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A Study on Optimization of Rural Public Facility Layout Based on Mixed Integer Planning and Strategies for Improving Social Governance Effectiveness in the Era of Big Data

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ABSTRACT

Since the strategic plan for rural revitalization was put forward, the related contents of public facilities have been continuously written into national policies. Promoting the high-quality construction of rural public facilities has become a hot topic of research in China's rural areas. In this paper, optimization ideas and frameworks are proposed for the layout of rural public service facilities. Using the mixed integer planning model, the optimal solution of facility layout is obtained by calculating the distance between facilities to realize the optimization of rural public facility layout. Moran's I index in global spatial autocorrelation is used to analyze the degree of spatial autocorrelation of rural public basic facilities accessibility. Construct a multivariate linear model to assess the impact of mixed integer planning applications on rural residents' sense of social governance effectiveness. Evaluating the efficiency of rural basic public service facility accessibility coverage, the number of rural clinics is much larger than other facilities, with 26 facilities, and the number of middle schools, township general hospitals, and post offices is smaller, all with only two, indicating that there are certain problems in the configuration and spatial layout of public service facilities in a certain rural area nowadays. The application of the mixed integer planning model has a significant impact on rural governance in terms of human development index, public services, social security, public safety and social participation, with regression results of 0.075, 0.068, 0.125, 0.083 and 0.164, respectively.

Keywords: Mixed integer programming, Moran's I index, multivariate linear modeling, rural public facilities layout

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1. Introduction

At present, China has entered the decisive stage of building a moderately prosperous society in all aspects, and is in the critical period of economic transformation and upgrading, accelerating the construction of socialist modernization, and the public service facilities, as one of the important indexes reflecting the people's material, spiritual and cultural living standards, have a fundamental position in the comprehensive construction of a moderately prosperous society [1]. To fully realize a moderately prosperous society, first of all, we must constantly improve the urban and rural public service facilities configuration, improve the level of facilities configuration [2-3]. Only by improving the configuration of urban and rural public service facilities can we promote the economic and social development of urban and rural areas, improve the happiness index of urban and rural residents, and promote the completion of a rich, strong, democratic, civilized and harmonious socialist modernization country, so as to realize the Chinese dream of the great rejuvenation of the Chinese nation [4-7].

However, unbalanced development in urban and rural areas and insufficient development in the countryside are the development conditions that China is currently facing. High-quality public facility resources, especially education and medical facilities, are basically concentrated in towns and cities, while remote rural areas have weak infrastructures and limited service capacity, coupled with the fact that some villages are often located in mountainous environments and have low levels of transportation access, which makes it impossible for the majority of rural areas to obtain satisfactory services [8-11]. In order to solve these problems, it is certainly necessary to increase the financial expenditure of the local government and improve the service level of facilities by building new public service facilities [12-13]. However, compared with urban areas, rural areas are often sparsely populated and there is a great difference in rural population and village density, and the loss of a large number of rural laborers to urban areas also affects the supply and demand structure of rural public service facilities, so the unreasonable layout and construction of new public facilities are likely to result in the low utilization of public facilities and the waste of resources [14-17]. At the same time, different from urban areas, the location of rural public facilities must take into account the accessibility of roads, and the construction of new or upgraded facilities and roads in complex mountainous environments to improve accessibility will only increase the cost of construction, which will increase the burden on rural finances [18-20]. Therefore, how to improve the public service level of rural basic public service facilities and scientific layout of rural infrastructure is one of the important tasks to realize the rural revitalization strategy.

Emergency medical service facilities are an important part of China's health service system, facing the problem of insufficient sites and the layout is concentrated in the city, which is likely to cause patients in remote rural areas to miss the best rescue time of the golden 15 minutes for medical aid. Some scholars have constructed optimization models by integrating intelligent algorithms to propose optimization suggestions for the location of rural medical facilities. Chen, Y. and Lai, Z. studied the problem of siting optimization of rural emergency medical service (EMS) facilities, and established an optimization model based on an improved multi-objective simulated annealing algorithm with full consideration of road accessibility, aiming to improve the efficiency of rural medical emergencies in mountainous areas [21]. Li, S. et al. examined the distribution and accessibility of healthcare facilities within the living circles of rural residents and proposed to optimize the spatial layout accessibility of healthcare facilities using K-means clustering algorithm to improve the equity and quality of rural public health services [22]. Deng, Y. et al. used a GIS-supported location set coverage model to describe the problem of siting optimization of emergency medical service facilities and used a genetic algorithm to solve it to achieve a larger population coverage by fewer medical service facilities [23].

In addition, as China's urbanization level continues to rise, a large number of people are moving from the countryside to the cities, and in order to optimize the allocation of educational resources and improve the efficiency of scale, large-scale school mergers have been carried out in the countryside, making it difficult for students in remote mountain villages to go to school over long distances. Based on this, some scholars have studied the siting of rural educational facilities, taking into account the fairness of educational resources, construction costs, and future development plans. Chen, Y. showed that transportation network conditions have an important impact on the location of rural educational facilities, established a mixed integer planning model with the objective of minimizing the cost of student transportation, school construction, and road upgrades, and solved it using a simulated annealing algorithm, which effectively improves the allocation efficiency of educational resources [24]. LIU, Z. and LIU, Z. Aiming at the problem of incompatibility between static planning methods and spatio-temporal development characteristics of the countryside, they put forward a method of selecting the location of basic education facilities based on multi-featured spatio-temporal equilibrium model, which fully takes into account the developmental changes of the countryside's land and demographic structure, and guarantees the fairness and equilibrium in accessing the countryside's educational resources [25]. Yao, L. et al. used ordinary least squares and geographically weighted regression models to explore the influencing factors on the accessibility of educational facilities in impoverished mountainous areas, which provided valuable references for the optimization of the layout of local educational facilities and helped to improve the supply of rural educational resources [26].

Of course, for other functional attributes of rural public service facilities for a long time there is also a structural imbalance between supply and demand, which seriously impedes the realization of the equalization of basic public services in the countryside. Therefore, it is a better way to analyze the optimization strategy of rural public facilities layout from the demand and service level. Zhou, H. analyzed the key factors affecting the siting of rural public sports facilities and introduced fuzzy logic and neural network algorithms to construct a siting optimization model to achieve higher resource allocation efficiency in the strategic decision-making of rural layout [27]. Huang, Y. et al. explored the spatial accessibility and visual integration of rural streets based on the theory of spatial syntax, and optimized the rural commercial space layout based on the spatial resistance model in order to improve the utilization value of rural commercial space and tourism effect [28]. Qiu, Z. et al. constructed a “demand-frequency” coupling model for public service facilities in villages with different functions, and by analyzing the synergistic mechanism between the service functions and spatial accessibility of public facilities, they proposed a public service facility layout strategy with high resource utilization efficiency and fairness [29]. Shen, Y. and Wang, C. designed a rural garbage can layout optimization path based on Actor Network Theory (ANT), which identifies and classifies participants in order to construct a stable heterogeneous network, and then plans a garbage can layout strategy with the most efficient utilization [30].

This paper puts forward the optimization idea of rural public service facility system from the implementation of the use efficiency and service quality, taking into account the asymmetric flow, and establishes the rural public facility layout model based on the mixed integer planning algorithm. Moran's I index in global spatial autocorrelation is used to analyze the spatial autocorrelation degree of the accessibility of the rural basic public service facilities, and corresponding optimization strategies for the layout of facilities are proposed for the four aspects of education, medical care, culture and sports. A multivariate linear model is used to analyze the impact of mixed integer planning on rural residents' sense of social governance efficacy, and based on the regression analysis results, strategies for improving social governance efficacy are listed.

