Scientific and Social Research, 2025, Volume 7, Issue 11
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Policy Intelligence Agents: Toward an Agile Governance Model in Rural Tianjin

Yice Zhang, Junde Han*

Tianjin Agricultural University, Tianjin 300392, China

**Author to whom correspondence should be addressed.*

Abstract: In the context of the rapid development in the contemporary era, the socio-economic environment has become increasingly intricate and volatile, resulting in more diversified demands among farmers. The traditional top-down and hierarchical models of rural governance have gradually exposed multiple deficiencies. Against this background, the "policy agent", as an emerging technological instrument, provides new perspectives and methods for agile governance in rural areas of Tianjin. The combination of policy agents and agile rural governance represents a more in-depth application of digital technologies in strengthening state governance at the grassroots level, significantly reshaping the pattern of traditional rural governance. By integrating the conceptual framework of policy agents into the agile rural governance system, local governments intend to drive a fundamental transformation in rural governance structures and production relations through technological innovation.

Keywords: Policy intelligence agent; Agile governance; Grassroots government; Digital technology

Online publication: November 14, 2025

1. Introduction

Over an extended time frame, traditional rural governance has predominantly been typified by a top-down bureaucratic paradigm. Although this structure guarantees well-defined hierarchies, it frequently encounters slow adaptability, resulting in inadequate responsiveness and reduced governance effectiveness. These constraints are manifested in several practical predicaments: the attenuation of policy information during its dissemination, substantial informational obstacles between decision-makers and grassroots communities, inefficiencies in public decision-making processes, and structural discrepancies between the provision of public services and the actual requirements of residents.

Simultaneously, the most recent wave of digital innovation, propelled by artificial intelligence, big data, and cloud computing, is on the verge of instigating a revolutionary transformation in social governance. As an emerging and salient sub-domain of AI, intelligent agent technology, especially the notion of a "policy intelligence

agent", presents a novel outlook for tackling the long-standing governance challenges in rural regions.

The rural areas under Tianjin's jurisdiction exhibit a distinct and multi-dimensional governance context. These areas include the suburban areas of a large-scale metropolis, coastal agricultural regions, and traditional farming communities, leading to intricate and diverse governance situations. This diversity emphasizes the importance of precision and timeliness in governance. In this context, the application of policy intelligence agents in Tianjin not only offers a significant opportunity to improve rural governance through process re-engineering and model innovation but also constitutes an urgent and essential task.

2. Conceptual definitions and theoretical foundations

2.1. Core conceptual definitions

2.1.1. Policy intelligence agent

A "Policy Intelligence Agent" refers to an intelligent entity that integrates technologies such as artificial intelligence, big data, machine learning, and neural networks to simulate human cognitive processes. It is designed to serve policy formulation and implementation, as well as policy evaluation and feedback. Equipped with "perception–analysis–decision–feedback" capabilities, the agent can perceive real-time information related to rural governance, conduct analytical assessments, and make rapid decisions to achieve predefined objectives. Through iterative feedback, it adjusts input parameters and refines governance models, thereby enhancing the agility of rural governance.

2.1.2. Rural agile governance

Rural agile governance represents a novel approach to rural governance, contrasting with traditional methods. It denotes the capacity to respond swiftly to complex and unpredictable events and changes, adapt in a timely manner, and foster multi-stakeholder collaboration. Through continuous improvement, it aims to achieve effectiveness in rural governance [1].

2.2. Theoretical foundations

Complex Adaptive Systems (CAS) theory posits that individuals within a system are adaptive agents capable of modifying their behaviors and rules in response to environmental changes. The rural governance system constitutes a complex adaptive system composed of interconnected and interacting actors, including government entities, residents, enterprises, and social organizations. The introduction of a policy agent equates to embedding an intelligent entity with robust perception, analysis, and decision-making capabilities into this system. In the context of rural governance, agile governance theory provides theoretical guidance for the application of such agents. It enables policy actors to rapidly perceive emerging issues and changes, adjust decisions dynamically, and achieve continuous optimization of rural governance.

This study employs literature review and case study methodologies to ensure scientific rigor and comprehensiveness. By collecting and analyzing relevant domestic literature, it synthesizes current research on agile governance and digital rural construction, thereby establishing a solid theoretical foundation. In terms of innovation, this research theoretically integrates cutting-edge "policy agent" technology with "agile governance" theory. Focusing on the typical context of rural areas in Tianjin, it constructs a novel governance paradigm characterized by data-driven intelligence, simulation, and dynamic optimization, thereby advancing the transformation of rural governance frameworks.

