Towards Collaborative Innovation in Government Governance: Leveraging Artificial Intelligence for Enhanced Public Services

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Abstract: *With the rapid advancement of technology and the continuous evolution of society, Artificial Intelligence (AI) has become a key driver of technological development. While AI is accelerating social transformation, it also presents a range of challenges. This study utilizes the Analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation methods to explore collaborative innovation mechanisms for AI-driven government public services. The goal is to enhance governance efficiency and service quality, ultimately fostering sustainable urban development. By analyzing the application of AI in chinese government operations, this research identifies key issues and challenges in leveraging AI for collaborative governance. Based on these findings, the study proposes optimization strategies to strengthen AI's role in government governance in china. This research offers both theoretical and practical insights into the collaborative innovation of AI in public services, providing new perspectives and methodologies for advancing AI-driven government governance.*

Keywords: *Government collaborative governance, artificial intelligence, government public services, public service innovation.*

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1. Introduction

The development of Artificial Intelligence (AI) in China has become a pivotal component of national strategy. With the rapid advancements in information technology and the trend of globalization, both the Chinese government and enterprises have significantly increased their investment and promotional efforts in AI development [41]. The progress of AI is not merely the application of digital technology but also represents a new model of urban development [6]. The utilization of AI spans various aspects such as digital cities, sensor-equipped cities, wireless cities, smart cities, eco-cities, and low-carbon cities. By integrating diverse information resources and fostering smart participation, AI aims to enhance urban management capabilities, optimize resource utilization, and achieve sustainable urban development and improved quality of life for residents [38]. The collaboration between government and enterprises has increasingly become the mainstream model for AI development, with the government providing policy support and infrastructure development, and enterprises driving the progress of the urban AI industry through technological innovation and capital investment [1]. This government-enterprise cooperation model serves as a foundation to promote enhanced urban management capabilities and sustainable economic development.

Traditional urban management models often suffer from issues such as isolated information across departments, resource wastage, and inefficient operations. These obstacles, including inefficiency, uneven resource allocation, and information silos, hinder the improvement of public service levels and the satisfaction of citizens' needs [11]. Furthermore, the traditional one-size-fits-all management approach has struggled to meet the individualized demands of citizens. Enhancing government collaborative governance models has become crucial to addressing these governmental challenges [12]. With the widespread application of AI, government departments are leveraging intelligent technologies to improve public services [21]. By jointly utilizing big data, the Internet of Things (IoT), and other technologies in AI construction, governments can more accurately grasp citizens' needs and the operational status of the city, thereby optimizing resource allocation and policy formulation [23]. This fosters a win-win cooperation framework between governments, enterprises, and social organizations, ultimately enhancing the efficiency and quality of public services and driving innovation and upgrades in the governance system. The application of AI in government collaborative governance allows governments to focus more on personalized and refined public services, achieving precise service provision and enhancing citizen satisfaction and urban governance outcomes. AI can assist governments in better understanding the patterns of city operations through data analysis and mining, making more accurate decisions, optimizing resource allocation, and improving the quality of public services.

The development of China's AI industry faces several challenges. While some developed regions have achieved significant outcomes in AI development, progress in underdeveloped areas remains slow, with relatively lagging technological levels, leading to imbalances in urban governance standards [8]. Meanwhile, with the widespread application of AI and big data technologies, issues of personal privacy data leakage and misuse have become increasingly prominent. If data security and personal privacy cannot be effectively protected, it will affect citizens' trust and support for smart city construction [15]. Furthermore, the development of AI confronts the challenge of innovating and transforming urban collaborative governance systems. The healthy development of the AI industry necessitates government departments to enhance cross-departmental collaboration and information sharing, constructing an open and shared governance platform [17]. However, the current management systems and mechanisms often struggle to adapt to the demands of AI in government collaborative governance. Therefore, to achieve healthy development of the AI industry, it is urgent for the government and various social sectors to undertake systemic and institutional reforms and management innovations.

To comprehensively explore the application of AI in the field of government collaborative governance, this study constructs a multidimensional evaluation framework. Specifically, six key dimensions are identified: efficiency, service quality, data security, social application, social governance, and Pending Challenges. These dimensions are designed to capture both the functional performance of AI technologies and their broader social and institutional implications. In order to assess the relative importance and interrelationships among these dimensions, the Analytic Hierarchy Process (AHP) is first employed to establish a hierarchical evaluation index system and to determine indicator weights through expert judgment. This step ensures that the evaluation framework is both systematic and grounded in rational prioritization. Subsequently, the fuzzy evaluation method is applied to address the inherent ambiguity and uncertainty in qualitative assessments, thereby enhancing the robustness and reliability of the evaluation results.

By integrating the results of AHP hierarchical analysis with the evaluation matrix and weight distribution derived from fuzzy assessment, the study provides an empirical basis for examining the effectiveness of AI in government governance. More importantly, the findings are translated into safeguard measures for collaborative innovation in government oublic services, offering practical recommendations for strengthening the institutional foundations, ethical safeguards, and technological mechanisms that support AI-enabled collaborative governance.

2. Summary

2.1. Application of AI in Government Collaborative Governance

The rapid development of technologies such as AI, IoT, and blockchain has triggered significant societal transformations, offering new possibilities for enhancing the efficiency and quality of public services. Smart city governance represents a novel mode of urban development, with its core focus on leveraging information technology and intelligent means to improve the effectiveness of city management and public services [20]. However, traditional urban governance models face numerous challenges in terms of informatization, data-driven approaches, and service coordination, necessitating innovative solutions to address the increasingly complex urbanization and societal demands [16]. AI is widely used in many aspects, such as machine learning, data mining, and natural language processing have been widely applied in smart city governance [42]. In areas such as intelligent transportation management systems, smart environmental monitoring and early warning systems, as well as intelligent city planning and resource allocation, AI is gradually becoming a crucial support for enhancing the effectiveness of urban governance. The emergence of AI has provided new ways to enhance the fairness of government governance. People are more inclined to use AI in government governance, thereby better achieving automation and fairness in government collaborative governance [13]. The application of AI in government requires consideration of factors such as operational fitness, alignment with societal development in cognition, and whether norms deviate from objectives. In the development of government collaborative governance, interdisciplinary dialogue should be actively promoted, and the operationalization of AI should be encouraged [34]. The proposed N-Conjugate Shuffle Cluster (NCSC), with its high bandwidth, low latency, and linearly scalable architecture, offers important technical support for building large-scale AI computing platforms. Its router-less and highly reliable interconnection mechanism provides a valuable reference for governments seeking to enhance cross-departmental data integration, intelligent decision-making, and real-time governance capabilities [29].

2.2. Concept of Collaborative Innovation in Government Public Services

Collaborative innovation in government public services refers to the cooperative innovation among government departments and their collaboration with social organizations, enterprises, and citizens, with the aim of optimizing resource allocation, enhancing service quality, and improving response efficiency [40]. In the context of smart cities, AI leveraging big data analysis and intelligent decision-making algorithms, provides a scientific basis for government decision-making, enhances governance effectiveness and social satisfaction [4]. The construction of an intelligent service collaboration platform integrates service resources from multiple departments and levels, enabling cross-departmental collaboration and integrated service response, thereby enhancing the timeliness and coverage of services. By utilizing AI to promote information sharing and interaction between the government, citizens, and enterprises, shared governance and democratic participation can be achieved, enhancing the transparency and fairness of public services.

2.3. Exploration of Collaborative Innovation Mechanism for Government Public Services Based on Artificial Intelligence

Collaborative innovation in government public services is a pivotal measure concerning city governance and social progress, with its core lying in achieving collaborative cooperation among governments, enterprises, social organizations, citizens, and other parties, enhancing the quality and efficiency of public services through innovative technologies and methods [9]. From a novel perspective, collaborative innovation in government public services essentially represents a transformation and upgrading of urban governance models [37]. Government public service collaborative innovation represents a reconstruction of the governance system, government public service collaborative innovation emphasizes interaction and co-governance between the government and citizens, fully stimulating citizens' innovative vitality and enthusiasm for participation through the establishment of smart participation platforms, making citizens the main actors and co-builders of governance, and realizing an important pathway for the transformation of the governance system from "government-led" to "collaborative governance between the government and citizens" [5]. Government public service collaborative innovation emphasizes a "people-oriented" approach, focusing on citizens' needs and participation. Based on this philosophy, the government is no longer an isolated decision-maker and executor but participates, decides, and governs together with enterprises, social organizations, and citizens, forming an open, inclusive, and collaborative governance structure [22]. Government public service collaborative innovation introduces innovative technologies and methods to achieve information sharing, resource integration, and decision optimization, enhancing the government's governance capabilities and making urban governance more scientific, democratic, and effective.

2.4. Innovation

This study not only methodologically integrates the advantages of Analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation to construct an effective analytical tool for assessing AI-enabled governance in the public sector, but also theoretically reveals a core issue of ‘‘efficacy-structure mismatch,’’ thereby providing new analytical perspectives and policy implications for future research.

To start with, in terms of research methodology, this study constructs a hybrid analytic model combining AHP and fuzzy comprehensive evaluation, effectively addressing the challenges of informational ambiguity and weight allocation in subjective assessment. Traditional evaluation methods often rely solely on deterministic weighting or direct scoring, which struggle to simultaneously account for both the importance of indicators and the fuzzy nature of actual performance. This research employs the AHP to systematically deconstruct the key dimensions of AI in governmental collaborative governance and scientifically determines the weight of each dimension based on expert judgments through the construction of pairwise comparison matrices, thereby establishing an evaluation framework with a logical structure and clear priority order. Furthermore, the fuzzy comprehensive evaluation method is introduced to process qualitative assessments' fuzzy information via membership functions, converting expert linguistic evaluations of different cities' performances into quantitative scores. This enables a systematic quantification and comparison of actual performance across cities such as Beijing, Shanghai, and Xiamen. Methodological integration combines the rigor of AHP in weight derivation with the flexibility of fuzzy evaluation in handling uncertain information, not only enhancing the scientific validity and reliability of the evaluation results but also providing a replicable research framework for multi-criteria decision-making in similar domains of human-AI collaborative governance.

Besides, at the theoretical level, this study reveals a "structural efficacy mismatch" in AI-enabled governmental collaborative governance through weight-score comparative analysis, expanding the analytical depth and policy implications of research in this field. Unlike existing literature, which often remains confined to descriptive summaries or technical application discussions, this paper uses cross-analysis of AHP weights and fuzzy scores, which uncovers that the actual performance of high-weight dimensions does not significantly outperform that of low-weight dimensions. This manuscript indicates that critical governance aspects have not received sufficient resource investment or performance feedback, highlighting a notable "objective-performance" misalignment. The results expose deep-seated contradictions in current governance practices, such as distorted resource allocation and ambiguous policy priorities, suggesting that the core issue lies not merely in insufficient technological application but more fundamentally in systemic lag in governance structures and organizational collaboration mechanisms. Consequently, this study advocates for a shift from “holistic improvement” to "targeted optimization," recommending that policymakers identify critical shortcomings based on weight-performance disparities and implement tailored resource allocation and institutional designs, thereby advancing AI governance from “usable” to “effective.”

3. Research Method

To systematically evaluate the role of AI in government collaborative governance, this study adopts a combined methodological framework. Considering the multidimensional and complex nature of governance evaluation, it is necessary to employ approaches that can both assign rational weights to indicators and capture the uncertainty inherent in governance processes. To begin with, AHP is utilized to construct the hierarchical evaluation system and determine the relative weights of indicators based on expert judgments. What’s more, to address the fuzziness and ambiguity in qualitative assessments and to enhance the robustness of the evaluation, the fuzzy evaluation method is introduced. By integrating these two methods, the study ensures a more comprehensive and reliable assessment of AI’s contribution to government governance.

