system because the essential factor of society includes sustainable development and the primary motive force of all systematic development – a human being. A human being is not only the primary motive but also the primary force of realising sustainable development and the most direct beneficiary of this process. A human being is also the action subject and beneficiary object of maintaining social stability, promoting economic development, advancing scientific and technological innovation, and protecting the ecological environment. Economic development is the core element of the sustainable development system. Economic development is not only the fundamental driving force to meet the material and spiritual needs of human beings in society but also the basis for supporting the construction and protection of the ecological environment and the primary prerequisite for promoting scientific and technological innovation. In addition to social and economic factors, technical and environmental factors are also the core elements of the sustainable development system; in short, these elements complement each other and are inseparable.

The scientific connotation of sustainable urban development refers to the collaborative and lasting development of the urban economy, social environment and science and technology. In other words, on a specific spatial and temporal scale, moderate population, high-quality labour force, high-quality economic growth, advanced industrial structure, comprehensive economic benefits, environmental quality without pollution or even less pollution, sustainable utilisation of resources and reasonable consumption to achieve the agglomeration benefits of urban development, promote the sustainable development of the city.

The level of sustainable urban development can be reflected through the performance of various factors of urban development: the performance of urban economic factors; the performance of urban social factors; the performance of urban environmental factors; the performance of urban scientific and technological innovation factors, as shown in Fig. 1.8.

The main body of communities' development has three elements. First, the government – the representative of the macro level of community construction – plays a significant role in the whole community design and construction process, leading a series of appropriate activities. The government formulates development policies, relevant laws and regulations, and action initiatives. The government guides, supervise and controls community construction and development activities. The second is the market, which represents the middle level of community construction and the collection of various industries and enterprises in the city. In urban construction, its primary responsibility is more focused on promoting sustainable development, running through the government's instructions and policies in industries and enterprises so that the relevant policies of community construction have an excellent impetus and support.

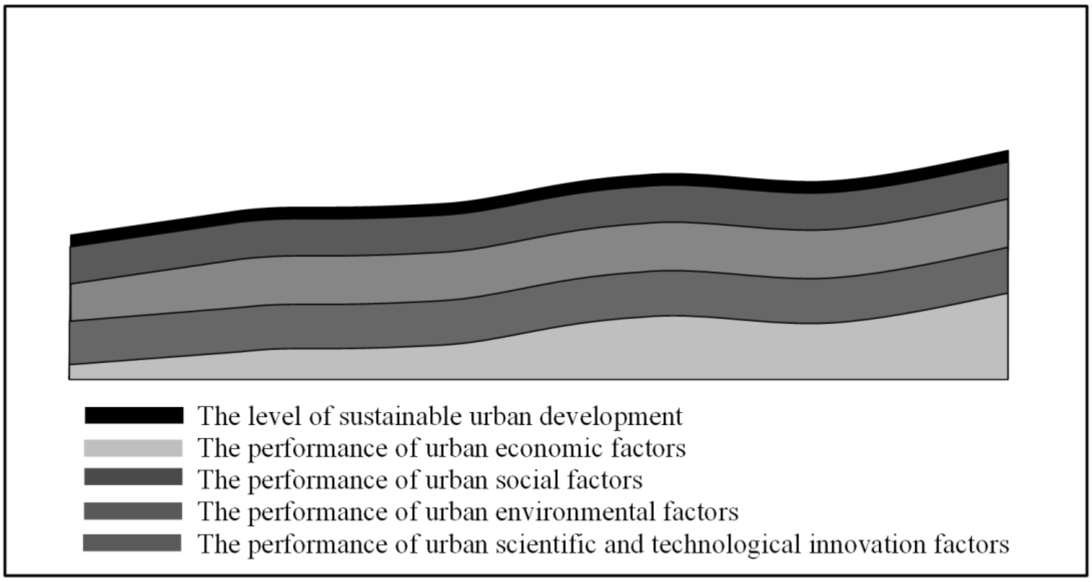


Figure 1.8 – Relationship between urban sustainable development level and development factors

Source: author's development

The third is the public, which includes individuals, groups or other organisations and represents community construction at the micro level. In the process of community construction, the primary responsibility of the public is to participate: the public is asked to practice relevant policies and regulations actively and to complete the tasks and objectives of community construction in a bottom-up manner. In the process of sustainable urban construction, the primary responsibilities of the government, the market and the public are shown in Fig. 1.9.

Concerning the city, its primary functions can be divided into eight parts: life, production, transportation, communication, environmental protection, safety, disaster prevention, and culture (Simon & Masters, 2021). Under the condition of possessing the essential elements of the city, the main urban body formulates the development goals and cooperates, makes full use of the resources of all aspects of the town, and realises these essential functions to ensure the stable operation of the city, including meeting the development needs of the main urban body and ensuring the stability of the urban development elements (Lytvynchuk et al., 2020).

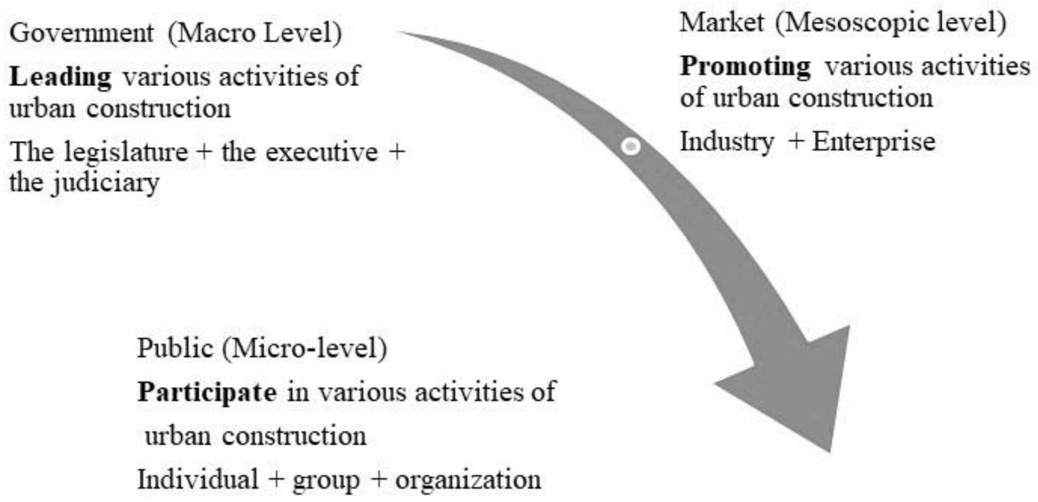


Figure 1.9 – Main responsibilities of government, market, and the public in urban construction

Source: author's development

The essential functions of the town are also interrelated. For example, life and production depend on the city's transportation, communication, and other functions. Urban transit also needs to take safety as the principle, and environmental protection as the requirement, to reduce the pressure on the environment (Borysova et al., 2021). Urban safety and disaster prevention provide security for life and production but are also inseparable from the role of urban transportation and communication. Urban culture is not only the function of urban development but also the product of urban development, which is complementary to other essential functions. Culture deepens the concept of other urban functions, and other urban functions can guarantee the formation and accumulation of culture.

The comprehensive development of the city's economy, society, environment, science and technology is a complex dynamic system engineering (Long & Huang, 2019). To promote sustainable and efficient urban development, decision-makers must rely on urban management through effective management to regulate people's behaviour (Kattel et al., 2021) and to coordinate social, economic, and ecological development. Urban government needs to adjust local and global interests, short-term and long-term interests, to make the use of various urban resources sustainable, and guide urban growth to achieve sustainability.

The reason the existing urban management modes in China can't solve the urban problems from the overall point of view is restricted mainly by traditional development and management ideas (Danko & Reznik, 2019). Urban management is to manage urban development, but for a long time. On the one hand, it is limited by traditional conventional development concepts; on the other hand, it is affected by the planned economic system. There are two limitations in the thinking of urban management. First, it is understood that "development" in the direction of urban development is mainly economic growth and physical expansion. As a result, urban social development and urban environmental protection are placed in a secondary position, or the development and management cannot be carried out by integrating economy, society, environment and science and technology. Second, "management" in the direction of urban development is understood as the behaviour of a single subject of the government, which is dominated by the organisational behaviour based on the traditional bureaucracy.

Therefore, the key to reforming urban management mode is to carry out the reform according to the human development thought characterised by "sustainable development and good governance" since the 1990s. To realise the transformation, there is the need to change two ideological premises: the understanding of "development" from mainly pursuing urban economic growth to emphasising the sustainable development of the hybrid urban economy, society, and environment and to transform the knowledge of "management" into a process of urban governance in which government, enterprises, market or public organisations, private organisations, and social organisations participate. In doing so, the management mode of sustainable urban development with integrity and origin is established (Monastyrskyi & Volosyuk, 2021).

Given the problems in the traditional urban management model, the following two aspects of urban management policies and tools should be emphasised.

The need to strengthen the strategic management of the whole process of urban *development* to understand the planning, construction, and operation of urban development from the perspectives of prevention and cause orientation and to have an overall understanding of the macro process of urban management (Danko et al., 2020). Urban development, especially the development of urban infrastructure, has a process from planning and design to construction implementation and then to operation and maintenance, that is, the trilogy of urban planning, urban construction, and urban operation in the usual sense (Peng et al., 2021). Therefore, urban management should include the whole process or the whole life cycle of urban development, including planning control in the design stage, construction management in the implementation stage, and functional management in the operation stage, which can be regarded as the strategic formulation, implementation, and regulation of urban strategic management. Therefore, the urban management concept that only emphasises one link will cause an artificial management division, affecting the overall efficiency of urban governance. The three links of urban management influence and support each other, among which planning management is the leader of healthy urban development, which stipulates the future functions of urban development and provides a framework for coordinated and orderly urban construction. Construction management is the foundation of the healthy development of the city; it is the intermediary of the planning goal from conception to realisation and provides the premise for the effective play of the function. Functional management is the key to the healthy development of a city. It determines whether the city functions are realised and the regular operation of infrastructure. It often becomes the external manifestation and direct symbol of the coordinated development of a city's economy, society, and environment (Zhang & Li, 2021). As urban development shifts from municipal construction to functional development, operation management, characterised by infrastructure maintenance and urban function development, is becoming increasingly important in urban management (Zhou et al., 2021). Compared with planning and construction management, the current understanding of urban operation management needs to be improved. Therefore, on the one hand, contemporary urban management should pay attention to the three links of planning, construction, and operation to form a system; on the other hand, it should focus on strengthening the research and practice of urban operation management. In our opinion, "heavy construction and light management" in daily affairs mainly refers to the lack of research and insufficient attention to operation management.

The need to strengthen prevention management in all links of urban development. The management thought of prevention first should not only be used to understand the whole process of planning, construction, and operation but also be reflected in each specific link because the causes of many urban problems can be found in these links to guide the improvement of countermeasures. Preventive function in urban planning. The 1996 United Nations Conference on Human Settlements (Habitat II) emphasised that cities should recognise the role of planning from a strategic perspective, which called for good urban planning to prevent urban problems or diseases (Sun & Wang, 2022). For a long time, urban planning has paid more attention to the physical form of planning, while the potential problems in the social, economic, and environmental fields lack research. To pay attention to the role of urban planning in preventive management is to change from traditional material objects planning to forward-looking comprehensive planning based on " human".

Urban construction is significant in urban development. No matter how well urban planning is, serious problems can occur in the construction stage, and the expected results can't be achieved (Chen, 2021). Currently, some urban construction not only neglects prevention but also aggravates urban problems. For example, the structure of luxurious real estate along the flood control river, the construction of harmful buildings in the protected tourist attractions, and so on. Prevention-oriented urban management thought should also run through the whole process of urban construction. Even if sufficient attention has been paid to the prevention of urban problems in urban planning and construction, if the management in the urban process is not in place, it will lead to or aggravate the occurrence of urban diseases. Many problems in cities, such as traffic congestion, and dirty and disorderly public space, are related to inadequate management. On the other hand, even if the supply of urban infrastructure is temporarily short, good management can make up for and improve it to the extent possible. The frequency and intensity of urban problems can be reduced or mitigated by preventive management in operation.

The scientific decision-making basis of the urban strategic management and preventive management process is constructing an urban, comprehensive development index system and evaluation model. A complete index system and evaluation model are essential for urban sustainable development management. They constitute an important part of the decision-support system for urban sustainable development (Zhu & Chen, 2022). To be specific, the function and value of the index system of sustainable urban development are not only reflected in a particular aspect or a clear step in the implementation of urban sustainable development policies; in fact, it can play a role in the whole process of sustainable urban development (Fig. 1.10).

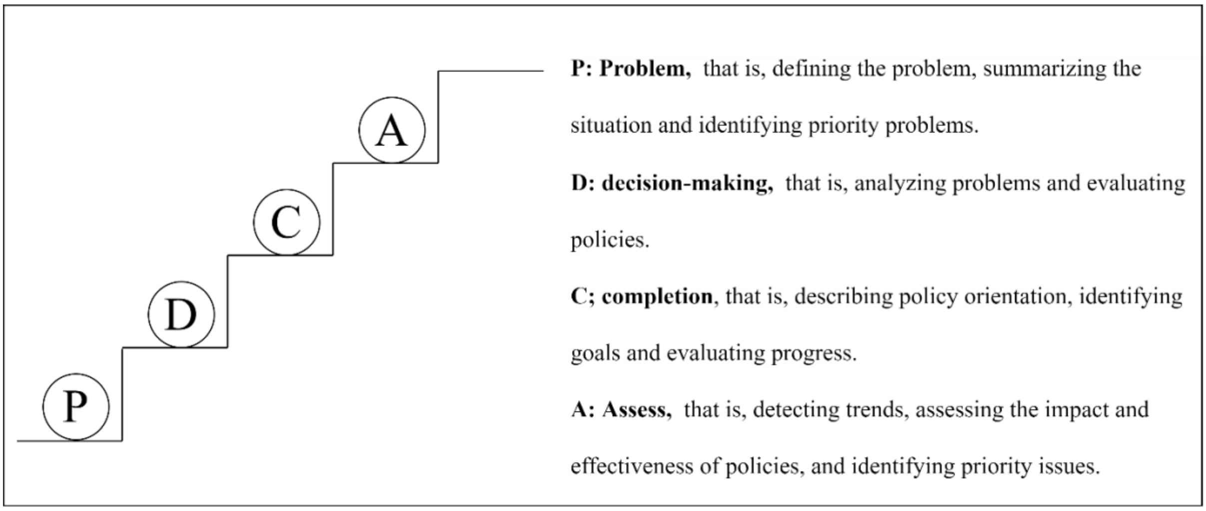


Figure 1.10 – The circular function of the urban sustainable development index system in the whole process of urban management

Source: author's development

Fig. 1.10 describes the critical role of urban sustainability assessment in management. Starting with the identification of urban problems, the evaluation index system has been continuously providing information support for the implementation of urban sustainable development policies until after the policy evaluation, new problem issues have been found, thus constantly promoting the development of urban sustainability to a higher level. The evaluation index system of sustainable urban development affects the formulation, implementation, and assessment of urban development policies in the whole process and then starts a cycle of higher levels. In this way, the capacity of urban management toward sustainability will be continuously improved.

Since the first half of the 20th century, with the rapid progress of global industrialisation and urbanisation, humans have taken excessive resources from nature. Destroying the ecological environment people relied on almost regardless of the cost and consequences (Biswas et al., 2021). In the 1950s, Japan's Kumamoto Prefecture experienced water disease, London area detected smog pollution. The severe blowout of the waters near the Yucatan Peninsula in the Gulf of Mexico was detected in the 1970s. In the 1980s, the Bhopal gas leak disaster in India occurred, and the Chornobyl nuclear reactor accident took place in Ukraine. (Yan et al., 2018). In the 21st century, such disasters have not stopped, such as the atomic leakage accident in Fukushima, Japan (2011) (Ortiz-Moya et al., 2021) and extremely intense weather disasters in various places. These incidents become more and more frequent, bringing health and even life threats to local people, but also gradually raising great attention of people around the world. The most important thing is to stimulate people's reflection and summary on the relationship between environmental protection and economic, social, scientific and technological development. Government departments, social organisations and groups, business units, and individual citizens are doing their bit for the coordination and sustainable development of the environment, economy, society, and science and technology, which also triggered a series of environmental performance evaluation research. The ecological efficiency assessment started at the end of the last century, mainly to assess the possible impact on the natural environment after the implementation of specific planning projects and, on this basis, to suggest countermeasures. However, although a single environmental assessment may be able to find the urban development path of energy saving, emission reduction, and cleaner production, it isn't easy to mobilise other subsystems (economy, society, science, and technology) from the perspective of only one system. For example, although cleaner production is conducive to the realisation of energy saving and emission reduction, enterprises and individuals are unwilling to invest funds, science and technology in research and development, nor are they willing to invest large-scale human and material resources to achieve the so-called green growth (Shevchenko & Danko, 2021). Therefore, pure environmental efficiency assessment is not significant for any urban development. To realise sustainable development, we must combine all systems: environment, economy, society, science and technology to make a comprehensive evaluation. To sum up, the sustainable development evaluation allows measuring whether a region has achieved comprehensive and coordinated green development from the four dimensions of environment, economy, society and science and technology, which not only meets the needs of contemporary people but also does not restrict future generations to meet their needs.

Urban sustainable development is inseparable from the guidance of urban sustainable development planning (Wang et al., 2011). When the current situation, characteristics and needs of urban development are fully considered in the formulation and planning of urban sustainable development policies, the possibility of achieving better results in urban construction activities is greater, and opposite (Montero, 2020). Therefore, the city's decision-makers can fully understand the advantages and disadvantages of the current stage of urban development by evaluating the level of its sustainability and can grasp the changing trend of various factors affecting it. Thus, it is necessary to establish a scientific, objective, and comprehensive evaluation system to evaluate the level of urban sustainable development. The evaluation results can provide a reference for the next stage of sustainable urban development planning: identification of problems, driving factors and improvement of the policy-making efficiency (Fig. 1.11). Such an approach to formulating strategy could be called “knowledge-oriented” sustainable development strategy.

Identification of the strengths and weaknesses of urban development. By evaluating and analysing the level of sustainable urban development, we can understand the advantages and disadvantages displayed in the process of urban development. This analysis is helpful in the optimisation of the critical content of urban sustainable development plans (Ma & Ma, 2013). It will help cities learn from each other, make up for their deficiencies, reduce the impact of their shortcomings on urban sustainability, make up for defects, and improve the overall level and quality of urban development (Opschoor & Hans, 2011).

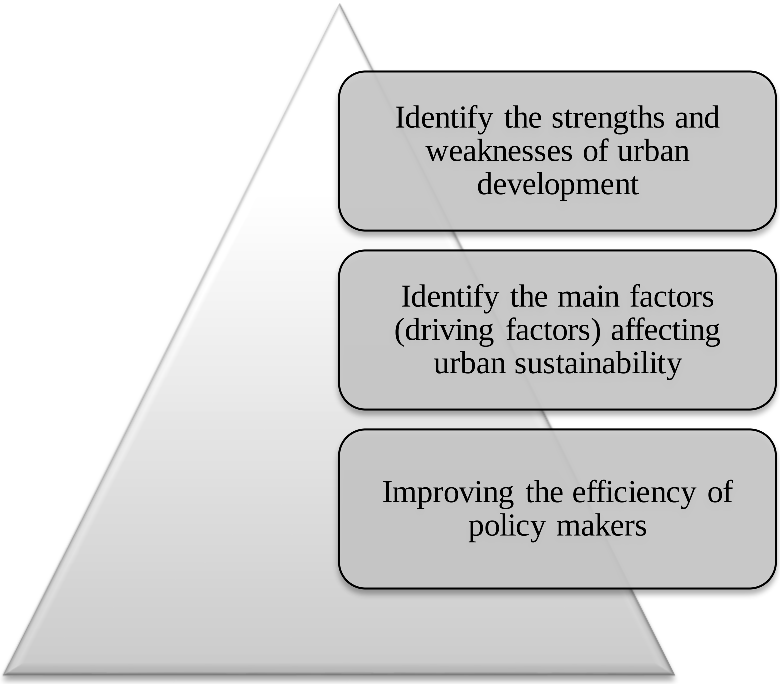


Figure 1.11 – The importance of evaluating sustainable urban development

Source: author's development

Identification of the main factors affecting urban sustainability. The city is a complicated system; the factor influencing the sustainable development of the town is also anfractuous. Setting up the sustainable development level of the city to appraise the design and carry on the main functions needs quantisation of every influencing factor through calculating and analysing. This will help to sum up the main factor influencing urban sustainability and so to define the incentive mechanism (Opschoor & Hans, 2011). Determining the driving factors of urban sustainability will help to clarify the critical direction of urban development, elaborate the urban policy design and construction activities around these vital points, complete the application effect of sustainability idea more ideal, and accelerate the speed of sustainable urban development.

Improvement of the policymakers' efficiency. According to the original data of the indicators, the performance results can not only measure the level of sustainable development of cities but also understand the spatial distribution of characteristics and trends of urban development. Based on a comprehensive understanding of sustainable urban development, it is convenient for urban policymakers to formulate relevant countermeasures concerning all elements of the city's sustainability performance and improve the efficiency of planning and management.

1.3 Methodical approaches to measure and manage urban and regional territorial communities' sustainability

Agenda 21, adopted at the United Nations Conference on Environment and Development in 1992, proposed that all countries build their own sustainable development indicator systems (Sylemez et al., 2016). Since then, studies on the theory, strategy, and evaluation of sustainable development have flourished, making sustainable development not just a theoretical notion. Experts, scholars, and research institutions began to explore the construction and application of sustainable development evaluation indicators and then formed a research system combining norms and empirical evidence (Gunnarsdottir et al., 2020).

Based on theoretical research, institutions and scholars have constructed various levels of sustainable development evaluation indicator system (Dyatlov & Selishcheva, 2020), mainly represented by: the sustainable development indicator system built by the United Nations Commission for Sustainable Development (UNCSD); indicator system of the United Nations Scientific Committee on Environment; Sustainable Development Indicator System Framework of the United Nations Statistical Office (FISD); United Nations Development Programme (UNDP) Human Development Indicator System (HDI); The World Bank's (WB) sustainable development indicator system; Eurostat's sustainable development indicator system; Organization for Economic Cooperation and Development (OECD) sustainable development indicator system. Other representative indexes are as follows: the consumption pressure index and life planet index; Cobb et al.'s absolute development index; sustainable economic welfare index, and so on (Da Silva et al., 2020).

Indicator system of the United Nations Commission on Sustainable Development. The sustainable development index system (driving force–state–response, DFSR) initially proposed by the United Nations Commission for Sustainable Development in 1996 has 134 indicators, including 23 economic indicators, 41 social indicators, 55 environmental indicators and 15 institutional indicators (Kirilchuk et al., 2018). The characteristic of this preliminary indicator is that it highlights the causal relationship between environmental stress and environmental degradation; that is, it shows a very close relationship with the environmental objectives of sustainable development. At the same time, there are some problems with its economic and social indicators. For example, there is no logical connection between driving force indicators and state indicators. As a result, the definition of individual indicators as "driving force" or "state indicators" is unclear; that is, the attribution is very fuzzy, with an excessive number of indicators and other defects. After 22 countries and regions in the world conducted experiments on this preliminary indicator system at the national level, it was finally determined that it is composed of "four major systems of society, economy, environment, and system" and "driving force-state-response". The indexing framework contains 15 thematic factors and 38 sub-theme factors, 58 core indicators (Cialis et al., 2020). There was a set of 14 economic indices, 19 social indices, 19 environmental indicators and six systemic indices. Establishing the index system of sustainable development provides a widely accepted model and precedent, especially for the new century, where the national and regional sustainable development index system is of great guiding significance. However, since the indicators of the system built by the UN Commission on Sustainable Development (UNCSD) cannot be added together, and UNCSD does not provide an effective solution to it, excessive indicators will weaken the function of the indicator system to serve policymaking. More importantly, the UNCSD does not offer a way to measure the connections between different systems, and it lacks a holistic understanding of sustainability. In addition, the index system pays too much attention to environmental and biophysical index factors, resulting in insufficient attention to social and economic aspects (Hák et al., 2016).

The indicator system of the United Nations Scientific Committee on the Environment. In 1995, the United Nations Scientific Committee on Environment, aiming to solve the problem of an excessive number of indicators in the sustainable development indicator system proposed by UNCSD, cooperated with the UNEP and jointly presented a highly integrated model of sustainable development indicator system. This method is a combination of the indicators used by Albert Adrians of the Dutch Ministry of Housing, Urban Planning and Environment in his 1993 book Indicators on the Implementation of Environmental Policies (Yumashev & Lusarczyk et al., 2020). This index system has a high degree of integration, including environmental ecology, resources and energy, natural system, and air and water pollution. It is a comprehensive sustainable development index system constituted of 25 essential indices (Bebbington et al., 2017). From the composition perspective, this indicator system involves three subsystems: economy, society, and environment. Compared with the UNCSD index system, this index system is concise and clear and adopts the idea and method of weighted synthesis, which is very worthy of reference and promotion. However, the weight coefficient method is relatively subjective and needs further research and improvement.

The sustainable development indicator system of the United Nations Statistics Office. In 1994, the sustainable development indicator system of the United Nations Bureau of Statistics was established based on the modification of the indicator system of UNCSD. The index system does not adopt environmental factors as a basis for classification. The main issues to be considered are economic (Kwatra et al., 2020), social issues, air, land and soil, water and other resources, solid waste, people's livelihood, natural disasters, and other (Allen et al., 2017). The indicators are classified into four fundamental elements: economic and social activities and events, impact and consequences, response to impact, and quantity and background conditions (Yuan, 2021). There are as many as 88 indicators, which reflect, however, more environmental problems, fewer problems in the economy and society, and no indicator factors in science and technology. Economic and social activities correspond to "pressure", impact, effect, and reserves; stock and background conditions correspond to "state"; the response to impact corresponds to "response". Therefore, like the indicator system of UNCSD, the data given by this index system are also numerous and chaotic.

Sustainable Development Indicator System of the World Bank (WB). In 1995, the World Bank unveiled its indicator system for measuring sustainable development and declared the system's relation with wealth, not just income, in defining national development strategies (Rogers et al., 2012). This approach challenges traditional ways of thinking and extends the meaning of wealth beyond investment and money, representing the real wealth of countries and regions in a three-dimensional model (instead of relying on the single-factor model used before) (Swain, 2018). With "national wealth" as a measure of sustainable development (Paliova et al., 2019), the traditional concept of capital has carried on the creative development, the combination of natural capital, manufactured capital, human capital, and social capital. Four kinds of capital elements are assessed through the four aspects of the index system (Estoque et al., 2021). Applying this approach, the WB identified 192 countries and regions of the world's wealth and value and established a 25-year time series for 90 of them. The WB sustainable development indicator system enriches the composition of capital and the traditional concept of wealth. It emphasises the importance of human capital, pointing out that it is the most critical investment to promote national and regional development and is also essential to maintain sustainable growth. However, the application of this method is limited to some extent because of the different difficulties in monetising the other three kinds of capital except for man-made capital.

Eurostat's sustainable development indicator system. In its report "Progress Measurement towards a More Sustainable Europe", Eurostat points out that the sustainable development strategy consists of four pillars (economic, social, environmental, and institutional) and proposes an appropriate sustainable development indicator system. The index system includes 63 indicators, among which 22 are social, 21 are ecological indicators, and six are institutional indicators (Hák et al., 2016b; Szopik-Depczyńska et al., 2018). This set of indicators follows the more policy-oriented view of the sustainable development concept and provides an initial description of the main issues highlighted by the EU strategy. However, for most environmental variables, data availability is insufficient, and social indicators often do not meet the quality standards of economic indicators.