2. Optimization of the layout of rural public facilities

2.1. Construction of public service facilities system

2.1.1. Optimization ideas. The layout of public service facilities should not only consider the equalization of facilities, but also consider the efficiency of the use of various types of facilities and quality of service [31]. The construction of high-quality public service facilities, the need to start from the public, service, that is, focusing on the total layout of urban and rural public service facilities (the main body of the supply) at the same time to accelerate the construction of high-quality public services (facilities) system, this paper puts forward the "status quo, looking for deficiencies, building frameworks, dividing the area, to protect the needs of the excellent layout, and focus on fairness, improve quality". This paper puts forward the research idea and framework, as shown in Figure 1.

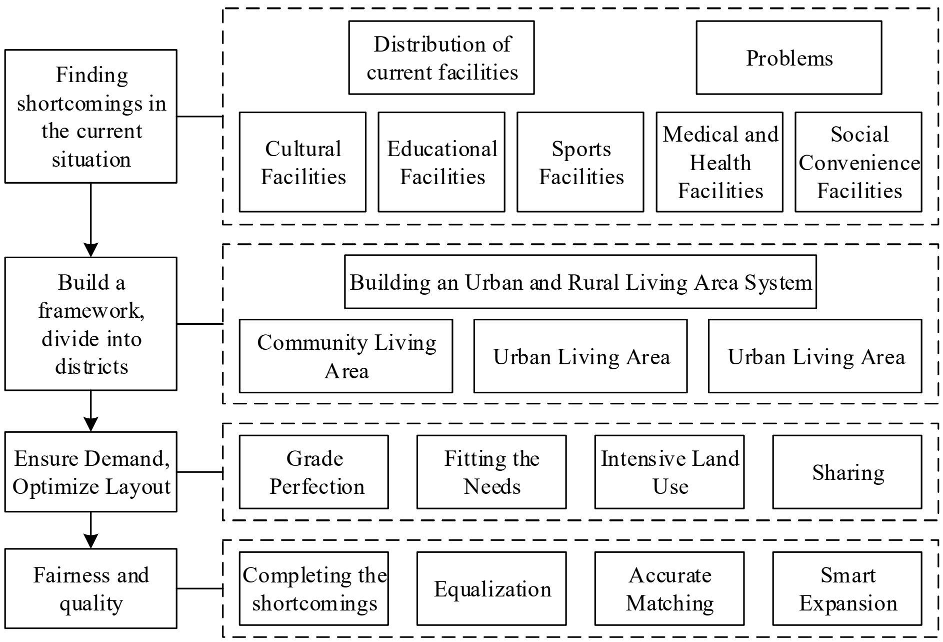


Fig. 1. The rural public facilities layout research thought

2.1.2. Building a system of urban and rural living areas. In accordance with the basic concept of returning to the "people-centered" approach, a three-tiered system of urban and rural living areas is being constructed, based on the maximum distance in time that residents are willing to bear in order to use certain types of public service facilities, namely, the "community living area, the town living area, and the urban living area".

2.2. Optimization of the layout of public service facilities

2.2.1. Equalization of public services in accordance with their hierarchy of facilities. The layout of urban and rural public service facilities is graded according to four spatial scales: regional, urban, peri-urban and rural; the optimization and integration of urban and enterprise-related service facilities is based on the principle of the intensive, efficient and convenient use of public service facilities; and the optimization and integration of public service facilities in rural areas is based on the fact that the loss of rural populations is increasing and that there is a possibility of optimizing and integrating rural settlements, so as to avoid inefficient investment.

The distribution of natural villages and administrative villages in rural areas is relatively decentralized, which can be called "loose community". According to the characteristics of rural population distribution, age structure, and villagers' willingness to gather, the layout of rural settlements in the whole region is centralized; public service facilities in centralized settlements are provided in accordance with the needs of the community-level living circle, and the rest of the settlements are provided in accordance with the principle of making up for the shortcomings and preserving the basics.

Suburban combined area is connected to the city center and its surrounding towns and villages in the transition, the configuration of public service facilities based on demand, equalization of configuration while paying attention to the use of efficiency. In terms of cultural facilities, the township-level comprehensive cultural stations are improved, with libraries, fitness rooms, activity rooms for the elderly, and so on. In terms of educational facilities, in accordance with the basic requirement that "secondary education should be concentrated in towns", the status quo secondary school facilities in the towns of Wenshu and Xincheng should be improved. In terms of medical facilities, the townships are equipped with general hospitals and emergency networks to serve the townships and neighboring administrative villages, and branches of the CDC, Health Supervision Office, and Maternal and Child Health Stations are set up as appropriate to extend public health services.

2.2.2. Configuration according to intensive shared clustering. Figure 2 shows the implantation of multiple public service functions in rural spaces, and the allocation of high-quality urban and rural public service facilities should adhere to the principle of stock development, improve all kinds of public service facilities, realize the intensive arrangement of the same-level living circle and cross-level living circle, and promote the sharing of public service facilities and the coordinated development of urban and rural areas.

Making full use of idle resources, in the configuration of public service facilities, elementary school classrooms can be transformed into kindergartens, health rooms, farm bookstores, etc., while activity venues can be used to hold regular sports and fitness activities.

By centralizing the arrangement of various facilities, the vitality of urban and rural communities will be enhanced. Some of the existing public service facilities can be co-located with administrative facilities to form public service complexes.

The use of other urban and rural spaces (commercial complexes, community service centers) to implant a variety of public service functions and achieve the intensification of the allocation of public service facilities.

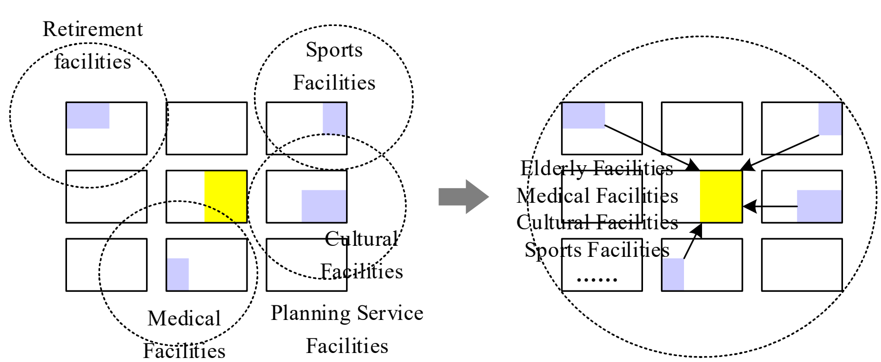


Fig. 2. Rural space is implanted in multiple public services

2.3. Optimization of rural public facility layout based on mixed integer planning

2.3.1. Modeling rural utility layout considering asymmetric flows. The rural utility layout problem has been proved to be NP-hard, and a common approach for NP-hard problems is to design heuristic algorithms that are specific to the characteristics of the problem [32-33]. However, in order to understand the structure of the rural utility layout problem, scholars construct mathematical models for the problem in order to design more efficient heuristic algorithms. Usually, solving the problem using a mathematical model is the first step in solving a new layout problem. For small-scale problems, an optimal solution can be obtained by solving the mathematical planning model, and for medium- to large-scale problems, an upper bound value of the problem can be obtained within a certain time frame (e.g., 1 hour), which can be used as a benchmark to measure the performance of the heuristic algorithm. Past researchers and scholars have constructed mathematical models for facility layout problems, however, due to the complexity of the problem and the different ways of model construction, the use of mathematical planning models to solve a particular problem has not been studied deeply enough. In theoretical studies, a deeper understanding of the different properties of optimization models can be of great help in proposing more efficient solution methods. Different forms of decision variables in the model construction process make there are different ways of model construction. There are differences in the performance of different optimization models in solving the facility layout problem, and it is of practical importance to develop an efficient solution model for the problem.