3.1. AHP Method

AHP is a multi-criteria decision-making method that integrates both qualitative and quantitative approaches. Its theoretical foundation derives from systems science and decision science, emphasizing the decomposition of problems, pairwise comparisons, and weight calculations to transform complex issues into a structured hierarchical model, thereby assisting decision-makers in making rational judgments under uncertain environments. This method is designed to address complex decision-making factors by decomposing them into different constituent elements and aggregating these elements into a multi-level analytical structure model based on their interrelationships, mutual influences, and subordinate relationships [19]. In this model, the decision-making problem is decomposed into a clear hierarchical structure, including the overall objective, various sub-objectives at different levels, evaluation criteria, and specific alternative solutions. By solving the eigenvector of the judgment matrix, the priority weights of each element at a certain level relative to an element at the previous level can be obtained. The core idea of AHP is to decompose complex problems step by step and establish judgment matrices through pairwise comparisons. The main steps include:

1) Constructing the hierarchical structure model (goal layer-criteria layer-sub-criteria layer-alternative layer).
2) Building the judgment matrices (using Saaty’s 1-9 scale method).
3) Calculating the weight vectors (via the maximum eigenvalue method, geometric mean method, etc.),
4) Conducting consistency tests (Consistency Index, CI; Consistency Ratio, CR),
5) Performing comprehensive ranking and decision-making (progressive weighting to obtain the final scores of alternatives).

The weighted sum method is used to hierarchically merge the final weights of each alternative solution relative to the overall objective, and the alternative with the largest final weight is considered the optimal solution (see Figure 1).

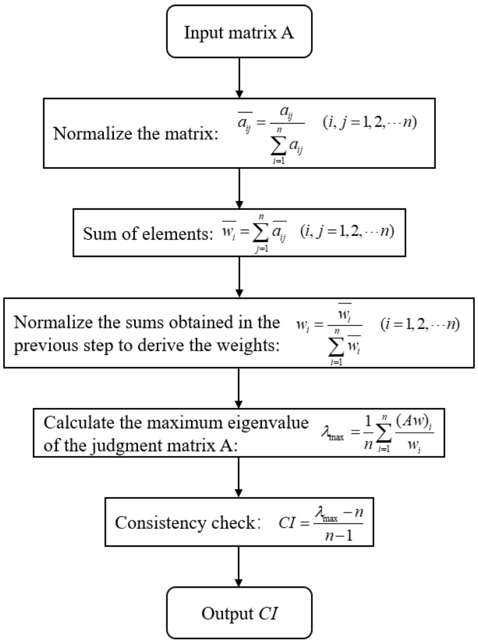

Figure 1. Calculation process of AHP analysis.

3.2. Fuzzy Evaluation Method

Fuzzy evaluation method is a comprehensive evaluation approach based on fuzzy mathematics theory [7]. Fuzzy evaluation method originates from Zadeh’s (1965) fuzzy set theory. Based on fuzzy mathematics, this method introduces fuzziness and uncertainty into evaluation and decision-making processes, making it particularly suitable for problems with complex indicator systems, difficulties in quantification, vague boundaries, or strong subjectivity. Its core idea is to transform qualitative assessments into quantitative results through membership functions, thereby achieving systematic and scientific comprehensive evaluation. It utilizes fuzzy mathematical tools such as fuzzy sets and membership functions to conduct a comprehensive and objective evaluation of things or systems influenced by multiple factors. This method aims to address the ubiquitous fuzziness and uncertainty in the real world, transforming qualitative evaluations into quantitative ones to make the evaluation results more objective and accurate [26]. The fuzzy evaluation method includes several steps: determining the evaluation factor set, establishing the evaluation set, determining weights, constructing the fuzzy evaluation matrix, and performing fuzzy synthesis [36]. Through these steps, fuzzy evaluation method can comprehensively consider multiple factors and their interrelationships, yielding an evaluation result that reflects the overall performance of the thing or system.

The fuzzy evaluation matrix *R* is obtained by quantifying the membership degree of each evaluation factor in the evaluation set through expert scoring, questionnaires, or other methods. Fuzzy synthetic operation is the process of synthesizing the weight vector A and the fuzzy evaluation matrix *R* to obtain the comprehensive evaluation result vector B. Commonly used fuzzy synthetic operators include the weighted average model and the prominent factor model. Taking the weighted average model as an example, its calculation formula is:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{pmatrix} \quad (1)$$

(for j = 1, 2, …, m).

Each element bj in the comprehensive evaluation result vector B indicates the degree to which the evaluated object belongs to the j_{th} evaluation.

In summary, fuzzy evaluation method constructs an evaluation factor set, an evaluation set, a fuzzy evaluation matrix, combines them with the weight vector for fuzzy synthetic operation, and obtains a comprehensive evaluation result. This method has unique advantages in dealing with fuzziness and uncertainty and is widely used in the comprehensive evaluation of various complex systems.

4. Evaluation Dimensions of AI in Government Collaborative Governance

In the rapidly evolving digital era, government sectors are confronted with unprecedented challenges and opportunities. To enhance service efficiency, optimize resource allocation, and improve service quality, the establishment of comprehensive inicator systems has become an indispensable tool. This chapter aims to explore an in tegrated indicator system across dimensions of efficiency, service quality, data security, social applications, social governance capabilities, and challenges, addressing the heightened demands placed on government management and public services in modern society. The efficiency dimension's indicator system is grounded in data analysis and intelligent scheduling, achieving significant improvements in work efficiency through precise resource forecasting and optimized allocation. The service quality dimension focuses on service equity and inclusivity, leveraging satisfaction surveys and innovative interaction modes to enhance service precision and fairness. The data security dimension emphasizes data transparency, authenticity, and compliance, ensuring the safety and legality of data management and usage. The social applications dimension comprehensively evaluates the effectiveness of smart city construction through indicators such as smart cities, smart education, and smart healthcare, promoting the intelligentization and digital transformation of urban management. The social governance capability dimension prioritizes enhancing service levels for vulnerable groups, strengthening social inclusivity and emergency response capabilities, and improving governance transparency and efficiency through data visualization. Lastly, the challenge dimension addresses issues of data privacy, technology implementation, talent gaps, and ethics, ensuring technological advancements proceed while safeguarding public interests. By comprehensively considering indicators across these dimensions, this study provides systematic evaluation tools and decision-making bases for government departments, enabling them to navigate complex social management challenges and laying a solid foundation for enhancing the quality and efficiency of public services

4.1. Efficiency Dimension

To investigate the effectiveness of AI in enhancing collaborative governance, this section establishes efficiency as a key dimension, enabling better evaluation of AI's performance. The construction of the efficiency dimension index system and the selection of indicators are primarily based on the requirements of enhancing efficiency, optimizing resource utilization, and improving service quality [2]. By analyzing and predicting government public service data, AI can achieve precise forecasting and intelligent scheduling of resource demands in various aspects of social life, thereby shortening collaborative governance service cycles and enhancing work efficiency [31]. In talent management, AI's application in intelligent recruitment, customized training programs, and performance evaluation within government collaborative governance optimizes the allocation of talent resources and enhances the operational effectiveness of collaborative governance across government departments. In financial management, AI's ability to generate intelligent budgets and conduct real-time financial monitoring optimizes financial resource utilization, supporting more effective government collaborative decision-making and reducing capital investment [31]. In terms of optimizing material and information transfer, AI enhances the efficiency of material utilization and information transfer between government departments through measures such as infrastructure data sharing, automated process management, and multimodal information transmission. In information transfer, AI ensures transparency in policy implementation and precision in effect evaluation by establishing a sound supervision mechanism and a precise decision support system, further promoting the digital and intelligent transformation of government management. In terms of capital investment, AI contributes to the effectiveness of government collaborative governance by precisely positioning government department operations, intelligent operation, and precise decision-making. The selection and application of these indicators not only assist government departments in effectively addressing complex social management challenges but also lay a solid foundation for improving the quality and efficiency of public services (see Figure 2).

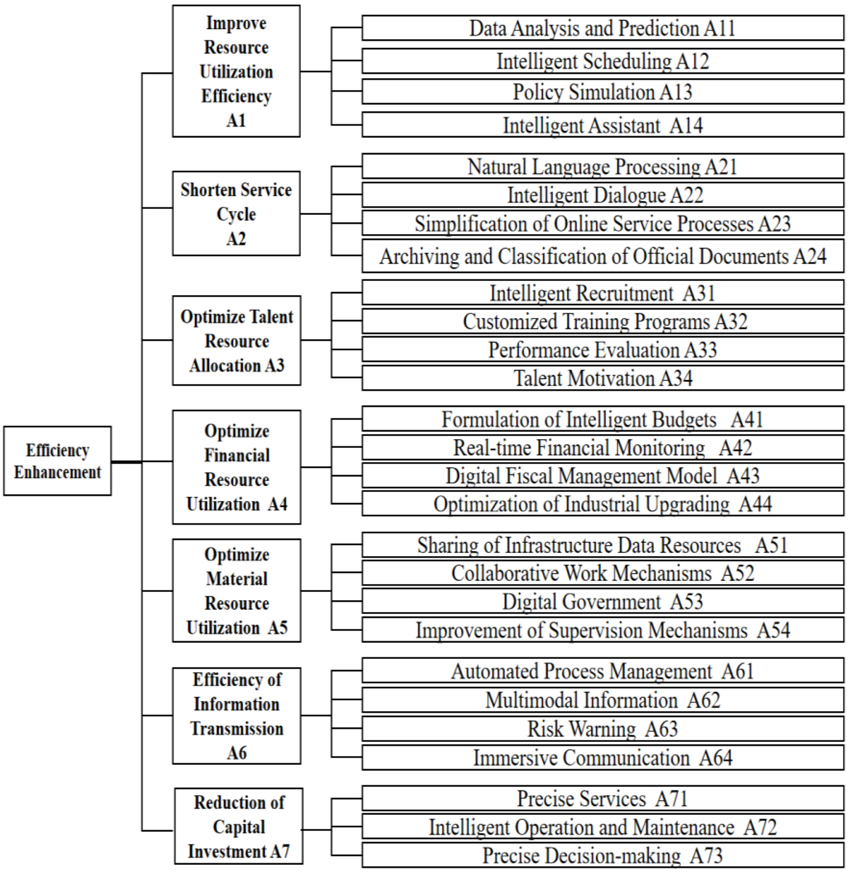

Figure 2. Efficiency dimension model.

4.2. Dimensions of Service Quality

Service quality, as a core indicator of collaborative governance efficiency, encompasses multiple dimensions such as service equity, inclusiveness, and complaint rates, aiming to ensure that every citizen receives fair and unbiased services. By predicting user needs, AI facilitates a more objective law enforcement process in government collaborative governance, further enhancing the pertinence and impartiality of government collaborative governance services [10]. AI breaks geographical limitations in government collaborative governance, provides multi-channel access, and enhances user experience, all of which are aimed at improving service inclusiveness and convenience, enabling more people to easily access the services they need. To quantify the effectiveness of AI in enhancing service quality in government collaborative governance, service quality ratings and satisfaction surveys are introduced, including resident satisfaction, enterprise satisfaction, and satisfaction of other service recipients, which directly reflect the true feelings and needs of service recipients, providing valuable feedback and improvement directions for the application of AI in government collaborative governance [32]. In particular, the introduction of the “good or bad comment” system for government services and new interaction modes makes services closer to the people, while the integrated matching of related items and adjustment of service supply ensure the precision and efficiency of services. In terms of citizen participation, the application of AI in precise information delivery, provision of intelligent platforms, and collaborative governance mechanisms not only broadens the channels for citizen participation but also enhances its convenience and effectiveness. The establishment of an AI-based real-time feedback and early warning system enables the government to quickly respond to public opinions, enhance citizen trust, and ultimately improve citizen satisfaction with participation (see Figure 3).