3. Analysis of the current state and challenges in rural governance in Tianjin

3.1. Current state of rural governance in Tianjin

Tianjin has made strides in refining the structure of its rural governance system. Adhering to the principle of Party leadership as the cornerstone, the city has established a governance framework characterized by "Party committee leadership, government responsibility, social collaboration, public participation, and legal safeguards." A series of policy measures concerning rural economic development, social construction, and ecological protection have been formulated and implemented. For instance, in the realm of rural economic development, policy funds for rural industrial revitalization have been established to guide the integrated development of primary, secondary, and tertiary industries in rural areas. This includes supporting the development of specialized planting and breeding, agricultural product processing, and rural leisure tourism. Regarding social development, policies focus on establishing and improving rural infrastructure and public service systems, including the "Four Good" rural road initiatives, water conservancy projects, and communication networks. In terms of ecological protection, measures have been enacted for rural environmental remediation, involving increased financial investment in rural waste treatment, sewage disposal, and the promotion of rural waste classification, resource utilization, and water source protection. These policy instruments have played a positive role in fostering rural development.

3.2. Challenges confronting rural governance in Tianjin

Firstly, there is a notable issue of delayed governance responses. Under the traditional rural governance model, Tianjin exhibits pronounced shortcomings in the speed of information transmission and decision execution. Secondly, policy precision is insufficient. A discernible disconnect exists between policy formulation and the actual needs of rural communities in Tianjin's governance practice. Thirdly, resource allocation efficiency remains low. A prominent challenge within Tianjin's rural governance is the inadequate integration and utilization of resources. Finally, risk response capabilities are weak. Rural areas demonstrate certain deficiencies in coping with public emergencies and various risks. In the public health domain, for example, weaknesses are evident in medical and health infrastructure, coupled with a shortage of medical resources.

4. Systemic architecture and operational mechanisms of "policy intelligence agents" in empowering agile rural governance

4.1. Systemic architecture and functional design of policy intelligence agents

4.1.1. Architecture design

The framework of the Policy Intelligence Agent system comprises five hierarchical layers: Perception, Data, Analytics, Decision-Making, and Application. The Perception Layer facilitates real-time information acquisition for rural governance through integrated sensors, Internet of Things, and data interfaces. It captures multidimensional data pertaining to economic, social, ecological, and livelihood aspects of rural areas. In agriculture, sensors monitor soil moisture, temperature, and crop growth conditions, while infrastructure monitoring relies on sensors deployed across rural roads, bridges, and hydraulic facilities.

The Data Layer serves as the foundational stratum of the Policy Intelligence Agent system. It is responsible for storing, cleansing, preprocessing, and integrating raw data collected by the Perception Layer. By establishing distributed databases and data warehouses, this layer enables efficient management and governance of massive rural datasets, breaking down data silos and fostering data convergence to supply high-quality inputs for subsequent analysis and decision-making.

The Analytics Layer employs advanced computational techniques—such as big data analytics, machine learning, and deep learning—to conduct in-depth analysis and knowledge extraction from the Data Layer. Through systematic data examination, it identifies underlying patterns, developmental trends, and correlations, thereby furnishing evidence-based insights for policymaking. For instance, data mining algorithms analyze trajectories of rural industrial development to forecast market demands; machine learning models assess ecological and environmental data to evaluate potential risks; and deep learning techniques process public sentiment data to discern villagers' concerns and needs.

The Decision-Making Layer synthesizes analytical outputs from the Analytics Layer and, guided by predefined rules and models, generates policy recommendations and decision options. It adopts a multi-agent collaborative decision-making approach, wherein distinct intelligent agents contribute differentially to the decision process. The Policy Evaluation Agent assesses and refines policy options; the Policy Recommendation Agent formulates actionable suggestions based on analytical and evaluative results; and the Policy Implementation Agent oversees the execution of decisions.

The Application Layer constitutes the user-facing interface of the Policy Intelligence Agent system. It translates decision outputs into accessible and comprehensible formats, delivering tailored services via web portals and mobile applications to governmental bodies, rural administrators, and residents [2]. Government entities utilize this layer to monitor policy implementation dynamically and adjust strategies accordingly; rural cadres employ it for daily governance tasks such as information dissemination and assignment allocation; villagers access policy information, submit feedback, and engage in participatory governance through the same platform.

4.1.2. Functional module design

The core functional modules of the "Policy Agent" include perception, analysis, decision-making, and feedback. These modules operate collaboratively to facilitate agile governance in rural areas.

The perception module serves as the "eyes and ears" of the Policy Agent, enabling real-time sensing of rural governance information. It acquires data across various domains—such as economy, society, ecology, and livelihood—through diverse data collection methods, including sensors, Internet of Things devices, social media platforms, and questionnaire surveys.

The analysis module functions as the "brain" of the Policy Agent, conducting in-depth analysis and mining of the data collected by the perception module. Leveraging technologies such as big data analytics, machine learning, and deep learning, this module performs data cleansing, preprocessing, modeling, and analysis to extract meaningful insights. Through these analytical processes, it identifies existing issues in rural governance and provides a scientific basis for decision-making.