The performance of the models is further compared using linear programming relaxations of the models. The linear programming relaxation can provide a lower bound for the mixed integer programming model in a shorter time. The closer the linear programming relaxation value is to the optimal solution, the tighter the model is and the better the model is. Linear programming relaxation has an important role in solving mixed integer programming models, in branch-and-bound algorithms, linear programming relaxation separates the solution space (branching process) and obtaining a lower bound value helps to reduce the extent of the solution space (bounding process). For mixed-integer programming models, although there are many delimitation methods, the linear programming relaxation is one of the most effective. In fact, the linear programming relaxation yields lower bounds due to the fact that the quality of the solution of the relaxed model is always lower (or the same) than the optimal solution of the mixed integer programming model. Obtaining a linear programming relaxation facilitates the use of more advanced algorithms, such as branch-and-cut and column generation algorithms.

2.3.2. Problem description. This chapter examines an extended form of the Rural Utility Layout Problem: the Rural Utility Layout Problem Considering Asymmetric Flow and Aisle Width (SRFLP_AC). The SRFLP_AC that considers these two factors makes the problem more realistic. Given the number of facilities n, the volume of material flow between two facilities f_{ij}, and the width of the aisle w, the objective of the problem is to minimize the sum of the logistics costs between the two facilities.

The modeling of the SRFLP_AC problem in this chapter is based on the following assumptions:
1) Facilities are arranged along straight lines.
2) Facilities are rectangles of different sizes.
3) The distance between two facilities is calculated using the center point of the facilities.
4) There is no gap between the facilities, i.e., the gap is zero.
5) The facilities are aligned in the given direction.

Without loss of generality, it is assumed that all the given parameters are integers. The set of SRFLP_AC and the definition of the parameters are shown in Table 1.

Table 1. Sets and parameters used by the SRFLP_AC model

Symbols	Description
n	Number of facilities
i, j	Facility index $i, j \in N$,among $N = 1, \cdots, n$
l_i	Length of facility i
f_{ij}	Flow from facility $i \in N_1$ to Facility $j \in N_2$ Flow rate,among $N_1 = \{1, 2, \cdots, n-1\}$,

	$N_2 = \{i+1,\cdots,n\}, i \in N_1$
w	.Aisle width,hypothesis $w = \min(l_1,\cdots,l_n)$
T	The total length of the facility, $T = \sum_{i=1}^{n} l_i$

2.3.3. Mixed-integer planning models. The model uses the absolute value of the difference between the coordinates of the two facilities to represent the distance between the facilities, using the fact that the distance between the two facilities should be greater than half of the sum of the lengths of the two facilities as a non-overlap constraint. The variables of the model are described as follows:

α_{ij}: Binary variable that takes the value of 1 when facility i is distributed to the left of facility j and 0 otherwise.

y_i: Continuous variable that represents the horizontal coordinates of the center point of facility i.

Based on the above variables, the mixed integer planning model MIP2 is:

Objective function:

$$Minimize \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left(f_{ij} + f_{ji}\right)\left(\left|y_i - y_j\right| + w\right) \tag{1}$$

Subject to:

$$\left|y_i - y_j\right| \geq \frac{1}{2}\left(l_i + l_j\right), i \in N_1, j \in N_2 \tag{2}$$

Since the objective function and constraints of this model contain absolute values in them, it is not possible to solve it directly using a mixed integer programming solver to obtain an optimal solution, in order to transform this model into an equivalent mixed integer programming model, the following two variables are introduced [34]:

y_{ij}^{+}: Continuous variable that takes the value $\left(y_i - y_j\right)$ if device i is distributed to the right of device j, i.e. $y_i - y_j > 0$, and 0 in all other cases.

y_{ij}^{-}: Continuous variable which takes the value $\left(y_i - y_j\right)$ if device i is distributed to the left of device j, i.e. $y_i - y_i \leq 0$, and 0 in other cases.

Based on the above definitions, it can be obtained:

$$\begin{aligned} \left|y_i - y_j\right| &= y_{ij}^{+} + y_{ij}^{-} \\ \left(y_i - y_j\right) &= y_{ij}^{+} - y_{ij}^{-} \end{aligned} \tag{3}$$

The model is transformed into the following mixed integer programming model MIP2:

Objective function:

$$Minimize \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left(f_{ij} + f_{ji}\right)\left(y_{ij}^{+} + y_{ij}^{-} + w\right) \tag{4}$$

Subject to:

$$y_i - y_j + M\alpha_{ij} \geq \frac{1}{2}\left(l_i + l_j\right), i \in N_1, j \in N_2 \tag{5}$$

$$y_j - y_i + M\left(1 - \alpha_{ij}\right) \geq \frac{1}{2}\left(l_i + l_j\right), i \in N_1, j \in N_2 \tag{6}$$

$$y_{ij}^{+} - y_{ij}^{-} = y_i - y_j, i \in N_1, j \in N_2 \tag{7}$$

$$y_{ij}^{+}, y_{ij}^{-} \geq 0, i \in N_1, j \in N_2 \tag{8}$$

$$\alpha_{ij} \in \{0,1\}, i \in N, j \in N \setminus i \tag{9}$$

Equation (4) is the objective function. Constraints (5) and (6) are analytic constraints to prevent overlapping facilities, and since α_{ij} is a binary variable, only one of constraints (5) and (6) holds. Use constraint (7) to calculate the distance between the two facilities. Constraints (8) and constraints (9) define the range of values for the variables. In this model, $M = \sum_{i=1}^{n} l_i$. It is important to note that the model also contains decimation constraints.

3. Optimization analysis of the layout of rural public facilities

3.1. Evaluation of global spatial parity in the layout of rural public facilities

3.1.1. Comparison of the results of the evaluation of the accessibility of public facilities. Comprehensively comparing the efficiency of the accessibility coverage of basic public service facilities in villages within the study area, Figure 3 shows the results of the evaluation of the accessibility of public service facilities, and on the whole, the differences in the number and spatial layout of various types of basic public service facilities are more obvious, among which the number of rural clinics is much larger than that of other facilities, with the number of facilities being 26. The number of secondary schools, township general hospitals and post offices is smaller, with only 2, which on the one hand indicates that the demand for public service facilities in the rural settlements within the study area is more differentiated, and the degree of supply and demand is more different, and on the other hand indicates that there are certain problems in the configuration and spatial layout of the current public service facilities.