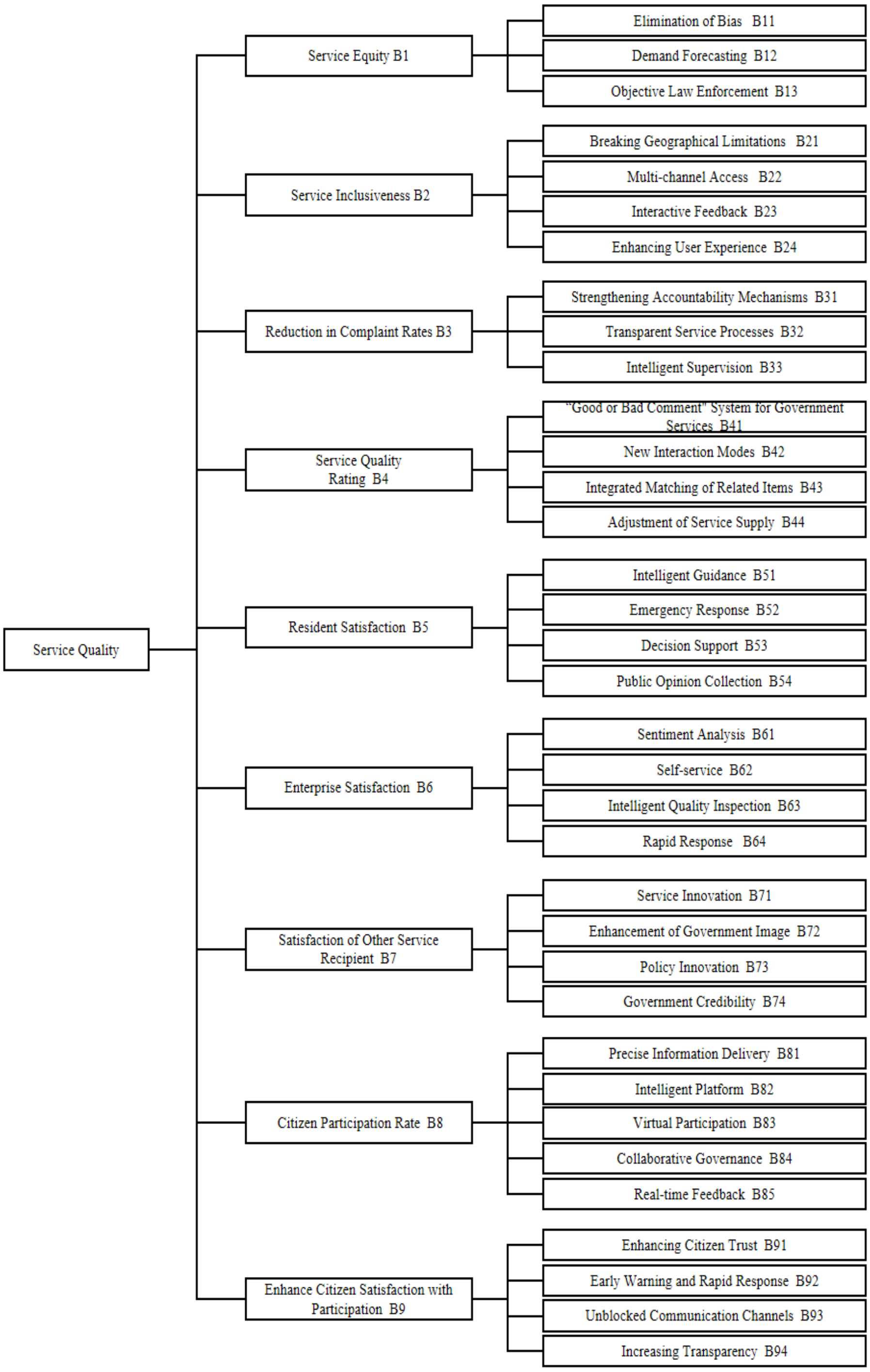

Figure 3. Service quality model.

4.3. Data Security Dimension

To better investigate the application of AI in government collaborative governance, this section establishes a data security indicator system that enables enhanced measurement of AI's data security. The data transparency indicator is designed to ensure that the sources, processing procedures, and outcomes of data are open and transparent during AI's application in government collaborative governance, thereby enhancing data credibility and usability. Data authenticity serves as a fundamental indicator of data value, and the use of AI can assist various government departments involved in collaboration to ensure data accuracy and integrity, preventing decision-making errors or risks caused by data errors or tampering [33]. Data security compliance is a basic requirement for data management and usage, and this indicator is selected to ensure that data collection, storage, processing, and usage in AI applications within government collaborative governance comply with relevant laws, regulations, and standards, thereby avoiding legal risks arising from violations. Stringent personal privacy protection measures can safeguard citizens' personal information security, protect their legitimate rights and interests, and contribute to building harmonious social relationships [30]. By guaranteeing public service data security, network security, and system security, the digital transformation process of public services can be accelerated, improving their efficiency and quality to meet the growing service demands of the populace (see Figure 4).

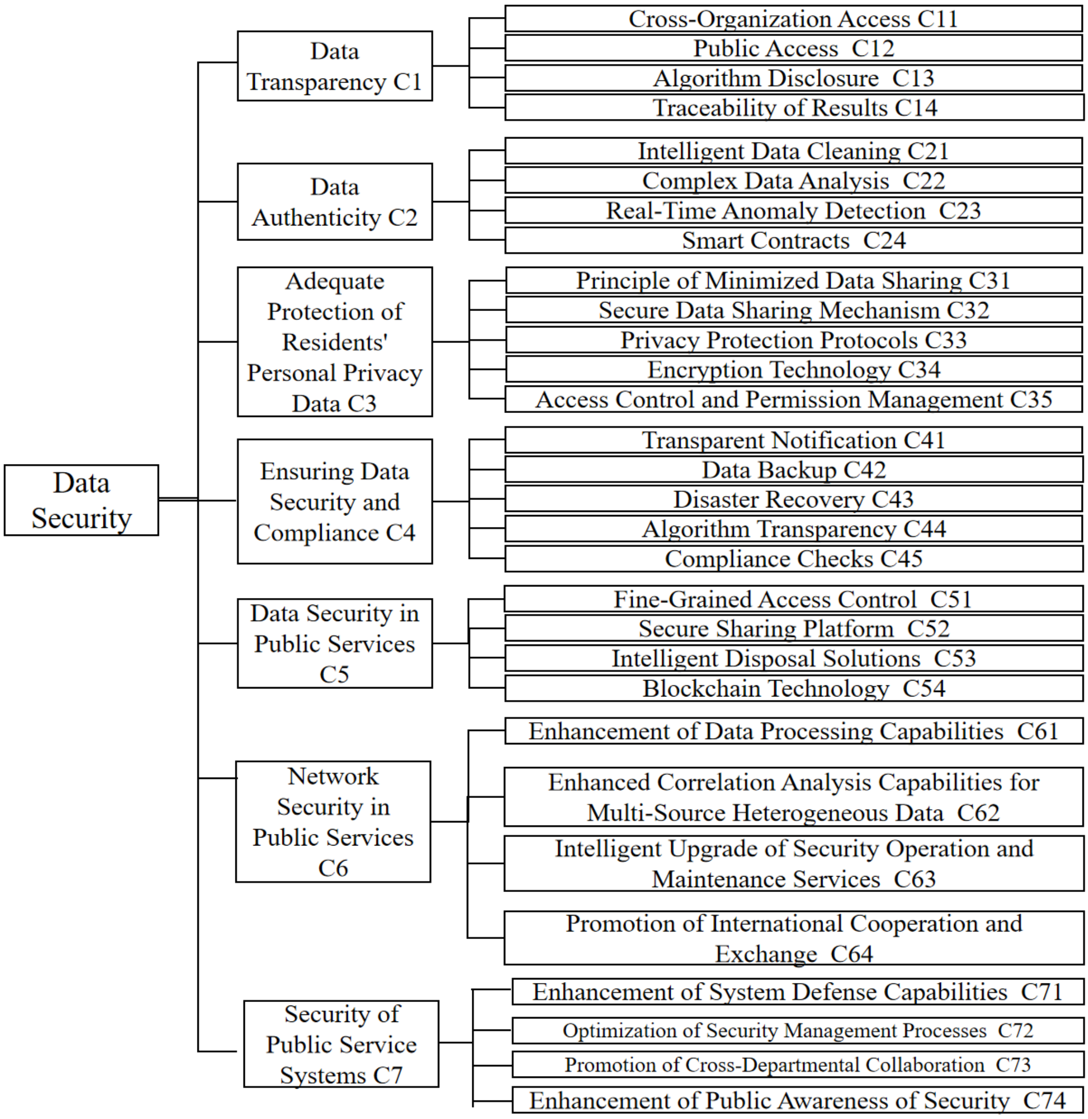

Figure 4. Data security model.

4.4. Social Application Dimension

AI encompasses multiple aspects of smart cities, including public services, safety management, and social governance. Selecting social application indicators can comprehensively measure AI's impact and degree of improvement on various societal fronts, such as enhancing service efficiency and optimizing resource allocation [28]. In urban construction, AI's applications involve building energy efficiency, intelligent management, and indoor environmental quality. In the field of education, AI primarily focuses on the digitization of educational resources, personalized teaching services, and the intellectualization of learning environments. Within communities, AI's application draws more attention to community governance, the enhancement of residents' quality of life, and the convenience and intelligence of community services, thereby strengthening residents' sense of happiness and belonging.In the social environment sector, AI encourages greater focus on environmental monitoring, resource management, and ecological protection. In the energy sector, AI's deployment involves intelligent management of energy supply, optimization, and conservation of energy consumption.

The adoption of AI aims to enhance residents' quality of life and happiness by improving their living conditions through smart services and environmental optimization. By establishing AI application indicators for various aspects of social life, we can comprehensively assess the progress and effectiveness of smart city construction in different fields, provide scientific bases for decision-makers, promote the digitization and intelligence of urban management, and improve the efficiency and response speed of city administration (see Figure 5).

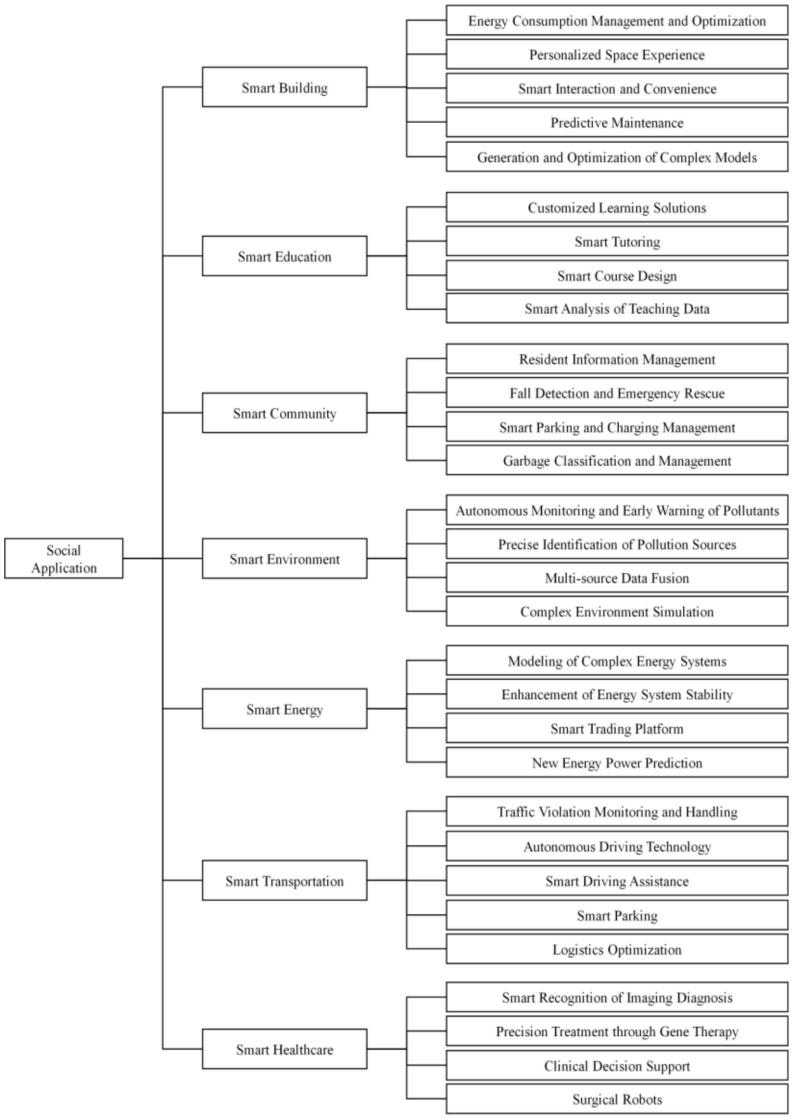

Figure 5. Social application model.