The decision-making module acts as the "command center" of the Policy Agent, generating policy recommendations and decisions based on analytical outcomes. Evaluating factors such as feasibility, cost-benefit, and social impact according to predefined rules and models facilitates scientifically sound and rational decision-making. This module also supports multi-agent collaborative decision-making, wherein different agents assume distinct roles to collectively formulate policies.

The feedback module operates as the "calibrator" of the Policy Agent, responsible for tracking and evaluating the implementation outcomes of decisions and relaying assessment results to preceding modules for policy optimization and adjustment. It establishes a set of monitoring indicators to oversee the execution of decisions in real time, gathering relevant data and information throughout the process. Through data analysis and evaluation,

this module assesses the effectiveness of decisions, identifies shortcomings and challenges, and provides timely feedback to the decision-making and analysis modules, as illustrated in **Figure 1** [3].

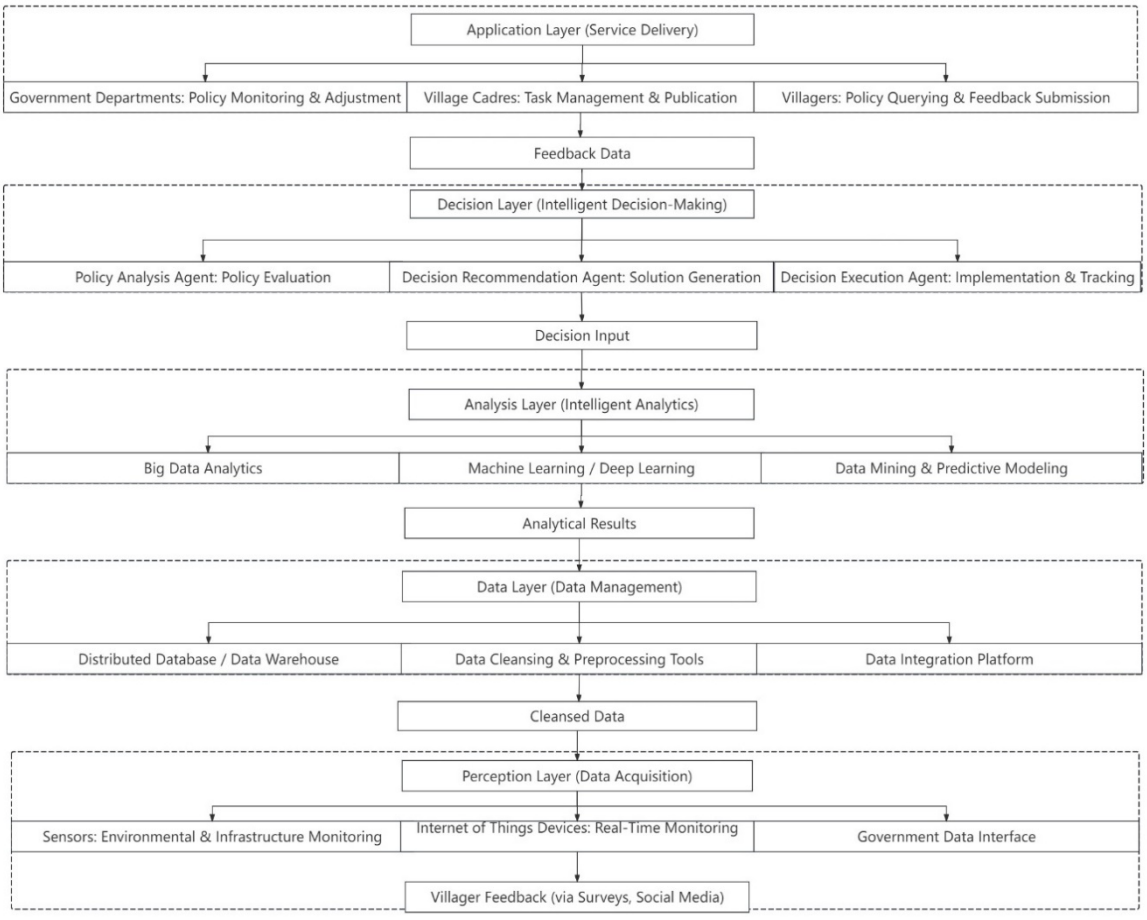


Figure 1. Architectural overview of the policy intelligence agent system

4.2. Operational mechanisms of the "policy agent" in enabling agile rural governance

4.2.1. Agile decision-making mechanism

The "Policy Agent" adopts a data-driven and simulation-based decision-making paradigm. In its data-driven dimension, digital technologies are deployed to systematically collect real-time data generated throughout rural governance processes. This encompasses governmental administrative data, Internet of Things, and resident feedback, among others. Through comprehensive big data analytics, the agent captures developmental trajectories and emergent patterns within rural contexts, enabling timely identification of governance challenges and demands. These insights form an empirical foundation for policy formulation.