The degree of accessibility coverage of basic public service facilities in villages varies greatly, and the proportion of villages with general and above grade accessibility and the proportion of population covered by rural savings banks are the highest. Cultural and sports facilities and elderly facilities, middle schools, post offices and other facilities have the smallest proportion of villages and population with general and above grade accessibility, indicating that the spatial layout of existing facilities such as rural savings banks and cultural and sports facilities have relatively obvious effects in terms of accessibility expression, while the secondary schools and post offices have poorer performance in terms of layout accessibility. From the perspective of layout efficiency of single-type facilities, it can be found by calculating the ratio of the proportion of general and above-grade accessibility to the number of facilities that middle schools, township general hospitals, and post offices are the top three of all facilities, and the layout efficiency of rural clinics is the worst, mainly because the service distance of middle schools and general hospitals is relatively large, and the number of facilities is low while the degree of facility accessibility coverage crosses is small, and therefore it can realize a higher high spatial layout efficiency. The study found that the optimization of the layout of public service facilities should be considered in terms of both “quantity and quality”, and that under the premise of ensuring a reasonable number of facilities without wasting the spatial coverage of resources, the layout of existing public service facilities should be adjusted, and new facilities should be added appropriately to fill in the spatial loopholes of the facilities, so as to increase the efficiency of the spatial layout of public service facilities.

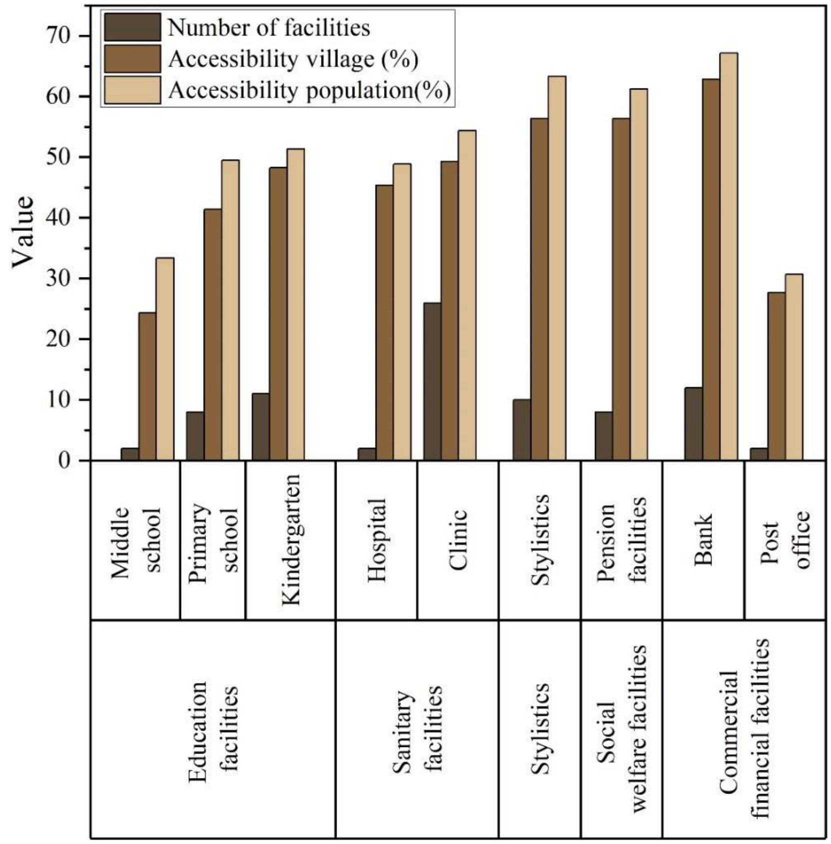


Fig. 3. Results of accessibility evaluation of public services facilities

3.1.2. Accessibility of administrative districts. Figure 4 shows the distribution of accessibility in each administrative district of a rural area. Under the search radius of 1500m and 2500m, the spatial distribution of spatial accessibility of public facilities in a rural area has a small difference in general, and all of them show a pattern of north-south divergence, but the difference in the distribution of accessibility between administrative districts is obvious. Natural villages with high accessibility are concentrated in the north of JN and LS districts, while natural villages with low accessibility are clustered in LH district. For example, under the 2500m search radius, the spatial proportion of low accessibility in JN district is 11.12%, while the corresponding proportion in LH district both reaches 54.52%. Specifically for the number of natural villages and population, the accessibility of public service facilities under the 1500m search radius, about 38% of the villages are low accessibility, that is, this part of natural villages and population can not enjoy the standard service of public service facilities with a minimum of 1.5m^2 per capita within 1500m walking distance. When the search radius is expanded to 2500m, the proportion of natural villages with low accessibility drops to 14.17%, and the coverage of public service facilities is significantly expanded. Generally speaking, the spatial accessibility of public service facilities in a rural area under the search radius of 2500m can cover most of the natural villages and population, but the spatial distribution of the accessibility of public service facilities between and within administrative districts is relatively unbalanced, with nearly half of the natural villages and population in individual administrative districts still located outside the scope of service of public service facilities, and not able to receive effective services within the maximum walking distance, and the construction of public service facilities is relatively lagging behind. The construction of public service facilities is lagging behind.

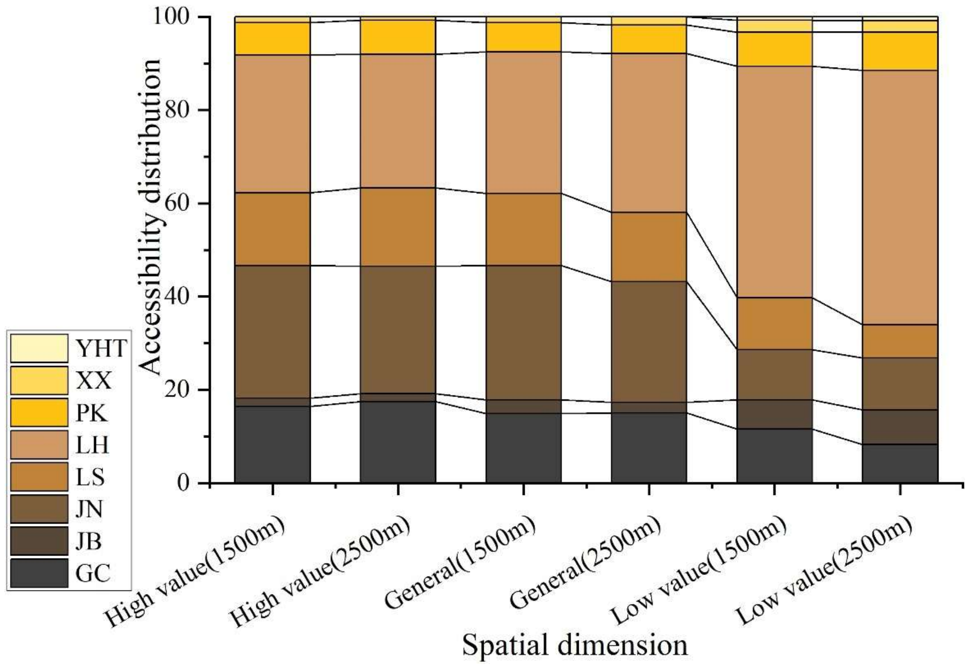


Fig. 4. The distribution of various political zones in a village

Figure 5 shows the distribution of spatial accessibility of public facilities in different types of villages in a certain area. There are a large number of villages of other general types in the rural areas of a certain area, and the number of natural villages with low accessibility is the largest among the five types of villages, which accounts for 53.08% of the total number of natural villages with low accessibility, i.e., the overall spatial accessibility of public service facilities of villages in the rural areas of a certain area of the other general types is relatively low, and a variety of measures should be taken in the future to In the future, various measures should be taken to improve the accessibility of public service facilities by increasing the supporting construction or adjusting the tilted construction land indexes of village types, etc., so as to improve the overall spatial accessibility of public service facilities in the rural areas of a certain place, and thus to realize the equal distribution of the resources of public service facilities within the region.