The indicator system of the United Nations Organization for Economic Cooperation and Development. In 1991, the Organization for Economic Cooperation and Development (OECD) of the United Nations put forward a preliminary environmental indicator system, the world's first ecological indicator. In 1994, OECD published the sustainable development indicator system, including three types of indices (Bolcárová & Kološta, 2015; Wood et al., 2018). OECD core environmental indicator system contains about 50 indicators in total, covering the major ecological problems reflected by OECD member countries. Based on the pressure-state-response model, this system is subdivided into three types of indicators: environmental pressure, environmental state, and social response. These indicators are mainly used to track, evaluate, and monitor the dynamics and trends of ecological problems (Destek & Sinha, 2020; Yumashev & Ślusarczyk et al., 2020). OECD’s indicator system mainly focuses on specialised sectors, including indices reflecting the changing situation of the sector environment, the internal role of the industry and environment, and economy and policy (Fritz et al., 2019; Sachs et al., 2021). Environmental accounting indicators refer to the sustainable utilisation and management of natural resources, as well as ecological expenditure indicators, such as the structure and degree of pollution reduction, pollution control investment, and the intensity of natural resource use.

Representative indices. There is abundant experience and achievements in researching sustainable development indexes in foreign countries. Comprehensive analysis of these index indicators can be roughly divided into three categories: economic progress index, environmental and ecological index, and social progress index. Examples are the World Bank's “real savings” index and “national wealth” index, consumption pressure index, life planet index, ecological footprint index, absolute development index, sustainable economic welfare index, UNDP's human development index and so on. Respectively, economic development, environmental conditions, and social progress, as well as the interaction between them, were analysed.

The evaluation of urban sustainability aims to assess the comprehensive ability of a city to develop via the coordination and the coupling ability of each module in the process of urban development (Yu et al., 2020). Evaluation generally includes a single and comprehensive evaluation. Single evaluation does not mean that the object of assessment is single, but that the standard of evaluation is single and clear. On the contrary, the comprehensive review is more complex and abstract. Thorough comprehensive assessment requires that the evaluation model can systematically make a global and overall evaluation of the object with multiple attributes and complex structure (Hai-yang & Fang, 2009; Luo et al., 2017; Xing et al., 2013). Urban sustainable development involves the environment, the economy, the society, and the science and technology subsystems. The coordinated development and the mutual coupling ability of each of these subsystems play a crucial role in sustainable urban development. Through the analysis of each system's coordinated ability and state, a sustainable city development mode can be obtained. This requires constructing the synthesis model to ensure an extreme scientific nature in the rationale and the method practice.

There are many evaluation models used to assess the urban sustainable development (Ruan & Wu, 2015; Sun & Wang, 2022b), mainly involving two categories:

- subjective assignment methods, such as fuzzy clustering, Delphi, analytic hierarchy, etc.;

- objective valuation methods, such as factor analysis, principal component analysis, regression analysis, and so on (Feng & Xu, 1999; Van Beuzekom et al., 2015; Xing et al., 2009).

However, many problems have been questioned in academic circles, such as the rationality of the selection of evaluation indicators, the scientificity of the weights given by hand and the accuracy of the results. To obtain a reasonable and comprehensive scientific evaluation method, it is necessary to compare its advantages and disadvantages, which are integrated into this paper (Table 1.2).

Table 1.2 – Standard methods for urban sustainability assessment

Evaluation method	Advantage	Disadvantage
1	2	3
Exponential method and synthetic exponential method	Comprehensiveness, hierarchy, objectivity, and comparability of the evaluation results	It is difficult to empower and quantify accurately, and the description of the evaluation results is still static
Principal component analysis	Variables can be simplified, repetitive meaning variables can be deleted, and the whole can be comprehensively expressed through a few variables	The alternation of the symbols of the factor loads somewhat obscures the meaning of the function
Fuzzy comprehensive evaluation method	With the characteristics of clear results and strong system, it can better solve fuzzy, difficult to quantify problems, suitable for all kinds of non-deterministic problems	Subjectivity is strong, easy to make the evaluation results of the classification is not clear or even deviate from the actual situation
Delphi method	Wide range of application, not limited by whether the sample has data. Several important indicators that are difficult to quantify with mathematical models or which have insufficient data to collect could also be taken into account	Affected by subjective factors such as expert knowledge and experience, the process is cumbersome, takes a long time and is relatively poor in operability, which reduces the reliability of the results of quantitative ranking of evaluation indicators
Analytic hierarchy process	The essence, influencing factors and internal relations of complex decision-making problems are analysed in depth, and the thinking process of decision-making is mathematized by using less quantitative information, to provide a simple decision-making method	It not only does not destroy the operability of the original analytic hierarchy process, but also makes the model more consistent with the cognitive law and the whole model more consistent with the objective reality
Entropy weight method	It can deeply reflect the utility value of the evaluation index information, and the solved weight avoids subjective interference and has high reliability	The evaluation process lacks horizontal comparisons between indicators

Continue of Table 1.2

1	2	3
Data envelopment analysis	It is applicable to deal with input-output indicators and can evaluate the relative effectiveness of decision-making units	Less information can be given to effective decision-making units
TOPSIS method	It can obviously improve the scientific, accuracy and flexibility of multi-objective decision analysis	Its weight is affected by the iterative method, and the result is not very accurate because there is no definite method to transform the neutral index

Source: prepared by the author based on Ruan & Wu, (2015); Sun & Wang, (2022)

With the development of science and technology, comprehensive evaluation method has made significant progress (Stoyanets et al., 2020). When applying different evaluation methods, there are differences mainly in three aspects: the dimensionless treatment formula, the comprehensive index synthesis method, and the index weighting method determination. However, in applying the total evaluation method, how to make it more accurate and ensure the results will be presented objectively is one of the problems that must be analysed and studied. Currently, using two or more evaluation methods has become one of the focuses of scholarly attention. Using different methods will be prominent to get a more objective understanding of the problem; such a comprehensive evaluation has a more robust accuracy, objectivity, and scientificalness.

Conclusions to section 1:

1. Because the intersection and combination of ecological, economic, and social parameters of the socio-economic space take place at the regional level, this research explores the evolution of sustainable development ideas in the context of regional development. The significant role of urbanisation and the development of cities in regional development is emphasised. The role of urbanisation and cities in developing regional territorial communities is vital in China, where the current urbanisation rate amounts to more than 60%. In this study, a regional territorial community is seen as a

regional complex composed of one or two central cities as the core and several cities of different scales, types, and nature within a particular spatial scope, with the division of labour and cooperation, complementary functions, and interconnection.

2. Based on the role of cities in developing regional territorial communities in China, ideas contributing to the sustainable development of urban territories are analysed: Eco-city, Compact city, Green city, Healthy city, Knowledge city, and Smart city. In the new era, knowledge has become the driving force of urban development. The concepts of Knowledge city and Smart city, which emerged recently, indicate that science, knowledge, and innovation support sustainable transformations and growth through technological solutions. On this basis, a five-dimensional PESTD vision of the smart city functioning system was developed, which consists in understanding information as an essential component that integrates other elements of urban development (economy, society, technology and politics) and, at the same time, is a source and means of building a proper system of urban governance.

3. Existing theories of sustainable development (Multi-objective synergy theory, Urban PRED system theory, Urban development cybernetics, Degree of sustainable development, Theory of urban ecology, Theory of man-land relationship, and Circular economy theory) accentuate a close relationship between the economic, social, and ecological foundations of territories development, as well as the need for their coordination. The latter requires the involvement of data, assessments, and relevant criteria for decision-making to ensure the proper performance of cities and management functions.

4. Since the three-dimensional model of sustainable development is classical, considering the role of data and the coordination aspect of city management is possible through science and technology as a particular component of a sustainable urban development vision. The scientific connotation of sustainable urban development refers to the collaborative and lasting development of the urban economy, social environment, ecological environment, and science and technology.

5. Three main elements of community development are identified: the

government, which plays the leading role in the design, creation and management; the market, which represents the middle level and ensures the promotion of sustainable development through the implementation of government initiatives at the level of sectors and enterprises; the society (micro level), the primary role of which is active participation in the implementation of these initiatives. The government, through proper management, should promote the best combination and performance of city functions. A vital aspect of the urban governance mode improvement is carrying out reforms following sustainable development and good governance concepts.

6. Given the features of traditional urban management in China, the main issues to be addressed are outlined: the need to strengthen the strategic context in the general process of city management (considering the interdependence of the components of the design-creation-functioning cycle of urban infrastructure and their functional aspect); the need to strengthen preventive management in all aspects of city management (planning, construction, operational management). In this regard, elaborating on a comprehensive index system and evaluation model is necessary to guide the urban development path towards sustainability. Such a framework is an essential component of the decision support system.

7. A review of approaches to assessing the sustainable development of communities at different levels showed the presence of different points of view regarding the main influencing factors. Some assessment approaches focus on environmental, social, and economic aspects; in others, the emphasis is on a broader approach to interpreting capital, well-being, and institutional factors. The complexity of measurement, incompleteness of data, weak clarity and transparency of indicators, and lack of attention to indicators of scientific and technological development - such problems are characteristic of existing models of complex sustainable development measurement.

8. Since urban development depends on many interacting factors (and evaluation of the ability to interact is essential), a proper synthetic evaluation model should be formed. This will ensure the appropriate level of validity of the assessment for their practical application in urban management. Analysis of the methods used by scientists to

build an evaluation system showed that scientists use subjective assessment of the factors' influence (fuzzy clustering, Delphi, analytic hierarchy) and objective ones (factor analysis, principal component analysis, regression analysis). Each of these methods has its advantages and disadvantages. Combining two or more ways to get better results is expected. Using the TOPSIS model, the role of the human factor can be excluded, ensuring greater objectivity of the assessment.

SECTION 2. EVALUATION FRAMEWORK TO GUIDE REGIONAL TERRITORIAL COMMUNITIES' SUSTAINABILITY PATH

2.1 Current state and approaches to measure Chinese regions sustainability

Over the past 30 years of reform and opening, China's urbanisation process has been accelerating, and the urbanisation rate has increased at an average annual rate of 1% (Shahat et al., 2021). Statistics show that in 1999, China's urbanisation rate was 30.89%, and by 2011, China's urbanisation rate reached 51.27%, and the urban population exceeded the rural population for the first time (Yang et al., 2020). In 2021, China's urbanisation rate reached 64.72%, an increase of 74% compared with 1999 (Fig. 2.1). In 1978, the number of cities in China was 193, and by 2021, it had increased rapidly to 663. Currently, there are 142 cities with a population of more than one million in China, while there were only 29 cities in 1978. In addition, there are 25 cities in the world with a population of more than 10 million, six of which are in China. China also has ten densely populated towns, with between 5 and 10 million habitants. According to the United Nations forecast, by 2025, more than two-thirds of China's population will live in cities (Tang et al., 2011), and China's urbanisation process will be further promoted. Then, the city's sustainable development has gradually become a new challenge in the country's development. The deep-seated contradictions of environment, economy, society, science and technology in Chinese cities will further emerge.

At present, the central gap and dilemma between urban development and sustainable development in China can be condensed into the following three points: 1) unsustainable society and the environment caused by population problems, ecological environment pollution, and resource depletion; 2) extensive economic growth and short incubation of technological innovation resulting in unsustainable economy and technology; 3) unsustainable urban environment, economy, society, and science and technology.

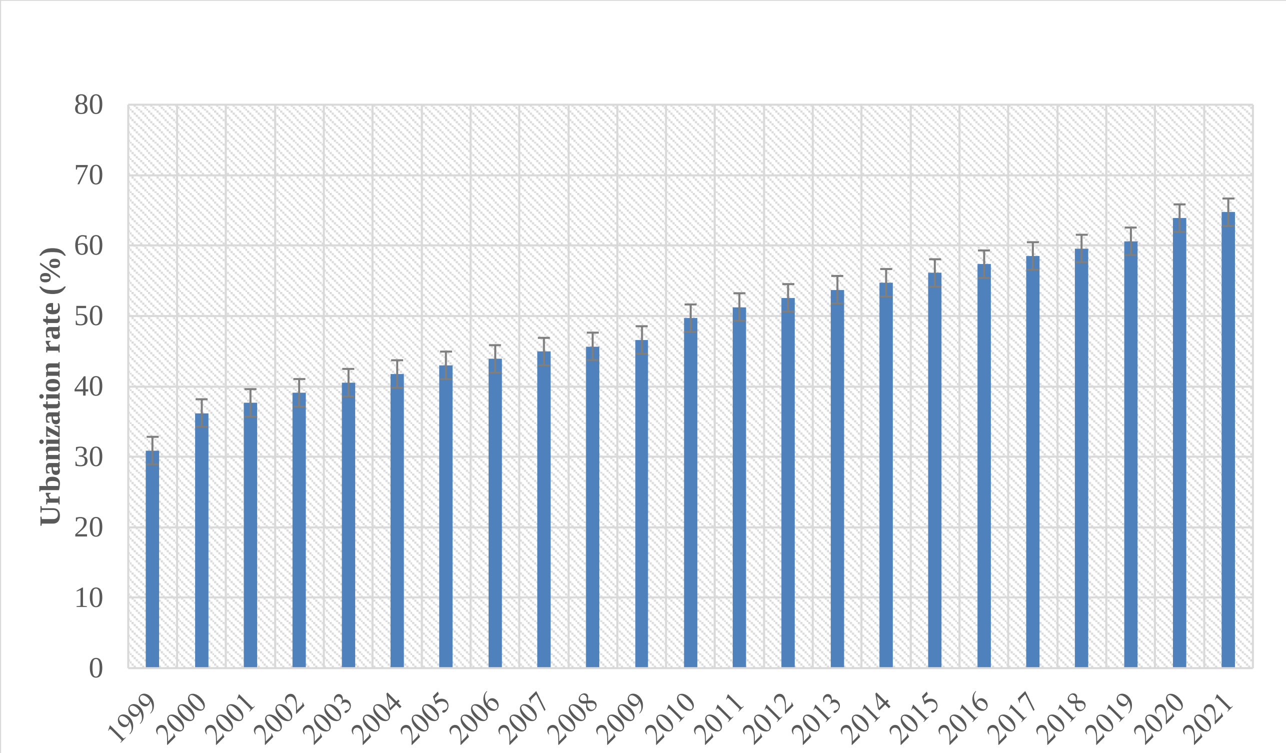


Figure 2.1 – The change in urbanisation rate in China for 1999-2021

Source: China Statistical Yearbook 2021

Unsustainable societies and the environment are caused by population problems, environmental pollution, and resource depletion. The population problem has always been one of the focal problems of sustainable urban development. On the one hand, inadequate population control will lead to a small number of per capita resources, such as the shortage of per capita water resources and per capita land resources in some areas. Moreover, the rapid growth and influx of population have led to the emergence of "big city disease" in many regions of China, which has caused much pressure on the improvement of social pension, social welfare level, and social labour force level. On the other hand, with the rapid development of China's economy in recent years, the fertility rate has rapidly changed from high to low. The principal contradiction facing China's population has changed from excessive growth to approaching the ultra-low fertility level. The disappearance of demographic dividend, ageing, gender imbalance and other issues have gradually become prominent (Fig. 2.2). The Party and the government attached great importance to it, and a series of population policies and fertility policies were implemented one after another: in November 2011, the national "double single two children" policy was implemented; in October 2015, the Fifth Plenary Session of the Eighteenth Central Committee of the Communist Party of China put forward a comprehensive "two-child" policy; in August 2021, the state formally adopted the decision to amend the population and family planning law, and fully liberalised the three-child policy. Although the three children are fully liberalised, the country's total population has not blowout growth, and some problems, such as uneven distribution of per capita resources, severe environmental pollution, and lack of natural resources in some economically developed regions, still need to be solved urgently.

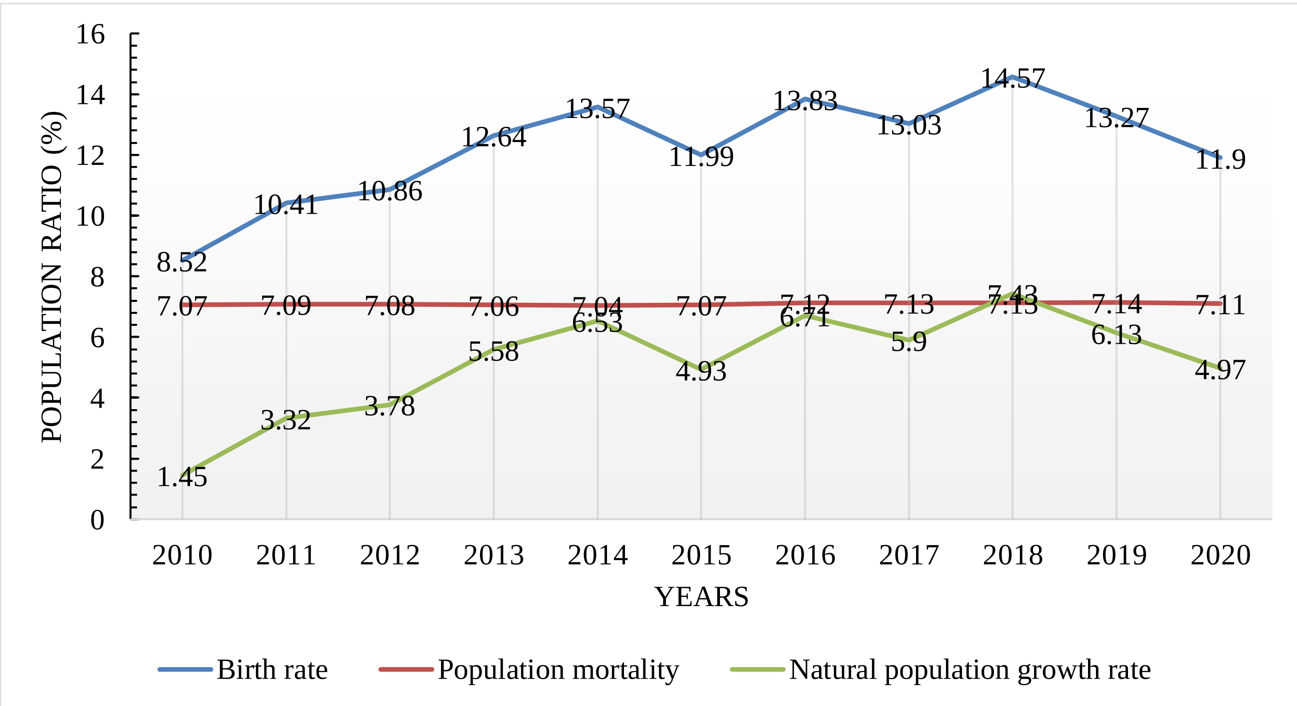


Figure 2.2 – The change in population rate of China for 2010-2020

Source: China Statistical Yearbook 2020

Extensive economic growth and short incubation of technological innovation result in an unsustainable economy and technology. During the 13th Five-Year Plan period, the whole country made unremitting efforts to build a well-off society in an all-around way and implement the development concept of innovation, coordination, green, open, and sharing. However, there are still some problems in China's economic and industrial structure, especially in the western and north-western regions, where economic development still relies too much on the exploitation and utilisation of resources and causes a severe burden on the environment, such as industrial wastewater, solid waste, waste gas, and the discharge and treatment of domestic garbage, which aggravate environmental pollution and lead to increase of related fiscal expenses (Fig. 2.3). These problems have led to the slow transformation of the mode of economic growth from extensive to intensive, although China's various regions have made great efforts to promote pollution control, environmental protection, scientific and technological innovation research, but the disjointed production, teaching and research make the hatching ability of scientific and technical achievements weak. These problems have resulted in unsustainable economic and technological development.

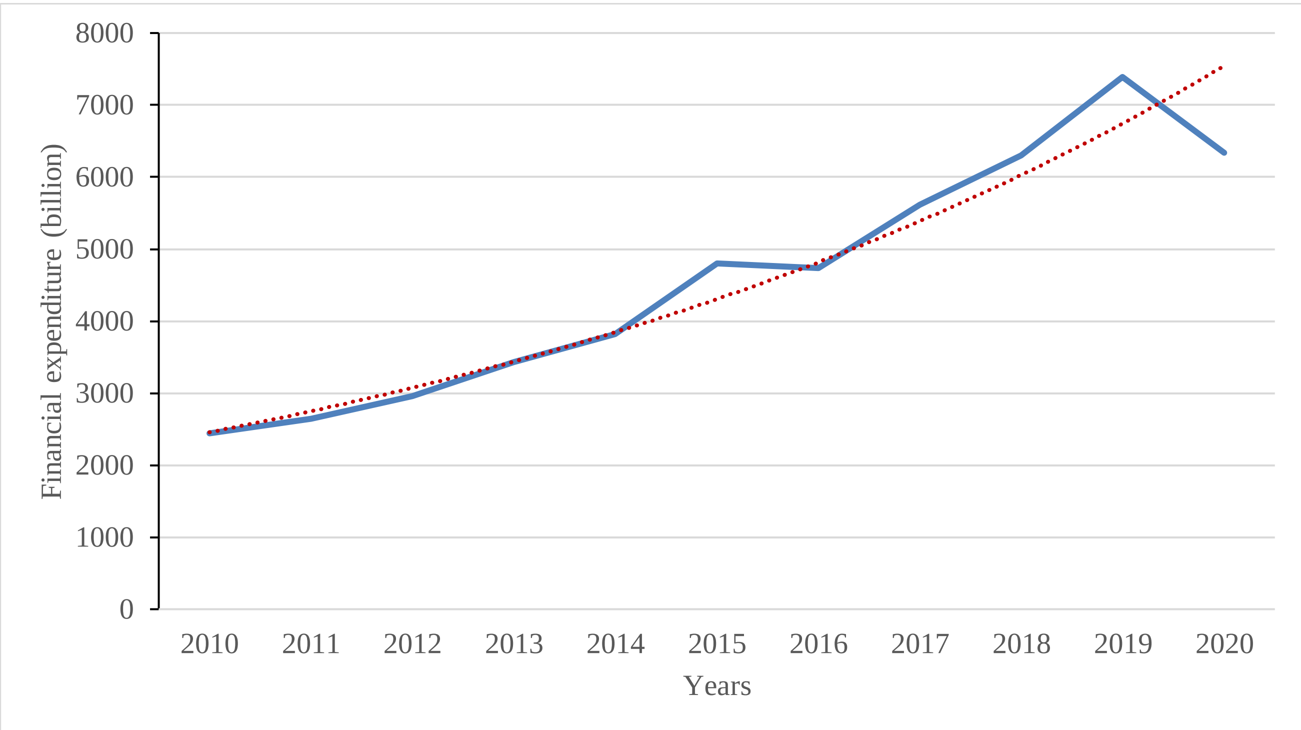


Figure 2.3 – China's fiscal expenditure on environmental protection

Source: China Statistical Yearbook

Unsustainable urban environment, economy, society and science and technology. Since the reform and opening up in the 1980s, the economy and society in various regions of China have developed by leaps and bounds. Still, the development of economic, social, environmental, scientific and technological modules among regions is not balanced; it also obviously shows a trend of agglomeration from inland to coastal areas. With the general direction of population flow from underdeveloped to developed regions and the acceleration of industrialisation and urbanisation, problems such as space congestion, resource shortage, environmental pollution, and social disharmony have gradually emerged in developed provinces in China. Although the development of science and technology has made remarkable progress, the driving force of scientific and technological innovation on the sustainable development of the environment, society and economy has yet to be entirely played. However, the concept of “science and technology are the first productive force” is deeply rooted in the hearts of the people, “science and technology” has not played its due sustainable development thrust in people's imagination.

In sum, the root cause of the above constraints on achieving the goal of sustainable development in different regions is the lack of holistic, systematic, and sustainable approaches and policies. The most important thing for city decision-makers is to use quantitative research methods to clarify the driving factors and incentive mechanisms and propose a set of scientific urban development strategies to promote sustainable urban development. For this reason, well-designed index systems and evaluation methods are essential for managing urban growth and providing scientific guidance for achieving sustainable development.

Since the 1990s, China's theoretical and academic circles have done much research on a sustainable development index system for measuring sustainable development. The early research focused on establishing the sustainable development indicators’ significance, connotation, selection principle, and structure of qualitative research. Further research explored tools based on computer and information technology, gradually strengthened the selection of index method, modelling, and practical aspects of the quantitative analysis (Cheshmehzangi et al., 2021; Deng, 2021).

The research on China's sustainable development index system are very intense, and many index systems with better effects and higher recognition have been proposed. Among them, the representative researches mainly include the sustainable development index system proposed by the Sustainable Development Strategy Research Group of the Chinese Academy of Sciences; the sustainable development indicator System jointly established by the Institute of Statistical Sciences of the National Bureau of Statistics and the Research Group of China Agenda 21 Management Center; the evaluation index system for sustainable development of the pilot area established by the China Research Center for Science and Technology for Development of the State Science and Technology Commission; Mao Hanying's Index system of Sustainable Development in Shandong Province.

China's sustainable development index system is organised by the Ministry of Science and Technology of the People's Republic of China. The Ministry of Science and Technology called the China Agenda 21 Management Center, the Institute of Geography of the Chinese Academy of Sciences, and the Scientific Research Institute of the National Bureau of Statistics to jointly form a research group to conduct a systematic study on China's sustainable development indicator system. Based on the action objectives, China's Agenda 21, and drawing lessons from foreign experience, the index system of China's sustainable development is jointly proposed (Chen & Zhang, 2021; Fang, Shi, & Phillips et al., 2021). The index system is divided into a target layer, reference layer one, reference layer two and indices of four structural levels, including economic, social, population, resources, environment, and science and education, including 295 indicators. The research group divides the indicators of the indicator system into two categories, namely descriptive indicators and evaluation indicators, each including 195 and 100 indicators (Huang et al., 2021; Xie et al., 2021; Yi et al., 2021). This index system highlights the complex relationship of mutual influence, mutual causation, and mutual condition between the whole development thought of sustainable development and the indices. The index covers a wide range and can scientifically measure and evaluate the overall situation of national sustainable development based on expert scoring and systematic analysis.

However, in the operation process of specific practice, there are various indicators of different geographical scopes, which makes it difficult to measure and compare results for different territories; the data used is subject to certain restrictions, and some data can only reflect the local situation and problems, so the conclusion inevitably has a certain one-sidedness.

The sustainable development evaluation index system of the experimental area of the State Science and Technology Commission. In 1997, the China Research Center for Science and Technology for Development of the State Science and Technology Commission constructed the evaluation index system of sustainable development of the Comprehensive Experimental Area for Social Development in the Report on Theory and Practice of the Comprehensive Experimental Area for Social Development (Tan et al., 2021; Tang et al., 2021). The system consists of the target layer, criterion layer and index layer. The target layer is the strategic target of sustainable development. The criterion layer consists of the "premise of sustainable development", "driving force of sustainable development", "means of sustainable development", "sustainable development goals", and "government's guarantee and support for sustainable development", and the indicator layer consists of 42 fundamental indicators (Fu et al., 2021; Y. Li & H. Ye et al., 2021). The index system has a good hierarchy and structure, and the construction ideas and methods of the target layer, criterion layer, and index layer enrich and expand the construction mode of the index system.

Sustainable Development Index System of the Sustainable Development Strategy Research Group of the Chinese Academy of Sciences. Since 1999, the Sustainable Development Strategy Research Group of the Chinese Academy of Sciences, headed by Niu Wenyuan, has published its annual report, China's Sustainable Development Strategy Report. According to the principle of systems engineering, the research group proposed a sustainable development index system based on the concept of "five-level superposition, layer-by-layer convergence, standardised weight, unified ranking". The index system is divided into five structural levels, including the overall level, system level, state level, variable level, and factor level, which is composed of 208 basic indicators(Chen et al., 2022; Fang, Shi, & Gao, 2021). In the system layer, the overall system of sustainable development is divided into five subsystems: the survival support subsystem, development support subsystem, environment support subsystem, social support subsystem, and intelligence support subsystem. The index system strives to make the internal logical level clear and reasonable. Authoritative universality is strong and can carry out international comparative research on a unified scale; the hierarchy has a rigid structure, different levels of time and space, and three-dimensional sorting. Adopting five levels of superimposed hierarchical indicators, layer-by-layer convergence, and standardising the weight coefficient, it is possible to achieve the role and effect of simplification and refinement of indicators for China's provinces; urban sustainable development status can be comprehensively assessed, highlighting the approach’s essential theoretical significance and practical value. However, given a large number of indicators, the selection of indicators is significantly influenced by human subjective factors, and there is a close correlation between individual indicators. The calculation of some indicators is repeated, which affects the objectivity, accuracy and applicability of the analysis and evaluation results.