4.2.2. Precision service mechanism

By leveraging intelligent systems for automated demand recognition and resource allocation, the "Policy Agent" establishes a precision service framework [4]. Regarding demand identification, artificial intelligence methodologies are employed to analyze behavioral patterns and feedback from residents, thereby excavating latent needs that inform tailored service delivery.

4.2.3. Dynamic feedback and optimization mechanism

The "Policy Agent" implements a cyclical optimization process through real-time impact assessment and self-adjusting strategic adaptations. For evaluation, it operationalizes a multidimensional indicator system to continuously monitor policy implementation outcomes. In rural environmental governance, for instance, the agent tracks parameters including air quality, water purity, and soil conditions to quantify policy efficacy. Concurrently, during rural industrial policy execution, metrics such as sectoral scale, economic returns, and employment dynamics are monitored to evaluate developmental synergies, as schematized in **Figure 2**.

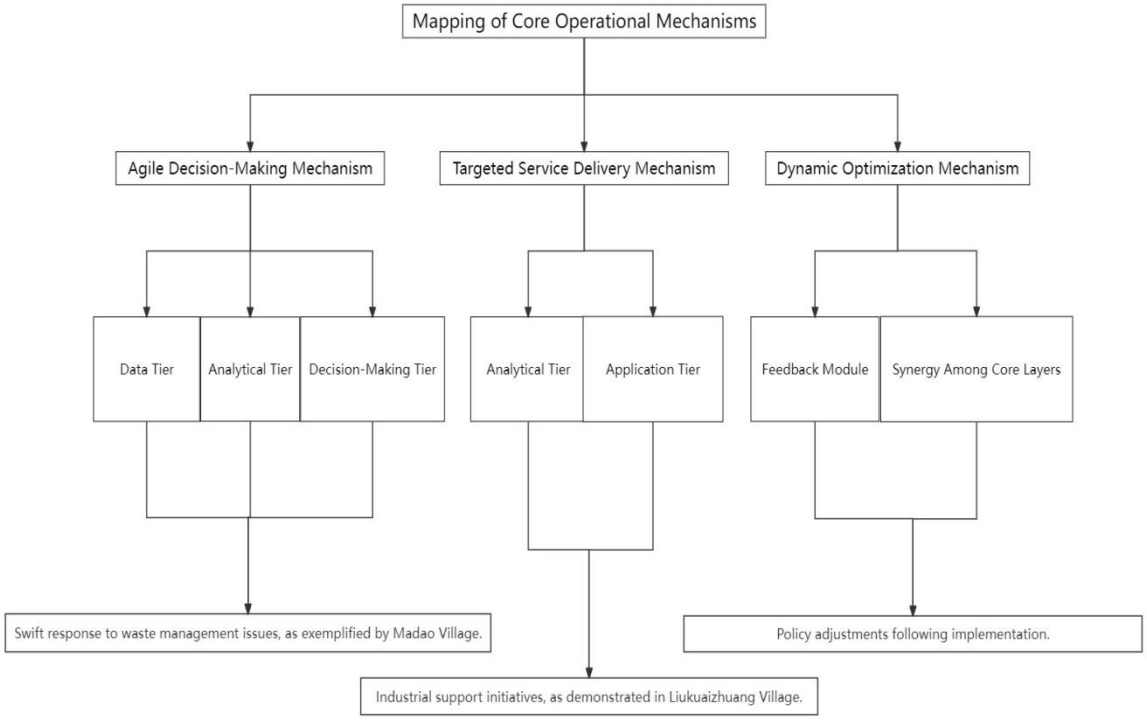


Figure 2. Schematic of policy intelligence agent operational mechanisms

5. Case analysis on the application of "policy agents" in rural governance in Tianjin

5.1. Case selection and introduction

Madao Village in Sangzi Town, Jizhou District, and Liukuaizhuang Village in Xiditou Town, Beichen District, of Tianjin Municipality have introduced "Policy Agents" into their rural governance, achieving notable governance outcomes. While Madao Village enjoys a relatively favorable geographical location and convenient transportation, it confronted challenges including increasing developmental demands, growing needs for public services, inadequacies of existing governance methods, and low villager satisfaction. This prompted the decision to integrate "Policy Agents" into its governance processes. Liukuaizhuang Village, a larger village experiencing rapid urbanization, grappled with issues such as population shifts and evolving social structures, against which prevailing governance measures proved insufficient. To address the pressing need for governance modernization, Liukuaizhuang Village incorporated "Policy Agents" to refine governance procedures and optimize methodologies.