Above all, the spatial accessibility of public service facilities in planned development villages in a certain rural area is generally good, but the accessibility of some planned development villages in the seven administrative districts other than HYT is low, so in the future, corresponding measures should be taken to ensure that these villages are equipped with supporting public service facilities, so as to give full play to their ability to provide services for the neighboring villages of other types.

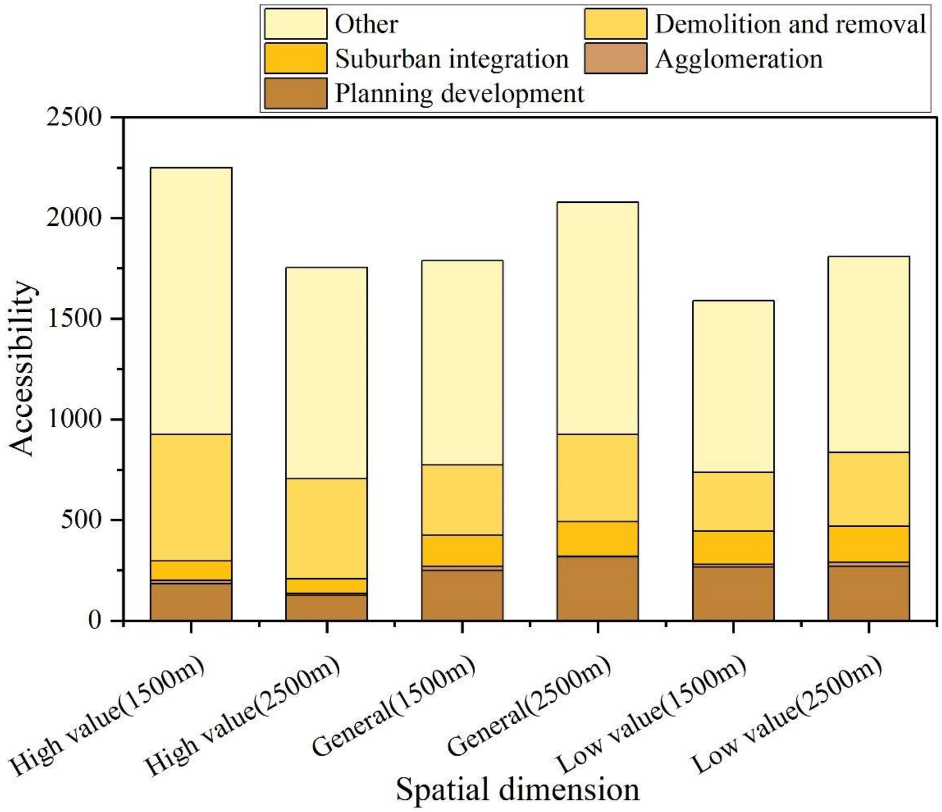
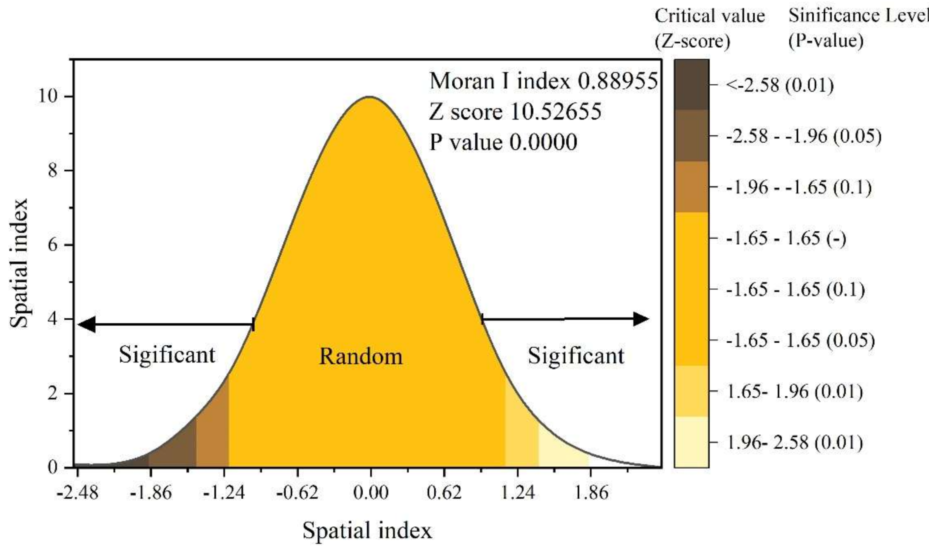


Fig. 5. The public facilities space accessibility distribution in different types of rural areas

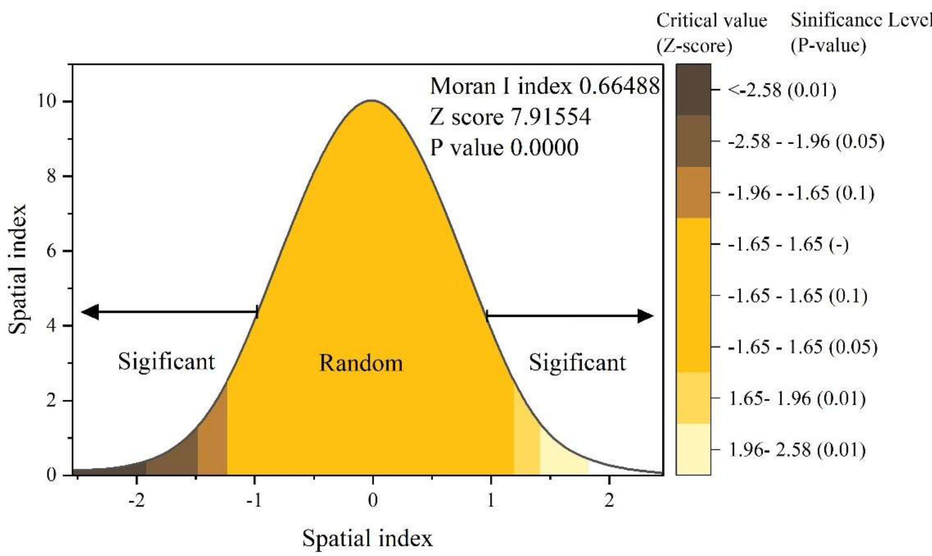
3.1.3. Evaluation of parity in the layout of basic public service facilities in villages. In this paper, we mainly use Moran's I index in the global spatial autocorrelation to analyze the spatial correlation degree of the accessibility of rural basic public service facilities in a certain place [35]. Figure 6 shows the global spatial autocorrelation of rural public facilities accessibility, Figure (a) is educational facilities, Figure (b) is medical facilities, Figure (c) is cultural and sports facilities.

By the correlation cut-off point of Moran's I value is zero, the value is greater than zero indicates that it has positive correlation attribute, which is spatially represented as aggregation, the value is less than zero indicates that it has negative correlation attribute, which is spatially represented as discrete, and when the value is equal to zero it does not have correlation, which is spatially represented as a free distribution. The results of the analysis of the standardized z-value are mainly divided by ±2.48 and ±1.86, and the results are not obvious in the spatial correlation between -1.24 and 1.24. When the results of the standardized z-value are less than -2.48, the discrete layout of the facilities is very obvious, and the accessibility aggregation layout of the facilities is quite obvious when the value is greater than 2.48.