4.5. Social Governance Dimension

The application of AI in government collaboration focuses on the basic living needs and rights to protect the most vulnerable groups in society, such as the poor and people with disabilities. Enhancing social inclusiveness in urban governance reduce social division and inequality, promoting harmonious social development and long-term stability. By focusing on the needs of vulnerable groups through AI, it can be ensured that social governance addresses and resolves the various issues faced by these groups, improving their quality of life and social integration. AI enables government collaborative governance to focus more on participation opportunities and equal treatment for all social groups, driving inclusive development in social governance. Strengthening emergency response capabilities effectively addresses emergencies and disasters, reducing disaster losses and safeguarding public safety and life and property. To focus on AI's emergency response capabilities during social emergencies and disasters, emergency response capability indicators are selected, thereby enhancing the agility and effectiveness of governments and social organizations in responding to emergencies and ensuring public safety and security. Data visualization enhances the scientific nature and precision of decision-making, helping governments and social organizations better formulate and adjust policies and measures to solve complex problems in social governance. Through data openness and visualization, the transparency of social governance is enhanced, allowing the public to have a clearer understanding of the progress and effectiveness of government work, thereby increasing trust and support for the government. AI enhances the scientific nature and efficiency of decision-making through data analysis and visualization. To measure the role of AI in data transparency and effective utilization during the social governance process, data visualization indicators are selected to enhance the transparency and credibility of government collaborative governance. Through the integrated application of these indicators, the modern transformation of the social governance system is promoted, enhancing governance effectiveness and the overall level of social development (see Figure 6).

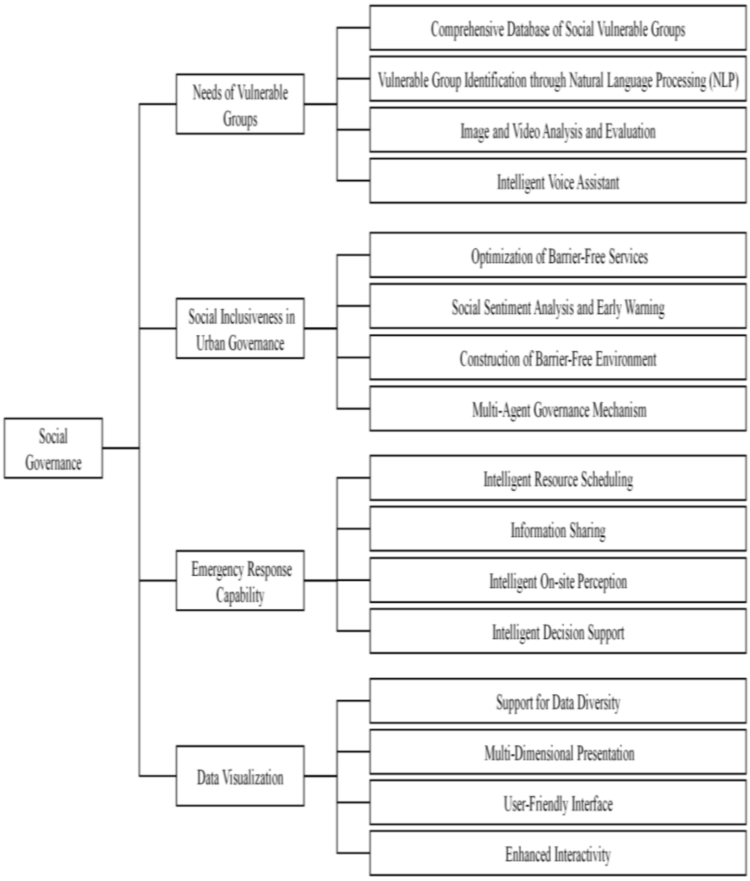

Figure 6. Social governance model.

4.6. Pending Challenges Indicator Dimensions

AI has emerged as a transformative force in the modernization of public administration, particularly in facilitating collaborative governance across multiple stakeholders [14]. By enhancing data-driven decision-making, optimizing resource allocation, and improving the efficiency of service delivery, AI holds great promise in addressing complex societal challenges. However, its integration into collaborative governance structures is not without significant barriers. Several critical issues and challenges must be acknowledged and systematically addressed to ensure the effective and responsible application of AI technologies.

1) Data fragmentation and interoperability barriers. One of the foremost challenges is the fragmentation of data resources across departments, regions, and sectors. Government agencies, private enterprises, and social organizations often maintain separate databases with heterogeneous standards and incompatible formats. This lack of interoperability not only hampers real-time information sharing but also constrains the construction of integrated AI governance models. Without unified protocols for data exchange and quality assurance, AI systems are likely to produce biased or incomplete outputs, undermining the effectiveness of collaborative governance.

2) Privacy protection and ethical concerns. The deployment of AI in governance requires the collection and analysis of massive volumes of personal and urban data, which inevitably raises concerns over privacy, data ownership, and algorithmic fairness. Inadequate legal safeguards may lead to unauthorized data usage, discriminatory decision-making, and erosion of public trust. Ethical governance frameworks and stringent data protection mechanisms are therefore indispensable to balance efficiency with legitimacy.

3) Algorithm transparency and accountability. Most AI systems, particularly deep learning models, function as "black boxes" that provide little insight into their decision-making processes. In collaborative governance, where inclusiveness and accountability are fundamental principles, the absence of explainability can undermine legitimacy and limit the willingness of stakeholders to adopt AI-based recommendations. Ensuring algorithm transparency and enabling mechanisms for external audit are essential steps toward building public confidence.

4) Uneven technological capacity and resource allocation. There exists a significant disparity in the availability of digital infrastructure, technological expertise, and financial resources across regions and institutions. While advanced cities or agencies may integrate AI seamlessly, less developed areas often

lack the capacity to deploy such systems, thereby reinforcing pre-existing governance inequalities. This uneven diffusion of AI technologies challenges the principle of balanced and inclusive governance.

5) Institutional resistance and governance culture. AI-driven governance requires adaptive institutional frameworks and cross-sectoral collaboration. However, entrenched bureaucratic structures, siloed administrative boundaries, and resistance to organizational change frequently impede AI adoption. Building a culture of openness, inter-agency trust, and shared responsibility is a prerequisite for overcoming institutional inertia.

6) Risk of over-reliance on technology. While AI can enhance efficiency, an overemphasis on automation may neglect the value of human judgment, contextual sensitivity, and civic participation. Such technocratic governance risks marginalizing vulnerable groups and weakening the democratic legitimacy of collaborative processes.

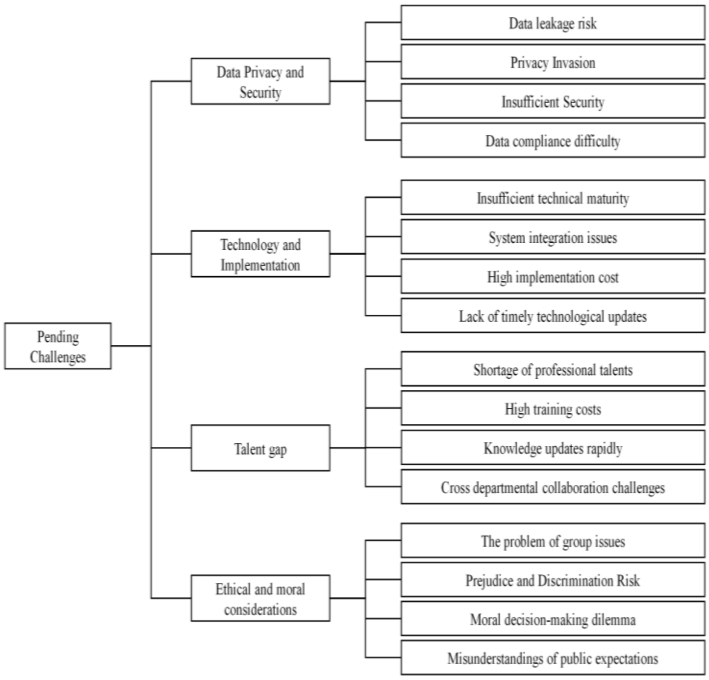

Figure 7. Pending challenges model.

As AI faces various challenges in its application process, to address this, establishing an indicator system for the challenges faced in AI application can enable governments to identify and assess data privacy, technical implementation, talent gaps, and ethical risks during collaborative governance [24]. This allows for the proactive adoption of preventive and control measures to reduce operational risks and legal liabilities. Through data analysis and indicator monitoring, resource allocation can be optimized, effectively addressing technical implementation challenges and talent shortages, and enhancing organizational operational efficiency and competitiveness [3]. In a data-driven environment, protecting personal privacy and data security is crucial. Faced with a rapidly changing technological environment, AI can be used to assess the maturity and feasibility of technologies, leading to the selection of the most suitable technical solutions for implementation. Modern technologies like AI require high-end talent, yet there is a significant gap between talent supply and demand in the market. Establishing an AI talent indicator system involves assessing the effectiveness of talent training and recruitment strategies, as well as the enhancement of employees' technical capabilities and quality, to help enterprises and organizations address talent bottlenecks. The indicator system for challenges faced in AI application ensures that government collaborative governance adheres to laws, regulations, and industry standards in data management, technology application, talent development, and ethical behavior, enhancing public trust and recognition of organizations. It provides a scientific basis for government collaborative governance strategic planning and decision-making, guiding long-term development and innovative implementation, and promoting organizations towards advanced technology, compliance, and efficiency (see Figure 7).

5. Result analysis

The evaluation outcomes derived from the integrated delphi-AHP approach and fuzzy comprehensive assessment are systematically interpreted in this section, aiming to elucidate the structural relationships and performance gaps among various governance dimensions. The synthesized expert opinions and pairwise comparisons provide a robust foundation for evaluating the relative importance of each dimension.

5.1. Delphi-AHP Evaluation

To conduct a more professional analysis of the effectiveness of AI in government collaborative governance, this section employs the delphi method for evaluation. The government, as the purchaser of public services, and social forces, as the service providers, can offer valuable insights into the directivity and relevance of evaluation indicators based on their work experience. Staff from social forces actively keep abreast of social dynamics, understand the latest news on technological development, and are aware of pressing challenges that need to be addressed. Scholars, with their long-term academic exploration of related issues, can provide professional perspectives on theoretical frameworks and indicator logic. Given that both theoretical understanding and practical experience play irreplaceable roles in indicator design, this study selects experts from three domains: 30 government staff engaged in purchasing services, 30 staff from social forces undertaking public services, and 30 university scholars conducting relevant research, to collect their opinions. According to the research design, this study distributes a total of 90 questionnaires through direct provision of paper copies and electronic versions, with 86 valid questionnaires returned, achieving an effective response rate of 95.6% (see Figure 8).