5.2. Application and implementation process of "policy agents"

5.2.1. Data collection and integration

To provide comprehensive and accurate data support for the "Policy Agent", Madao Village employed diverse data collection methods. Data pertaining to air quality, water quality, and soil moisture content were gathered via sensors, enabling real-time monitoring of the village's ecological environment. Internet of Things technologies were utilized to collect data on the usage status of infrastructure such as roads, bridges, and canals, facilitating the timely identification of facility issues and potential safety hazards. Questionnaires and villager reporting mechanisms were used to ascertain basic villager information, demands, opinions, daily life circumstances, and participation in village governance.

Regarding data integration, Madao Village established a data-sharing platform to centrally consolidate the collected information. Raw data underwent cleaning and preprocessing to remove noise and errors, followed by standardization to ensure compliance with data norms and standards. Through data correlation and integration, barriers between disparate data sources and types were dismantled, unifying the original data. This processed and integrated dataset serves as the foundation for analysis and decision-making by the "Policy Agent."

Liukuaizhuang Village acquired substantial volumes of governmental, economic, and social data through collaborations with enterprises and government departments. This included agricultural production data from agricultural departments, business operation data from industrial and commercial authorities, and educational resource data from education departments. The village also leveraged big data technologies to gather internet-based data, such as public sentiment data from social media platforms and agricultural product sales data from e-commerce platforms.

During the data integration process, Liukuaizhuang Village established stringent, unified data standards and specifications to ensure consistency and accuracy. A data-sharing mechanism was implemented to facilitate the flow and exchange of data among different departments and stakeholders, thereby enhancing data utilization efficiency.

5.2.2. Agent deployment and operation

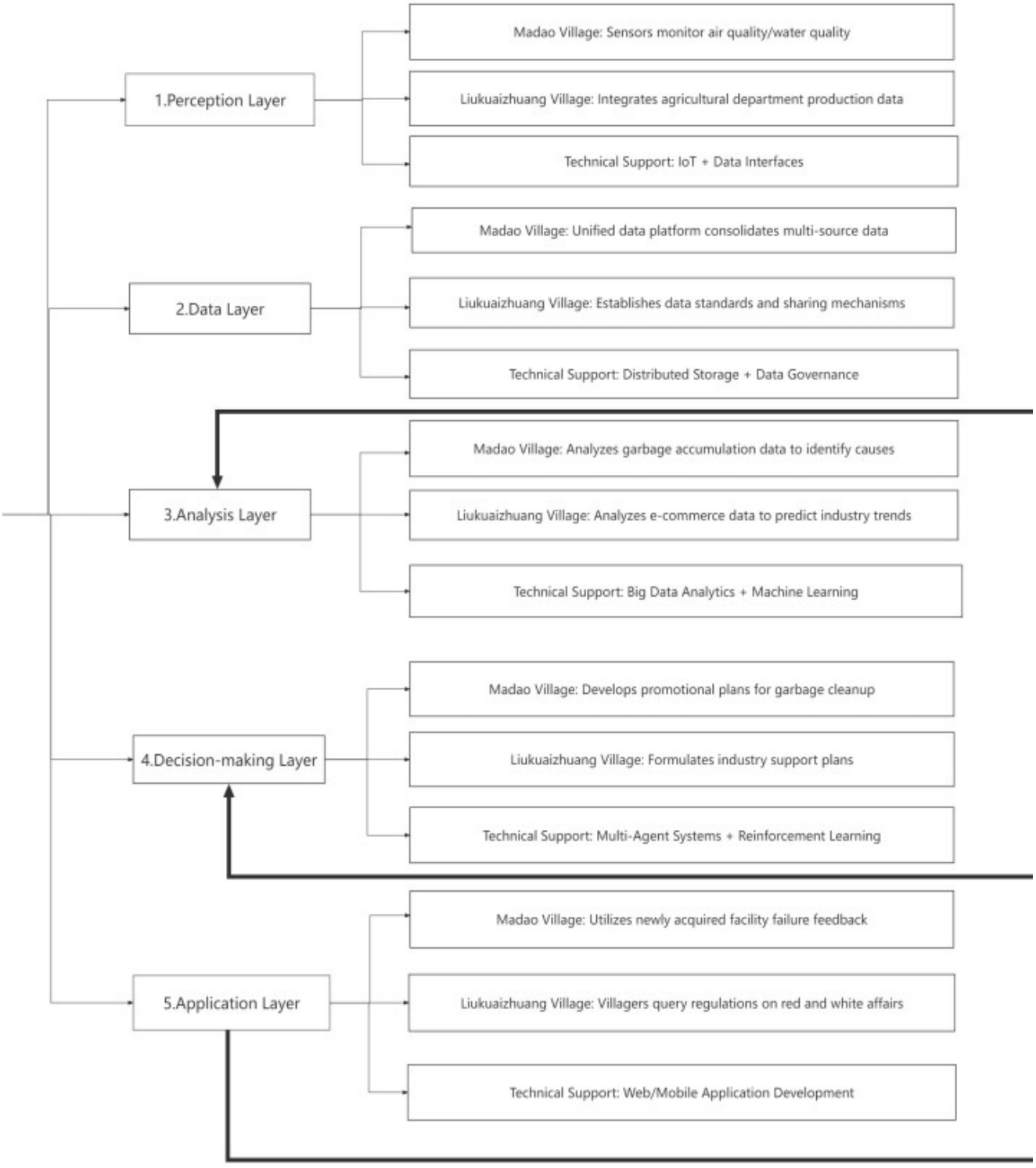
Madao Village deployed multiple types of agents based on its specific governance needs. Monitoring Agents collect data and transmit it to Analysis Agents. The Analysis Agents employ technical means to analyze the data, identify patterns and trends, and provide evidence for decision-making. Decision-Making Agents formulate policy options based on the analytical results and predefined rule-based models. Execution Agents are responsible for implementing these decisions and providing feedback on the outcomes.