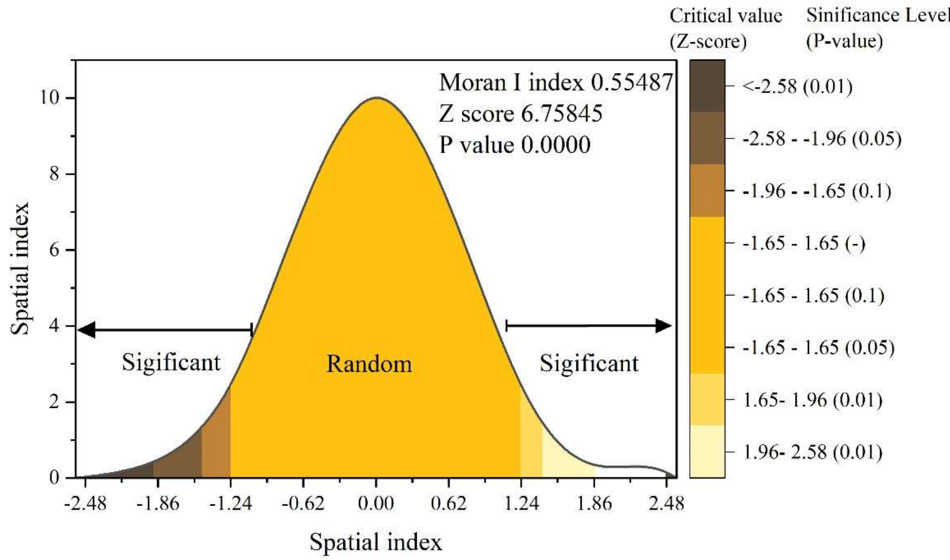
By analyzing the global autocorrelation values, it is possible to make relevant judgments about the degree of relevance of public service facility accessibility and the form of its distribution from the overall space. Analyzing the results of global spatial autocorrelation calculation on the accessibility of public service facilities, from the point of view of the positive and negative Moran's I values, there is a positive spatial correlation between the accessibility of all public service facilities within the study area, and the Moran's I values of rural education, medical care, and cultural and sports facilities are 0.89, 0.66, 0.55, all of which have positive correlation. , 0.55, all of which are positively correlated. This indicates that the spatial layout of various types of facilities is relatively centralized, mainly due to the relatively centralized layout of construction land other than residential land in rural areas. In most cases, public service facilities are centrally distributed along the main roads in the countryside and form one or more facility clusters, which simultaneously serve a certain range of rural settlements and safeguard the basic public service needs of rural residents in a larger area.



(a)Education facilities



(b)Medical facilities



(c)Cultural and sports facilities

Fig. 6. Rural public facilities can be connected to global space

3.2. Results of optimizing the layout of rural public facilities

Using mixed integer planning, an optimization strategy is proposed for the layout of public facilities in a rural village in 2035 in terms of education, health care, culture, and sports.

3.2.1. Education. Table 2 shows the optimization strategy of the layout of educational facilities, although the number of 1,000 students exceeds the standard, but from the point of view of the per capita land size, a large number of educational facilities in the county there are still gaps in the unutilized land, in a little bit of time to meet the needs of the students under the jurisdiction of the school, and due to the limited radius of the kindergarten service, the service coverage is limited, which leads to the existence of some areas of school-age children to get enrolled in school difficulties, so the number of kindergartens need to be increased appropriately. The analysis of the optimization method based on mixed integer planning shows that the optimization method of the layout of educational facilities in the test area increases the number of classes from 1 to 5, which corresponds to the implementation of expanding the scale or building a new school. Compared with the problems in other rural areas, the lack of educational facilities in Yazhe Township is more serious. Therefore, optimizing the layout of educational facilities in Yazhe Township will be the focus of the next study. In terms of the future development of Geji County, by 2035, the number of school-age students enrolled in basic education will increase massively, which makes it necessary to re-plan the size and number of schools. By predicting the scale of school-age students to be taken up by schools at each stage in 2035, and combining with the appropriate class size already proposed in the previous section, the adjustment of the scale and number of various types of schools will be determined.

Table 2. Education facilities layout optimization strategy

		Status quo		2035		Optimization mode	
Serial number	Subordinate township	Student size	Class quantity	Student size	Class quantity	Increased class	Implementation method
1	Keji town	72	3	198	7	4	A new school was built
2		36	2	88	3	1	Scale up
3		22	1	54	2	1	Scale up

4		25	1	60	2	1	Scale up
5		19	1	45	2	1	Scale up
6	Fumu·Taungsang township	38	2	95	4	2	Scale up
7	Shomba township	23	1	57	2	1	Scale up
8		15	1	34	3	2	Scale up
9		45	1	110	4	3	Scale up
10		18	2	44	3	1	Scale up
11	Yager township	40	1	105	4	3	Scale up
12		30	1	79	3	2	Scale up
13		72	2	183	7	5	A new school was built
14		65	1	165	5	4	A new school was built
15	Salt lake township	35	2	84	3	1	Scale up
16		18	1	44	2	1	Scale up
17		30	2	79	5	3	Scale up

3.2.2. Medical care. Table 3 shows the planning layout of medical facilities, it can be seen: the number of people served, building area, the number of medical personnel in this paper is basically lower than the target, which reflects the rural areas as poor land resources for construction, the medical facilities configuration and construction under the premise of meeting the normal medical needs of the residents, and as far as possible, control the development and construction intensity, in order to ensure the efficient use of resources. At the same time, the indicators proposed in this paper are relatively more detailed, which is mainly reflected in the control of the number of physicians and beds per 1,000 people: the minimum size of the indicator is clearly defined, and it is proposed that every increase in a certain size of the population, the corresponding increase in a certain size of the medical configuration of the facilities and personnel, which to a certain extent not only guarantees the operation of medical facilities under the normal scale, but also takes into account the differences in population size between different settlements. This not only ensures the operation of medical facilities under normal scale, but also takes into account the differences in population size between different neighborhoods and their different medical needs. In general, the indicators of medical facilities proposed in this paper are in line with the needs of local rural residents. Combined with the various types of indicators already proposed in the previous article, to determine the scale and number of medical facilities adjustment, based on the mixed integer planning proposed, in the case of the number of medical personnel remains unchanged, the number of people to enhance the number of services, enhance the number of people in the range of 34 ~ 321, the proposed optimization program: on the basis of the existing scale, the beautification of the medical environment, and can be considered to optimize the management mode and other non-hard conditions.