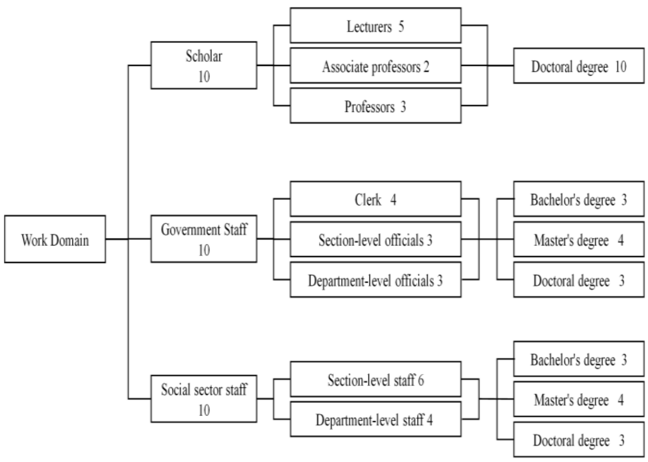

Figure 8. Overview of basic information of experts consulted in the delphi method.

5.1.1. Hierarchical-Delphi Analysis Results of First-Level Index Weights

The judgment matrix constructed through the Delphi method evaluates AI models, providing a systematic quantitative assessment for the application of AI in government collaborative governance while establishing a scientific foundation for the relative importance of various factors in the hierarchical structure model. In the process of delphi method evaluation, experts assess the relative impact of each factor on other factors through pairwise comparisons of different factors, thereby forming a detailed judgment matrix. These evaluation results can help understand and quantify the relationships between different factors, providing a deep understanding of the relative importance of AI in enhancing efficiency, service quality, data security and transparency, social applications, social governance, and addressing challenges, thus offering important references for subsequent strategic planning and decision-making, which will comprehensively promote the development and optimization of technologies and social governance. According to the formula for calculation, the results of each matrix are obtained as follows in Table 1:

Table 1. Results of AHP hierarchical analysis.

Indicator	Eigenvector	Weight (%)	Largest eigenvalue	CI
Efficiency enhancement	1.274	25.476	5.078	0.02
Service quality	1.803	36.064		
Data security	0.892	10.005		
Social application	0.535	10.697		
Social governance	0.496	9.927		
Pending challenges	0.451	7.830		

By employing the AHP for weight calculation, the hierarchical structure of challenges faced by artificial intelligence in enhancing efficiency (C1), service quality (C2), data security and transparency (C3), social application (C4), social governance (C5), and encountered difficulties (C6) can be observed. According to the calculation results, service quality (C2) is assigned the highest weight of 36.064%, indicating that improving service quality is considered one of the most crucial factors in the application of artificial intelligence in government collaborative governance. This is followed by enhancing efficiency (C1) with a weight of 25.476%, demonstrating its significant influence in decision-making. Data security and transparency (C3), social application (C4), social governance (C5), and encountered difficulties (C6) respectively have weights of 10.005%, 10.697%, 9.927%, and 7.830%, reflecting their smaller but still notable roles in the overall decision-making process of AI in government collaborative governance. During the consistency check, the maximum eigenvalue is 5.078, corresponding to a consistency index (RI) value of 1.11. The calculation yields $CR=CI/RI=0.018< 0.1$, satisfying the consistency test.

5.1.2. Hierarchical-Delphi Analysis Results of Second-Level Index Weights

After completing the weight analysis of the first-level indicators, this paper further delves into the hierarchy of second-level indicators by inviting experts to conduct pairwise comparisons among them, aiming to reveal their relative importance and interrelationships, in order to more thoroughly explore and evaluate the specific roles of various factors under the overall goal of government collaborative governance improving.

5.1.3. Efficiency Enhancement Scoring Matrix

The effectiveness of AI in enhancing government collaborative governance can be refined through the study of secondary indicators, enabling targeted application of AI and achieving advancements in technology alongside improvements in government collaboration efficiency. Results of AHP Hierarchical analysis of efficiency enhancement is shown in Table 2:

Table 2. Results of AHP hierarchical analysis of efficiency enhancement.

Indicator	Eigenvector	weight (%)	largest eigenvalue	CI
Improve Resource Utilization Efficiency A1	1.239	16.396	8.201	0.029
Shorten Service Cycle A2	0.346	6.328		
Optimize Talent Resource Allocation A3	0.406	7.079		
Optimize Financial Resource Utilization A4	2.21	29.623		
Optimize Material Resource Utilization A5	0.671	9.384		
Efficiency of Information Transmission A6	1.654	22.679		
Reduction of Capital Investment A7	0.524	8.551		

The weight calculation results using AHP reveal that financial resource optimization (C14) holds the highest weight of 29.623%, indicating that effective management and optimization of financial resources are crucial factors in enhancing resource utilization efficiency. efficiency of information transmission (C16) has a weight of 22.679%, highlighting the importance of smooth and efficient information flow for achieving overall objectives. Improve resource utilization efficiency A1 occupies 16.396% of the total weight, demonstrating that effective allocation and management of resources are also vital. Although the weights of optimize material resource utilization A5 and reduction of capital investment A7 are lower, at 9.384% and 8.551% respectively, they still play significant roles in improving overall resource utilization efficiency. In the data analysis, the maximum eigenvalue is 8.201, with a corresponding consistency index (CI) of 0.02. By referencing the random consistency ratio (RI) table, the RI value is calculated to be 1.404, yielding a Consistency Ratio (CR) of 0.02/1.404 = 0.02, which is less than the standard of 0.1, thus passing the one-time test.

5.1.4. Service Quality Scoring Matrix

To quantify and evaluate the relative importance and influence relationships among various factors in the service quality model through the delphi method, multiple scoring matrices are constructed to deeply explore the importance and impact of AI in enhancing service quality in government collaborative governance. Table 3 is the results of service quality results of AHP.

Table 3. Service quality results of AHP.

Indicator	Eigenvector	Weight (%)	Largest eigenvalue	CI
Service equity B1	0.835	9.283	9.259	0.032
Service inclusiveness B2	0.479	5.322		
Reduction in complaint rates B3	0.335	3.728		
Service quality rating B4	0.588	6.537		
Resident satisfaction B5	2.323	25.811		
Enterprise satisfaction B6	0.485	5.393		
Satisfaction of other service recipient B7	1.416	15.733		
Citizen participation rate B8	1.02	11.338		
Enhance citizen satisfaction with participation B9	1.517	16.855		

The weight calculation results using AHP with the sum-product method reveal that service equity B1 has a weight of 9.283%, indicating its significant contribution to service quality, especially when considering social justice and equality in service delivery. Service Inclusiveness B2 has a weight of 5.322%, reflecting the moderate impact of service accessibility on overall service quality, particularly in terms of user experience and service efficiency. Reduction in Complaint Rates B3 has a weight of 3.728%, with a low complaint rate generally indicating high service quality, which is particularly important in assessing service providers' ability to maintain high standards and customer satisfaction. Service quality rating B4 has a weight of 6.537%, highlighting the importance of quantitative assessments of service quality, necessitating the establishment of an objective scoring system to aid service providers in continuously improving and managing service quality. Resident satisfaction B5 has the highest weight of 25.811%, emphasizing that the satisfaction of end-users of AI dominates the overall service quality assessment, and the core objective of service quality should be to enhance resident satisfaction. Enterprise Satisfaction and satisfaction of other service recipient B7 have weights of 5.393% and 15.733% respectively, reflecting the perspectives and needs of other relevant stakeholders beyond the end-users, indicating that assessments of service quality in social public services involving artificial intelligence require comprehensive consideration of multiple interests. Citizen participation rate B8 and enhance citizen satisfaction with Participation B9 have weights of 11.338% and 16.855% respectively, highlighting the importance of artificial intelligence in social participation and democratic decision-making processes, and suggesting that assessments of service quality should not be limited to the technical aspect but also need to consider the perspectives of public participation and feedback. The maximum eigenvalue of these indicators is 9.259, and the corresponding RI value from the RI table is 1.451. Therefore, CR=CI/RI=0.022<0.1, indicating that the consistency test is passed.

5.1.5. Data Security Scoring Matrix

Based on the aforementioned analysis, this paper further delves into the importance and impact of AI in promoting data security and transparency, a crucial metric in evaluating the construction of government collaborative governance. Table 4 displays the results of AHP of data security.

Table 4. Results of AHP of data security.

Indicator	Eigenvector	Weight (%)	Largest eigenvalue	CI
Data transparency C1	0.365	5.221	7.184	0.031
Data authenticity C2	1.613	23.041		
Adequate protection of residents' personal privacy data C3	2.262	32.313		
Ensuring data security and compliance C4	1.105	15.781		
Data security in public services C5	0.383	5.471		
Network security in public services C6	0.551	7.87		
Security of public service systems C7	0.721	10.303		

The weight calculation results using AHP show that the weight of fully protecting residents' personal privacy data (C3) is 32.313%, occupying the primary position, indicating that residents have a strong desire to protect their data privacy. In the application of AI in government collaborative governance, how to strengthen the protection of residents' privacy is an urgent issue to be addressed. The weight of data authenticity (C2) is 23.041%, indicating that government collaborative governance should strengthen data verification. The use of AI should reflect the true aspects of society, and only then can it provide feasible suggestions for government governance. The maximum eigenvalue of each indicator is 7.184. According to the RI table, the corresponding RI value is 1.341. Therefore, CR =CI/RI=0.023<0.1, passing the consistency test.

5.1.6. Social Application Scoring Matrix

To delve deeper into the application of AI in the process of government collaborative governance, this paper continues to explore the key indicators and their interrelationships in social application areas, based on a comprehensive analysis of critical indicators such as efficiency enhancement, service quality, and data security and transparency. Results of social application AHP is shown in Table 5:

Table 5. Results of social application AHP.

Indicator	Eigenvector	Weight (%)	largest eigenvalue	CI
Smart building D1	0.754	10.767	7.205	0.034
Smart education D2	1.634	23.344		
Smart community D3	2.277	32.533		
Smart environment D4	1.085	15.504		
Smart energy D5	0.29	4.147		
Smart transportation D6	0.422	6.035		
Smart healthcare D7	0.537	7.669		

The weight calculation results using the AHP with the sum-product method reveal the distribution of importance across different sectors in smart city development. Notably, smart community and smart education hold higher weights of 32.533% and 23.344% respectively, indicating that the AI application in community and education sectors is prioritized in urban development. Meanwhile, smart building, smart environment, smart transportation and smart healthcare level also occupy certain proportions, reflecting the importance of AI in multiple aspects of city construction. The largest eigenvalue is 7.205, and the corresponding RI value from the RI table is 1.341. Therefore, the CR is calculated as CI/RI=0.026< 0.1, indicating that the consistency test is passed.

5.1.7. Social Governance

Balancing diverse needs, enhancing management efficiency, and ensuring fairness and effectiveness in decision-making pose ongoing challenges in planning and formulating urban governance policies. To ensure the scientific and rational nature of urban governance policies, various evaluation methods and tools are widely employed. results of social governance AHP are shown in Table 6:

Table 6. Results of social governance AHP.

Indicator	Eigenvector	Weight (%)	Largest eigenvalue	CI
Needs of vulnerable groups E1	0.366	34.571	4.34	0.037
Social inclusiveness in Urban governance E2	1.547	29.338		
Emergency response capability E3	0.786	19.825		
Data visualization E4	0.572	16.266		

The results of the weight calculation using the AHP indicate that the needs of vulnerable groups (E1) and social inclusiveness in urban governance (E2) are considered the most important factors, accounting for 34.571% and 29.338% of the weight respectively. This suggests that in urban governance, addressing the needs of vulnerable groups and enhancing social inclusivity are seen as priority directions, which are closely related to social equity and public satisfaction. The relatively low weight of emergency response capability(E3), which is 19.825%, indicates that urban emergency governance receives less attention in urban governance strategies, requiring more policy focus and resource allocation to increase its significance. The maximum eigenvalue is 4.34, and the corresponding RI value from the RI table is 1.404. Therefore, CR=CI/RI=0.023< 0.1, passing the consistency test.

5.1.8. Pending Challenges Indicator Dimensions

To assess the dilemmas posed by AI in government collaborative governance, a scoring matrix constructed using the delphi method and the AHP analysis are employed to conduct a multi-dimensional analysis,this aims to clarify the challenges faced by AI in government collaborative governance and pave the way for its better development (see in Table 7).