Taking village environmental sanitation management as an example: when a Monitoring Agent detects severe waste accumulation in a specific area, it relays this information to an Analysis Agent. The Analysis Agent identifies potential causes and reports its findings to the Decision-Making Agent. The Decision-Making Agent then devises a response plan, which is carried out by the Execution Agent. During implementation, the Execution Agent feeds back the on-the-ground situation to the Monitoring and Analysis Agents, enabling continuous optimization of subsequent decisions.

Liukuaizhuang Village emphasized collaborative synergy in its agent deployment. Different agents assume distinct roles within the rural governance framework and operate in a coordinated manner. Using rural industrial development as an illustration: Monitoring Agents gather data on market conditions and agricultural product prices; Analysis Agents process this information and forecast trends; Decision-Making Agents formulate policies

based on these insights; and Execution Agents oversee implementation. Effective management is achieved through seamless information exchange among these agents.

Furthermore, Liukuaizhuang Village focused on integrating the agent system with the existing governance structure. The agent system was incorporated into the workflow of the Village Committee, providing decision support during village affairs deliberations and facilitating more scientific and informed policymaking, as schematically represented in **Figure 3**.



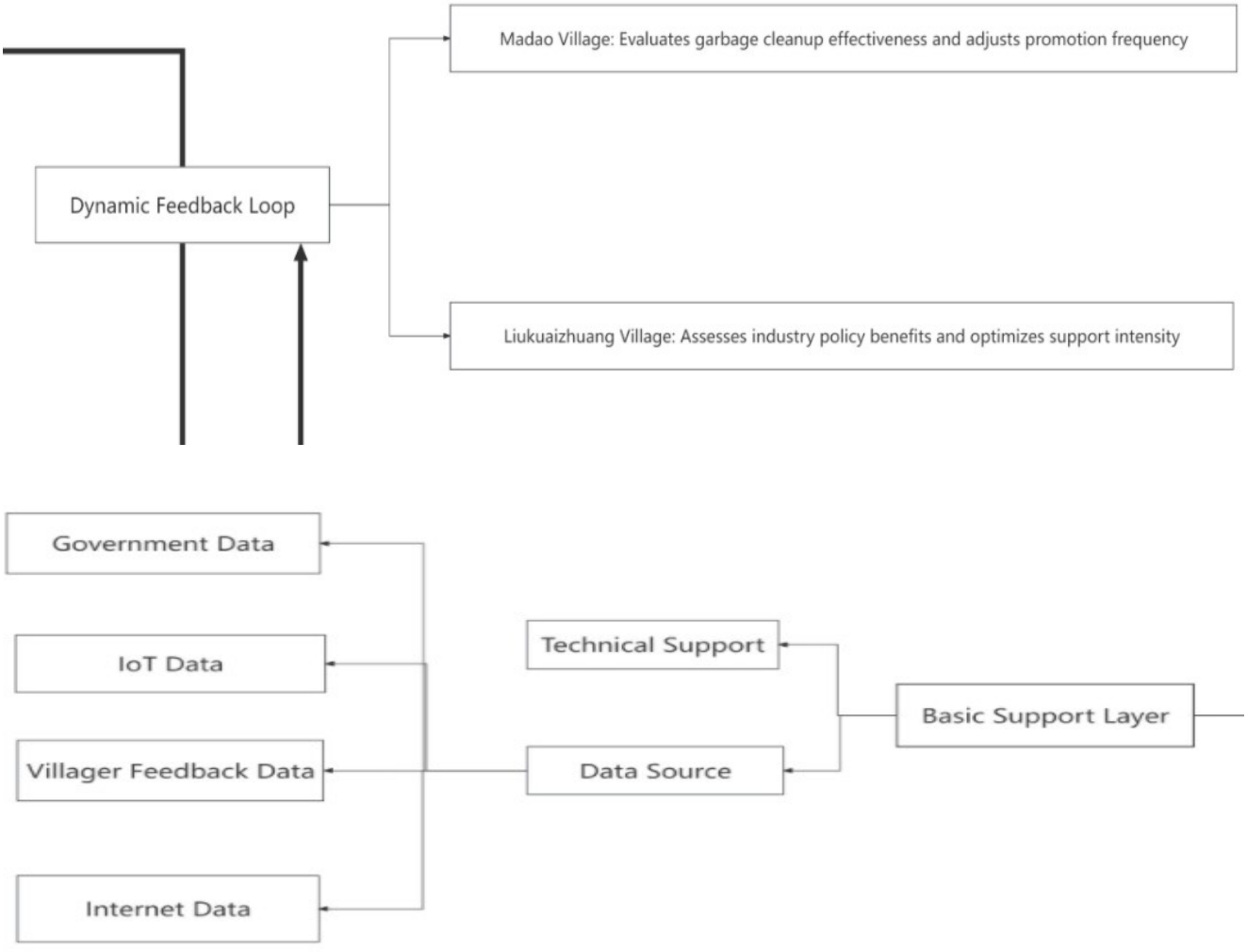


Figure 3. Diagram of case mapping for policy intelligence agent

5.3. Summary and implications from case studies

The successful implementation of "policy agents" in Madao Village and Liukuaizhuang Village yields valuable insights. These cases underscore the prioritization of data acquisition and integration, employing diverse methodologies to comprehensively collect rural governance data, which undergoes cleansing, preprocessing, and consolidation to dismantle data silos and facilitate shared utilization. They also highlight an emphasis on collaborative synergy among intelligent agents, where different agents work in concert to address governance challenges, thereby enhancing operational efficiency. Furthermore, significant attention is given to the seamless integration with existing governance frameworks, enabling the "policy agents" to more effectively serve rural governance objectives [5].

Concurrently, several challenges associated with "policy agents" have been identified. A segment of the villager populace exhibits limited awareness and recognition of these systems, resulting in low participation rates and an unclear understanding of their utility and value. Moreover, concerns regarding data and privacy security persist, encompassing issues such as potential leakage and misuse during data collection and utilization. Consequently, it is imperative to intensify publicity and training initiatives to elevate villagers' awareness, foster

acceptance, and stimulate engagement. Additionally, continuous refinement of data security management protocols is essential, incorporating measures such as encrypted storage to prevent unauthorized disclosure and misuse, thereby safeguarding villagers' privacy and security.