Table 3. Medical facilities planning layout

		Status quo			2035			
Serial number	Subordinate township	Service number	Medical personnel number	Floor area(m^2)	Service number	Medical personnel number	Floor area(m^2)	Optimization mode
1	Keji town	1465	2	494.48	1685	2	200	On the
2		786	2	624.54	898	2	100	basis of

3		1648	2	348.48	1948	2	80	existing scale, beautify the medical treatment environment, but consider the non-hard conditions such as optimizing the management side
4		203	2	557.36	266	2	100	
5		253	2	2148.88	295	2	80	
6		298	2	273.32	348	2	80	
7		303	2	278.63	359	2	80	
8	Fumu·Taungsang township	548	2	198.32	615	2	80	
9		539	2	214.96	636	2	100	
10		685	2	337.12	725	2	100	
11	Shomba township	267	2	248.98	301	2	100	
12		1236	2	125.63	1465	2	80	
13		364	2	137.36	469	2	80	
14		834	2	108.66	965	2	100	
15		1688	2	248.36	1936	2	80	
16	Yager township	1236	2	1188.69	1423	2	100	
17		786	2	160.48	925	2	80	
18		2248	2	123.66	2569	2	80	
19	Salt lake township	536	2	348.21	605	2	-	
20		1869	2	134.98	2166	2	100	

3.2.3. Style. Table 4 shows the optimization of the layout of the problem facilities, through mixed integer planning, predicting the population size in 2035, and combining the various types of indicators already proposed in the previous section, to determine the size and number of cultural and sports facilities to adjust the situation. Therefore, the optimization of cultural and sports facilities in a certain place mainly focuses on the new village comprehensive activity center in Sengbu Village of Geji Township, Loma Village of Wembu Dangsang Township, Jiangma Village of Yaje Township and Chuozang Village, the expansion of the scale of the construction of village comprehensive activity centers in other villages, as well as the construction of new facilities in some rural settlements, and optimization of the environment of the facilities can be aimed at the provision of a complete range of fitness equipment, renovation of the ground level of the activity site to meet the standards of the upgrading of the facility and facilities around the natural environment and landscape design. Natural environment and landscape design. At the township level, Boonbudangsang Township to increase the national fitness center, all townships need to increase the scale of cultural and sports facilities, cultural facilities in 2035 to increase the land area to more than 750 m ^{2}, sports facilities to increase the land area to more than 1,000 m ^{2}.

Table 4. Problem facility layout optimization

Town name	The status quo				2035			Optimization mode	
	Cultural facilities		Sports facilities						
	Facility name	Land are(m^2)	Facility name	Land are(m^2)	2035 Population scale	The area of cultural facilities(m^2)	Area of sports facilities(m^2)	Cultural facilities	Sports facilities
Keji town	Keji town Comprehensive cultural station	1247.48	Keji town Universal fitness center	624.31	5546	3348	5546	To meet the	The minimum

								minimum size, it is recommended to increase the scale	size should be expanded
Shomba township	Shomba township Comprehensive cultural station	392.64	Shomba township Universal fitness center	543.96	2936	1769	2936	None of the smallest size, all Should be expanded	
Salt lake township	Salt lake township Comprehensive cultural station	679.36	Salt lake township Universal fitness center	734.12	2745	1635	2745	To meet the minimum size, it is recommended to increase the scale	The minimum size should be expanded
Yager township	Yager township Comprehensive cultural station	648.68	Yager township Universal fitness center	387.65	7798	4623	7798	To meet the minimum size, it is recommended to increase the scale	The minimum size should be expanded
Fumu·Taungsang township	Fumu·Taungsang township Comprehensive cultural station	344.63	Fumu·Taungsang township Universal fitness center	-	1269	768	1269	The minimum size should be expanded	Lack of facilities and new additions

4. Improving the effectiveness of social governance with mixed-integer planning

4.1. Data Sources, Variable Descriptions and Model Setting

4.1.1. Data sources. The research subjects as a whole were sampled using a multi-stage stratified sampling method, and the specific sampling process was as follows: first, based on the level of economic development and social governance, five provinces, Jiangsu, Zhejiang, Guangdong, Shandong, and Fujian, were selected from the eastern region, and six provinces, Henan, Ningxia, Shaanxi, Gansu, Sichuan, and Yunnan, were selected from the central and western regions as the primary sampling units. Second, two to four locations were selected from each province, one of which was a district county under the provincial capital of that province, and the other locations were districts and counties under the jurisdiction of other regions of that province. Finally, three to five rural communities in each district and county were selected for the study. Based on the population size and distribution structure of the villages, 20 to 30 households were randomly selected from each village, and a member of each household familiar with the situation of the household and the village was selected for face-to-face questionnaire interviews. There are obvious regional differences in the state of development of mixed-integer planning technology and social governance effectiveness in China, and the research sample covers the three regions of East, Central, and West China, which can reflect the use of mixed-integer planning and social governance effectiveness in villages in different regions. The questionnaire includes basic information of individual families, basic conditions of villages, application of mixed integer planning, social governance, and individual perceptions. The validity of the questionnaire was tested, and unqualified samples such as those with too much missing information, outliers, and inconsistent answers were eliminated, resulting in 2,279 valid questionnaires from rural residents.

4.1.2. Description of variables. The explanatory variable of this paper is the sense of social governance effectiveness. In this paper, the explanatory variable is the sense of social governance efficacy, which is constructed from the measurements of social governance efficacy in the “China Social Governance Evaluation Indicator System” constructed by the group of “China Social Management Evaluation System” and from the subjective evaluations of six dimensions, namely, human development, social equity, public service, social security, public safety and social participation. The subjective evaluation of the six dimensions measures the sense of social governance effectiveness.

4.1.3. Model setup. It has been confirmed in the literature that individual characteristics of rural members, family characteristics and regional characteristics, etc. have an impact on social governance efficacy and its perception. Drawing on existing research, this paper categorizes the control variables that may affect rural residents' perception of governance efficacy into three groups: first, the respondents' individual characteristics and cognitive variables, such as the respondents' gender, age, education level, and political identity; second, the variables of family characteristics, such as the annual family income and the family's social status; and, third, the regional location of the countryside, such as whether it is situated in the eastern developed region or in the central and western underdeveloped regions. The settings, descriptions and descriptive statistics of the relevant variables are shown in Table 5, in which the mean values of governance efficacy and mixed integer programming are 23.04 and 1.76, respectively.

In this paper, a multivariate linear model is used to analyze the impact of mixed integer planning application on rural residents' sense of social governance efficacy, with the following expressions:

$$efficacy_i = a_0 + a_1 digital_i + a_2 control_i + \sigma_i \tag{10}$$

Table 5. Definition, assignment and descriptive analysis of variables

Variable name	Variable definition and measurement	Observed value	Mean value	Standard deviation	Minimum value	Maximum value
Sense of governance effectiveness	The six subindicators integrated income	2278	23.04	3.88	5	32
Mixed integer programming	The degree of integration of mixed integers,0~3	1969	1.76	1.16	1	4
Gender	Male=1,Female=0	2296	0.56	0.58	0	1
Age	Actual age	2296	42.59	17.16	15	89
Nations	Han=1,Ethnic minorities =0	2296	0.94	0.24	0	1
Education level	Primary school and below =1,Junior high school=2,High school,Junior college and undergraduate =4,Graduate student =5	2296	2.59	1.16	1	6
Political appearance	Have a party = =1,Non-partisan =0	2296	0.15	0.34	0	1
Family income	Total household income for the previous year In (below 20,000 =1:-2$10,000 - $50,000 = $250,000-100,000 = 3:100,000-150,000 =4: 150,000-200,000 = 5.2 million-500,000 = 6:500,000Above =7)	2296	2.89	1.34	1	8
Social relative status	Lowest level =1: lower level =2; Middle =3; Higher level =4; Highest level =54	2296	2.58	0.59	0	7
Region	East =1; Midwest=0	2296	0.24	0.48	1	2

4.2. *Correlation analysis*

In this paper, SPSS 26.0 was used to analyze the correlation analysis of the study variables in order to verify whether there is an association between the variables, what kind of association and the level of association. Correlation analysis uses correlation coefficients to show the direction and level of association between variables and in this study Pearson correlation coefficient was used for the analysis. In order to determine the level of significance, a two-tailed test was used and the Pearson correlation coefficient ranges from -1 to 1. A positive value indicates a positive correlation, while a negative value implies a negative relationship. The purpose of this section is to examine the correlation between the independent variable (mixed integer planning) and the dependent variable (social governance effectiveness) as a means of determining the level of reasonableness of the research model.