Table 7. AHP Results of pending challenges

Indicator	Eigenvector	Weight (%)	Largest eigenvalue	CI
Data privacy and security F1	3.366	44.571	4.16	0.035
Technology and implementation F2	1.547	19.338		
Talent gap F3	0.925	21.564		
Ethical and moral considerations F4	1.201	14.527		

From the above analysis, it can be seen that the eigenvector value of data privacy and security (F1) is 3.366, with a weight of 44.571%, indicating that data privacy and security are regarded as the greatest challenge faced by AI development in government collaborative governance, occupying the largest proportion of weight. The eigenvector value of technology and implementability is 1.547, with a weight of 19.338%, suggesting that technology and implementability of AI occupy a relatively smaller weight among the challenges faced by government collaborative governance, but they are still important considerations. The eigenvector value of talent gap (C57) is 0.925, with a weight of 21.564%, ranking third in weight among the four indicators, indicating that the talent gap is a significant aspect of the challenges faced by AI development. The eigenvector value of ethical and moral considerations (C58) is 1.201, with a weight of 14.527%. Although its weight is relatively low, the ethical and moral considerations faced by AI are still a factor that cannot be ignored in the application of AI in government collaborative governance. The maximum eigenvalue of each indicator is 4.16, indicating good consistency in the matrix. The consistency index (CI) value is 0.035, suggesting that the judgment matrix has good consistency.

5.1.9. Summary Weight Result

Based on the detailed analysis of key indicators in the aforementioned areas, Table 8 presents the weight allocation and comprehensive weights of each primary indicator and its subordinate secondary indicators in smart city construction. These weight results provide a comprehensive perspective, revealing the relative importance of AI in enhancing efficiency, service quality, data security, social applications, social governance, and the challenges faced in government collaborative governance.

Based on the weight analysis results in Table 8, a deep understanding of the importance and contributions of various primary and secondary indicators of AI in government collaborative governance can be gained. In the overall weight allocation, service quality occupies the highest proportion (36.06%), highlighting the crucial role of AI in city governance. Followed by efficiency improvement (25.48%), data security and transparency (17.84%), social applications (10.70%), social governance (4.06%), and the challenges faced (5.87%), these areas demonstrate the relative importance of AI in driving the development of government collaborative governance. The specific weight analysis of secondary indicators shows that, for example, resident satisfaction (25.81%) and financial resource optimization (27.62%) play significant roles within their respective primary indicators of service quality. Additionally, the full protection of residents' personal privacy data (32.31%) and information transmission efficiency (20.68%) in the data security and transparency section reflect the importance of AI in ensuring data security and enhancing information transmission efficiency in government collaborative governance.

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Table 8. Weight result of indicators.

Primary index	Weight	Secondary indicators	Weight	Comprehensive weight
Efficiency enhancement	0.2548	Improve resource utilization efficiency A1	0.1548	0.0394
		Shorten service cycle A2	0.0433	0.0110
		Optimize talent resource allocation A3	0.0508	0.0129
		Optimize financial resource utilization A4	0.2762	0.0704
		Optimize material resource utilization A5	0.0838	0.0214
		Efficiency of information transmission A6	0.2068	0.0527
		Reduction of capital investment A7	0.0655	0.0167
		Improve resource utilization efficiency A8	0.1187	0.0302
Service quality	0.3606	Service equity B1	0.0928	0.0335
		Service inclusiveness B2	0.0532	0.0192
		Reduction in complaint rates B3	0.0373	0.0134
		Service quality rating B4	0.0654	0.0236
		Resident satisfaction B5	0.2581	0.0931
		Enterprise satisfaction B6	0.0539	0.0194
		Satisfaction of other service recipient B7	0.1573	0.0567
		Citizen participation rate B8	0.1134	0.0409
		Enhance citizen satisfaction with participation B9	0.1686	0.0608
Data security	0.1784	Data transparency C1	0.0522	0.0093
		Data authenticity C2	0.2304	0.0411
		Adequate protection of residents' personal privacy data C3	0.3231	0.0576
		Ensuring data security and compliance C4	0.1578	0.0281
		Data security in public services C5	0.0547	0.0098
		Network security in public services C6	0.0787	0.0140
		Security of public service systems C7	0.1030	0.0184
Social aplication	0.1070	Smart building D1	0.1077	0.0115
		Smart education D2	0.2334	0.0250
		Smart community D3	0.3253	0.0348
		Smart environment D4	0.1550	0.0166
		Smart energy D5	0.0415	0.0044
		Smart transportation D6	0.0604	0.0065
		Smart healthcare D7	0.0767	0.0082
Social governance	0.0406	Needs of vulnerable groups E1	0.0457	0.0045
		Social inclusiveness in urban governance E2	0.1934	0.0192
		Emergency response capability E3	0.0983	0.0098
		Data visualization E4	0.0716	0.0071
Pending challenges	0.0587	Data privacy and security F1	0.2738	0.0272
		Technology and implementation F2	0.0516	0.0051
		Talent gap F3	0.1156	0.0115
		Ethical and moral considerations F4	0.1501	0.0149

Based on the weight analysis results in Table 8, a deep understanding of the importance and contributions of various primary and secondary indicators of AI in government collaborative governance can be gained. In the overall weight allocation, service quality occupies the highest proportion (36.06%), highlighting the crucial role of AI in city governance. Followed by efficiency improvement (25.48%), data security and transparency (17.84%), social applications (10.70%), social governance (4.06%), and the challenges faced (5.87%), these areas demonstrate the relative importance of AI in driving the development of government collaborative governance. The specific weight analysis of secondary indicators shows that, for example, resident satisfaction (25.81%) and financial resource optimization (27.62%) play significant roles within their respective primary indicators of service quality. Additionally, the full protection of residents' personal privacy data (32.31%) and information transmission efficiency (20.68%) in the data security and transparency section reflect the importance of AI in ensuring data security and enhancing information transmission efficiency in government collaborative governance.

5.2. Fuzzy Evaluation

To better study the role of AI in government collaborative governance, this paper distributes and collects questionnaires targeting scholars, government staff, and social force personnel, ensuring data diversity and representativeness. The questionnaire design covers multiple important aspects, including resource utilization efficiency, service processes, optimization of human and financial resource utilization, information transmission efficiency, service equity, complaint rates, service quality ratings, satisfaction of residents and businesses, citizen participation rates and satisfaction, data transparency and security, and challenges faced. To better analyze the data, a combination of online and offline methods is adopted to facilitate questionnaire distribution and collection. The questionnaire sets a five-level comment set, denoted as U, where U= {U1, U2, U3, U4, U5}={very dissatisfied, dissatisfied, average, satisfied, very satisfied}, and a score set denoted as P, where P={P1, P2, P3, P4, P5}={1, 2, 3, 4, 5}.In this section, a total of 500 questionnaires were distributed, with 481 valid questionnaires collected, resulting in a questionnaire validity rate of 96.2%.

5.2.1. Determining Indicator Membership Degrees

Ensuring the objectivity and scientific rigor of the investigation and research, this paper invited 200 experts to participate in a questionnaire evaluation to assess various indicators of AI's role in collaborative government governance. The analysis of the fuzzy matrix enables us to identify the factors that play the most significant roles in promoting the process of artificial intelligence facilitating collaborative government governance. It not only reflects the relative importance among various factors but also reveals their contribution to the overall synergistic effect, thus providing policymakers with clear directions for optimization and strategic suggestions. The construction of matrix, based on the fuzzy comprehensive evaluation of each primary indicator, transforms qualitative evaluations into a more comparable and operable data form through quantitative processing, allowing for the analysis and identification of the factors with the greatest influence of artificial intelligence in government collaborative governance. The evaluation matrices for each primary indicator are as follows:

$$Efficiency\ Enhancement\ Evaluation\ Matrix: R_1 = \begin{pmatrix} 0 & 0 & 0.35 & 0.52 & 0.12 \\ 0 & 0 & 0.36 & 0.42 & 0.15 \\ 0 & 0 & 0.38 & 0.45 & 0.12 \\ 0 & 0 & 0.38 & 0.44 & 0.13 \\ 0 & 0 & 0.28 & 0.53 & 0.14 \\ 0 & 0 & 0.44 & 0.35 & 0.11 \\ 0 & 0 & 0.15 & 0.31 & 0.16 \\ 0 & 0 & 0.27 & 0.42 & 0.14 \end{pmatrix} \tag{2}$$

$$Service\ Quality\ Evaluation\ Matrix:\ R_2 = \begin{pmatrix} 0 & 0 & 0.42 & 0.27 & 0.12 \\ 0 & 0 & 0.31 & 0.44 & 0.13 \\ 0 & 0 & 0.36 & 0.34 & 0.08 \\ 0 & 0 & 0.42 & 0.35 & 0.13 \\ 0 & 0 & 0.38 & 0.37 & 0.12 \\ 0 & 0 & 0.33 & 0.48 & 0.11 \\ 0 & 0 & 0.36 & 0.42 & 0.12 \\ 0 & 0 & 0.44 & 0.34 & 0.12 \\ 0 & 0 & 0.37 & 0.40 & 0.10 \end{pmatrix} \tag{3}$$

$$Data\ Security\ and\ Transparency\ Evaluation\ Matrix: R_3 = \begin{pmatrix} 0 & 0 & 0.30 & 0.47 & 0.11 \\ 0 & 0 & 0.30 & 0.43 & 0.12 \\ 0 & 0 & 0.45 & 0.21 & 0.08 \\ 0 & 0 & 0.42 & 0.37 & 0.09 \\ 0 & 0 & 0.44 & 0.31 & 0.10 \\ 0 & 0 & 0.43 & 0.33 & 0.10 \\ 0 & 0 & 0.40 & 0.36 & 0.11 \end{pmatrix} \tag{4}$$

$$\text{Social Application Evaluation Matrix: } \mathrm{R}_4 = \begin{pmatrix} 0 & 0 & 0.35 & 0.48 & 0.13 \\ 0 & 0 & 0.27 & 0.51 & 0.16 \\ 0 & 0 & 0.27 & 0.53 & 0.14 \\ 0 & 0 & 0.35 & 0.50 & 0.11 \\ 0 & 0 & 0.30 & 0.52 & 0.15 \\ 0 & 0 & 0.27 & 0.53 & 0.14 \\ 0 & 0 & 0.31 & 0.50 & 0.11 \end{pmatrix} \tag{5}$$

$$Social\ Governance\ Evaluation\ Matrix: R_5 = \begin{pmatrix} 0 & 0 & 0.32 & 0.42 & 0.12 \\ 0 & 0 & 0.35 & 0.45 & 0.11 \\ 0 & 0 & 0.40 & 0.35 & 0.14 \\ 0 & 0 & 0.26 & 0.52 & 0.19 \\ 0 & 0 & 0.33 & 0.50 & 0.13 \\ 0 & 0 & 0.29 & 0.48 & 0.19 \\ 0 & 0 & 0.27 & 0.53 & 0.13 \\ 0 & 0 & 0.31 & 0.51 & 0.12 \end{pmatrix} \tag{6}$$

$$Pending\ Challenges\ Evaluation\ Matrix:\ R6\ = \begin{pmatrix} 0.02 & 0.06 & 0.12 & 0.48 & 0.32 \\ 0.02 & 0.02 & 0.04 & 0.44 & 0.48 \\ 0 & 0 & 0.18 & 0.64 & 0.18 \\ 0.06 & 0.1 & 0.24 & 0.56 & 0.04 \\ 0 & 0.08 & 0.08 & 0.48 & 0.36 \\ 0 & 0.02 & 0 & 0.52 & 0.46 \\ 0 & 0.02 & 0.06 & 0.68 & 0.24 \\ 0 & 0 & 0.22 & 0.3 & 0.48 \\ 0 & 0.1 & 0.22 & 0.22 & 0.46 \end{pmatrix} \tag{7}$$

The fuzzy comprehensive evaluation of the first-level indicator layer (Q1, Q2, Q3, Q4, Q5) is obtained by multiplying the weights (W1, W2, W3, W4, W5) of the second-level indicators relative to their corresponding first-level factors by the membership matrix (R1, R2, R3, R4, R5) of the first-level indicator layer.