6. Challenges and countermeasures of "policy agent"-enabled agile governance in rural Tianjin

6.1. Challenges

6.1.1. Technical dimension

In terms of data security, the operation of policy agents necessitates the collection and processing of extensive rural data, including personal information of villagers, economic records, and governmental documentation. Unauthorized disclosure of such data could pose significant risks to villagers' privacy and rural development. Potential threats include cyberattacks, vulnerabilities in data storage and transmission, and mishandling of data by internal personnel.

6.1.2. Ethical dimension

First, the digital divide in rural Tianjin prevents certain villagers, due to age, cultural background, education level, income, and other subjective or objective factors, from accessing digital technologies and benefiting from policy agents. Furthermore, algorithmic opacity and the ambiguity of accountability make it difficult to attribute responsibility for decision-making errors. For instance, the outcomes of environmental governance initiatives in rural areas often lack clear qualitative evaluation. Lastly, the collection and application of villagers' data inevitably raise privacy concerns. Non-compliant data usage may infringe upon privacy rights—for example, when individuals' health data are analyzed without their consent, creating distress and potential threats to their lives.

6.1.3. Institutional dimension

The integration of policy agents requires adjustments and restructuring of the existing grassroots governance framework to align with the new governance system. However, in practice, institutional inertia and entrenched departmental interests often impede such reforms. Some departments resist organizational changes due to concerns over power redistribution and potential loss of benefits, thereby hindering the new structure from functioning effectively [6]. Moreover, operating policy agents demand a certain level of technical competence and knowledge, which is currently scarce in rural Tianjin. Both grassroots cadres and villagers need to enhance their digital literacy and technical skills. Many local cadres lack familiarity with technologies such as big data and artificial intelligence, limiting their ability to effectively utilize policy agents in rural governance and impeding the broader adoption and implementation of these systems.

6.2. Countermeasures

6.2.1. Technical safeguards

First, it is essential to strengthen data security supervision by establishing comprehensive data security management systems and technical protection protocols. Data encryption technologies should be employed to ensure encrypted storage and transmission, thereby preventing unauthorized access or tampering. Second, a robust data access control mechanism must be implemented to regulate the scope of data access and operational permissions, ensuring secure data utilization. Lastly, algorithmic design should be refined to enhance transparency

and interpretability. By adequately incorporating data diversity into algorithmic frameworks, the risk of algorithmic discrimination can be mitigated. Furthermore, promoting technical integration through the formulation of unified technical standards and interface specifications will improve interoperability across system platforms.