Sustainable development indicator system proposed by other scholars. Mao Hanying, a researcher from The Chinese Academy of Sciences and the Institute of Geography, State Planning Commission, created the framework of the sustainable development index system in Shandong Province in a preliminary Study on Sustainable Development Index System in Shandong Province (Mao, 1996; Mao & Yu, 2001). The main ideas based on the index system include highlighting the sustainable and rapid development of the economy, ensuring the coordinated and healthy development of the social system, attaching great importance to the rational development and utilisation of natural resources and the protection and management of the ecological environment, and strengthening the capacity building of sustainable development. The index system he established includes four subsystems: the economic growth subsystem, social subsystem, resource environment subsystem, and sustainable development ability subsystem, with one subject layer and 90 essential index factors. Among them, the subsystem of economic growth consists of the total index, intensification index and benefits index. The sub-system of social progress consists of four thematic indexes: population index, quality of life index, social stability index, and social security index. The resource and environment-supporting subsystem comprise the resource index, environmental governance index, environmental pollution index, and ecological index. The subsystem of sustainable development ability is composed of economic power, intellectual ability, resource and environment ability, and decision-making and management ability.

Individual scholars also investigated problems of sustainability assessment and proposed their own index systems. Guo Huaicheng et al., according to the nature of environmental bearing capacity, the structure and function of the external environment system and performance, think the ecological bearing capacity index system should reflect the substance of the environment, social, and economic systems, and energy and information exchange. The proposed indicators are divided into natural resources supply, support of social conditions, and pollution capacity indexes from three categories (Guo & Tang, 1995). Based on an in-depth analysis of the urban environment, health, sustainable development, and their relationship. Wu Lindi et al. and Yang Xianzhi et al. summarised the indicators for evaluating sustainable urban development into the economic index, social index, and environmental index, and finally integrated into the comprehensive index of "coordination degree" (Wu & Fang, 1995; Yang & wu, 1985). By comparing Shanghai with other big cities in the world, they concluded that Shanghai was in an uncoordinated development state at that time, so the government needs to achieve a more balanced development by 2025. Cao Lijun selected the constituent elements of the regional composite system, such as society, economy, science and technology, population, resources, environment, and government behaviour to describe regional development and select the primary and comprehensive indicators to define sustainable development (Cao, 2008; Wang, 1998). Finally, they proposed a system of 22 indexes in general to illustrate the level of development, 23 indicators to demonstrate the development efficiency, 15 indexes to illustrate potential, four indicators to calculate the development of coordination degree, seven indicators to illustrate the development of openness, 13 indicators to show the development regulation, and two indicators to calculate the equilibrium degree of development.

By systematically sorting out relevant literature in China, we can find that the existing research work on sustainable development index systems in China reflects a good level of administrative divisions and industry divisions; these index systems are based on different modes of creation, absorb the strategic idea of sustainable development, and show good systematicness and hierarchy. It has laid a good foundation for researching and comparative analysis of China's sustainable development index system.

At the same time, the existing sustainable development index system also has many problems. The index system is complex, and the number of indicators is too large, which makes it difficult to operate. In addition, there are also some problems in the collection and selection of indicators: indicators cannot be selected according to the trend of the times of urban development, indicators of scientific and technological innovation are involved only by a few scholars, there is a limited ability to build a comprehensive index system. Some indicators inevitably fall into the indicator trap and fail to select representative indicators.

2.2 Constructing the index system to assess regional territorial communities' sustainable development

The first task is to establish an index system to evaluate the sustainable development of different regions scientifically and effectively. Because it is the scientific and objective foundation to ensure the follow-up work, the goal of the evaluation index system constructed in this study is to describe and evaluate the environmental sustainability, economic sustainability, social sustainability, and scientific and technological sustainability of each region, which is fundamentally essential to evaluate the ability and efficiency of communities' sustainable development. Therefore, the primary task is to seek significant and relevant indicators. At the same time, it should start from the system structure of communities' sustainable development and follow the scientificity principles: objectivity, completeness, sensitivity, reliability, dynamics, and coordination (Fig. 2.4).

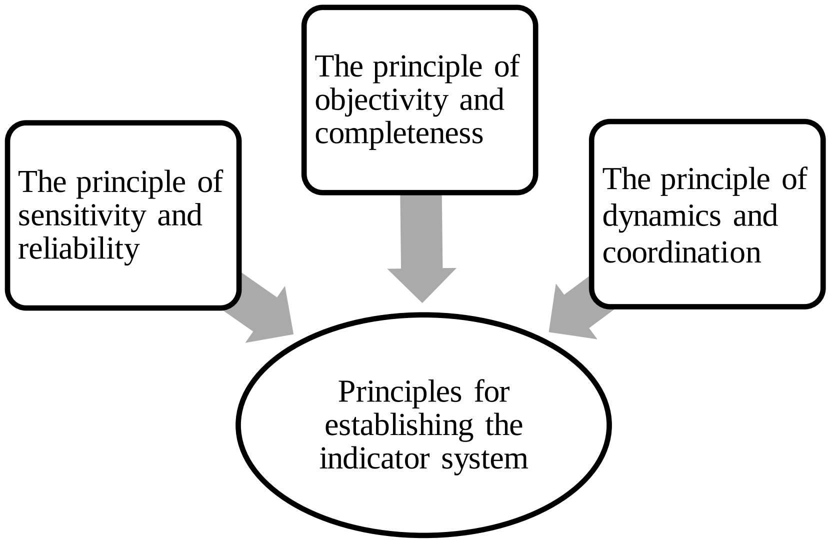


Figure 2.4 – Principles for setting evaluation index system of communities' sustainable development

Source: author's development

The principle of objectivity and completeness. As mentioned above, we use a complex giant system with multi-layer and dynamic characteristics to describe the problem of sustainable urban development. To evaluate each region's effect and ability of sustainable development, the selected evaluation index needs to be complete; that is, it can describe the development state of each region comprehensively and objectively from macro to micro levels covering all the main aspects of sustainable development. However, the number and categories of the indicator system often need to be more manageable, which increases the difficulty of data statistics and aggravates the problem of repeated calculation, resulting in a high correlation between indicators. In addition, the types of statistical indicators have changed in time. For example, this year's new statistical indicators may not have been counted in previous years. All these increase the difficulty and accuracy of data acquisition and ultimately affect the evaluation level of sustainable urban development. Therefore, this study believes that the simplicity of indicators should not be relaxed based on the pursuit of completeness so that comprehensive and accurate indicators can be selected under relatively complete data.

The principle of sensitivity and reliability. The selection of the evaluation index must keep high relevance with sustainable urban development, and the fluctuation of index value should reflect the status and changes of sustainable urban development. Some indicators may be critical when they are used to evaluate the economic development of a single region. However, they are not sensitive to measuring the sustainability of urban economic development, so they should not be included in the evaluation index system of sustainable urban development. At the same time, a high degree of index sensitivity should also be matched with the authenticity and reliability of the index data. The data source must ensure authenticity, effectiveness, and high credibility. The indicators selected in this study are from a series of statistical yearbooks related to environment, energy and high-tech industries represented by the China Statistical Yearbook in different years.

The principle of dynamics and coordination. To scientifically evaluate the sustainable development of provinces in China, this study selected a specific time interval of panel data to consider each region's sustainable development capacity and efficiency accurately. The evaluation based on a single index of a particular year cannot reflect the actual situation of sustainable development comprehensively because sustainable development, as its name implies, is a dynamic process in which the environment, economy, society, and science and technology in a certain period in the region continue to change in the interaction. Therefore, regions are in different stages of sustainable development in different periods, and their development capabilities, effects, and even phased goals differ. This requires us to select the evaluation index with a certain degree of flexibility, to reflect the characteristics of these regions in different stages of development, and to describe the region's sustainable development capacity and efficiency in different stages. In addition, because sustainable urban development is a complex giant system, there are links and mutual influences between each subsystem. Therefore, this study, from the coordination characteristics, focuses on the main points of index selection to ensure that the selection of urban sustainable development evaluation index should pay attention to the coordination between the system to ensure that the development of the economy, society, and science and technology and the carrying capacity of the ecological environment is coordinated and adapted.

The index system of urban sustainable development evaluation is composed of a single evaluation index that will significantly impact the whole evaluation work. To ensure the scientificity and objectivity of the evaluation results, the following principles must be followed when selecting and setting individual evaluation indicators (Fig. 2.5).

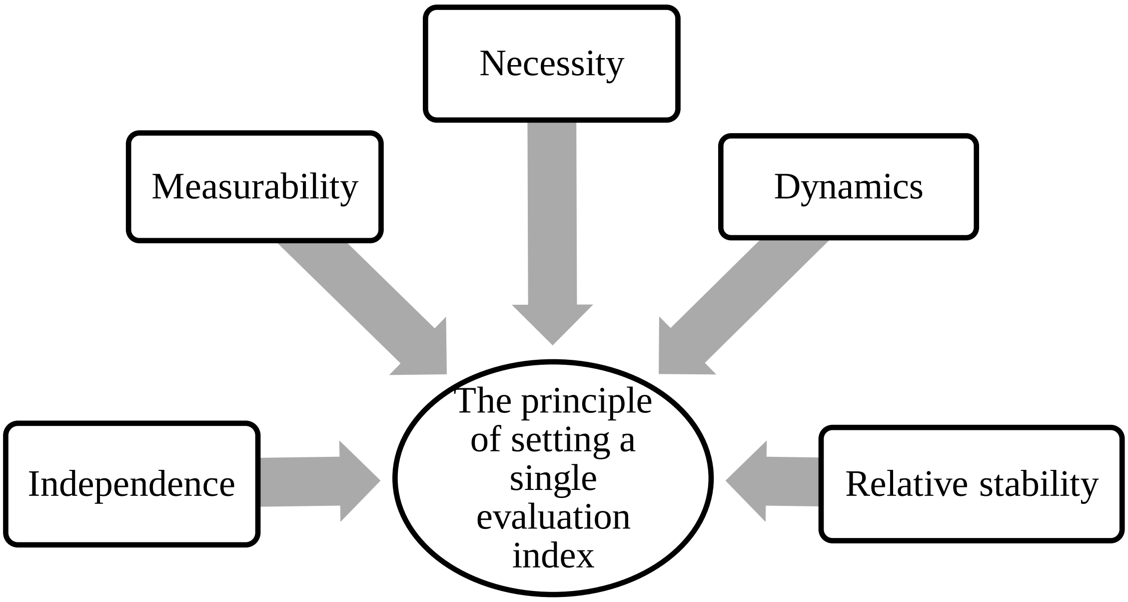


Figure 2.5 – Principles for setting a single evaluation index of regional communities' sustainable development

Source: author's development

Independence means the indexes in the index system should be independent, and the evaluated contents should not cross or overlap. Measurability is that the indexes in the index system should be able to measure and evaluate the level of sustainable urban development. The indexes should be easy to quantify, and the units should be precise. The data should be accessible and easy to collect. Necessity – the indexes in the index system must be helpful in the evaluation process and purpose, impact the evaluation result, and cannot be blindly selected. Dynamics means the indexes in the index system should not only reflect the changes of time and space and system structure sensitively but also adjust according to the changes in socially sustainable development and the changes of social emphasis on efforts. Relative stability is that the indexes in the index system should be able to keep relatively stable in a specific range of time and space and reflect the overall situation because of avoiding short-term problems. In the long run, the index can be adjusted with the change of time and space and the development of society.

This study combines qualitative and quantitative methods: extensive use of literature research, frequency statistics and theoretical analysis to screen indicators. The frequency statistics method is mainly to conduct frequency statistics on the literature related to the evaluation of urban sustainable development level, screen out the frequently used indicators, and establish a preliminary indicator system. The theoretical analysis method mainly analyses the structure, function, characteristics, and elements of the evaluation index system of urban sustainable development level, and modifies, supplements, or deletes the preliminary index system. The steps of constructing the evaluation index system are shown in Fig. 2.6.

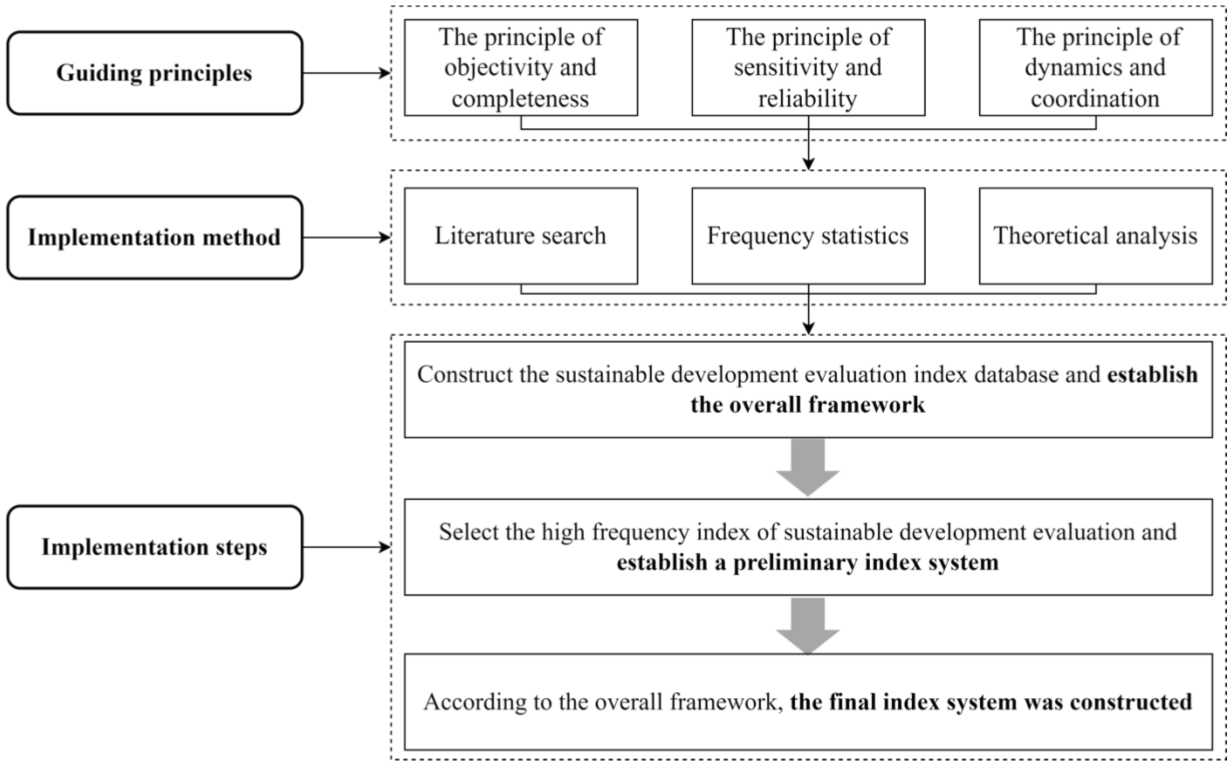


Figure 2.6 –The design approach of the evaluation index system construction

Source: authors' development

The literature research method was adopted, and the literature related to the evaluation of sustainable urban development was searched and analysed using the database. Search for keywords such as "Sustainability", "Assessment of Sustainability", and "Urban Sustainability Development Efficiency" in Google Scholar, Web of Science, Science Direct, Elsevier, CNKI (China National Knowledge Infrastructure) and other databases. A total of 128 papers, including 83 journal papers and 45 doctoral and master's theses, were selected to meet the requirements of relevance, frontier, timeliness, and authority. After reading and analysing the literature, the literature that only made a qualitative analysis of sustainable urban development but did not establish an indicator system was removed. A total of 27 valuable references were screened to build a candidate indicator database. The index system's principal elements and frequency of occurrence in the literature are counted from the ecological environment, economic development, social well-being, and scientific and technological innovation. The specific information is shown in Table 2.1.

According to the specific principles of index selection, the indicators with the highest and lowest frequency are sorted and classified. From the systematic perspective, combined with the scientific connotation of sustainable urban development, this study classifies the population dimension as the social dimension, the industry dimension as the economic dimension, the resource and ecology dimension as the environmental protection dimension, and culture and education dimension as scientific and technological innovation dimension. Since then, the indicators of sustainable urban development have been preliminarily screened.

The theoretical analysis method mainly carries on the thorough analysis of the urban sustainable development connotation and the integral part. This allows us to understand each primary essential factor, its' causes of the existence and make the final choice (Yan et al., 2018; Yang et al., 2017). From the system theory perspective, sustainable urban development is a scientific system that reflects the overall development of urban society. It is not only related to the development of each subsystem of environment, economy, society, and science and technology but also to the relationship and interaction between each subsystem (Bukovszki et al., 2019; Demaziere, 2020). Urban sustainable development is a complex and systematic problem. By using the method of systematology, the interaction between subsystems can be expressed by feedback loops; that is, interwoven feedback loops can express the whole complex system. Therefore, this study first discusses the system structure of sustainable urban development and the division mechanism of a four-dimensional complex system from the system theory perspective and then establishes a scientific evaluation index system of sustainable urban development.

Table 2.1 – Main elements and occurrence frequency of urban sustainable development evaluation subsystem

System element	Subsystem element	Frequency	Subsystem element	Frequency
Environmental subsystem	Resource reserve	37	Environmental quality	75
	Biodiversity	12	Environmental protection initiatives	82
	Resource utilization	88	Land efficiency	61
	Resource consumption	19	Pollutant discharge	89
Economic subsystem	Economic level	101	Economic sustainability	55
	Economic development	98	Economic structure	41
	Green economy	41	Ecological economy	33
	Low carbon economy	36	Economic biorientation	9
	Resource consumption	19	Pollutant discharge	89
Social subsystem	Social development	92	Environmental policy	43
	Social environment	25	Public health	71
	Population	90	Social welfare	77
	Social responsibility and security	12	Fiscal revenue and expenditure	93
Science and technology subsystem	Cultural education	56	Innovative ability	82
	Scientific and technological innovation achievements	69	New energy utilization	77
	Input in scientific and technological innovation	89	New energy development	65
	Science and technology progress	24	High-tech industry	55

Source: prepared by the author

The system is a complete whole composed of many interrelated and interdependent elements (Tonne et al., 2021). According to the complex system theory, the object of this study is treated as a complex system problem. Then it meets the three necessary conditions that the system should have: first, it is composed of the main elements such as environment, economy, society, and science and technology. Secondly, the elements are interrelated and interact with each other, and there are cross-vertical and horizontal structures and orders among them. Third, this complex system has specific functions and roles. The function of sustainable urban development depends on the elements of the environment, economy, society, science and technology, and their reciprocal links and structures. So, suppose there is the need to evaluate the urban sustainable development ability. In that case, one should use the thought of the system, identify the components of sustainable urban development and its specific content and function, and use the scientific method of concise evaluation.

According to the systematic framework of sustainable urban development analysed in this study (*see Section 1*), the theoretical framework diagram for establishing the evaluation index system of sustainable urban development can be obtained, as shown in Fig. 2.7.

There are four core carriers of sustainable urban development: policy, talent, capital, science and technology. From the point of view of each subsystem of sustainable urban development, to realise the sustainable economic development of the economic subsystem, the most direct and vital way is through capital investment. To realise the sustainable innovation of the science and technology subsystem, the most intuitive and core is to rely on science and technology development. To realise the sustainability of the environmental subsystem, the most critical and universal way is to rely on the guidance and norms of relevant policies. The most effective and scientific way to achieve sustainable social well-being is through talents' wisdom, ability, and relationships. Because society is a group of people, people are the main body of scientific and technological development; science and technology is the carrier to promote social progress and economic development, and policy is the bridge to achieve the goal of sustainable development of the economy, society, environment, science, and technology, so policy, talent, capital and science and technology are interrelated with the four subsystems of sustainable urban development and cannot be separated.

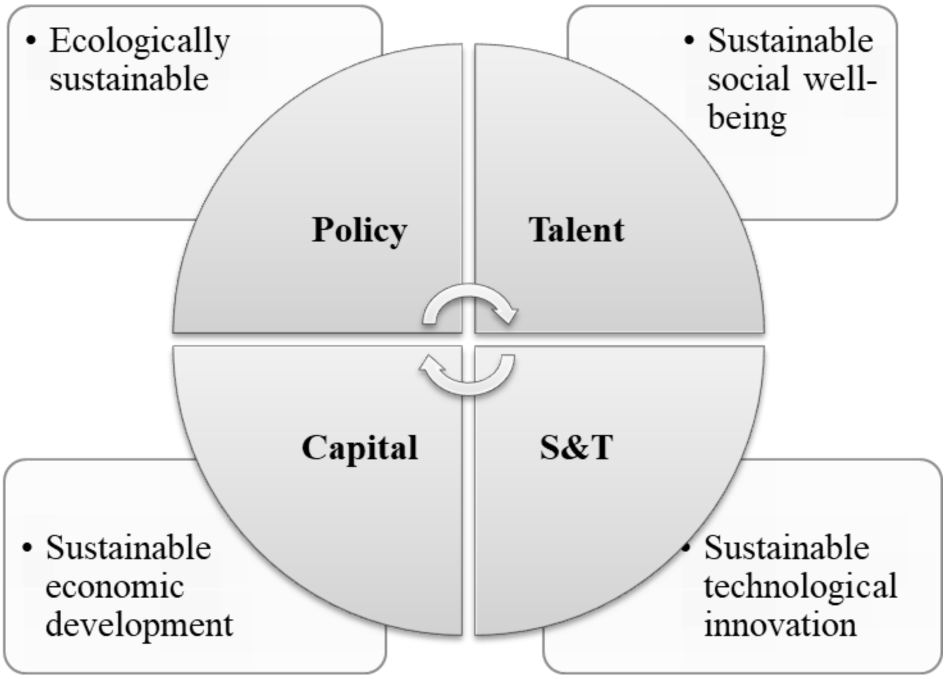


Figure 2.7 – The theoretical framework of "four-dimensional interactive structure" for sustainable urban development

Source: author's development

Furthermore, looking at the intuitive performance of the four subsystems to achieve sustainable development, one should point the following: the performance of a sustainable ecological environment is the effective implementation of laws and regulations on energy conservation and environmental protection. When society changes from labour-intensive to knowledge-intensive and talent-intensive, it meets the requirements of social well-being and sustainable development. Sustainable economic development is mainly manifested in the advocacy of a low-carbon economy, green industry, green enterprises, and other economic entities occupying a dominant position, and so on. The intuitive manifestation of sustainable development of science and technology is the organic combination of the Internet and renewable energy when the research and development of energy-saving and environmental protection science and technology have made adequate progress. The four subsystems' sustainable development goals and performances are different, but they can effectively connect and interact with each other. For example, the sustainable macroscopic performance of science and technology and social subsystems is establishing and developing science and technology think tanks. The sustainability of the environment and society can be achieved by building a "two-oriented society": a resource-saving society and an environment-friendly society. The sustainability of the economy and environment can be realised by entering the post-carbon era of new energy. The sustainability of technology and economy needs to be implemented by adhering to the essence of the fifth industrial revolution.

Sustainable urban development is a hot research topic currently. Many scholars study and classify the elements of sustainable urban development. The mainstream classification of elements includes economy, society, science and technology, population, resources, environment, energy, ecology, and so on (An et al., 2021; Bauer et al., 2021). However, there are many overlapping elements, so many research institutions, experts, and scholars hope to condense the general model of the elements of sustainable urban development. However, due to the differences in specific issues, research directions, and emphases, there are differences in the elements and structures of sustainable urban development vision. From the systematic perspective of urban development, this study divides sustainable urban development into four dimensions: environment, economy, society, science and technology.

The environmental subsystem is the essence of sustainable development. Development without environmental protection, pollution control, new energy development, and rational resource utilisation can never be called "sustainable development". Therefore, there is no doubt that the environmental subsystem is a component of sustainable urban development. It is worth noting that because notions such as energy, ecology, and resources are closely related to the environment, problems such as repeated descriptions often arise in selecting indicators. The environmental subsystem can be represented to avoid overlapping the underlying indicators with similar properties so as not to affect the scientificity of the research results.

According to the above considerations, the proposed indicators of the urban sustainable development environment subsystem are land construction utilisation rate, green coverage in built-up areas, sulphur dioxide emissions, the ratio of wastewater centralised treated, and the harmless treatment rate of domestic waste (Table 2.2).

Table 2.2 – Indices of environmental subsystem

No.	Indicator title	Specific meaning
1	Land construction utilization rate	Reflect the status of urban land use
2	Green coverage in built-up areas	Reflect the achievements of ecological construction
3	Total sulphur dioxide emission	Reflect the degree of environmental pollution.
4	Ratio of wastewater centralized treated	Reflect the current situation of urban green production
5	Harmless treatment rate of domestic waste	Reflect the ability of environmental pollution control

Source: author's development

The economic subsystem is the foundation of sustainable urban development. Economic development today has not only meant the expansion of the national economy – it is a measure of urban living standards and development ability, an essential element of social structure. Meeting human material life and spiritual and cultural life needs a foundation – economy, which is also the core of the state, and the collective and individual pursuit (Blanco, 2021; Da Silva Neiva et al., 2021). Regarding sustainable urban development, economic factors are the basis of realising social welfare, scientific and technological innovation, and resource and environment protection. According to the above analysis, the indicators proposed for the economic subsystem of sustainable urban development include per capita gross product, total retail sales of consumer goods, water consumption per ten thousand yuan of GDP, power consumption per ten thousand yuan of GDP, and proportion of tertiary industry (Table 2.3).

The social subsystem is the root of sustainable urban development because the people constitute the entity of urban development and are the mainstay of promoting its sustainability (Laituri et al., 2021; Schraven et al., 2021).

Table 2.3 – Indices of economic subsystem

No.	Indicator title	Specific meaning
1	Per capita gross regional product	Reflects the economic scale and measures the economic development
2	Total retail sales of consumer goods	Reflect people’s consumption level and purchasing power of social commodities
3	Water consumption per ten thousand yuan of GDP	Reflect the degree of environmental pollution
4	Power consumption per ten thousand yuan of GDP	Reflect the degree of environmental pollution
5	Proportion of tertiary industry	Reflect the industrial structure of the city and inspect the comprehensive strength of the city

Source: author’s development

A region without people cannot achieve development goals, and the region's composition, development, and management are inseparable from people. At the same time, social well-being is the fundamental criterion to measure sustainable development, and the quality of life, social welfare, health care, and happiness index in a region are some of the most fundamental criteria to measure the level and prospects of region’s sustainability. Therefore, the indicators selected for the social subsystem of sustainable urban development in China include the number of healthcare spaces (beds) per 10,000 people, barrier-free facilities coverage ratio, per capita residential building area, the coverage rate of green space in the park within 500m, and urban registered unemployment rate (Table 2.4).

Table 2.4 – Indices of social subsystem

No.	Indicator title	Specific meaning
1	Number of healthcare beds per 10,000 people	Reflect the status of basic public services
2	Barrier-free facilities coverage ratio	Reflect the status of basic public services
3	Per capita residential building area	Reflect the quality of life of residents
4	The coverage rate of green space in the park within 500m	Reflect the quality of life of residents
5	Urban registered unemployment rate	Reflect the basic level of urban social development

Source: author’s development

The science and technology subsystem is the driving force of sustainable urban development. The relatively definite structure of the sustainable development system – environment-economy-society – is not sufficient because of the rapid development of science and technology in this era, which is expected to transform every building into a "house and micro-power plant" (Kopp et al., 2021; Kramarz & Przybylska, 2021). In the future, hundreds of millions of people may produce green energy in their homes, offices, and factories and on the "energy Internet" to exchange needs with everyone; the energy democratisation created by scientific and technological innovation will fundamentally reshape the whole society. Therefore, the power of scientific and technological innovation has penetrated all aspects of the system: not only the environment protection, pollution control, and development of new energy need the support of scientific and technological innovation, but also the development of the economy cannot be separated from innovation. Every time the economic crisis is broken, it is based on a new technological revolution. The arrival of every industrial revolution means the opening of a new era. Whether it is the first industrial revolution driven by steam power technology, the second industrial revolution led by telecommunication technology and fuel internal combustion engine, or the third industrial revolution combined with Internet information technology and renewable energy, the infinite thrust of scientific and technological innovation is more and more affecting the development direction and pace of the whole society. Therefore, as an essential driving force, science and technology should be studied as a subsystem of sustainable urban development (Table 2.5).