Weight for the evaluation of efficiency improvement:

$$W_1 = [0.1548\ \ 0.0433\ 0.0508\ 0.2762\ 0.0838\ 0.2068\ 0.0655\ 0.1187\ ] \tag{8}$$

$$Q_1 = W_1 * R_1 = [0.0000\ 0.0000\ 0.3513\ 0.4314\ 0.1284\ ] \tag{9}$$

Weight for the Evaluation of Service Quality：

W_2 = [0.0928 0.0532 0.0373 0.0654 0.2581 0.0539 0.1573 0.1134 0.1686] (10)

$Q_2 = W_2 * R_2 =$ [0.0000 0.0000 0.3824 0.3771 0.1156] (11)

Weights for the evaluation of data security and transparency:

W_3 = [0.0522 0.2304 0.3231 0.1578 0.0547 0.0787 0.1030] (12)

$Q_3 = W_3 * R_3$ = [0.0000 0.0000 0.3973 0.3318 0.0957] (13)

Weights for the evaluation of social applications:

$W_4 =$ [0.1077 0.2334 0.3253 0.1550 0.0415 0.0604 0.0767] (14)

$Q_4 = W_4 * R_4$ = [0.0000 0.0000 0.2932 0.5132 0.1369] (15)

Weights for the Evaluation of Social Governance:

W_5 = [0.0457 0.1934 0.2738 0.0516 0.0983 0.0716 0.1156 0.1501] (16)

$Q_5 = W_5 * R_5$ = [0.0000 0.0000 0.3349 0.4515 0.1335] (17)

Weights for the Evaluation of Pending Challenges:

$W6$ = [0.1548 0.0433 0.0508 0.2762 0.0838 0.2068 0.0655 0.1187] (18)

$Q6 = W6 * R6 =$ [0.0211 0.0481 0.0826 0.5956 0.2526 (19)

Since the result of the fuzzy comprehensive evaluation is a fuzzy vector rather than a specific numerical value, it does not intuitively reflect the evaluation outcome. Therefore, an assignment vector P= {1, 2, 3, 4, 5} is set. The score of the overall objective layer is calculated by summing the products of the weights of the first-level indicators relative to the overall objective layer and their respective scores. The final score of each first-level indicator is calculated as Qi*P= (1, 2, 3, 4, 5), while the final score of the second-level indicators is calculated as the product of their membership matrix and P (1, 2, 3, 4, 5). The final scores at all levels are summarized in the following Table 9.

Table 9. Final score table.

Target layer	Primary index	Score	Secondary indicators	Score
4.0319	A: Efficiency enhancement	4.0105	Improve resource utilization efficiency A1	4.14
			Shorten service cycle A2	3.7
			Optimize talent resource allocation A3	3.92
			Optimize financial resource utilization A4	3.86
			Optimize material resource utilization A5	3.8
			Efficiency of information transmission A6	4
			Reduction of capital investment A7	4.32
			Improve resource utilization efficiency A8	4.34
	B: Service quality	4.0309	Service equity B1	4.02
			Service inclusiveness B2	4.34
			Reduction in complaint rates B3	4
			Service quality rating B4	3.42
			Resident satisfaction B5	4.12
			Enterprise satisfaction B6	4.42
			Satisfaction of other service recipient B7	4.14
			Citizen participation rate B8	4.26
			Enhance citizen satisfaction with participation B9	4.04
	C: Data security	4.1078	Data transparency C1	4.06
			Data authenticity C2	4.16
			Adequate protection of residents' personal privacy data C3	4.18
			Ensuring data security and compliance C4	3.98
			Data security in public services C5	4
			Network security in public services C6	4.32
			Security of public service systems C7	3.88
	D: Social application	3.8206	Smart building D1	3.98
			Smart Education D2	3.94
			Smart Community D3	3.78
			Smart Environment D4	3.58
			Smart Energy D5	3.96
			Smart Transportation D6	3.74
			Smart Healthcare D7	3.88
	E: Social governance	3.9536	Needs of Vulnerable Groups E1	3.78
			Social Inclusiveness in Urban Governance E2	3.92
			Emergency Response Capability E3	3.94
			Data Visualization E4	4.08
	F: Pending challenges	3.985	Data Privacy and Security F1	3.92
			Technology and Implementation F2	4.1
			Talent gap F3	3.88
			Ethical and moral considerations F4	4.04

Service quality B, with a score of 4.0309, demonstrates that AI has also made notable achievements in enhancing government service quality. high scores in “service inclusiveness B2,” “enterprise satisfaction B6,” “satisfaction of other service recipient B7,” and “Citizen participation rate B8” highlight outstanding performance in service inclusiveness, enterprise satisfaction, satisfaction of other service recipients, and citizen participation rates. The lower score in “Service quality rating B4” indicates a need for improvement in service quality ratings.

Data security C, with a score of 4.1078, is the highest among the five primary indicators, indicating that AI excels in data security and transparency in government collaborative governance. High scores in “data authenticity C2,” “Adequate protection of residents' personal privacy data C3," and "network security in public services C6" demonstrate effective safeguarding of data authenticity, residents' personal privacy protection, and public service network security. The relatively lower score in "security of public service systems C7" suggests a need to further strengthen the security of public service systems.

Social application D, with a score of 3.8206, indicates that AI's social applications in government collaborative governance require further enhancement. higher scores in "smart building D1," "smart education D2," and "smart energy D5" suggest relatively better applications in smart buildings, smart education, and smart energy. Lower scores in "smart community D3," "smart environment D4," and "smart transportation D6" indicate a need for further improvement in smart community, smart environment, and smart transportation applications.

Social governance E scores 3.9536, placing it at a moderate level. The higher score in "data visualization E4" indicates good performance in data visualization. Lower scores in "needs of vulnerable groups E1" and "social inclusiveness in urban governance E2" suggest areas for improvement in addressing the needs of vulnerable groups and enhancing urban governance inclusiveness.

Pending challenges F score 3.985, indicating that AI still faces challenges in government collaborative governance. Higher scores in "Technology and Implementation F2" and "ethical and moral considerations F4" suggest relatively better performance in technology and implementation, as well as ethical and moral considerations. Lower scores in "data privacy and security F1" and "talent gap F3" indicate a need for further attention to data privacy and security, as well as addressing the talent gap.

In summary, AI excels in enhancing the efficiency and service quality of government collaborative governance, as well as ensuring data security and transparency. However, social applications, particularly in smart communities, smart environments, and smart transportation, require strengthening. Attention to vulnerable groups and urban governance inclusiveness also needs improvement. Additionally, data privacy and security, as well as the talent gap, pose ongoing challenges.

Therefore, in the process of AI-driven government collaborative governance, it is essential to enhance the development of social applications. Specific focus should be given to areas with lower scores, such as smart communities, smart environments, and smart transportation, by increasing investment and research efforts to improve AI's application effectiveness in these domains. When formulating and implementing policies, greater attention should be given to the needs of vulnerable groups, leveraging AI advancements to ensure they also benefit from AI applications. To enhance urban governance inclusiveness, AI should further promote inclusive development, ensuring that different groups can enjoy equitable services. Addressing the talent gap, the government should intensify efforts to cultivate and attract professionals in the AI field, providing a solid talent foundation for the optimal utilization of AI in government collaborative governance.

The evaluation results in Figure 9 reveal significant disparities in the effectiveness of AI-enabled collaborative governance across major Chinese cities in 2025. Beijing (0.83), Shanghai (0.78), and Guangzhou (0.76) demonstrate relatively advanced implementation, likely attributable to their superior technological infrastructure and policy support. In contrast, Urumqi (0.34) lags considerably, highlighting the need for targeted investments in digital capacity building and interagency coordination mechanisms in less developed regions. These findings underscore the importance of balancing regional development to achieve nationwide AI-driven governance modernization.

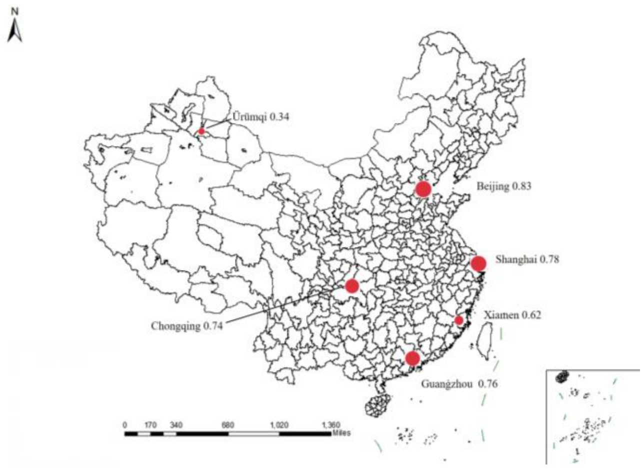

Figure 9. Evaluation of AI-enabled collaborative innovation in government governance of 6 cities in 2025.

5.3. Conclusions

In the Figures 10 and 11, the weight assignment reveals that service quality constitutes the most critical dimension, accounting for approximately 35% of the total weighting, followed by efficiency at around 25%, indicating its prominent role in the overall evaluation framework. Data security holds an intermediate weight of 15%, while social application accounts for approximately 10%. Both pending challenges and social governance received weights below 5%, reflecting their relatively peripheral roles within the current assessment system. Overall, the weight distribution exhibits a distinct quality-efficiency-oriented structure. According to the fuzzy comprehensive evaluation results, all indicators received scores around 5, which are substantially lower than their respective weight values. The absence of significant dispersion in scores across dimensions suggests uniformly moderate-to-low performance levels without notable strengths in any particular area.

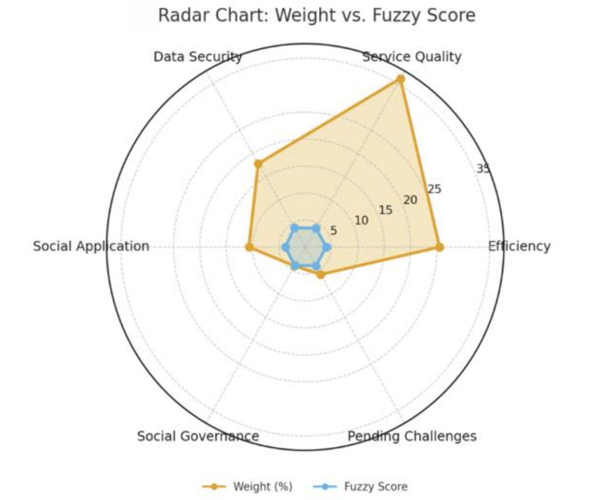

Figure 10. Radar chart: the results of weight and fuzzy score.

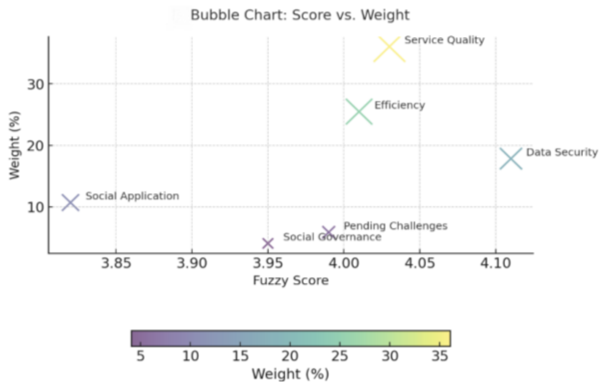

Figure 11. Bubble chart: the results of weight and fuzzy score.