6.2.2. Ethical norms and supervision

An ethical review system should be established to conduct ethical assessments throughout the design, development, and deployment of "Policy Intelligence Agents." Strengthened regulatory oversight is necessary, involving the refinement of supervisory and review mechanisms. Clear identification of regulatory bodies and their responsibilities will facilitate enhanced monitoring of data security, algorithmic discrimination, and privacy protection. Additionally, digital literacy education for rural residents must be reinforced to improve their digital application capabilities and bridge the digital divide. Tailored digital skills training programs should be developed for villagers of different age groups and educational backgrounds, equipping them with essential knowledge and practical skills in digital technologies.

6.2.3. Institutional innovation and improvement

The organizational structure of rural governance should be adjusted to establish a framework compatible with the operation of "Policy Intelligence Agents." Defining the roles and authorities of various departments in the functioning of these agents will improve interdepartmental coordination. A dedicated management unit should be set up to oversee the operation, maintenance, data management, and decision-making support of "Policy Intelligence Agents." Enhancing the flexibility and applicability of the organizational framework will allow for adjustments based on evolving needs, thereby improving governance efficacy. Finally, education and training initiatives must be intensified to elevate the digital literacy and technical competencies of grassroots officials and villagers alike.

7. Conclusions and future research directions

This study has achieved several key outcomes at the theoretical level. It has clarified the definitions and core connotations of the central concepts—"policy agent" and "agile rural governance"—thereby establishing a coherent theoretical framework. This framework elucidates the underlying mechanisms and pathways through which policy agents operate. Specifically, policy agents leverage advanced technologies to develop intelligent systems, thereby enhancing the agility of rural governance. On the practical front, the research involved an in-depth analysis of the application outcomes in two case studies: Madao Village, Sangzi Town, Jizhou District, and Liukuaizhuang Village, Xiditou Town, Beichen District, both in Tianjin. This analysis extended to examining the attendant technological, ethical, and institutional challenges, alongside proposing potential countermeasures.

Future research efforts should be directed towards the following areas:

Expanding the empirical scope: Broaden the research by incorporating a larger and more diverse set of rural case studies. This expansion is crucial for validating the findings across varied contexts, thereby enhancing the reliability and generalizability of the results.

Investigating contextual variations: Systematically explore the typologies of performance and the differential impact of policy agents across diverse rural scenarios. Based on the distinct characteristics and needs of different regions, this line of inquiry should yield more targeted and context-specific application recommendations.

Advancing technical capabilities: Deepen research into the technological development and innovative refinement of policy agents. A sustained focus on enhancing their capabilities and functional repertoire is essential to better serve the evolving demands of rural governance.

Through continued research and practical implementation, this work is poised to provide well-documented practical cases and actionable insights for advancing agile governance in rural areas, not only within Tianjin but also across the nation.

Disclosure statement

The author declares no conflict of interest.

References

[1] Chen RH, 2025, "Digital Assistance for Agriculture": Boundary Conflicts in the Embeddedness of Internet Platforms in Rural Society and Practices of Agile Governance. Journal of Shandong Normal University (Social Sciences Edition), 70(5): 97–108. https://doi.org/10.16456/j.cnki.1001-5973.2025.05.009

[2] Hao W, Zhang Q, 2025, Value Balancing, Factor Coordination, and Functional Coupling: A Systemic Approach to the Digital Transformation of Rural Governance— Evidence from X County, Shanxi, a National Digital Village Pilot County. Journal of the Party School of Tianjin Committee of the CPC, 27(3): 66–74. https://doi.org/10.16029/j.cnki.1008-410X.2025.03.007

[3] Zhang LR, Fang SJ, Zhang ZC, 2025, Innovations in Agile Governance for Digital Villages and the Driving Logic of New Quality Productive Forces: A Case Study of the "Unified Grid Management" in Yuntan Town. Journal of Henan Normal University (Philosophy and Social Sciences Edition), 52(2): 32–40. https://doi.org/10.16366/j.cnki. 1000-2359.2025.02.05

[4] Shen FW, 2022, The Practical Logic and Optimization Pathways for Agile Governance in Digital Villages. Truth Seeking, 2022(5): 96–108 + 112.

[5] Li QL, Zhu RS, 2022, Constructing Nodal Platforms for Rural Digital Governance: Logical Framework, Case Analysis, and Synergistic Strategies. Study and Practice, 2022(3): 82–92. https://doi.org/10.19624/j.cnki.cn42-1005/c.2022.03.008

[6] Han RB, 2021, Rural Digital Governance Driven by Agile Governance. Journal of South China Agricultural University (Social Science Edition), 20(4): 132–140.