Table 2.5 – Indices of science and technology subsystem

No.	Indicator title	Specific meaning
1	The R&D expenditure of industrial enterprises	Reflect the importance of enterprises for innovation and investment level
2	The turnover of technology market	Reflect the status of science and technology, innovation driving force
3	The financial expenditure of science and technology	Reflect fund investment to promote the advancement of science, technology, and education
4	The amount of domestic patent application authorization	Reflect the achievements of a region in scientific and technological innovation
5	The full-time equivalent of R&D personnel of industrial enterprises	Reflect the number of personnel invested in research and innovation by enterprises

Source: author's development

The scientific and technological innovation capability of this region can be evaluated from four indexes: the R&D expenditure of industrial enterprises, the turnover of the technology market, the financial expenditure of science and technology, the amount of domestic patent application authorisation, and the full-time equivalent of R&D personnel of industrial enterprises.

Based on the internal coupling idea of the "environment-economy-society-science and technology" system, this study uses the organic combination of quantitative and qualitative research methods to decompose the urban sustainable development evaluation index system into three levels of four subsystems, including the target layer, criterion layer, and index layer. As shown in Table 2.6.

Table 2.6 – Indicator system for urban sustainable development

Criterion layer	Index layer	Index unit	Indicator attribute
Ecological environment (A)	Land construction utilization rate (A1)	%	Positive
	Green coverage in built-up areas (A2)	%	Positive
	Total sulphur dioxide emission (A3)	Ten thsd. tons	Negative
	Ratio of wastewater centralized treated (A4)	%	Positive
	Harmless treatment rate of domestic waste (A5)	%	Positive
Economic Development (B)	Per capita gross regional product (B1)	Yuan	Positive
	Total retail sales of consumer goods (B2)	Billion yuan	Positive
	Water consumption per ten thsd. yuan of GDP (B3)	Cubic meter million	Negative
	Power consumption per ten thsd. yuan of GDP (B4)	KWh/ billion yuan	Negative
	Proportion of tertiary industry (B5)	%	Positive
Social well-being (C)	Number of beds per 10,000 people (C1)	Person	Positive
	Barrier-free facilities coverage ratio (C2)	%	Positive
	Per capita residential building area (C3)	Square meter	Positive
	The coverage rate of green space in the park within 500m (C4)	%	Positive
	Urban registered unemployment rate (C5)	%	Negative
Science and Technology Innovation (D)	The R&D expenditure of industrial enterprises (D1)	Ten Thousand Yuan	Positive
	The turnover of technology market (D2)	Billion yuan	Positive
	The financial expenditure of science and technology (D3)	Billion yuan	Positive
	The amount of domestic patent application authorization (D4)	Term	Positive
	The full-time equivalent of R&D personnel of industrial enterprises (D5)	Person/year	Positive

Source: author's development

Target layer index. The target layer is the level of sustainable urban development, which represents the core of the design of the evaluation index system. It is characterised by the sustainable development ability and efficiency of the urban environment, economy, society, science and technology.

Criterion level index (first-level indicators). The four subsystems, environment, economy, society, and science and technology can reflect the changes in urban sustainable development level. Therefore, this study selected four subsystems as the criterion layer of the index system: sustainable ecological environment, sustainable economic development, sustainable social welfare, and sustainable scientific and technological innovation.

Index layer (secondary indicators). The index layer is composed of indexes that can be measured directly, and it is the most basic layer in the comprehensive index system. According to the characteristics and significance of each part of the index criterion layer, combined with the principles of scientificity, completeness, sensitivity, reliability, dynamics, and coordination of index selection, this study established the index set corresponding to the criterion layer represented by 20 characterisation indexes: five indicators for each subsystem analysed.

2.3 Evaluation model of regional territorial communities' sustainability

Urban sustainable development involves the subsystems of environment, economy, society, science and technology and has the characteristics of multi-objective, multi-level and complexity (Cong et al., 2021; J. Han et al., 2021). This type of systematic evaluation is usually solved by a comprehensive evaluation method. First, the weight of indicators is determined to measure the impact of each indicator on the evaluation target. Then the appropriate evaluation model is selected according to the object assessed. Therefore, the construction of a sustainable urban development evaluation model includes the determination of index weight and measuring approach.

Determination of index weight. The urban sustainable development level is a comprehensive estimate, and the assessment of each index contribution needs weighting procedure application (Fang, Shi, & Phillips et al., 2021, 2021). The index weight is directly related to the authenticity and reliability of the evaluation results. There are two kinds of methods to determine the weight, namely, the weighting method based on the "function-driven" principle and the weighting method based on the "difference-driven" principle (Wang & J. Song et al., 2021). The weighting method based on the "function-driven" principle determines the weight of the evaluation index according to its relative importance to the criterion layer. Mainly according to the index in the whole urban development system to affect the system of the positive cycle of the result, mechanism, and the size of the cause, usually through the subjective approach, such as the Analytic Hierarchy Process (AHP), Delphi method and so on. The weighting method based on the principle of "difference-driven" determines the weight of an indicator according to its variation degree in the overall index and its influence on other indicators. The original data of weighting comes from objective data, and the weight of an indicator can be determined according to the amount of information provided by each indicator (Pavolová et al., 2021; Shi, 2021). In the comprehensive evaluation, the weight of the index system determined by the objective weighting method genuinely reflects the implied information in the original data, effectively avoiding the deviation caused by human factors. Thus, the index weight value obtained has higher credibility and accuracy than the subjective weighting method.

There are several commonly used objective weighting methods. Factor analysis can synthesise the complex index system into several new indexes. Still, it is also faced with the risk that the cumulative contribution rate of extracted principal components cannot reach the ideal level and explain the factual background and significance. The neural network algorithm uses the gradient descent algorithm to solve the index weight value by iterative operation, which is equivalent to a learning and memory problem; that is, the critical difference of each index to achieve the goal is obtained by learning the known samples, but the use of this method must be based on the existing training samples. The entropy value method, according to the size of the information provided by each index observation to determine the index weight, can be used to evaluate the inherent information of each scheme in the degree of contribution to the goal of each index; the evaluation index based on scientific and reasonable evaluation objects can be relatively accurate judged. Therefore, this study selects the entropy value method to determine index weight.

Overview of entropy weight method. Entropy used to be a thermodynamic concept: it was introduced into information theory in 1948 as the concept of information entropy used to measure the level of system chaos or disorder (Huang & Han, 2021; D. Li & J. Chen et al., 2021). The greater entropy weight indicates a greater variation extent of the relevant index, which enables much more information and has a more significant effect. So, the weight value of the corresponding index should also be more significant. In contrast, the index weight value should be smaller for the smaller entropy weight, which has little effect. This weighting entropy method effectively avoids the interference of human factors, better reflects the objectivity and authenticity of the evaluation index and has been widely used in the social and economic fields. After the weight of each index is determined, it is necessary to select an appropriate evaluation model to synthesise the index information. This study uses the TOPSIS method to construct a comprehensive evaluation function.

TOPSIS Fundamentals. TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) model is a commonly used multi-attribute decision problem model. It was first proposed in 1981. In essence, it is a method to evaluate the relative merits and demerits of existing objects, which is also known as the superiority and demerits solution distance method, and its results can accurately reflect the gap between evaluation objects (Pera, 2020; Song et al., 2020). The TOPSIS model is widely used in the performance evaluation process of economic, social, environmental, and other research fields. The evaluation object has no time and space, and there is no strict limit on the sample size. It is easy to calculate, and the most important thing is to use the original data's information fully. The main idea of this method is to determine the positive and negative ideal solutions of each evaluation object by constructing a weighted standardised matrix, in which the positive ideal solution is the best value of the evaluation index, and the negative ideal solution is the worst value of the evaluation index (Cheshmehzangi et al., 2020; Guo et al., 2020). The positive ideal solutions of all evaluation indexes form the best scheme, while the harmful ideal solutions form the worst scheme. Then the weighted Euclidean distance between each evaluation scheme and the best and worst scheme is calculated, and finally, the schemes are evaluated by comparing their proximity.

To sum up, this study selects the entropy weight method to calculate the index weight, uses the TOPSIS model to calculate the comprehensive evaluation index, and builds the TOPSIS comprehensive evaluation model based on the entropy weight method. The specific calculation steps of the entropy-TOPSIS model are shown in Fig. 2.8.

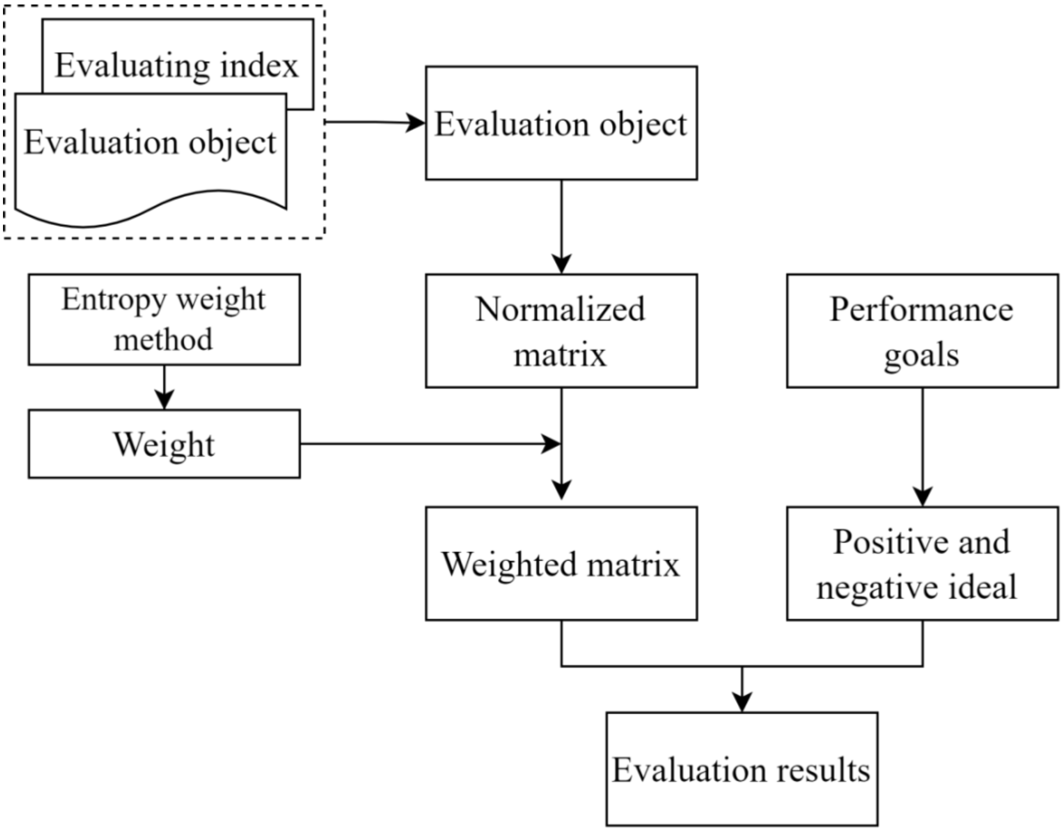


Figure 2.8 – Entropy-TOPSIS model evaluation scheme

Source: author's development

Construction of the original data matrix. To evaluate the sustainable development of m cities via n indicators, the initial X matrix of $m \times n$ is composed of the original data characterising cities' parameters (Eq. 1):

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ \cdots & \cdots & \cdots & .. \\ \cdots & \cdots & \cdots & .. \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}, \qquad (2.1)$$

Where m – is the number of objects to be evaluated;

n – is the number of assessment criteria;

x_{ij} – is the element of matrix X, the value of the j ($j = 1, 2, \ldots, n$) indicator of the i $(i = 1, 2, \ldots, m)$ object.

There are two types of indexes in the evaluation index system of urban sustainable development level. The first is the beneficial index, including per capita gross urban product, energy conservation and environmental protection expenditure, urban green area, and other positive indicators. The larger the value of these indicators is in a particular range, the better the urban development is at this level. Another type of indicator is the cost indicator, namely the negative indicator. The little such indicator is within a specific range, the less impact it will have on sustainable urban development (for example, the total sulphur dioxide emission, power consumption per ten thousand yuan of GDP, and water consumption per ten thousand yuan of GDP, etc.). On the other hand, different indicators represent different physical meanings, that is, non-dimensionality, which leads to the inability to evaluate things directly. To eliminate the incomparability caused by different dimensions and the positive and negative directions of the index, the index value needs to be dimensionless first by the data normalisation procedure.

Data normalisation. This study follows the normalisation procedures to make the original data of different dimensions and data sources comparable. Evaluation results are classified according to the index content: if a higher index value causes higher evaluation results, the impact will be judged positive (and negative – otherwise). For the positive effects of indicator x_{ij}, the normalised value S_{ij} can be calculated as follows:

$$S_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}, \quad (2.2)$$

For the negative impact of x_{ij}, the normalised value S_{ij} is calculated in the following way:

$$S_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}, \quad (2.3)$$

Where S_{ij} – is the normalised value;

$maxx_{ij}$ – is the maximum value of the j^{th} indicator of the i^{th} object;

$minx_{ij}$ – is the minimum value of the j^{th} indicator of the i^{th} object.

Using the entropy method to quantify indicators' weights presupposes calculating the standardised value p_{ij} of indicator j for object i following the Eq. 2.4, and an entropy value of the indicator – e_j (Eq. 2.5) is used then to assess an information utility d_j value of the indicator (Eq. 2.6). Finally, the weighting value – w_j – of the j indicator is quantified in line with Eq. 2.7:

$$P_{ij} = \frac{S_{ij}}{\sum_{i=1}^{m} S_{ij}}, \quad (2.4)$$

$$e_j = -\frac{1}{Inm} \sum_{i=1}^{m} p_{ij} Inp_{ij}, \quad (2.5)$$

$$d_j = 1 - e_j, \quad (2.6)$$

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, \quad (2.7)$$

Where P_{ij} – is the standardised value of indicator j for object i;

e_j - the entropy value for *j* indicator;

d_j - the information utility value of indicator *j*;

w_j - the weighting value for *j* indicator.

Use of TOPSIS model to quantify objects' performance. The first step is to compose the weighted assessment matrix (Eq. 2.8). The matrix elements are then classified as the best A^+ and the worst A^- solutions (Eq. 2.9, Eq. 2.10).

$$a_{ij} = w_j p_{ij} (i = 1,2, \dots, m; j = 1,2, \dots, n), \quad (2.8)$$

$$A^+ \{\max A_{ij} | i = 1,2, \dots, m\} = \{A_1^+ A_2^+, \dots, A_n^+\}, \quad (2.9)$$

$$A^- \{\max A_{ij} | i = 1,2, \dots, m\} = \{A_1^- A_2^-, \dots, A_n^-\}, \quad (2.10)$$

Where a_{ij} – is the weighted standardised matrix element;

A^+ – is the positive ideal solution;

A^- – is the negative ideal solution.

The next step is to calculate the Euclidean distance $D_i^{+/-}$ between the evaluation value and the best solution A_j^+ (Eq. 2.11), the evaluation value and the worst solution A_j^- (Eq. 2.12):

$$D_i^+ \sqrt{\sum_{j=1}^{n} (A_j^+ - A_{ij})^2 (i = 1,2, \dots, m)}, \quad (2.11)$$

$$D_i^- \sqrt{\sum_{j=1}^{n} (A_j^- - A_{ij})^2 (i = 1,2, \dots, m)}, \quad (2.12)$$

The relative proximity C_i of the object *i* allows to quantify the distance between the evaluation value and two ideal solutions:

$$C_i = \frac{D_i^-}{D_i^+ - D_i^-} (i = 1,2, \dots, m), \qquad (2.13)$$

Where D_i^+ – is the Euclidean distance between the evaluation value and the best solution;

D_i^- – is the Euclidean distance between the evaluation value and the worst solution;

C_i – is the relative closeness of the object *i*.

Finally, schemes are sorted according to the relative proximity: the larger the relative proximity is, the better the system is. According to the calculated closeness degree C_i value, the region's sustainable development level can be evaluated. The range of the C_i value is [0, 1]. The closer the C_i value is to 1, the closer the object in the *i*th year is to the optimal level. On the contrary, the closer C_i is to 0, the object in the *i*th year is to the worst level. Referring to the current research results (Chaguetmi & Derradji, 2020; Maranghi et al., 2020; Vafai et al., 2020), this study delimits the corresponding level grade standard for the large and small interval range of C_i value (Table 2.7).

Table 2.7 – Criteria for judging the level of urban sustainable development

Relative progress	Performance Level
0-0.05	Poor
＞0.05-0.10	Intermediate
＞0.10-0.30	Good
＞0.30-1.00	High Quality

Source: prepared by the author based on (Chaguetmi & Derradji, 2020; Maranghi et al., 2020; Vafai et al.)

Finally, this study applies a combination of entropy-weight and TOPSIS to quantify factors affecting the Chinese regions' sustainable development. The entropy weight method is used first to determine the weights of each indicator. Then the impact of each factor on regional sustainable development and the region's sustainability performance is evaluated through the TOPSIS approach.

Conclusions to section 2:

1. The level of urbanisation in China has increased significantly over the past two decades. Under such conditions, the sustainable development of regional territorial communities becomes a new dilemma for China's growth. Rapid urbanisation processes have a considerable impact on the social and ecological aspects of the region's functioning, exposing a new layer of problems that need to be solved: the instability of the natural and social environment caused by demographic issues, environmental pollution, and resource depletion; excessive economic growth and a small number of technological innovations, which leads to the instability of economic and technological systems; unsustainable urban environment, economy, society, and scientific and technological subsystems.

2. Many regions of China experience the "big cities disease, " affecting public welfare. Strengthening agglomeration processes at the coast leads to problems related to a lack of resources, environmental pollution, social disharmony, and lack of space in developed areas of the country. Science and technology have yet to become a real active, productive force. The main obstacle to sustainable development in various regions is the lack of a holistic, systemic, and genuinely sustainable policy approach. Using quantitative methods in decision-making to determine critical factors and incentives for promoting sustainable development is necessary to fill this gap.

3. Scholars of the People's Republic of China responded to this need promptly. They developed several approaches for assessing the sustainability of territorial development. A detailed analysis of the most used methods made it possible to outline their main advantages and disadvantages: the difficulty of comparing different regions with each other due to a significant amount of local data, lack of attention to technological aspects (only consideration of education), subjectivity in measuring indicators, and

different approaches to indicators' grouping and classification. Few methods consider science and technology within the regional sustainability assessment framework.

4. The system of indices for assessing the sustainable development of regional communities (according to the proposed four-aspect view on sustainable development) is proposed to follow several principles: objectivity, completeness, sensitivity, reliability, dynamics, and coordination. This means the need to consider the specifics of the sustainable development of cities and time aspects (to demonstrate the dynamism of sustainable development). Therefore, this study focuses on the main points of index selection to ensure that the urban sustainable development evaluation indices cover the environmental, economy, society, and science and technology elements and allows to trace their coordination.

5. To ensure the scientificity and objectivity of the evaluation results, several principles regarding the formation of the data set and intermediate calculations must also be met: independence, measurability, necessity, dynamics, and relative stability.

6. The theoretical framework diagram for establishing the evaluation index system includes four core carriers of sustainable urban development: policy, talent, capital, science and technology. At the same time, policy refers to environmental sustainability, talents – to social sustainability, wealth – to economic sustainability and science and technology to sustainable technological innovation. A set of five indices was formed for each of the specified subsystems: environmental (land construction utilisation rate, green coverage in built-up areas, total sulphur dioxide emission, a ratio of wastewater centralised treated, harmless treatment rate of domestic waste); economic (per capita gross regional product, total retail sales of consumer goods, water consumption per ten thousand yuan of GDP, power consumption per ten thousand yuan of GDP, the proportion of tertiary industry); social (number of healthcare beds per 10,000 people, barrier-free facilities coverage ratio, per capita residential building area, the coverage rate of green space in the park within 500m, urban registered unemployment rate); scientific and technological (R&D expenditure of industrial enterprises, turnover of the technology market, financial cost of science and technology, the amount of domestic patent

application authorisation, and the full-time equivalent of R&D personnel of industrial enterprises). The meaning and attributives of these indicators in the context of the sustainable development of urban areas were outlined. The proposed evaluation index system has three levels: the target layer, the criterion layer, and the index layer.

7. Since urban sustainability has the characteristics of multi-objective, multi-level, and complexity, a comprehensive evaluation method is needed. Such a method requires weighting procedures and a straightforward approach to calculate the overall indicator. Accurate weighting is achieved by applying the "difference-driven" approach, in particular, the entropy method, which effectively avoids the interference of human factors, better reflects the objectivity and authenticity of the evaluation index, and is widely used in the social and economic sciences.

8. To assess the region's sustainability performance, it is proposed to apply the TOPSIS method, which is also known as the superiority and demerits solution distance method, accurately reflecting the gap between objects analysed. So, this research proposes to use the entropy method to calculate the index weight and the TOPSIS model to estimate the comprehensive regional sustainability performance. The following scale was offered to measure the regions' sustainability maturity based on the evaluation results: poor, intermediate, good, and high-quality.

SECTION 3. MANAGING SUSTAINABILITY OF CHINESE REGIONS: EMPIRICAL ANALYSIS AND STRATEGIES ELABORATION

3.1 Empirical analysis of the overall regional sustainability in China

Provinces serve as primary statistical units in China – this determined the data selection approach. To grasp the overall state of China's region's sustainable development, this study explored regions under China's Central Government control (except for Hong Kong, Macao, and Taiwan). The data in this study comes from the relevant statistical data in the "China Statistical Yearbook 2016-2019", "Statistical Yearbook of China's High-tech Industry 2016-2019", "China Environmental Statistics Yearbook 2016-2019", and "China Energy Statistics Yearbook 2016-2019", and some raw data obtained by calculation. The above statistical data shows the statistical values of sustainable development-related indicators of 31 provinces and cities in China from 2016 to 2019 (Fig. 3.1), that is, the panel data of regional territorial communities' sustainable development. The vigorous growth of China's digital economy began with the "G20 Digital Economy Development and Cooperation Initiative" released at the G20 Hangzhou Summit in 2016. In this regard, the earlier data (before 2016) was judged as of little significance to this study. Following principles of data representativeness, regularity, and availability (the last complete statistical records are available only for 2020), 2016-2019 were selected to do this research. Due to the lack of statistical data, this study selects the missing data on the indicators to supplement the research by interpolation.

Panel data contains two dimensions of time and cross-section, the data in this study has three dimensions: sample, index, and time. Using the three-dimensional data, sustainable development performance values of different cities in each year can be compared not only horizontally, but also the sustainable development level of each province in different periods from 2016 to 2019 can be compared vertically. Through the horizontal and vertical two-way analysis, an in-depth study of sustainable urban development and its spatial trends can be conducted.

Figure 3.1 – Spatial distribution of 31 provinces and cities in China

Source: author's development

The evaluation index system constructed in this study includes multiple evaluation indexes, but the physical meaning and unit represented by each evaluation index are inconsistent. Therefore, it is necessary to standardise each evaluation index before evaluation. The procedure and results of the calculation of entropy values for each index are given in Appendix A (Table A.1). According to the calculated information entropy value, the entropy weight of 20 indicators can be obtained by using the calculation formula (2.6) and (2.7). Table 3.1 contains the calculation results.

Table 3.1 – Weights' dynamics of sustainable development indices in China

PI[1]	Primary weight, %					Secondary weight, %					SI[3]
	2016	2017	2018	2019	AW[2], %	2016	2017	2018	2019	AW[2], %	
						5.2	5.39	5.44	5.35	5.35	A1
						1.75	1.75	1.83	2.19	1.88	A2
A	10.36	11.31	12.07	11.19	11.23	1.50	2.65	2.85	1.89	2.22	A3
						1.13	0.94	0.94	0.96	0.99	A4
						0.78	0.58	1.01	0.80	0.79	A5
						5.59	5.24	5.29	5.37	5.37	B1
						5.06	5.20	5.28	5.44	5.24	B2
B	17.70	17.44	17.01	18.22	17.60	0.54	0.59	0.62	0.57	0.58	B3
						0.96	1.02	0.98	1.01	1.00	B4
						5.55	5.39	4.84	5.83	5.40	B5
						2.95	3.21	3.55	3.65	3.34	C1
						3.02	2.96	2.49	2.79	2.82	C2
C	17.86	16.43	16.78	14.34	16.40	1.73	1.42	1.69	1.80	1.66	C3
						6.34	5.83	5.93	6.08	6.04	C4
						3.82	3.01	3.12	1.74	2.92	C5
						9.48	9.81	9.75	9.67	9.68	D1
						16.12	15.22	12.54	12.38	14.07	D2
D	54.07	58.81	54.15	54.56	55.40	8.87	9.13	9.57	9.61	9.30	D3
						9.65	10.25	10.47	10.69	10.27	D4
						9.95	10.40	11.82	12.21	11.10	D5

Remarks: 1)PI – primary index, i.e. 2)AW – average weight; 3)SI – secondary index (according to the table

Source: author's development

To make the results of calculation clearer and more visible, they were grouped according to the values obtained. (Table 3.2).

From the average weight of the indicators, according to the importance of the indicators, the first-level indicators are scientific and technological innovation (D), which has the highest average weight (55.4%), followed by economic growth (B), and then social welfare (C), and finally environmental protection (A), have an average weight of only (11.23%) (Fig. 3.2). There is little difference between the weights of economic growth (B), environmental protection (A) and social development (C), indicating that these three indicators have little difference in the role of sustainable urban development and jointly affect the sustainable development capacity of cities. Technological innovation (D) is the driving force, and its influence in promoting sustainable development cannot be underestimated.

Table 3.2 – The contribution of criterion layer and index layer in four dimensions

Criterion Layer (First-level indicators)	Contribution degree of criterion layer	Index Layer (Secondary indicators)	Contribution degree of index layer
Ecological environment (A)	★	A1	▲▲
		A2	▲
		A3	▲
		A4	▲
		A5	▲
Economic Development (B)	★★	B1	▲▲
		B2	▲▲
		B3	▲
		B4	▲
		B5	▲▲
Social well-being (C)	★★	C1	▲
		C2	▲
		C3	▲
		C4	▲▲
		C5	▲
Science and Technology Innovation (D)	★★★	D1	▲▲
		D2	▲▲▲
		D3	▲▲
		D4	▲▲▲
		D5	▲▲▲

Source: author's development

Note: The marks ★ indicate the contribution of criterion layer in each dimension. Wherein, ★ represents that the contribution degree of the criterion layer is between 0% and 20%, ★★represents that the contribution degree of the criterion layer is between 20% and 40%, and ★★★represents that the contributions degree of the criterion layer is between 40% and 60%. The marks ▲ indicate the contribution of index layer in each dimension. Wherein, ▲ represents that the contribution degree of the index layer is between 0% and 5%, ▲▲represents that the contribution degree of the index layer is between 5% and 10%, and ▲▲▲represents that the contribution degree of the index layer is between 10% and 15%

Economic growth (B) is the fuel for sustainable urban development. High-quality economic growth can promote the rapid development of the urban economy, while social development (C) provides necessary environmental support for urban development. A city can achieve sustainable development only when social development reaches a certain level. Although the weight value of environmental protection (A) is lower than the average weight of 25.16% of these four indicators, the sustainable development of the environment and ecology still needs to be listed as an essential indicator for analysis and research because of its massive impact on urban development.