A comparative analysis between weights and performance scores further indicates that highly weighted indicators-namely service quality and Efficiency-failed to achieve correspondingly high scores, highlighting substantial deficiencies in these key dimensions. Conversely, the scores of lower-weighted dimensions such as social governance and pending challenges did not markedly differ from those with higher weights, implying a potential misalignment between resource allocation and the predefined priority structure embodied in the weighting scheme.

In conclusion, the evaluation system demonstrates suboptimal overall performance, underachievement in critical dimensions, and a possible disconnect between resource distribution and weighting priorities. It is recommended that future improvements focus on enhancing Service Quality and Efficiency, while strategically strengthening Data Security and other relevant aspects to better align operational outcomes with the intended policy objectives reflected in the weight assignments.

6. Safeguard Measures for Collaborative Innovation in Government Public Services

6.1. Support from Government Big Data Platforms

In government collaborative governance, a large amount of personal and urban data will be collected and applied, necessitating clear regulations to ensure data security and privacy [27]. To achieve the standardized application of AI, the government can build a smart city big data platform, explicitly stipulating that data collection, storage, transmission, and application must comply with laws and regulations. By strengthening data supervision and penalties for violations, the legality and security of public service data can be ensured, thereby enhancing citizens' trust in AI applications [25]. The construction of a government big data platform should be based on cloud storage, 5G, the Internet, and other cloud-based technologies, synergizing with data collection, processing, and computational analysis under AI to achieve embedded integration of physical hubs and technical support. Building a government big data platform can optimize redundant processes in the application of AI in government collaborative governance, thereby enhancing the collaborative innovation capability of government public services (See Figure 12).

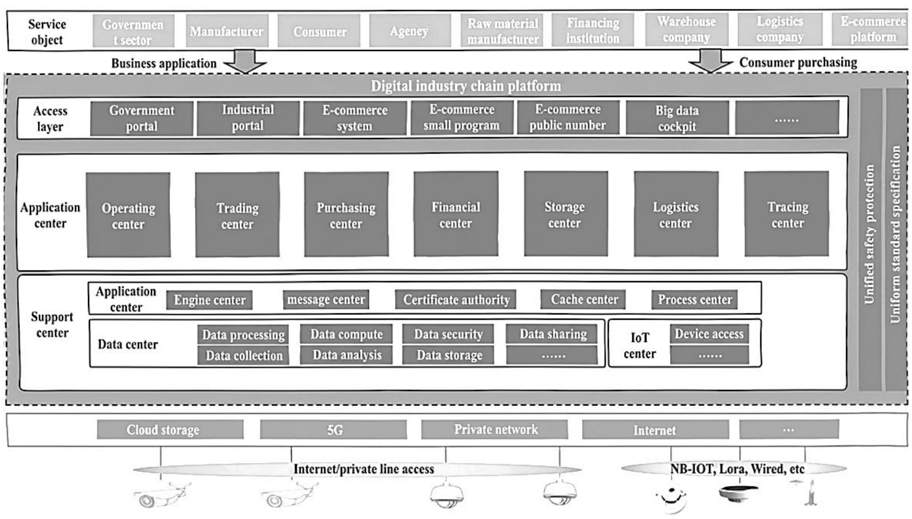

Figure 12. Digital governance industry chain under AI.

6.2. Advancement at the Technological Application Level

To achieve widespread application of AI in government collaborative governance, the government should support and promote the innovative application of AI technologies in the public service sector [35]. It should establish smart city technology innovation bases and laboratories, attracting outstanding research teams and enterprises to engage in technology research, development, and application practices. This will drive continuous breakthroughs and innovations in AI technologies within public services, improving service efficiency and quality, and fostering a digital governance industry chain under AI (see Figure 13). In the process of applying AI technologies, a large amount of data will be collected, analyzed, and utilized, necessitating enhanced security protection for the data. A smart city data security management system should be established, covering norms and standards for data collection, storage, transmission, processing, and sharing, to ensure the legality, security, and privacy protection of data, thereby increasing citizens' trust in smart city governance.

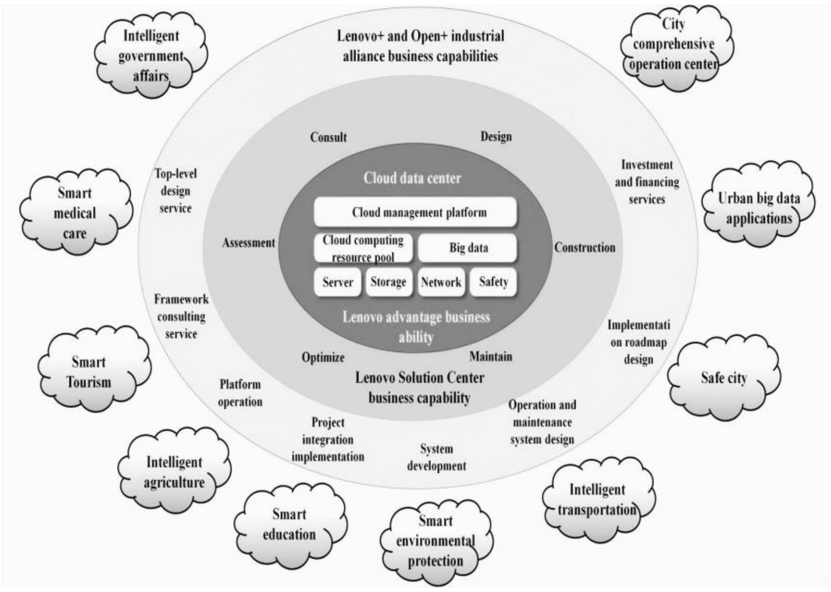

Figure 13. Technological integration of AI in smart city governance.

The construction of intelligent facilities is a crucial pathway for promoting smart city governance. The government should increase investment in smart city infrastructure, including intelligent traffic signals, intelligent traffic monitoring, and intelligent traffic management centers, to enhance transportation efficiency and safety. Additionally, smart environmental protection systems should be built, encompassing intelligent waste sorting, intelligent air monitoring, and intelligent environmental management, to improve urban environmental quality.

Talent cultivation is one of the important safeguard measures for ensuring smart city governance. The government should strengthen the cultivation and recruitment of talents in the field of AI, establishing a talent pool for smart city governance. A training mechanism for smart city governance talents should be established to provide relevant practitioners with training and cultivation in AI technologies and application knowledge [39]. Furthermore, efforts should be made to attract and retain outstanding talents in the AI field, drawing more technical experts and management personnel to participate in smart city governance work, thereby promoting the professionalization and intelligent development of smart city governance.

6.3. Management at the Mechanism Operation Level

Government collaborative governance involves multiple departments and sectors, requiring close collaboration and information sharing among them to achieve effective management [29]. To enhance the application capabilities of AI in the field of government collaborative governance, the government should establish a cross-departmental collaborative working mechanism, breaking down departmental barriers and promoting information sharing and resource integration [39]. This can be achieved by establishing a leading group or committee for government collaborative governance. The leading group, composed of leaders or experts from relevant departments, is responsible for overall coordination of smart city governance work and promoting collaborative innovation in public services.

The government can also establish an AI open platform, either through government leadership or public-private partnership, to provide data sharing, technical exchanges, project cooperation, and other services for all parties, thereby driving collaborative innovation and development in government governance. Additionally, an evaluation mechanism for AI in government collaborative governance should be established to regularly assess and review government collaborative governance work, identify problems and deficiencies, and make timely adjustments and improvements. The establishment of an open platform can ensure that smart city governance work is carried out in accordance with prescribed standards and requirements, promoting collaborative innovation and sustained development.

By providing shared resources and services through AI to government departments, enterprises, academic institutions, and social organizations, innovation cooperation and shared construction can be promoted, forming a management and application mechanism for smart city governance (see Figure 14).

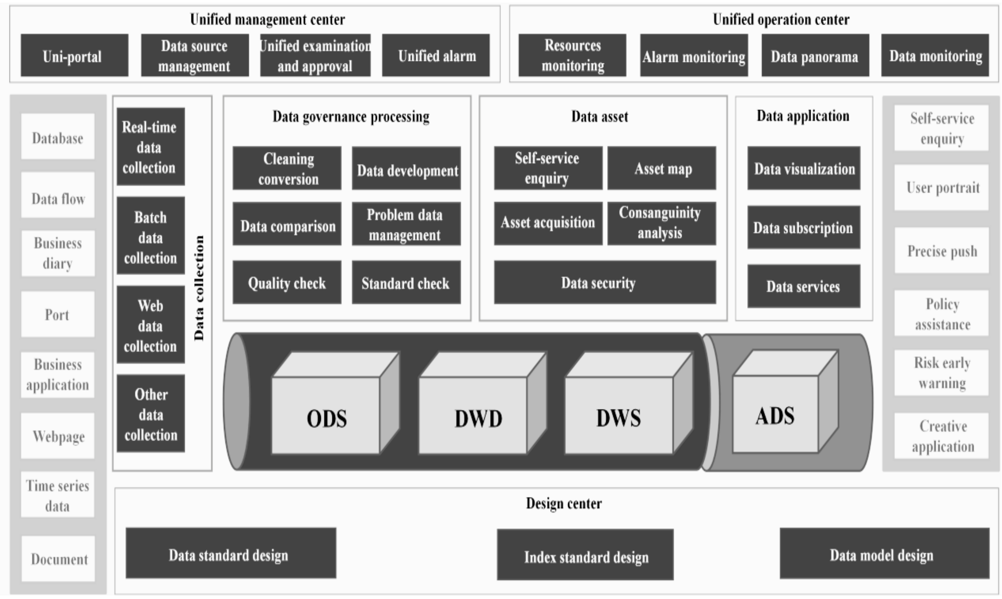

Figure 14. Operational mechanism for smart city governance and management.

7. Conclusions

In the context of smart city development, collaborative innovation in government public services is not only a necessary path to promoting the modernization and intelligence of urban governance, but also a crucial means of constructing a new pattern of co-construction and shared urban governance. Through the assessment and analysis of the levels of innovation mechanisms, the study finds that policy regulations, technology applications, and cross-departmental collaboration all play vital roles in smart city governance. However, in reality, there are numerous challenges, such as information silos and imperfect management mechanisms, which constrain the progress of smart city governance. To address these challenges, the study proposes establishing cross-departmental collaboration mechanisms, constructing open platforms and ecosystems, strengthening supervision and evaluation, and promoting public participation and social supervision. This will reinforce cooperation between the government and all sectors of society, jointly driving the advancement of smart city governance.

Given that China's governance system is characterized by a centralized administrative structure and strong government-led digital initiatives, the empirical results of this study primarily reflect the institutional context of China. These findings may not be directly generalizable to countries with decentralized governance systems or different policy-making traditions. While this study provides valuable insights into the role of AI in collaborative governance within China, caution should be exercised in extending the findings to other countries. Future research could benefit from cross-national comparative studies to examine the applicability of these conclusions in different governance and institutional contexts.

The paper introduces a collaborative innovation mechanism for government public services based on AI, but the in-depth exploration of the specific theoretical framework and model construction is not yet sufficient. Future research should further deepen the applicability analysis of collaborative innovation theory in smart city governance. There is a lack of large-scale empirical research to verify the effectiveness and impact of the proposed collaborative innovation mechanism in actual smart cities. Through practical cases and data analysis, the actual contribution of these mechanisms to enhancing urban governance efficiency can be demonstrated more persuasively. Smart city governance involves multidisciplinary knowledge, including information technology, public administration, sociology, and more. The paper does not fully integrate these disciplinary perspectives, leading to a relatively narrow vision in theoretical construction and empirical analysis. Future research should further explore breaking down information silos through cross-departmental collaboration mechanisms and achieving effective sharing and integration of various data in smart city governance. With the advancement of AI technology, future research should standardize and systematically apply these technologies, particularly seeking innovative solutions to challenges in data security and privacy protection. The role of public participation and social supervision in smart city governance should be emphasized, advocating for a more open and transparent governance model to enhance the democracy and fairness of governance.

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