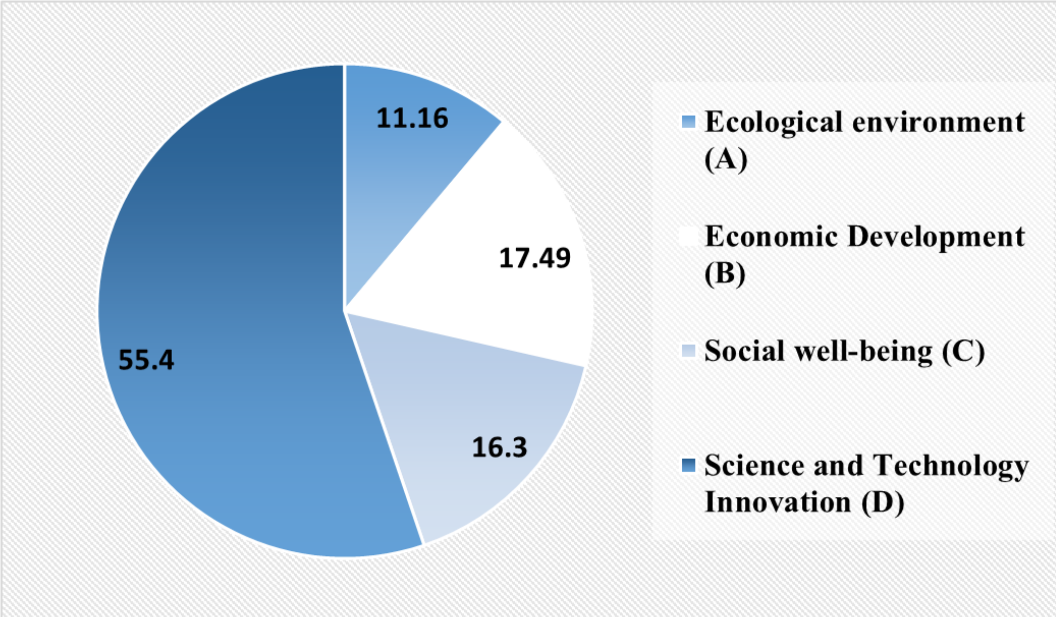


Figure 3.2 – The weights of the four dimensions of urban sustainability

Source: author's development

According to statistics, in the government work report of 2022, the word "science and technology" appeared 16 times, and the word "innovation" appeared 39 times, which shows its influence on the current sustainable development of cities. Combined with the empirical data of this study, the evaluation index selected in this study is more suitable, can effectively and accurately reflect the differences of various indicators in the city, and the index system has intense discrimination.

Analysis of the weight of the scientific and technological innovation subsystem indicators. Technological innovation (D) is the most critical factor affecting the sustainable development of the digital economy. The weight of the indicator has increased year by year, from 54.07% in 2016 to 54.56 in 2019 (Fig. 3.3). It shows that in the process of promoting the sustainable development of cities, various regions pay more and more attention to scientific and technological innovation, more and more scientific researchers are involved in innovation activities. Scientific and technological innovation achievements are also more and more abundant. In the secondary index of scientific and technological innovation (D), the technical market turnover (D2), the number of patent applications granted in China (D4) and the full-time equivalent of R&D personnel (D5) account for relatively high weights.

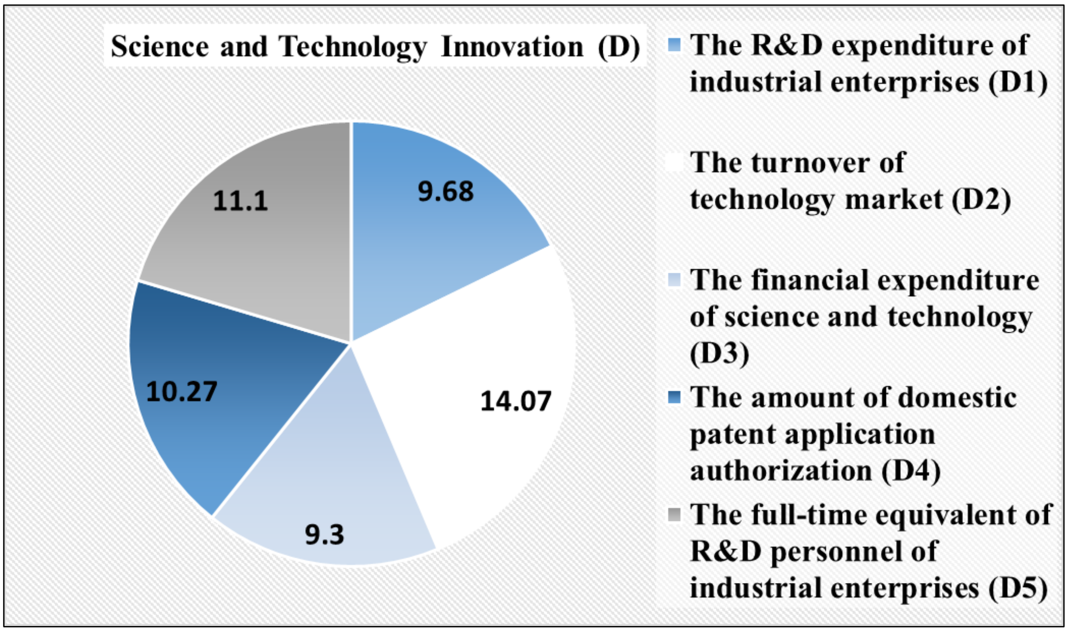


Figure 3.3 – Scientific and technological innovation subsystem index weight

Source: author's development

Although the average weight proportion of the technical market turnover in four years is the highest (14.01%), its influence has a decreasing trend year by year. However, the influence of R&D personnel full-time equivalent (D5) is increasing year by year, from 9.95% in 2016 to 12.21% in 2019, which shows that scientific researchers in a region play an increasingly important role in influencing the sustainable development of provinces, which is in line with the development goal of China's current strategy of strengthening the country by talents. The implementation of the strengthening the country with talent strategy in the new era and speeding up the construction of the world's essential talent centres and innovative highlands was repeatedly emphasised by the government at the

Central Talents Work Conference, which once again proves that the selection of the index system is representative. As an actual output of scientific and technological innovation, the influence of domestic patent application authorisation (D4) is relatively stable, and the index's weight changes little from 2016 to 2019 (8.87% -9.61%). Industrial enterprise R&D expenditure (D1) and science and technology financial expenditure (D3) have less influence in the five secondary indicators of scientific and technological innovation, with an average weight of 9.68% and 9.3%, respectively, and there are fluctuations in the middle, showing a trend of first rising and then falling.

Weight analysis of indicators of economic growth subsystem. The average weight of economic growth (B) is 17.6%. This is the second key factor in sustainable urban development. The slight fluctuation of index weight in the four years from 2016 to 2019 shows that in early-stage economic growth (B) has a more significant impact on sustainable development. However, with the deepening of digital economic development, science and technology proportion in national economic development is getting higher. Thus, the driving role of economic growth on sustainable urban development is weakening. However, its influence on sustainable regions' development cannot be ignored. In the secondary indicators of economic growth (B), the average weights of per capita GDP (B1), total retail sales of social consumer goods (B2) and the proportion of tertiary industry (B5) are 5.37%, 5.24% and 5.4% (Fig. 3.4), respectively. These three items have little impact on urban economic growth, and their weights are almost identical. The changes in the indicators in the four years from 2016 to 2019 show that the total retail sales of social consumer goods (B2) and the proportion of tertiary industry (B5) have a growing impact on economic growth, showing a good development trend, on the contrary, the impact of per capita GDP (B1) on economic growth has been declining year by year. Water consumption per 10000 yuan GDP (B3) and electricity consumption per 10000 yuan GDP (B4), compared with the other three indicators, have a relatively small impact on urban economic growth, with a weight ratio of 0. 58% and 1.00%, respectively. However, as essential indicators reflecting resource consumption in urban economic activities, their impact on sustainable urban development cannot be ignored.

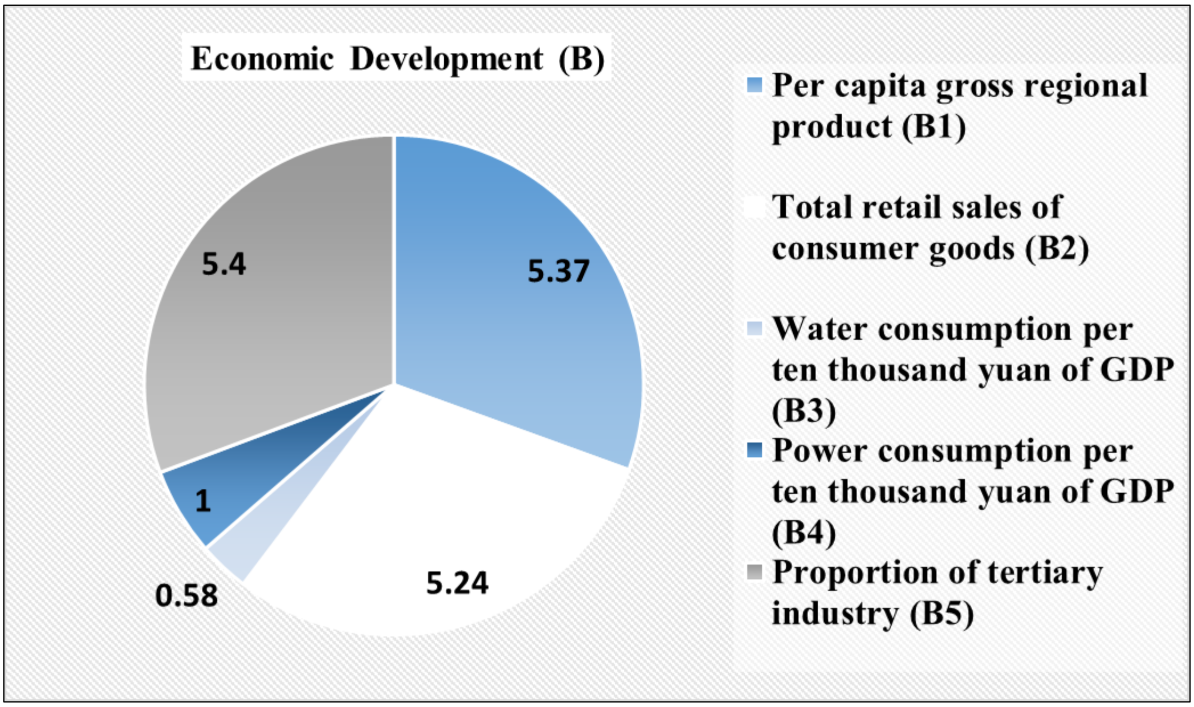


Figure 3.4 – Economic development subsystem index weight

Source: author's development

The index weight analysis of the social welfare subsystem. Indicators of social well-being (C) are second only to economic growth (C) in importance for sustainable provinces' development. Among the secondary indicators of social development (C), the coverage rate of green space in the park within 500m (C4) significantly impacts urban social well-being. However, it is worth noting that the weight of the indicators has a weakening trend by observing the data of 2016-2019. The number of healthcare beds per 10,000 people (C1), barrier-free facilities coverage ratio (C2) and the registered urban unemployment rate (C5) have little impact on urban social well-being, with an average weight of 3.34%, 2.82% and 2.92% (Fig. 3.5), respectively. Barrier-free facilities coverage ratio (C2) and registered urban unemployment rate (C5) over the years show that their impact on urban social development decreases yearly. Per capita, residential building area (C3) has the most negligible impact on urban social development, with an average weight of only 1.66%.

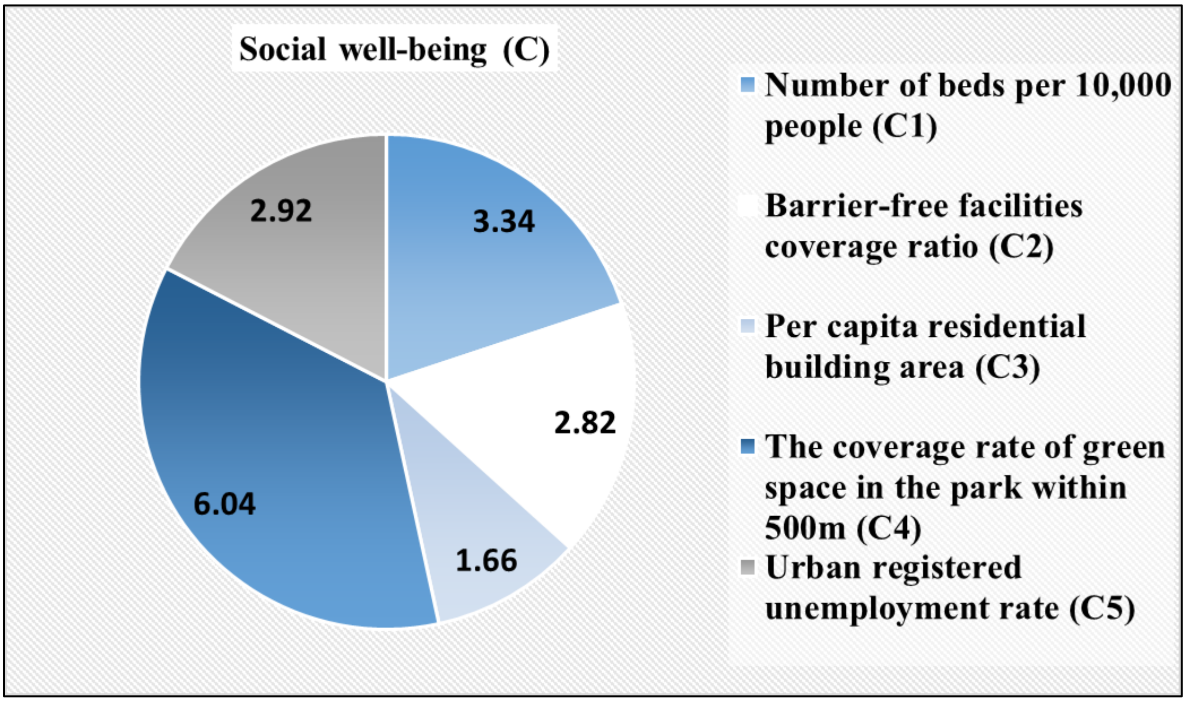


Figure 3.5 – Social well-being subsystem index weight

Source: author's development

The weighted analysis of the index of environmental protection subsystem. The average weight of the environmental protection (A) index is 11.23%, which has the weakest influence on sustainable urban development compared with the other three indicators. However, it is similar to the economic and social indicators and can still be listed as essential. In the secondary index of environmental protection (A), the land construction utilisation rate (A1) has the most noticeable impact, and the average weight of the index is as high as 5.35%, which shows that it is of great significance to the sustainable development of provinces. Secondly, the green coverage rate (A2) and total sulphur dioxide emissions (A3) in built-up areas accounted for 1.88% and 2.22% (Fig. 3.6), respectively. It shows that the atmospheric environment and pollutant emissions particularly impact the urban environment. Among the secondary indicators of environmental protection, the ratio of wastewater centralised treated (A4) and harmless treatment rate of domestic waste (A5) have less impact – only 0.99% and 0.79%.

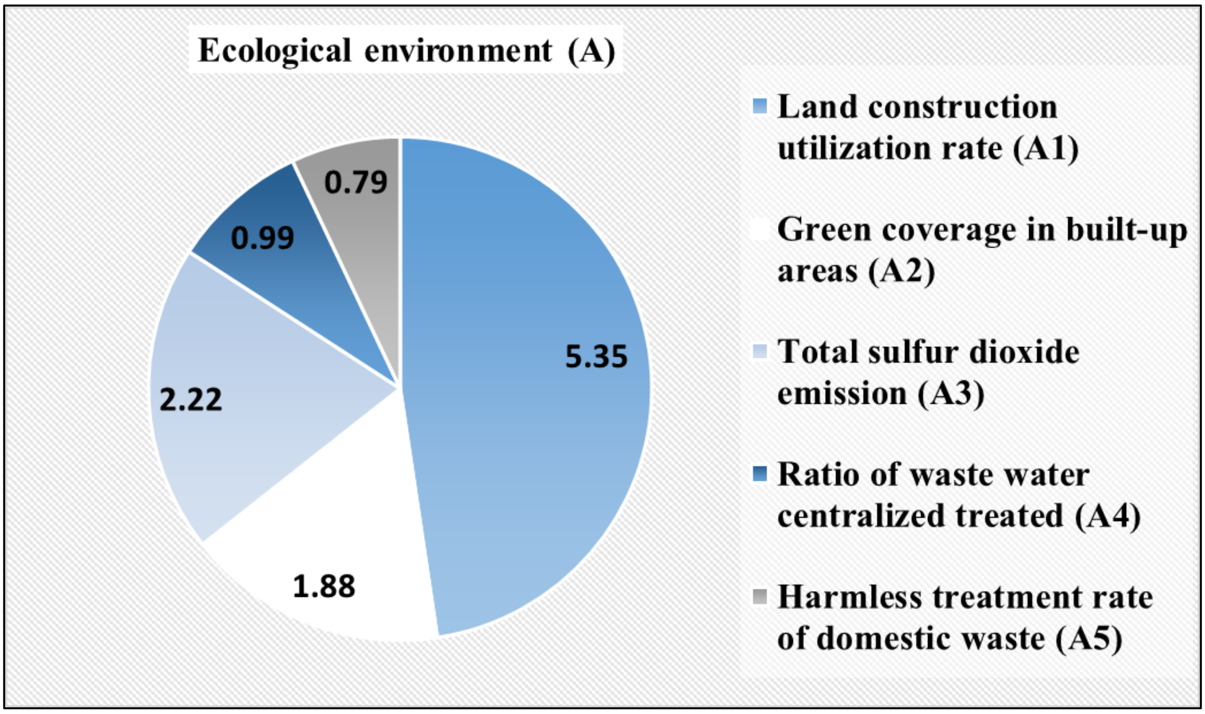


Figure 3.6 – Ecological environment subsystem index weight

Source: author's development

To sum up, the following factors have the most significant impact on sustainable urban development (according to the average weight, the top five): technology market turnover (D2), R&D personnel full-time equivalent of industrial enterprises (D5), domestic patent application authorisation (D4), R&D funds of industrial enterprises (D1), scientific and technological financial expenditure (D3). The average weight value of these five indicators accounts for nearly 54% of the total weight. The five indicators belong to the secondary indicators of scientific and technological innovation, which shows that scientific and technological innovation plays a decisive role in the sustainable development of cities. Similarly, the least significant impact is per capita residential building area (C3), the electricity consumption of ten-thousand-yuan GDP (B4), the ratio of wastewater centralised treated (A4), the rate of harmless treatment of domestic waste (A5), the water consumption of ten-thousand-yuan GDP (B4) – the average weight of these five indicators accounted for the proportion of the total weight is only 5%. This reveals the fundamental driving force of sustainable urban development: talent, science and technology, capital, and policy; urban sustainable development is more a business-driven process and then promoted by the authorities.

3.2 Framework to integrate evaluation and strategy elaboration procedures

Based on the scientific connotation of sustainable development of regional territorial communities driven by urbanisation processes, this study aims to put forward relevant suggestions on strategic planning for China's regions from four aspects: economy, society, environment, science and technology.

Considering the substantive and structural-process aspects of the strategic management process *(see paragraph 1.2)*, a scheme (algorithm) of actions based on the results of measuring sustainable development was formed (Fig. 3.7). According to the developed scheme, the application of the proposed measurement model makes it possible to determine the main factors that are drivers of sustainable development, and further to assess the degree of development of individual regions through performance analysis. The determined drivers should be the main focus of the country's development strategy and, differentiated by region, allow for the formulation of measures that are a priority for one or another territory (Fig. 3.7).

Development strategy of scientific and technological innovation subsystem. Scientific and technological innovation is essential for the sustainable development of China's regions. It is the cornerstone of urban economic development, the guarantee of industrial competitiveness improvement, the driving force of socially sustainable development, and the critical factor in determining the status of a city's participation in the international industrial division under the condition of globalisation.

From Table 3.1 and 3.2, talents and science and technology play a significant role in promoting sustainable regions' development. The suggestions of the scientific and technological innovation subsystem strategic movement should emphasise the following two aspects (Fig. 3.8).

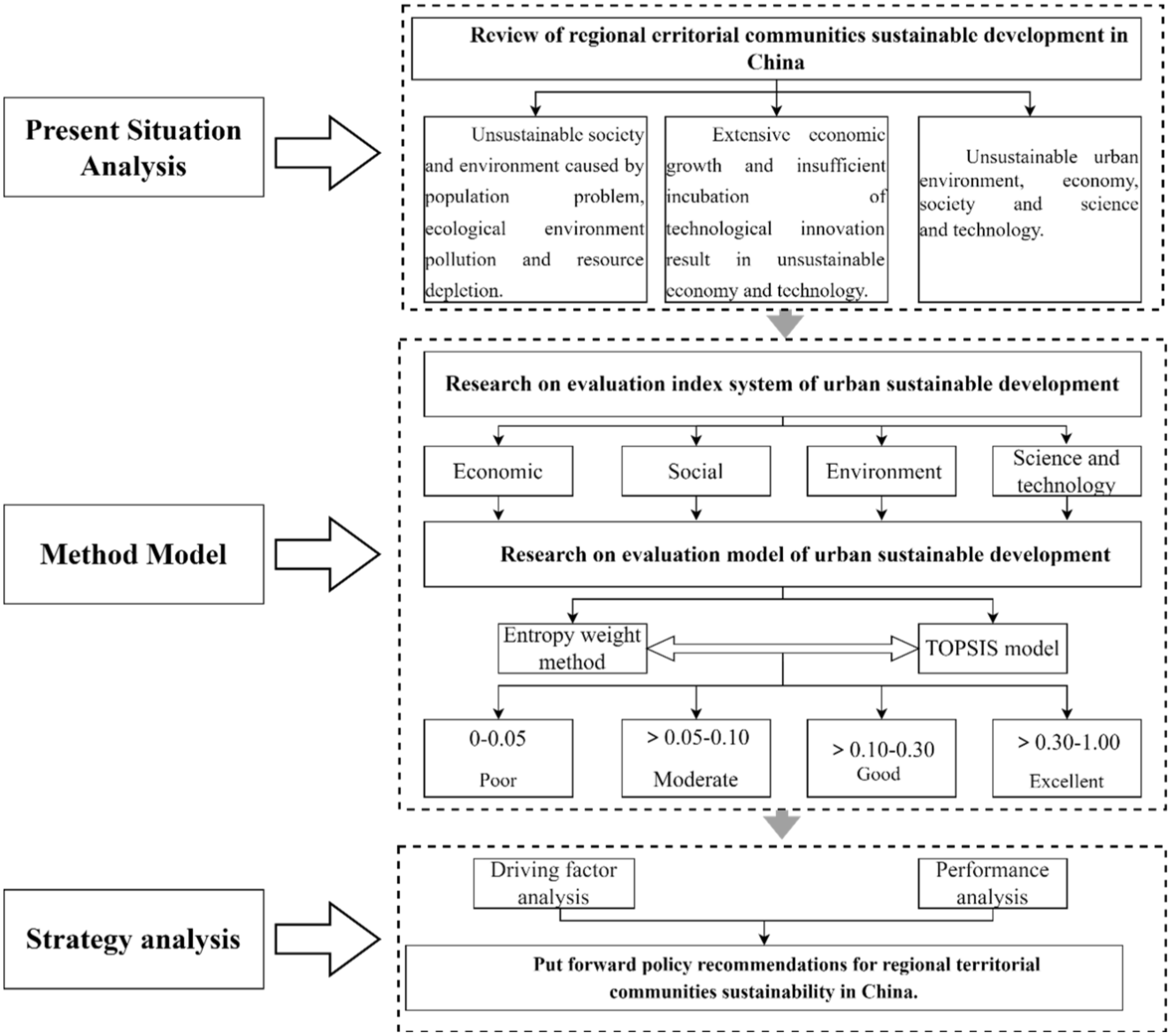


Figure 3.7 – Research scheme for regional territorial communities' sustainable development strategies elaboration

Source: author's development

The authorities need to implement laws and regulations on science popularisation, implement the project of popularising science to the whole people, establish a mechanism for science popularisation under the leadership of the government and with the broad participation of the public, and encourage and support social forces to launch science popularisation undertakings.

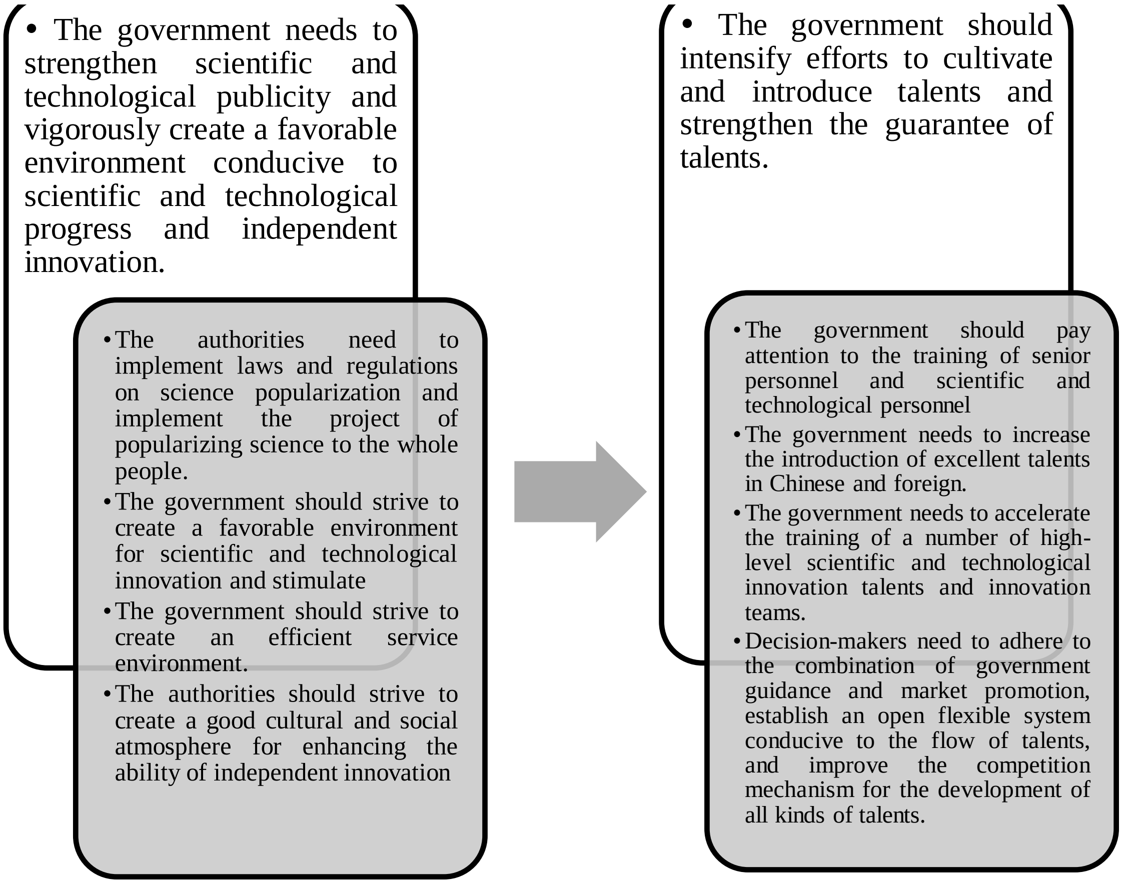


Figure 3.8 – Sustainable development strategy of science and technology innovation subsystem

Source: author's development

The government needs to increase financial investment in science popularisation, strengthen the construction of science popularisation facilities and networks, establish and consolidate science popularisation education bases at all levels, implement the national learning plan, build a lifelong education system, and improve the scientific and cultural literacy of the whole people. At the same time, it is necessary to give full play to the role of radio, television, newspapers, the Internet, and other media, vigorously publicise scientific knowledge, organise and carry out various forms of publicity activities to encourage scientific and technological innovation, and form a good atmosphere of public opinion in the whole society.

There is a need to create a suitable environment for scientific and technological innovation, stimulate innovation and vitality, solve the major problems in the environment of scientific and technological innovation and entrepreneurship, and create a good policy environment, legal environment, market environment, and cultural environment. It is necessary to implement the various policy requirements issued by the state, provinces, and municipalities to promote independent innovation and constantly improve China's policies to encourage and support innovation and entrepreneurship.

The authorities should create an efficient service environment, further, transform government functions, deepen the construction of institutional efficiency, strengthen the research on the universal and critical problems of various innovation subjects in the innovation process, timely coordinate and solve the practical difficulties encountered, and effectively solve the problems for enterprises. There is crucial to create a fair market environment and an excellent social environment for competition, strengthen the protection of independent intellectual property rights and brands, and strengthen law enforcement and inspection so that the rights and interests of inventors or owners of achievements can be effectively protected. It is necessary further to strengthen the development of urban and rural infrastructure, improve the living environment, and raise the level of civilisation.

Creating an excellent cultural and social atmosphere will enhance independent innovation, promote the scientific spirit, disseminate scientific ideas, advocate scientific methods, popularise scientific knowledge, and respect labour, knowledge, talents, and creativity. To mobilise the innovative and creative vitality of the whole society so that all creative aspirations conducive to social progress are respected, creative activities are supported, creative talents can be brought into play, and creative achievements are affirmed.

The government needs to attach importance to the training of senior talents and scientific and technological talents, give full play to the core supporting role of innovative talents, focus on training a group of scientific and technological innovative talents, high-skilled talents, rural practical technical talents, and entrepreneurs with a strong sense of independent innovation, and cultivate a group of scientific research teams and scientific and technological leaders with independent solid innovation ability. According to the needs of China's key construction projects and significant high-tech industrialisation projects, a group of experts in related fields will be hired to lead the development of science and technology and realise independent innovation of the enterprise. It is necessary to promote the gathering of high-level talent at home and abroad and focus on introducing high-level talent urgently needed in China's high-tech industries, pillar industries, emerging industries, and other fields.

Scientific and technological work should be people-oriented, and the government must take training and introducing talents as an essential task. The establishment and implementation of scientific and technological projects should focus on the discovery, cultivation, introduction, and rational use of talents and give full play to talents' expertise. Through joint efforts in major scientific and technological projects, the authorities must promote teamwork among science and technology talents. Using bidding for scientific and technological projects, the government needs to create an environment of equal competition and encourage young and middle-aged talents to stand out. By strengthening scientific and technological cooperation between Chinese and foreign, more Chinese and foreign scientific and technological talents will be attracted to participate in China's scientific and technological innovation.

Decision-makers must adhere to the combination of government guidance and market promotion, establish an open, flexible system conducive to the flow of talent, and improve the competition mechanism for developing all kinds of talent. The government should further reform the personnel system, formulate preferential policies to attract domestic and foreign scientific and technological experts and entrepreneurs to participate in high-tech research and the transformation of achievements, and coordinate the policies of relevant departments to ensure that technology owners, enterprise managers and high-level managers get corresponding remuneration or corresponding rights and interests with intellectual input. In defining intellectual property rights related to job inventions, the government should explore a more flexible distribution mechanism and try out equity and term systems. All kinds of enterprises should become the primary gathering place of innovative talents and give all scientific and technological talents honour, status, and benefits. Improving the environment for starting businesses and living there, building harmonious labour-management relations, and stimulating the vitality of talents will become a new situation in which high-tech and innovative talents gather.

*Development strategy of economic subsystem***.** Based on Table 3.2, the development of the regional economy ultimately needs the necessary support of regional industries and consumer goods markets. To this end, it is necessary to accelerate the transformation of the economic structure, change the extensive mode of economic growth, and vigorously develop the tertiary industry. The government needs to seize the current opportunities of "Internet +" and "green economic development", rely on the advantages of human resources, transportation resources, and educational resources in the cities, build innovative industries based on a large Internet platform, cultivate a group of emerging energy-saving and environmentally friendly green projects, accelerate the optimisation and upgrading of the industrial structure, and use policy funds to guide and support the development of recycling and environmental protection industries. At the same time, the government should also focus on the industrial structure adjustment of backward areas. On the one hand, armed with high gradient area of the advanced technology, to transform traditional industries extending the industry chain of low-end links to the high-end ones. On the other hand, there is the need to increase efforts to eliminate backward production capacity, guide the orderly exit of excess production capacity, adjust and optimise the structure of energy production and consumption, and optimise the industrial layout. Ensuring the sustained, steady, and healthy development of the consumer goods market is an effective way to improve the overall level of the economic subsystem. Therefore, the following countermeasures are proposed (Fig. 3.9).

An increase in urban and rural incomes and an improvement in people's spending power will expand consumer demand. Given this, it’s necessary to promote policies to increase capital, reform the performance-based pay system in public institutions, and raise the minimum wage. Additionally, the government should take advantage of "The Belt and Road" opportunity to expand the competitiveness of export products and improve the efficiency of enterprises.

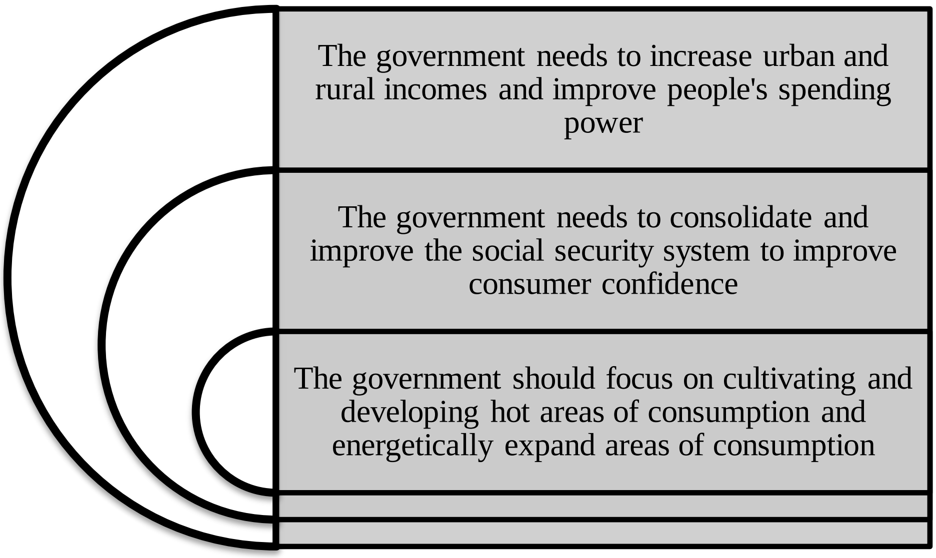


Figure 3.9 – Effective way to ensure sustainable development of the consumer goods market

Source: author's development

Consolidation and improvement of the social security system allow the strengthening of consumer confidence. Consolidation and improvement of the social security system, reduction of residents' expenditures, and narrowing of the income gap are vital prerequisites to enhancing residents' consumer confidence. The government must vigorously develop the economy and improve employment. Specific measures are as follows: the expansion of employment channels, an increase of employment capacity, an acceleration of the private enterprises and the self-employed private economy development, and an attraction of more employed personnel. At the same time, employment services should be provided for different groups. This requires strengthening of vocational skills education and training for workers, increasing employment guidance for college students, encouraging self-employment, and providing preferential policies for laid-off and unemployed people. Finally, through establishing a fair employment legal system, modification and improvement of the household registration system, increasing labour security supervision and other measures, it is possible to create a fair employment system.

The government should focus on cultivating and developing hot consumption areas. It is desirable to push forward the reform of the housing system and make residential goods a hot spot of consumption and a new growth point of the economy. Additionally, strengthening service consumption and fostering new consumption highlights could constitute a new area of policy’s attention. With the improvement of living standards, residents' consumption is transforming from simple material consumption to higher service consumption, where the proportion of leisure sports, tourism, education and training, cultural consumption, medical care, and other service consumption will constantly increase. The promotion of the development of e-commerce, information consumption, and driving the role of "Internet Plus" in the consumer goods market is also of particular significance currently. To make all this possible, breaking of the bottleneck in the offline retail industry and enhancing enterprises' competitiveness are needed.

Development strategy of social well-being subsystem. The ultimate purpose of all sustainable development is human well-being. Only when human society achieves sustainability, other aspects of this concept will become meaningful. The sustainable development of human society is not only related to contemporary people's happiness but also affects future generations' survival. Therefore, when formulating urban sustainable development policies, decision-makers should focus on potential factors affecting sustainable social development and make proper planning and guidance. According to Tables 3.1 and 3.2, increasing the construction of urban infrastructure and public facilities in the social subsystem is an effective way to achieve liveable social standards in China.

Infrastructure construction is an essential foundation to support urban material civilisation and an important guarantee to realise the sustainable development of urban society. At the national level, adequate infrastructure is often emphasised as an essential prerequisite for economic and social development. To ensure the smooth and timely construction of urban infrastructure, it is necessary to add special planning related to urban infrastructure construction when formulating urban sustainable development planning. Special planning should include comprehensive (scientific and forward-looking) plans for urban transportation, electricity, water supply, drainage pipelines, gas pipelines, household waste treatment, and other related services.

To better promote the sustainable development of society, in the process of infrastructure planning and construction, the authorities should also consider the construction of public service facilities such as urban and rural medical treatment, public security, community service, sports, education, and culture. There is a need to rationally arrange the construction of professional infrastructures such as agricultural wholesale markets and logistics distribution stations, and strengthen the construction of civil air defence facilities, public firefighting facilities, and places for disaster prevention and risk aversion. At the same time, the government should strive to promote the construction of people's livelihoods and drive the sustainable development of urban society.

It is necessary to ensure social equity and reduce the gap between the rich and the poor. Urban sustainable development planning should serve all social groups, including vulnerable ones. It is to safeguard the common interests of most members of the society, neither the simple superposition of individual interests nor the interests of specific and partial people. Only an equal and fair society can be stable, and only a stable society can achieve sustainable development.

As it is known, enjoying public services is essential for every resident to participate in social life fairly. Realising the fairness of public services is essential for the government to ensure citizens enjoy fair opportunities. At present, the degree of social equity in a city is reflected by the layout of public service facilities. Suppose the rich occupy areas with beautiful environments, complete medical and health care, developed transportation, commercial agglomeration, and other supporting facilities in the city. The poor live in poor sanitary environments and unfavourable transportation. In that case, it will inevitably affect social stability and is not conducive to the sustainable development of society. For a long time, the planning of public service facilities in China has been based on the idea of egalitarianism, only considering the issue of quantity distribution without considering the factors such as accessibility, resident characteristics, and residential space differentiation that affect the fairness of spatial distribution, ignoring whether different social classes have the same opportunities to access and use public service facilities.

Therefore, the distribution of public service resources reflects fairness in space so that different social classes have relatively fair use rights and creating a social environment of fair opportunities is an inevitable requirement for the construction of a public services system.

Development strategy of ecological environment subsystem. The suggestions for the environmental subsystem emphasise utilising water and land resources and improving air quality. The utilisation and natural resources protection concrete measures allow optimising and enhancing the level of the urban environmental subsystem (Figure 3.10).

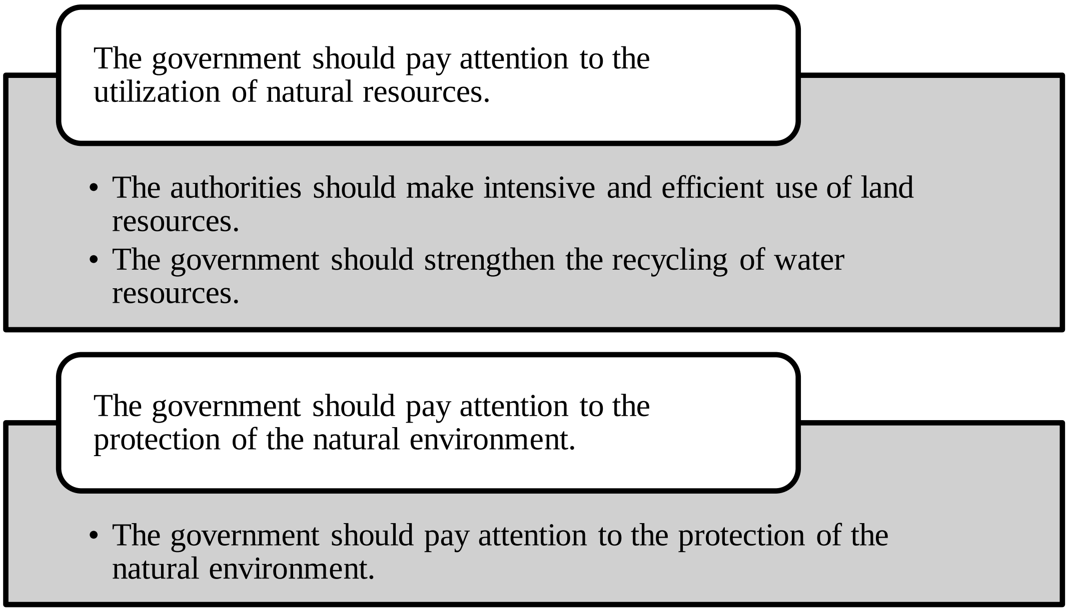


Figure 3.10 – Sustainable development strategy of ecological environment subsystem

Source: author's development

The land is a vital material carrier for urban development and social progress. Whether the government can efficiently and intensively use land resources is directly related to the rise and fall of new cities and their future development. Current urban problems such as construction land shortage, traffic congestion, environmental degradation, and so on have a particular relationship with land use; the solution to these problems will also involve land use optimisation. Therefore, the decision-makers should pay attention to the limited land resources when planning new towns' development. Strengthening the three-dimensional development of land resources is a crucial way to them efficiently. In urban development and construction, the government should actively advocate the comprehensive and three-dimensional development of urban land, improve the efficiency of land use, make rational and efficient use of land resources, and improve the level of intensive use of urban land resources. In addition, when making relevant urban land use plans, policymakers should be closely connected with the economic development and social needs of the city, coordinate development, ensure that the expansion of land scale is coordinated with the land use structure and social and economic development, and promote the orderly development of the urban system.

Water is the source of life; water resources are significant for people's production and life, social, or economic development. The utilisation of water resources is an essential issue of universal concern in the world, which not only affects the ecological environment but also restricts the sustainable development of society. Therefore, decision-makers should pay attention to the utilisation of water resources when formulating urban sustainable development plans. The water resources in the specified area are usually stable and will not change significantly except for special reasons. Therefore, to strengthen the utilisation of water resources, it is necessary to make efforts to the stock of water resources.

On the one hand, the policy should advocate water conservation, which is a cost-effective way to improve the utilisation efficiency of water resources, which needs the joint efforts of urban people. On the other hand, the attention should be paied to recycling water resources, which requires macro arrangement and comprehensive planning, the infrastructure of water resources recycling, and the coordination of water use among related industries. To realise the efficient utilisation of water resources, there is the need to pay attention to the economic, social, and ecological benefits of water resources for human well-being and communities' development.

Environmental protection is the spatial support for sustainable urban development, and its quality level is significant. On the one hand, the process of urban industrialisation and urbanisation aggravates the environmental damage; on the other hand, to realise the sustainable development of the natural environment, the government must invest a lot of workforce and material resources in environmental governance and protection. Paying attention to environmental management and improving environmental quality is essential to support sustainable urban development. Based on this, the Chinese government has made a lot of efforts in environmental governance and environmental protection, such as the promulgation of the China Urban Coordinated Development Ecological Environmental Protection Plan, increasing investment in pollution control, etc., which have achieved specific results and brought the discharge of wastewater and waste under control to a certain extent. However, due to the complex environmental problems accumulated in the process of industrialisation and urbanisation, the task of environmental governance is still very severe, and governance work cannot be slack. In the industrial system, the government should combine the end treatment with the source treatment, actively coordinate the relationship between industrial activities and the natural environment and improve the ability and efficiency of urban environmental pollution control. For enterprises with high pollution and emissions, it is desirable to implement challenging energy conservation and emission reduction standards, to improve supervision and punishment, and to incorporate this concern into the performance evaluation of local governments to promote it in a coordinated and robust way. There is a need to control the total amount of pollution discharged, reduce the increase of corruption and, more importantly, absorb the existing pollution.

3.3 Strategic suggestions on regional territorial communities' sustainability path

According to the proposed evaluation method *(see Section 2, paragraph 2.2, 2.3)* and scheme of strategy elaboration (Fig. 3.7), the sustainable development performance of 31 Chinese provinces was evaluated. To make these calculations and conduct regions' ranking, several intermediate calculations were made according to the Entropy-TOPSIS methodology. These calculations are described in Appendix B, Table B.1. Based on the results of the intermediate calculations, the Euclidean distance and relative proximity of each province scheme from the optimal scheme and the worst scheme using formulas (2.11) and (2.13) were calculated. The calculation results of relative proximity C_i are shown in Table 3.3. The range of the C_i value is [0,1]; the closer the C_i value is to 1, the better the province's sustainable development is, and otherwise. Finally, according to the size of the C_i value, the ranking of the sustainable development level of the provinces was obtained and visualised in Fig. 3.11.

Table 3.3 – The comprehensive performance of sustainable development of 31 provinces in China from 2016 to 2019

Time / Area	2016	2017	2018	2019	Average	Ranking
1	2	3	4	5	6	7
Beijing	0.695	0.662	0.53	0.501	0.597	1
Tianjin	0.162	0.143	0.14	0.146	0.14775	11
Hebei	0.086	0.091	0.109	0.119	0.10125	16
Shanxi	0.049	0.052	0.058	0.057	0.054	27
Inner Mongolia	0.055	0.053	0.057	0.058	0.05575	25
Liaoning	0.113	0.114	0.121	0.119	0.11675	15
Jilin	0.056	0.066	0.072	0.077	0.06775	20
Heilongjiang	0.063	0.056	0.054	0.055	0.057	22
Shanghai	0.261	0.254	0.278	0.273	0.2665	6
Jiangsu	0.383	0.408	0.488	0.524	0.45075	3
Zhejiang	0.277	0.301	0.391	0.431	0.35	4
Anhui	0.141	0.145	0.169	0.188	0.16075	9
Fujian	0.112	0.123	0.156	0.161	0.138	13
Jiangxi	0.063	0.073	0.097	0.11	0.08575	18
Shandong	0.256	0.275	0.31	0.299	0.285	5
Henan	0.119	0.13	0.159	0.173	0.14525	12
Hubei	0.233	0.231	0.224	0.227	0.22875	7

Continue of Table 3.3

1	2	3	4	5	6	7
Hunan	0.096	0.112	0.135	0.15	0.12325	14
Guangdong	0.436	0.483	0.623	0.682	0.556	2
Guangxi	0.062	0.067	0.077	0.069	0.06875	19
Hainan	0.058	0.058	0.067	0.069	0.063	21
Chongqing	0.084	0.082	0.1	0.1	0.0915	17
Sichuan	0.121	0.135	0.186	0.187	0.15725	10
Guizhou	0.044	0.05	0.062	0.066	0.0555	26
Yunnan	0.049	0.056	0.059	0.062	0.0565	23
Tibet	0.055	0.052	0.05	0.046	0.05075	29
Shaanxi	0.187	0.179	0.163	0.166	0.17375	8
Gansu	0.062	0.055	0.054	0.053	0.056	24
Qinghai	0.043	0.043	0.048	0.042	0.044	30
Ningxia	0.036	0.039	0.047	0.045	0.04175	31
Xinjiang	0.054	0.049	0.057	0.054	0.0535	28

Source: author's development

From the overall ranking (Fig. 3.11), the top five cities with the highest sustainability performance value among the 31 provinces are Beijing, Guangdong, Jiangsu, Zhejiang, and Shandong. The last five are Shanxi, Xinjiang, Tibet, Qinghai, and Ningxia. The overall level of sustainable development could be much higher; the average level is 0.158. The provinces are divided according to the relative progress, and the division criteria refer to Fig. 3.7.

Among the provinces analysed, only four scored in the range of 0.30–1.00, while the number of territorial communities scored in the two ranges of 0.1–0.30 and 0.05–0.10 was 12 and 13, respectively, accounting for 80% of the total number. There are two provinces in the lowest score range of 0.00–0.05. Overall, the sustainable development of the 31 provinces shows a "football" distribution, small at both ends and significant in the middle. The number of territories with high scores and low scores was relatively small, and the ones with medium scores and lower scores accounted for a large proportion, indicating that the overall level of sustainable development in China is relatively low and there is ample space for improvement.

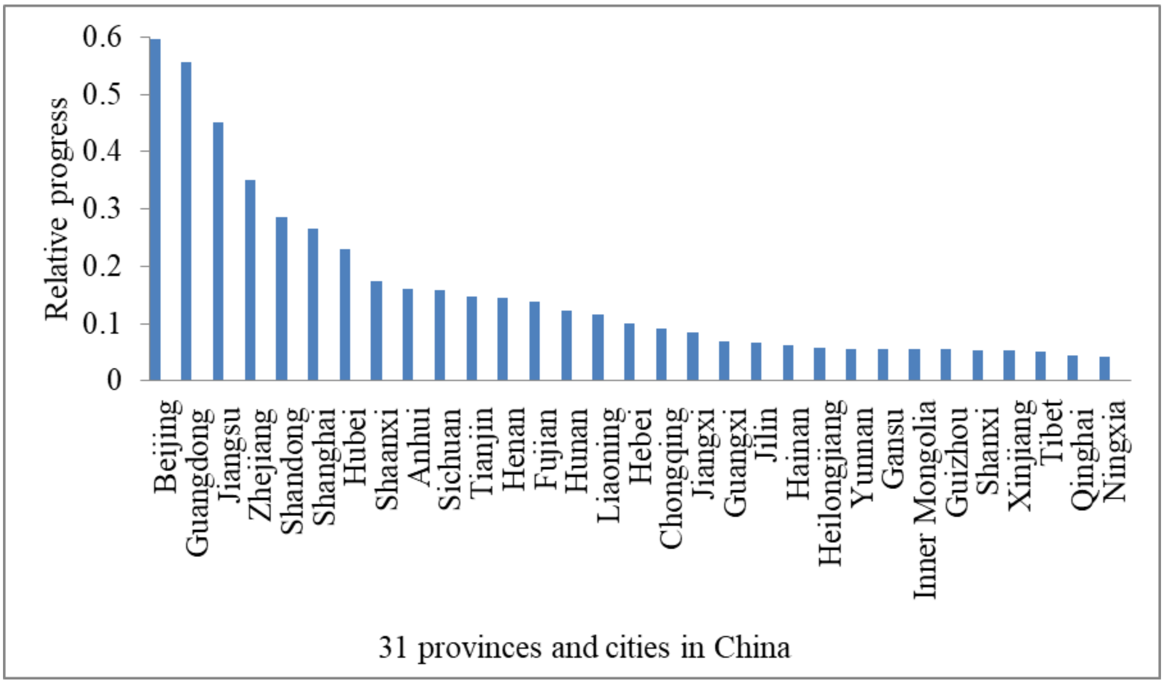


Figure 3.11 – Performance ranging of sustained development level of 31 provinces and cities in China

Source: author's development

According to the obtained results of a comprehensive evaluation of the sustainable development of provinces, autonomous regions, and municipalities directly controlled by the Central Government in China in 2019, the map of the regional territorial communities' sustainability performance distribution is obtained by using GIS (Geographic Information System) simulation technology, as shown in Fig. 3.12. This allows for visualising the overall situation and regional differentiation of sustainable development in China. According to the results, the sustainable development of various regions in China can be roughly regarded as a trend of attenuation from strong to weak from the eastern coastal areas to the western inland areas.

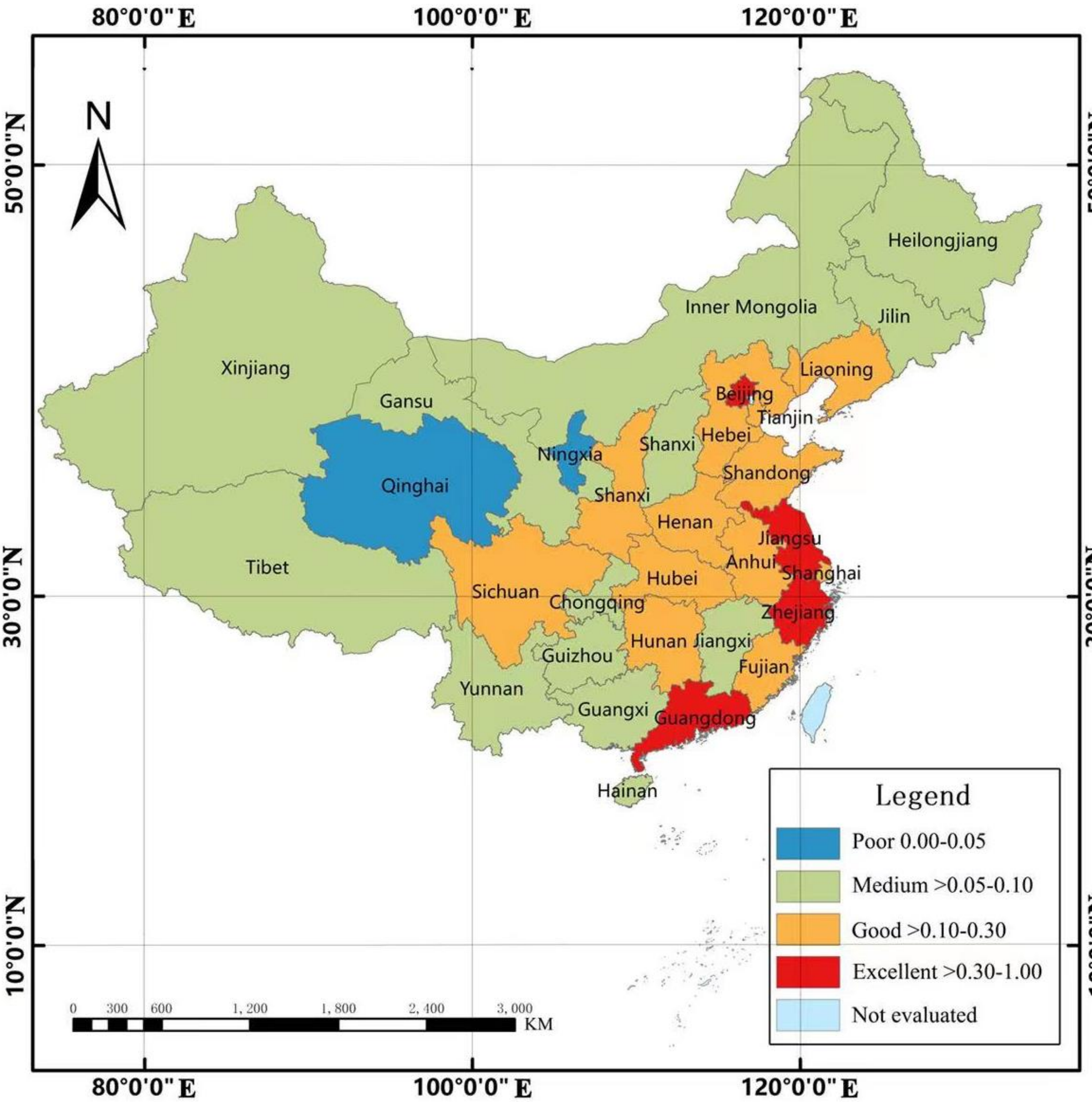


Figure 3.12 – Distribution map of regional territorial communities' sustainable development performance in China

Source: author's development

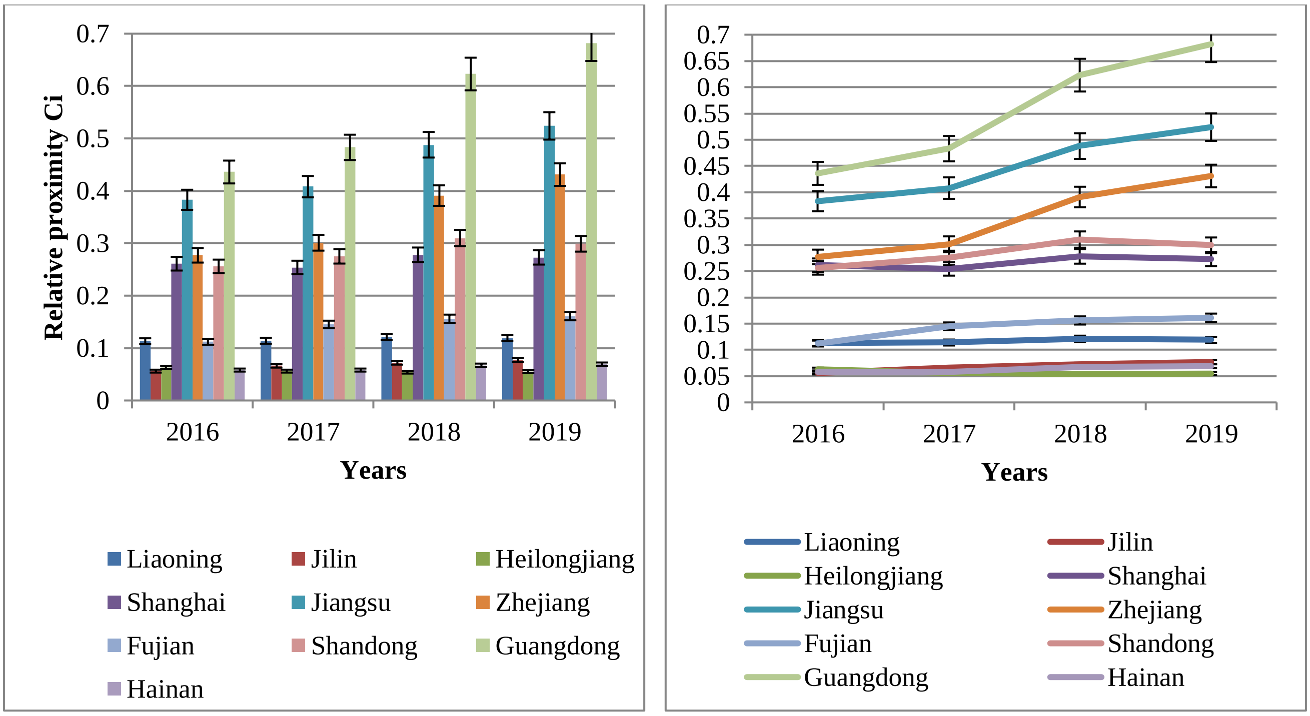
According to the regional division method proposed in the project report Analysis of China's Regional Social and Economic Development Characteristics of the Development Strategy and Regional Economic Research Department of the Development Research Center of the State Council, analysed provinces are grouped into four regions: the eastern coastal region, the Beijing-Tianjin-Hebei urban agglomeration, the central, and western regions. The average value of the sustainable development performance of each region was calculated (Table 3.4). The results also show the ranking of the level of sustainable urban development performance in the eastern coastal region, Beijing-Tianjin-Hebei region, central region, and western region.

Table 3.4 – Ranking of regions' sustainable development performance

Region	Relative proximity C_i	Ranking
The eastern coastal region	0.269	1
The Beijing-Tianjin-Hebei region	0.255	2
The central region	0.151	3
The western region	0.079	4

Source: author's development

Empirical analysis and strategic suggestions on the urban sustainability performance of the eastern coastal region. The eastern coastal areas mainly refer to the eastern coastal provinces and related cities in China, including Heilongjiang, Jilin, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan from north to south. Sustainability performance indicators for provinces constituting this region are visualised in Fig. 3.13. The changes and trends of sustainable development levels of cities in eastern coastal areas of China have had a certain regularity for four consecutive years. In previous values, the sustainable development efficiency of Shanghai, Shandong, Fujian, and other cities, which might be very high, has not reached the ideal height of "expected". The sustainable development efficiency value of Guangdong, Jiangsu and Zhejiang has been between 0.3 and 1, especially since the performance value of Guangdong is as high as 0.7, which is higher than that of other cities. The sustainable development level of Shanghai, Fujian, Shandong, and Liaoning has been hovering between 0.1 and 0.3 for four years, and the overall sustainability is in good condition. However, the sustainability of Shandong's cities has declined in the past two years. Heilongjiang, Jilin, and Hainan have relatively lower scores than other eastern coastal provinces, and the level of sustainable urban performance has been between 0.05 and 0.1.



a) Histogram *b) The trend*

Figure 3.13 – Sustainable development performance of eastern coastal urban agglomerations in China

Source: author's development

According to Fig. 3.13b, in general, the sustainable development of cities in 10 provinces and along the eastern coast has maintained a steady growth from 2016-2019, and the level of urban sustainability is significantly higher than that of other cities in the country. Going back to the origin, as early as after the first Opium War in 1842, Guangzhou, Xiamen, Ningbo, Fujian, and Shanghai were the first open trade ports in the Treaty of Nanjing, covering almost the entire eastern coast of China. Therefore, it is unsurprising that the eastern coastal area, the earliest area affected by Western capital, has the fastest economic development speed. However, only three provinces and cities in the eastern coastal area, namely Guangdong, Jiangsu, and Zhejiang, have always been at the forefront of the country regarding sustainable development efficiency. Fujian's urban sustainable development performance, known as "near the mountains and the sea", and Shanghai, the "financial centre of China", is not ideal. This is reflected by the authorities.

The reasons are summarised below. First, this is the inevitable stage of the historical law of sustainable urban development. According to the relevant theories of the relationship between environmental quality and per capita income developed by Grossman et al. and the relevant conclusions of the inverted “U” curve of environmental Kuznets initiated by Panayotou, it is difficult to avoid the road of "sacrificing environment and resources" in the initial stage of urban economic development (Ahmadova et al., 2022; Dragone et al., 2021; Pontarollo & Muñoz, 2020). As a developing country with the most potential, China is still in a difficult transition stage; that is, most cities are still on the left side of the inflexion point of the inverted “U” curve and will inevitably go through the stage of "pollution first and treatment later" experienced by western developed countries (Bures, 2021; Lawton & Pooley, 2021; Pradhan et al., 2021) (Friendly, 2021; Reis & Lukas, 2022). Ramon argues that the worst parts of China's air pollution today are collectively more polluted than continental Europe and parts of the United States were in 1970 measured in terms of pollution per unit of GDP but per population, developed countries emitted far more pollution per unit in 1970 than China does today (Ramon., 2021).

Second, the concept of urban and rural residents taking their economic interests as the first is deeply rooted, and they significantly lack public awareness of environmental protection. After the reform and opening, the economy of China's coastal areas has developed rapidly, and urbanisation has gradually intensified. According to the 2018 list of the ten most prosperous county-level cities in China released by Forbes, provinces and cities in Jiangsu and Zhejiang are included (Cartier, 2016a; Paris, 2013). In the eastern coastal areas, due to the superior geographical location, commercial activities gather, and it is customary to reduce costs and pursue personal interests in commercial activities. Sustainable development is a long-term development path; putting the equipment into the green, environmental protection science and technology innovation in the short term will only increase the enterprise cost, even need a well-paid professional, research and development personnel, etc., so sustainable development is often chasing profit maximisation of enterprises, institutions, and individuals in pursuit of immediate interests as an excuse to ignore. According to relevant statistics, in recent years, the number of small and medium-sized enterprises in the eastern part of China accounts for more than 60% of the total number of the country, and small and medium-sized enterprises are characterised as labour-intensive, with poor technology and equipment (Cartier, 2016b; Gu et al., 2017). To a certain extent, this explains why the sustainable development efficiency of other regions in the eastern coastal areas is not as significant as expected, except in Guangdong province, where the high-tech industry and optoelectronic information industry are the core.

Third, the government ignores the harmful environmental impact in industrial development. The sustainable development performance of three provinces in northeast China (Heilongjiang, Jilin, and Liaoning, has been low). As China's central industrial heartland, the northeast three areas and cities are advantaged with abundant oil and gas resources. Still, the trend of economic development has been sluggish in recent years, especially in the past two years of industrial overcapacity. Severe imbalance between supply and demand restricts the growth of the three northeast provinces. Although oil, gas, and forest resources are abundant, it is challenging to realise the optimisation of the sustainable development paths of cities only by seizing resources without changing the mode of economic growth. With the rapid development of science and technology and the digital economy becoming a global topic, Northeast China must focus on scientific and technological innovation, environmental protection, and economic transformation to achieve sustainable development in the future.

Development strategy for eastern Coastal areas. Due to China's regional differentiated development strategy and the inclination of national policies, many factors are concentrated in the eastern coastal area, making the urban construction and industrial development in this area significantly better than other areas, and it is currently the area with the highest level of sustainable urban development performance in China. With the acceleration of the urbanisation process in the eastern coastal areas and the accumulation of scientific and technological innovation elements and achievements, problems such as traffic congestion and environmental pollution have also arisen. Therefore, on the one hand, the eastern coastal areas need to pay attention to the sustainability and coordination of economic and social development in the region. On the other hand, they must also undertake the historical task of radiating and driving other cities.

The government should pay attention to the coordinated development of the social economy, aiming at the innovation and output of core science and technology. The eastern coastal areas involve most of the comprehensive big cities in China, such as Guangdong, Shanghai, Zhejiang and Jiangsu, whose economic level is advanced, urban infrastructure is perfect, urban maturity and overall civilisation are relatively high, but there are extensive city diseases without exception. Therefore, efficiency and fairness should be emphasised in sustainable urban development in the eastern coastal urban agglomeration. While pursuing an intelligent, healthy, and sustainable urban development path, the region should make full use of the existing economic foundation, resource advantages and innovation ability, assume the role of national scientific and technological innovation pioneer, and seek breakthroughs in the bottleneck core issues of the national innovation system. In particular, to encourage the innovation and output of core technologies, the government should actively provide support in the external environment and design for such regions that represent the strength and level of China's scientific and technological innovation to the greatest extent. For example, Japan has adopted a series of institutional designs for the government, manufacturers, and universities to achieve R&D-driven and policy-oriented innovation. The most successful model is the Very Large-Scale Integration project, which made Japan a super producer of semiconductor products. Therefore, in industries related to economic security or national core science and technology, the government can be considered to integrate resources and promote the formation of joint forces among enterprises to promote the overall competitiveness of China. In general, at the level of urban development, the eastern coastal urban agglomeration should pay attention to the fairness and coordination of economic and social development, actively deal with the contradictions highlighted in the urbanisation process and explore a healthy and sustainable path. In terms of scientific and technological innovation, the authorities should give full play to the advantages of talent gathering, aim at the forefront of the world, pursue the advanced degree of scientific and technological achievements, strengthen investment in essential innovation, and formulate more targeted strategies for international scientific and technical cooperation.

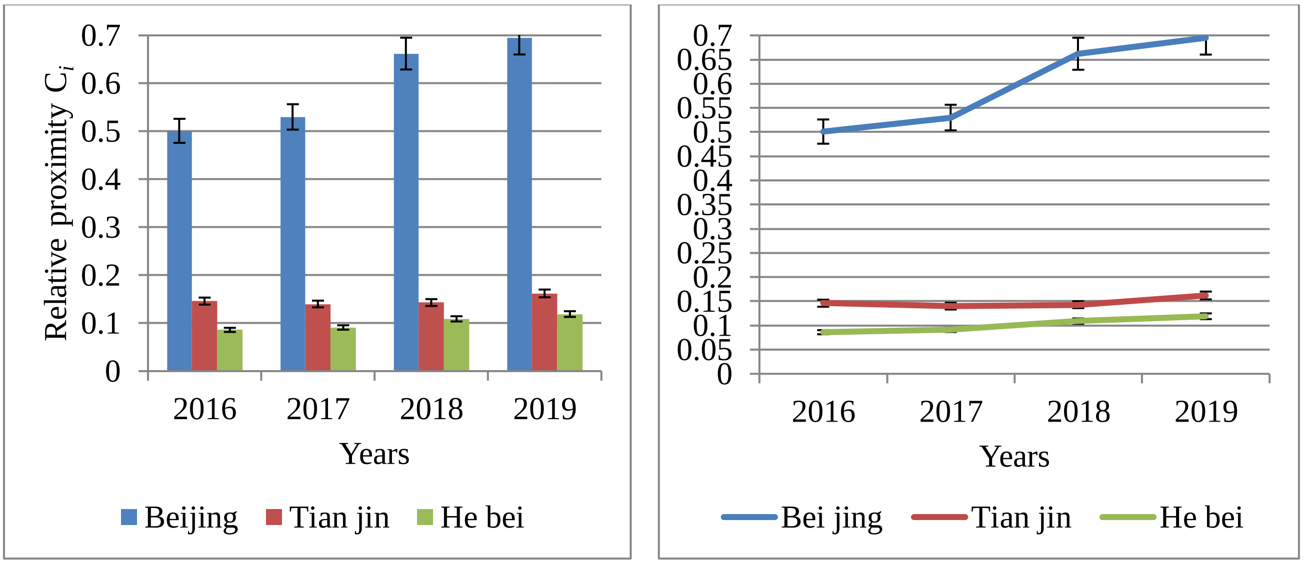
The government should pay attention to the radiation-driven effect of core areas and promote the development of surrounding areas. Since the reform and opening, the introduction of the growth pole theory has played a considerable role in promoting the take-off of China's economy. Still, it has also caused a massive gap in the development status of urban agglomeration. The non-coordinated situation, mainly characterised by the differences between the east, central and western regions, has been signed for a long time. This vast difference is shown at the economic and scientific and technological innovation levels. Although the malady of unbalanced development has been recognised gradually, the strategies for developing the western and central regions have been put forward successively, achieving some results in narrowing regional differences. However, they still need to reach the expected goal of promoting regional coordinated development with the first-mover advantage of the growth pole. Therefore, the eastern coastal urban agglomeration should clarify the focus of its own path and gradually transfer some functions to the surrounding provinces and cities. For example, when encouraging and vigorously developing the high-end equipment manufacturing industry, modern service industry, and other characteristic industries, Jiangsu-Zhejiang-Shanghai urban agglomeration (Jiangsu, Zhejiang, and Shanghai) can appropriately transfer some heavy industry projects with low-tech components to surrounding provinces and cities, promote the economic and social development of surrounding areas and cities, and focus on complex and high-tech industries. This could provide more radiation effects for neighbouring towns, weaken the siphoning effect, and boost the development of surrounding cities.

All regions strive to achieve overall planning and comprehensive, coordinated, and integrated sustainable development. Heilongjiang, Jilin and Liaoning, three provinces and cities in the northeast of China, have been at a low level all the time in the performance of sustainable development; this area is one of the regions that begin modern industrialisation earliest in China; it is the most important old industrial base of China too, but with the deepening of reform and opening-up, a series of social and economic problems have appeared, causing its urban development lag behind other cities of the eastern coast. Over the years, the economy of the three cities in Northeast China has been heavily dependent on the support of traditional heavy industry, so for the region, the first task is to optimise the industrial layout in an all-round way, focusing on regional characteristics. At the same time, the government should formulate a differentiated industrial upgrading route to avoid undesirable competition as much as possible. According to the existing national and regional planning, Jilin Province should prioritise agricultural biotechnology and high-tech agricultural technology and strengthen its natural advantages as a central agrarian province. Heilongjiang province should emphasise border trade, stimulate the development of some strategic emerging industries around bilateral cross-border cooperation, and contribute to the development of the national foreign exchange. To accelerate the upgrading of traditional industries, there is desirable to use the characteristics and advantages of conventional enterprises further to consolidate the development of specialised sectors in urban agglomerations: to achieve a proper positioning, to build links between strategic emerging industries and traditional industries, to achieve complementary advantages as far as possible in the process of action, and to achieve expected growth. For the three cities in Northeast China, the organic combination of accelerating the upgrading of traditional industries and the layout of emerging industries can bring their inherent resource advantages into full play and provide full guarantee and impetus for the future development of cities.

Empirical analysis and strategic suggestions on the urban sustainability performance of Beijing-Tianjin-Hebei urban agglomeration. The Beijing-Tianjin-Hebei urban agglomeration has always been an area of coordinated planning and development with Beijing – the capital, the political, and the cultural centre – as the core. The "capital economic circle" was first proposed in 1982 to gradually realise the joint development of the economy with Beijing and Tianjin as the centres. In 2018, the Chinese government accentuated strengthening the joint economic development of the Bohai Rim and the

Beijing-Tianjin-Hebei urban agglomeration. General Secretary Xi Jinping has also emphasised the importance of moving non-capital core functions out (H. Han et al., 2021; Hou et al., 2021). However, in recent years, the problem of environmental pollution has become a problem that plagues the development of the Beijing-Tianjin-Hebei urban agglomeration. Energy conservation and emission reduction, environmental protection and transformation of the economic development mode have become the top priorities for promoting the sustainable development of the Beijing-Tianjin-Hebei urban agglomeration. In 2018, the National Development and Reform Commission and the Ministry of Environmental Protection released the Ecological and Environmental Protection Plan for the Coordinated Development of Beijing, Tianjin, and Hebei. In the plan, it was explained that air and water pollution are the most severe environmental problems in the Beijing-Tianjin-Hebei urban agglomeration, and the lack of water resources is also a significant reason that restricts Beijing, Tianjin and Hebei (Bao et al., 2021; X. Li & W. Fan et al., 2021). It can be seen from the above appearances that the Beijing-Tianjin-Hebei urban agglomeration is the region with the sharpest contradiction between ecological environment, economy, and social development among the 31 provinces in China.

According to the evaluation results (Fig. 3.14), sustainable development efficiency in Beijing, Tianjin and Hebei provinces varies greatly. Combining the resources of Tianjin and Hebei, Beijing has a sound sustainable development momentum and achieved steady growth. The sustainable development efficiency has been in the range of 0.3–1 and continues to grow. By observing the relevant indicators of urban sustainable development evaluation, Beijing has been far ahead in the financial expenditure on science and technology, R&D, and investment for four consecutive years among 31 cities. Tianjin and Hebei have relatively diluted pollution emission indicators due to the relocation of industries. The evaluation result of Tianjin's sustainable development efficiency has always been between Hebei and Beijing. As the northern international shipping and logistics centre, Tianjin has a unique economic and geographical location and abundant resources. However, its political and cultural status is relatively inferior to Beijing, so the realisation of sustainable development is good, but there is still potential to improve. However, it is worth noting that the urban sustainable development level of Hebei is relatively low, and the sustainable efficiency has been hovering in the range of 0.05–0.1, which is a massive gap between the urban sustainable development level of Beijing and Tianjin. In fact, in Hebei province's per capita GDP, total retail sales of social consumer goods and other parameter values scored no less than some developed areas, but the "industrial wastewater emissions", "sulphur dioxide emissions", "hazard-free treatment rate of domestic garbage" rank the forefront. So, more severe environmental pollution in Hebei province restricts its sustainable development pace.



a) Histogram *b) The trend*

Figure 3.14 – Sustainable development performance of Beijing-Tianjin-Hebei urban agglomerations in China

Source: author's development

The reasons for the above evaluation results of sustainable urban development are summarised as follows. The strategic positioning of the Beijing-Tianjin-Hebei urban agglomeration needs to have overall planning, and the functional layout needs to be more reasonable. Presently, Beijing gathers too many non-capital functions, which is the cause of "big city disease" in the capital. The development orientation of Beijing-Tianjin-Hebei cities needs to be better connected, some functions of Beijing and Tianjin overlap, there is a certain degree of homogenous competition, and the layout of cities, transportation and industries within the city is unreasonable. Due to the lack of overall planning and overall arrangement of urban planning and development division, the development of Beijing and Tianjin is too strong compared with that of Hebei, which contrasts with the lack of development power and capacity of Hebei. As a result, the urban sustainable development fault phenomenon appears in The Beijing-Tianjin-Hebei urban agglomeration. The development of the comprehensive regional transport network needs to be more balanced: the level of connectivity and traffic efficiency between regions and some cities is not high, and the single-centre, radial, and unbalanced transport system around Beijing has increased the transit pressure of Beijing. The unreasonable inter-regional transport structure, the lag of inter-city rail transit construction, the severe problems of expressways, general national highways and provincial highways, the insufficient coordinated development of port and airport clusters, and the inconvenience of transportation hubs connection and transfer have increased the transport costs of the whole society and restricted the sustainable development process of urban agglomerations. In addition, the industrial layout needs to have overall planning and form an interconnected industrial chain. The industry in Beijing and Tianjin is over-concentrated and over-expanded. In contrast, the industry in Hebei is relatively scattered and uneven, and the industrial layout of Tianjin and the coastal area of Hebei is also prominent.

The distribution of public service resources in the Beijing-Tianjin-Hebei urban agglomeration is uneven, and the service level varies greatly. As can be seen from the original urban development data in 2019, the per capita GDP of Hebei and Tianjin is less than half of that of Beijing, and the per capita disposable income of urban residents is less than 55% of Beijing. Hebei has an urbanisation rate of about 49.3%, 37% and 34% lower than Beijing and Tianjin, respectively. Per capita fiscal expenditure is less than 30% and 33% of Beijing and Tianjin, respectively. In addition to the apparent differences between Beijing and Tianjin in economic development and urbanisation, the allocation of science and technology, education and social resources in Beijing and Tianjin lags. There are no

"Project 985" or "Project 211" universities in Hebei province, and neither the number of doctors with professional qualifications nor the number of domestic patent applications can compare with Beijing and Tianjin. The average length of schooling in Hebei is two to three years behind Beijing and Tianjin. In addition, the more severe and profound restriction of social harmony is the poverty belt around Beijing and Tianjin in Hebei Province. There are 39 critical counties of national poverty alleviation and development in Hebei Province, most of which belong to old revolutionary base areas, among which 9 are poor counties around the capital.

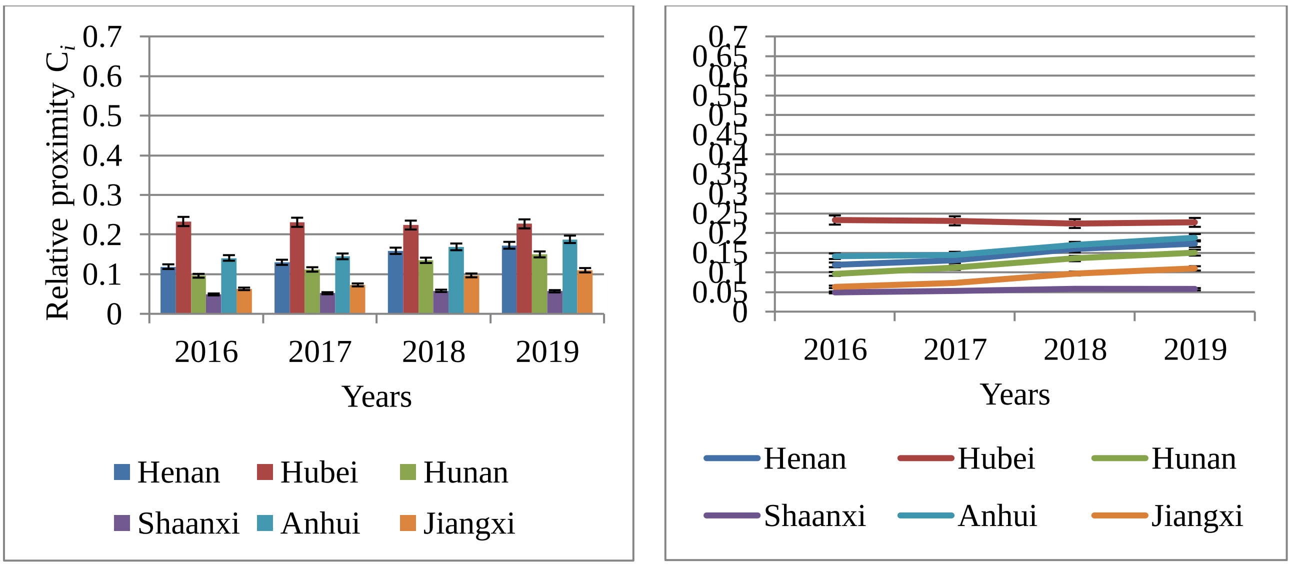
Beijing-Tianjin-Hebei regional development strategy. The general policy of sustainable development in the Beijing-Tianjin-Hebei region should carry out the spirit of the Nineteenth National Congress from top to bottom, adhering to the guiding ideology and general policy of the Party Central Committee on sustainable development. The government should aim to eradicate "big city disease" in the capital, grasp the focus of work, improve the ability of scientific and technological innovation, adhere to the cooperation between city clusters, and promote win-win cooperation. At the same time, in urban agglomeration development and construction, decision-makers should also consider the limited environmental carrying capacity of Beijing, Tianjin, and Hebei. They should take the division of labour and industrial planning of urban agglomeration as the centre of their work, coordinate resource allocation, and understand the institutional mechanism of sustainable urban development. In promoting the sustainable development of the Beijing-Tianjin-Hebei city cluster, the government must adhere to the guiding ideology of the goal, joint planning, complementary advantages, mutual benefit of resources, agglomeration and win-win situation.

The overall route of sustainable urban development is to uphold the direction of promoting collaborative integration. In detail, it is to achieve the goal through mutual benefit and collaborative progress of resources. There are five steps to be taken. First, policymakers should put reforms and promote the innovation ability of urban agglomeration. Through the promotion of industrial reform, the aim is to eliminate the invisible barriers between the Beijing-Tianjin-Hebei urban agglomeration and eliminate all the in-depth contradictions and core problems that affect the three cities to advance together and win. At the same time, promoting innovation can promote the establishment of collaborative integration systems and mechanisms between urban agglomerations. Second, regional cooperation should be mutually beneficial and win-win. By accurately grasping the three regional cities' specific functional positioning, the three regions' respective advantages can be utilised appropriately, and the layout of sustainable urban development can be optimised promptly. Third, market guidance and government leaders should be adhered to among regions. It is necessary to give full play to the abnormal adjustment mechanism so its leading role can be entirely played. In this way, the core functions of non-capital cities can be moved out so that the market factors of each city can be optimised and coordinated within any scope. Fourth, the government should make overall arrangements and implement them individually. Since it is a coordinated and integrated development, the three cities must break the localist thinking, formulate strategies from the overall layout, comprehensively coordinate, carry out strategic design collaboratively, and promote the overall optimisation of the industrial layout. Fifth, the government should pay attention to demonstration and pilot projects. Although the goal is coordinated and integrated development, the implementation should be driven by a few first-developed areas to drive the less-developed areas. Suppose the strategy is to walk in steps and advance together on a plane. In that case, the implementation of the strategy will be too mechanical, not flexible enough, and not conducive to the realisation of the goal. Based on this, the government must select qualified cities to take the lead in development and finally realise the sustainable development of the Beijing-Tianjin-Hebei urban agglomeration.

Policymakers should identify their respective positioning and layout in the process of sustainable development of the Beijing-Tianjin-Hebei region. To clarify the functional positioning of each city, relevant departments should first clarify the overall functional positioning. The authorities should take the sustainable development of the three cities of Beijing, Tianjin, and Hebei as a "chess game" and scientifically locate the division of labour and critical elements of the development of the three cities on this basis. In this way, it can not only enhance the integrity but also consider the characteristics of each city while fully expanding the comparative advantage to the maximum. Such functional orientation and strategic layout undoubtedly clarify the burden of the three cities in promoting sustainable development, clarify their respective roles and the work to be done. This will make it possible to understand their respective functional orientation and strive to develop towards their goals according to their orientation. In detail, Beijing, as the capital, is responsible for maintaining its position as the political centre and takes the cultural industry, international trade accommodation, and technology incubation as the focus of development. The positioning of Tianjin and Hebei could be more consistent; they are not political centres, but they can prioritise the development of manufacturing and efforts to promote the construction of an R&D base. At the same time, paying attention to the local characteristics and advantages allows for existing as a shipping and financial core centre in northern China. Although Hebei's political and economic status is not as good as that of Beijing and Tianjin, Hebei is a city with vast land and resources. It can be built into a modern logistics distribution base and rely on Tianjin's scientific and technological innovation to establish itself as the focus of industrial transformation. The most important thing for the base is to support the ecological environment of Beijing and Tianjin and become its backup ecological environment force. In the process of Hebei's urban development, the overall planning of urban and rural areas must be organically combined.

The government should pay attention to ecological rehabilitation and environmental optimisation. The construction of ecological civilisation is a necessary foundation and one of the primary tasks to promote the sustainable development of the Beijing-Tianjin-Hebei urban agglomeration. For the primary task, policymakers should adhere to specific criteria. For example, first, the goal of sustainable development requires unifying to carry out strict sustainable development standards, use of scientific and technological innovation reform to enhance the driving force of sustainable development of Beijing-Tianjin-Hebei urban agglomeration, to promote the synergy among the three provinces for a definite mutual advantage. Specifically, the government should establish a set of comprehensive land use and space planning procedures and improve the system of supporting policy; when it effectively implements, administrative boundaries between three cities can be effectively broken off to improve the resource use efficiency. In addition, the authorities should also attach great importance to environmental protection in the three cities so pollution control can be effectively realised.

Empirical analysis and strategic suggestions on the urban sustainability performance of Central region. In 2009, the central policy to promote urban agglomeration in central China was released: Henan, Hubei, Hunan, Jiangxi, Anhui, and Shanxi provinces together would realise the "rise of central China". The national strategy aims to achieve sustainable environmental, economic, social, and technological development in six central provinces and ultimately promote national development (S. Lu et al., 2021; Shen et al., 2021). As seen from Fig. 3.15, the sustainable development performance of the six provinces in central China have a similar trend with mediocre performance.



a) Histogram *b) The trend*

Figure 3.15 – Sustainable development performance of central urban agglomerations in China

Source: author's development

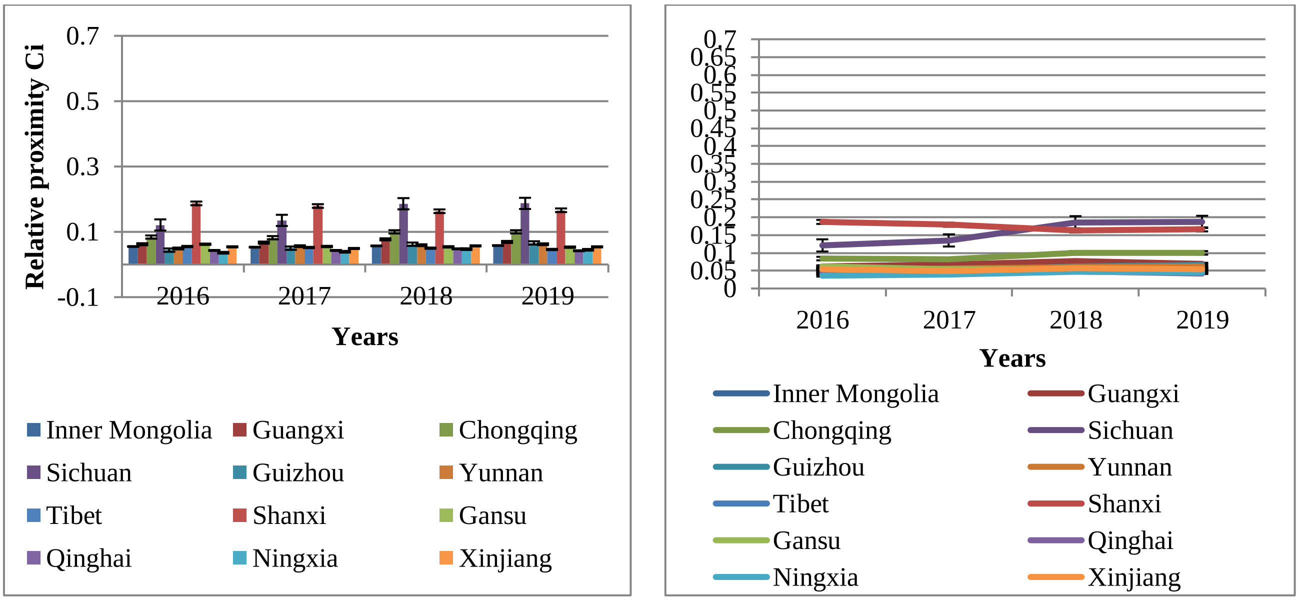
The comprehensive performance evaluation has been below 0.3 for a long time. Shanxi Province has always been on the short board of sustainable urban development in China and even presents an unsustainable situation. Through sorting the original index values, it was found that some index values in the central region are prominent and always in the middle level. For example, the GDP of Hubei, Hunan, and Henan is in the upper level of China, and Jiangxi's urban green space area has always been in the top three. The discharge index of various pollutants ranks relatively high. Individual indicators such as the industrial wastewater discharge demonstrate a leading position in the country.

The reasons for the above evaluation results are as follows. The resource utilisation efficiency of the central urban agglomeration is low, especially in Shanxi. Shanxi, a famous energy base with rich mineral resources, has recently been mining coal in large quantities, with various sizes of coal kilns all over Shanxi. And the wealth is in the hands of a few coal mine owners, the gap between the rich and the poor is large, social conflicts are sharp, and the economic development mode mainly relies on mining to consume the city's energy. Many urban infrastructures have been built in the central urban agglomeration. At present, the construction of many urban infrastructures seems to be the only way for China to develop its economy; to integrate with Beijing, Shanghai and other international metropolises, China's provinces are also competing to build urban infrastructure, such as railway repair, metro repair, vigorously develop real estate, etc. In recent years, no matter Hunan and Hubei, known as the land of fish and rice, are also in construction. As the Central Plains granary with a long history and culture, Henan has severe air pollution and other problems.

Central region development strategy. The major urban agglomeration is in the hinterland of China's inland, with the coast in the east and the inland in the west. It has a developed and convenient transportation network. The region is rich in internal medicine, education, culture, and health resources and has good economic and social development conditions. It is one of the critical areas for chemical construction and technological innovation and development. Implementing the strategy for the rise of the central region has boosted its growth. The Plan for Promoting the Rise of the Central Region offers clear guidance on the industrial system, innovation capability, internal coordination, east-west cooperation, and urban-rural integration in the central region. The trend of sustainable development evaluation results of the six central provinces is very similar, and the results are mediocre. There is significant room for improvement in all dimensions of their sustainable development level. Considering the geographical proximity of these six provinces, the development characteristics are similar, but the cooperation between cities is lacking, and the regional competition is intense. This study believes that the central urban agglomeration should be precisely positioned, develop industries according to local conditions, cultivate the core advantages of each city, and avoid homogeneous competition within towns.

Empirical analysis and strategic suggestions on the urban sustainability performance of the Western region. The metropolitan agglomerations in western China mainly comprise twelve provinces: Inner Mongolia, Guangxi, Chongqing, Sichuan, Yunnan, Guizhou, Tibet, Shaanxi, Gansu, Qinghai, Xinjiang, and Ningxia. According to the evaluation results in Fig. 3.16, the sustainable development efficiency of western China (except for a few areas) has been at the bottom of the country for a long time. The effect of the sustainable development of the western region has yet to be established, hovering at a performance value of 0.05. The sustainable development efficiency of several provinces and cities shows an overall upward trend and has certain advantages compared with the evaluation results of other western cities.

The western urban agglomeration covers more than half of China's land area, but these cities' economic development, social progress, and scientific and technological innovation are relatively slow. At the same time, the natural environment damage of the western region is much less than that of the central, eastern coastal, and Beijing-Tianjin-Hebei urban agglomeration. However, the slow development of the other three subsystems seriously restricts the vast improvement of the sustainable development level of the region. For example, although the performance value of sustainable development in Shaanxi ranked very high before 2018, it declined significantly after that. The evaluation trend of sustainable development was steep and sharply decreased.



a) Histogram *b) The trend*

Figure 3.16 – Sustainable development performance of western urban agglomerations in China

Source: author's development

The reasons why the sustainable development efficiency of western urban agglomeration is far lower than that of other regions in China are deeply analysed as follows. The energy utilisation efficiency of western urban agglomeration is low, and resources are scarce. Since the Western Development Office of the State Council officially began to implement the strategy of developing the west region in 2000, it has yet to achieve remarkable results. Xinjiang is rich in solar energy, oil resources, and the region of the west's vast territory. However, it has yet to be effectively utilised, mainly because of poor weather conditions, inconvenient transportation, lack of water resources, etc.

In recent years there have been some terrorist and turbulent incidents in Tibet and Xinjiang. Social instability leads to difficulties in introducing talent, and it is challenging to implement the policy of strengthening the country with skill and rejuvenating it through science and education. The western urban agglomeration is short of capital support, unattractive for talents, and has prolonged scientific and technological innovation. Although the national policy has encouraged the development of the western region, it is more challenging than the eastern coastal areas due to environmental and climate problems. Although the policy intends to assist the vigorous development of the western urban agglomeration, it is challenging to implement. Most western urban agglomerations are remote mountainous areas with poor environments, lack of funds, major poverty problems, large populations, and low education levels. In addition to Shaanxi, Sichuan, and Chongqing – economically developed areas with relatively rich educational resources – other cities such as Tibet and Xinjiang are underdeveloped. Scientific and technological innovation has yet to receive due attention in most western regions, such as Tibet, where the turnover of the technology market and the corresponding index value of R&D development are almost near zero. In the current society of science and technology, achievement of social progress and economic development needs to gather high-quality scientific and technological talents through the development of science and technology, the promotion of innovation, and the vigorous development of education. Most western urban agglomerations rely on robust tourism development to achieve residents' prosperity, which is also a good performance of utilising local resources.

Development strategy of the western region. The provinces in the west are inhabited mainly by ethnic minorities and have rich ecological resources. Therefore, tertiary industries such as eco-tourism should be developed according to the situation and local conditions. Yunnan, Guangxi, etc., due to their dependence on tourism, are also coupled with the support of national policies for minority areas and the input of resource elements, which have led to the lack of scientific and technological innovation power in the region. Given the apparent backwardness in scientific and technological innovation, the western urban agglomeration should strive to stimulate the local market economy, gradually transform from "policy-dependent" to "market-driven" development and concentrate resources to conquer scientific discoveries and technologies related to leading industries in the region. At the same time, with the help of the in-depth promotion of the "Belt and Road" initiative, it actively undertakes the transfer of the international service industry and vigorously develops the service market. Therefore, the focus of improvement in the western region can be on enhancing the power of industrial development and market vitality.

The government should pay attention to improving the industrial development power of the western urban agglomeration. Agriculture still plays a vital role in the urban economic structure of the region of the west, such as Inner Mongolia, Xinjiang, Ningxia, and other cities. Therefore, the realisation of agricultural modernisation is the primary goal. In this regard, the use of biology, machinery, and other modern science and technology to improve agricultural production mode and production efficiency is desirable and will help to promote innovative agrarian production, to introduce advanced experience of developed areas, and break the resources, market, and other problems faced by traditional agricultural development. However, it should be noted that both the introduction of modern systems and the reference of advanced models must be carried out under the principle of adapting measures to local conditions. For example, achieving an organic combination of rational development, repair, and protection in areas with rich grassland resources is necessary to promote animal husbandry agriculture. In areas rich in tourism resources, the development of leisure agriculture should be advocated, and the rural landscape should be organically combined with agricultural planting and animal husbandry. Regarding production and operation, relevant departments should actively promote land transfer, develop various forms of appropriate scale operation modes, improve farmers' knowledge, introduce and improve advanced technology and equipment, and improve agricultural technology innovation. While accelerating the realisation of agricultural modernisation, administrative departments should actively promote new industrialisation.

The government should enhance the market vitality of the western urban agglomeration. As the western region is far from the economically developed areas in the east, its economy has not been fully stimulated, and the market environment could be better. Therefore, respecting the market's laws should be the top priority in promoting the region's sustainable development for areas with less developed markets. The government should grasp the scale between the administration and the market so that more resources can be exchanged equally and flow reasonably in the market. Specifically, relevant departments can start from the following two aspects. Firstly, the government guides the establishment of fairness in the labour market, strives to eliminate various forms of employment discrimination, guarantees the fundamental rights and interests of the labour force, promotes the agglomeration of the population, and provides essential human support for the prosperity of the market. Secondly, the authorities should establish an open capital factor market. Urbanisation often requires vast funds and relying solely on the government is challenging to meet construction needs. In this case, market forces will fully tap the potential of private and foreign investment, innovative investment, and financing mode by the principle of who invests, who owns, and who benefits from carrying out commercial projects. Engaging investors to participate in urban development and construction is of special significance for western region sustainability.

Conclusions to section 3:

1. The suggested approach of assessing the level of sustainability of regional territorial communities was carried out on the example of regions under China's Central Government control (except for Hong Kong, Macao, and Taiwan) – 31 provinces for 2016-2019. Through the horizontal and vertical two-way analysis, an in-depth study of sustainable urban development and its spatial trends was conducted. The assessment of the entire general sample (31 provinces) showed that the first-level factors are scientific and technological, which have the highest average weight (55.4%), followed by economic growth (17.6%), social welfare (16.4%), and finally environmental protection (11.23%). Weights of economic growth, environmental protection, and social development indicate that these three indicators have little impact on sustainable urban development. Technological innovation is the driving force, and its influence in promoting sustainable development cannot be underestimated. Moreover, this factor’s weight is increasing

yearly, from 54.07% in 2016 to 54.56% in 2019.

2. The values of specific indicators testify that the technical market turnover, the number of patent applications granted in China, and the full-time equivalent of R&D personnel account for relatively high weights. In the secondary indicators of economic growth, the average weights of per capita GDP, total retail sales of social consumer goods and the proportion of tertiary industry are 5.37%, 5.24% and 5.4%, respectively. The total retail sales of social consumer goods and the balance of the tertiary sector have a growing impact on economic growth; on the contrary, the impact of per capita GDP on economic growth has been declining yearly. Among the secondary indicators of social development, the coverage rate of green space in the park within 500m significantly impacts urban social well-being. Residential building area per capita has the most negligible impact on urban social sustainability. In the secondary environmental protection index, the land construction utilisation rate has the most noticeable effect (5.35%). That reveals the fundamental driving forces of sustainable urban development: talent, science and technology, and capital and policy. Urban development is more a business-driven process and then promoted by the authorities.

3. Considering the substantive and structural-process aspects of the strategic management process, a scheme (algorithm) of actions based on the results of measuring sustainable development was formed. According to the scheme elaborated, applying the proposed measurement model makes it possible to determine the main drivers of sustainable development and further assess the regions' performance. The drivers identified should be the main focus of the development strategy and, differentiated by region, allow for the formulation of measures relevant to a particular territory.

4. The evaluation results made it possible to formulate the general principles of developing the strategy of the People's Republic of China to promote sustainable development. Strengthening scientific and technological publicity, creating a favourable environment conducive to scientific and technical progress and independent innovation, and facilitating the training and introduction of talents are suggested to improve sustainable development's science and technology element. Concerning the economic

subsystem, primary efforts should be made to change the extensive economic growth mode, develop the tertiary industry, and adjust the industrial system in backward areas. When making strategic decisions concerning social issues, it is advisable to focus on factors affecting the community's social sustainability (infrastructure, access to public facilities, equality, and fairness) and make proper planning and guidance. For the environmental dimension of regional sustainable development, the most critical issues to be solved are the efficient use of land resources and the strengthening the ecological governance role and functions.

5. Using the TOPSIS model, the sustainability performance of each of the 31 provinces was assessed and ranked. Overall, the sustainable development of the 31 provinces shows a "football" distribution: small at both ends and significant in the middle. The overall level of sustainable development in China is relatively low. According to the results, the sustainable development of various regions in China can be roughly regarded as a trend of attenuation from strong to weak from the eastern coastal areas to the western inland areas.

6. In general, the sustainable development of the eastern coast has maintained steady growth from 2016-2019, and the level of urban sustainability is significantly higher than that of other cities in the country. Strategic proposals for this region include paying attention to the coordinated development of the social economy, aiming at the innovation and output of core science and technology; to the radiation-driven effect of core areas and promoting the development of surrounding areas; to strengthening the overall planning, coordination, and integration of the region's provinces. The Beijing-Tianjin-Hebei urban agglomeration has always been an area of coordinated planning and development. In recent years, environmental pollution has become a problem that plagues the development of Beijing-Tianjin-Hebei. The urban sustainable development fault phenomenon appears here. The strategic positioning of the Beijing-Tianjin-Hebei urban agglomeration needs to have overall planning, and the functional layout needs to be more reasonable. The general route of sustainable development is to uphold the direction of promoting collaborative integration. Policymakers should identify positioning and design

in the process of sustainable development of the Beijing-Tianjin-Hebei region. The government should pay attention to ecological rehabilitation and environmental optimisation. The sustainable development performance of central China has been below 0.3 for a long time. Ecological problems are significant due to coal mining and infrastructure construction. The cooperation between provinces is lacking, and the regional competition is intense. The central urban agglomeration should be precisely positioned, develop industries according to local conditions, cultivate the core advantages of each city, and avoid homogeneous competition within towns. The sustainable development efficiency of western China (except for a few areas) has been at the bottom of the country for a long time. Improving the industrial development power and enhancing market vitality is critical for the western region's future sustainability.

CONCLUSIONS

This research deepens the theoretical-methodical foundations and provides practical recommendations to improve the management of regional territorial communities' sustainability in the People's Republic of China. The main conclusions and results obtained are summarised as follows:

1. With the continuous acceleration of industrialisation and urbanisation, regional territorial community development's ecological and environmental problems have become increasingly prominent. The role of urbanisation and cities in developing regional territorial communities is vital in China, where the current urbanisation rate amounts to more than 60%. So, cities are the internal engine of regional community development. This study explores urban development concepts. It appeals to the ideas of a knowledge city and a smart city, which have emerged recently. Science, knowledge, technology, and innovation are found to be the way to sustainable development through technological solutions. The growing importance of science, knowledge and information is also associated with the need to implement management functions – due to the significant amount of data used in decision-making today. Due to this, a five-dimensional vision of the functioning system of smart cities was developed, which means understanding information as an essential component that integrates other elements of urban development (economy, society, technology, and policy) and, at the same time, is a source and means of building a proper system of urban governance.

2. On this basis, this research expands the classical view of the three-dimensional sustainability concept integrating science and technology as a separate component of sustainable development. This transforms the conceptual understanding of the main aspects (factors) of sustainable territorial development: sustainable economic growth, sustainable society, sustainable environment, sustainable technologies and science as a source of sustainable innovations that can improve the functioning of all other spheres. The scientific understanding of sustainable urban development as a collaborative and lasting development of the urban economy, society, and the natural, scientific, and

technical environment was emphasised.

3. The most fundamental reason restricting sustainable development is the lack of holistic, systematic, and sustainable policies. The government, which plays the leading role in the design, creation, and management of community development, should contribute to the best combination and performance of the city's functions through proper management. One of the reasons limiting the ability of management regimes in China to ensure sustainable development of cities is the dominance of traditional approaches to management and the limitations of the planned economy system. There is a need to strengthen the strategic and preventive procedures in all areas of city management. The scientific decision-making basis of the urban strategic management and preventative management process is constructing a comprehensive development index system and evaluation model. It is an essential component of the decision support system for urban development planning. It plays a role in the overall process of sustainable urban development, increasing the ability of the management system to achieve the goals set. Sustainable development evaluation measures whether a region has achieved comprehensive and coordinated development from the four dimensions of environment, economy, society, science and technology. The evaluation results can provide a reference for the next stage of managing sustainable urban development: identifying problems, driving factors, and improving policy-making efficiency. This approach is an extension of the interpretation of sustainable urban development's "knowledge-oriented" strategy, and the scientifically-sound evaluation of urban sustainability constitutes the core of this approach.

4. The study makes a theoretical review of urban sustainability evaluation approaches in China and abroad. Although Chinese and foreign scholars have carried out multi-disciplinary and multi-angle designs and attempted a comprehensive review of regional territorial communities' sustainable development, the systemic research in this field is still in its initial stage. Specific research deficiencies still need to be addressed: there are many differences in the dimensions of the index system, from two-dimensional to five-dimensional, each has its reason, and the best extent needs to be studied; whether

the determination of index weight and dimensionless treatment are scientific or not and whether the index's originality is damaged remains to be resolved.

5. Urban sustainable development is a complex system composed of multiple interconnected and interacting subsystems and many elements. Based on the system theory framework, an organic combination of quantitative and qualitative methods, this study constructs the evaluation index system of sustainable urban development, following the principles of index selection (scientificity, completeness, sensitivity, reliability, dynamics, and coordination). Combined with the theoretical framework of the "four-dimensional" interactive structure of sustainable urban development drivers, the index system with three levels and four subsystems is established. It includes 20 measurable indicators in three groups and four subsystems. Analytic hierarchy process, fuzzy comprehensive evaluation and comprehensive index method are still widely used to evaluate sustainable urban development in China and abroad. The index weights in these evaluation models are usually obtained by the expert scoring method, which is too subjective and can only evaluate each system independently but cannot scientifically reflect the interaction between systems. Therefore, it cannot fully and objectively reflect sustainable development performance. The entropy weight–TOPSIS comprehensive evaluation model was proposed to evaluate urban sustainability performance. This approach makes it possible to objectively assess the level of sustainable development of cities and the critical factors through a quantitative assessment of the significance and fluctuations of each parameter's influence. A scale is proposed, which allows, based on the measurement results, to conclude the territory's poor, average, good, and high-quality sustainability performance.

6. The level of urbanisation in China has increased significantly over the past two decades. The intensity of urbanisation processes is apparent; moreover, according to experts' forecasts, in 2025, more than two-thirds of China's population will live in cities. Rapid urbanisation processes considerably impact the social and ecological aspects of the country, exposing a new layer of problems that need to be solved. The issue of "big cities disease" has arisen in many regions of China, affecting public welfare. Unbalanced

development of the economy, environment, society and technology in the different areas of the country leads to the strengthening of agglomeration processes at the coast (leading to additional environmental load). Thus, developed territories experience problems related to a lack of resources, environmental pollution, social disharmony, and lack of space. Science and technology have yet to become a real active, productive force.

7. The entropy weight method is used to empirically analyse the panel data of 31 provinces and cities in China from 2016 to 2019 and evaluate the impacts of the urban environment, economy, society, and science and technology factors. The results show that scientific and technological innovation is the most critical factor affecting sustainable development, followed by economic growth. At the same time, the ecological environment has the most negligible impact on urban sustainability. Through the in-depth analysis of the secondary indicators of the four dimensions, the driving factors of sustainable regional territorial communities in China have been clarified: talent, technology, capital and policy. This research result supports the proposed "four-dimensional" approach's relevance and reliability.

8. The evaluation procedure and evaluation scale were laid as the basis of an improved methodical approach to determining the main priorities of strategic management of the sustainable development of regions, which is based on specific values of parameters and assessments of the level of sustainable development of territorial entities and contributes to the formalisation of the decision-making process (which reduces the influence of the human factor and subjectivity in decision-making). Considering the substantive and structural-process aspects of strategic management, a scheme (algorithm) of actions based on measuring the level of sustainable development was proposed. According to the proposed scheme of the strategic decision-making process, the application of the evaluation system makes it possible to establish the main factors (drivers) of the sustainable development of the territory and further assess the performance of individual regions. The identified drivers should be the main focus in developing sustainable development policies and strategies and, differentiated by region, allow for the formulation of measures that are a priority for one or regional territorial

communities. According to empirical results, the contribution of the four dimensions in promoting sustainable urban development is summarised, and the strategies of urban development in four aspects of science and technology, environment, economy, and society are put forward.

9. The entropy weight-TOPSIS evaluation model was used to calculate the original data further. According to the specific situation, China's 31 provinces and cities were divided into the eastern coastal area, the Beijing-Tianjin-Hebei urban agglomeration, the central, and the western region and detailed empirical analyses were carried out. The sustainability performance in the eastern coastal areas is significantly higher than in the central and western regions, and there is a gradual decline from east to west. The cities of Beijing, Guangdong and Jiangsu have the best sustainability performance, while the towns of Tibet, Qinghai and Ningxia have the worst sustainability performance. Taking relative progress as the research criterion, the urban sustainable development level is divided into four grades: poor, intermediate, good, and high quality. An in-depth analysis of the performance level of each region allows for putting forward policy recommendations for promoting regional territorial communities' sustainable development from multiple perspectives, providing a scientific basis for public servants at all levels to formulate scientifically sound and universal sustainable development policies.

10. Obtained results have practical significance. In particular, the regional sustainable development laws and strategies suggestions proposed in this study can provide an accurate direction for practising the scientific concept of sustainable development. The entropy-weight TOPSIS evaluation model constructed in this study offers a yardstick for measuring the level of environmental, economic, social and technological sustainable development, which is conducive to the scientific assessment of the sustainability performance and can be used by the relevant government departments to manage sustainable development of regional territorial communities in a more efficient and targeted way.

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APPENDIX A

Entropy method intermediate calculations

According to formulas (2.4) and (2.5) (*Section 2*), the information entropy value of each index can be calculated, and the calculation results are shown in Table A.1.

Table A.1 – Information entropy value of each index in 2016-2019

Index	2016	2017	2018	2019
A1	0.9438	0.9423	0.9417	0.9438
A2	0.9811	0.9812	0.9804	0.977
A3	0.9838	0.9716	0.9695	0.9801
A4	0.9878	0.9899	0.9899	0.99
A5	0.9916	0.9938	0.9891	0.9916
B1	0.9396	0.944	0.9432	0.9436
B2	0.9454	0.9444	0.9433	0.9428
B3	0.9941	0.9937	0.9934	0.994
B4	0.9897	0.9891	0.9895	0.9894
B5	0.94	0.9424	0.9481	0.9387
C1	0.9682	0.9657	0.962	0.9616
C2	0.9674	0.9684	0.9733	0.9707
C3	0.9813	0.9848	0.9819	0.9811
C4	0.9316	0.9376	0.9364	0.936
C5	0.9587	0.9679	0.9666	0.9817
D1	0.8976	0.8952	0.8954	0.8983
D2	0.8258	0.8373	0.8655	0.8698
D3	0.9041	0.9024	0.8974	0.8989
D4	0.8958	0.8904	0.8877	0.8876
D5	0.8925	0.8888	0.8733	0.8716

Source: author’s development

APPENDIX B

Entropy-TOPSIS method intermediate calculations

Using formulas (2.8) and (2.10) (*Section 2*), combined with the standardized values of each city index, calculate the positive ideal solution (*A*+) and negative ideal solution (*A*-) of the index. The calculation results are shown in Table B.1.

Table B.1 – Positive and negative ideal solutions in 2016-2019

Index	Positive ideal solution A + / Negative ideal solution A-							
	2016		2017		2018		2019	
A1	0.007	0.001	0.008	0.001	0.008	0.001	0.008	0.001
A2	0.001	0	0.001	0	0.002	0	0.002	0
A3	0.001	0	0.002	0	0.002	0	0.001	0
A4	0.001	0	0.001	0	0.001	0	0.001	0
A5	0	0	0	0	0	0	0	0
B1	0.007	0.001	0.006	0.001	0.007	0.001	0.007	0.001
B2	0.006	0.001	0.006	0.001	0.006	0.001	0.007	0.001
B3	0	0	0	0	0	0	0	0
B4	0	0	0.001	0	0.001	0	0.001	0
B5	0.009	0.001	0.009	0.001	0.008	0	0.01	0.001
C1	0.004	0	0.004	0	0.005	0	0.005	0
C2	0.003	0	0.002	0	0.002	0	0.002	0
C3	0.001	0	0.001	0	0.001	0	0.001	0
C4	0.012	0.001	0.01	0.001	0.011	0.001	0.011	0.001
C5	0.004	0	0.003	0	0.003	0	0.001	0
D1	0.015	0.001	0.016	0.001	0.017	0.001	0.017	0.001
D2	0.06	0.002	0.054	0.002	0.038	0.001	0.034	0.001
D3	0.018	0.001	0.019	0.001	0.021	0.001	0.02	0.001
D4	0.017	0.001	0.021	0.001	0.023	0.001	0.024	0.001
D5	0.018	0.001	0.018	0.001	0.026	0.001	0.026	0.001

Source: author's development