Figure 7 shows the correlations of the research variables, firstly, human development, social equity, public services, social security, public safety, and social participation, respectively, maintain a significant positive correlation with the sense of social governance efficacy at the 0.01 standard, with correlation coefficients of 0.843, 0.842, 0.648, 0.745, 0.645, and 0.597, in that order.

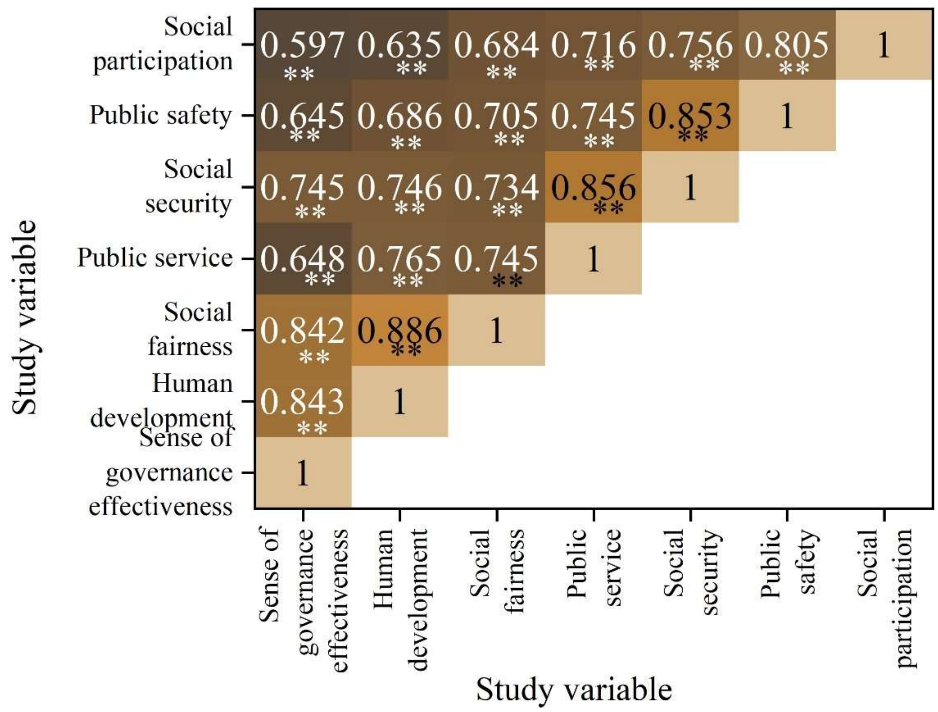


Fig. 7. Correlation of variables in each study (** At level 0.01 (two-tailed), the correlation was significant.)

4.3. Analysis of Mixed Integer Planning on the Perceived Efficacy of Rural Social Governance

4.3.1. Benchmark regressions and results on the impact of sense of efficacy in social governance. Table 6 shows the results of the baseline regression model. Model 1 reports the effect of mixed-integer planning application on the sense of governance effectiveness, and Models 2 to 7 report the effect of mixed-integer planning application on the six subvariables of the sense of governance effectiveness. The regression results show that mixed-integer planning application has a significant positive effect on the sense of governance efficacy in the countryside, indicating that the higher the ability and level of mixed-integer planning application of the countryside residents, the better their sense of governance efficacy in the countryside. The main reason is that the application of mixed integer planning enhances the governance capacity of the villages, improves the villagers' social governance knowledge and participation, and makes the rural residents more aware of the process and effectiveness of governance, which improves their sense of governance effectiveness. From the regression results of the subvariables of governance effectiveness, the application of mixed integer planning has a significant impact on rural residents in terms of the human development index, public services, social security, public safety and social participation, with regression results of 0.075, 0.068, 0.125, 0.083 and 0.164, and is significant at the 1% level, but is not as significant as the previous indicators are significant, with a regression result of 0.042.

Table 6. The results of the benchmark regression model

/	Governance efficacy	Human development	Social equity	Public Service	Social Security	Public safety	Social participation
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Mixed integer programming	0.485***	0.075***	0.042**	0.068***	0.125***	0.083***	0.164***
	(0.088)	(0.0199)	(0.018)	(0.019)	(0.016)	(0.013)	(0.019)
Gender	-0.048	-0.134	-0.042	-0.002	-0.036	0.078**	-0.013
	(0.162)	(0.034)	(0.045)	(0.025)	(0.036)	(0.035)	(0.024)
Age	0.033***	0.054***	0.009***	0.008***	0.007***	0.008***	0.003**

	(0.008)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)	(0.001)
Nation	-0.548	-0.143*	-0.016	-0.057	-0.187	-0.108	-0.164**
	(0.318)	(0.079)	(0.085)	(0.086)	(0.098)	(0.099)	(0.075)
Education	-0.248**	-0.023	-0.043*	-0.085***	0.026	-0.048***	-0.048***
	(0.103)	(0.024)	(0.026)	(0.026)	(0.024)	(0.023)	(0.028)
Political appearance	0.845***	0.095*	0.196***	0.178***	0.175***	0.082	0.154*
	(0.269)	(0.048)	(0.063)	(0.056)	(0.058)	(0.054)	(0.052)
Household income level	0.298***	0.045**	0.048***	0.053***	0.045***	0.034**	0.048***
	(0.078)	(0.015)	(0.016)	(0.019)	(0.013)	(0.018)	(0.013)
Social relative status	0.836***	0.187***	0.187***	0.148***	0.124***	0.135***	0.148***
	(0.186)	(0.039)	(0.048)	(0.045)	(0.052)	(0.026)	(0.032)
Region	0.815***	0.082**	0.166***	0.098*	0.187***	0.248***	0.148***
	(0.215)	(0.044)	(0.046)	(0.043)	(0.068)	(0.036)	(0.048)
Constant term	18.869***	3.551***	2.815***	3.158***	2.758***	3.485***	2.945***
	(0.811)	(0.198)	(0.266)	(0.185)	(0.183)	(0.167)	(0.178)
Observed value	1936	1936	1936	1936	1936	1936	1936
R^2	0.108	0.059	0.057	0.053	0.078	0.077	0.068

Note: ***, **and * indicate significant levels at 1%, 5% and 10%, respectively, parentheses inside is a robust standard error

4.3.2. Regression Results of Instrumental Variables Influencing Sense of Rural Governance Efficacy. Table 7 shows the effect of mixed-integer planning applications on the sense of governance efficacy, the estimation of the instrumental variable (mixed-integer planning application mean) in the first stage is significant at the 1% level, indicating that there is a significant correlation between the instrumental variable and the endogenous variable, and the problem of weak instrumental variables is examined through the Cragg and DonaldWald test, which shows that the Chi value is significant at the 1% level, indicating that the instrumental variable satisfy correlation and exogeneity. The results of the second stage estimation show that mixed integer planning application is significant at the 1% level on the sense of governance efficacy with a regression effect value of 0.514 and is consistent with the regression results reported in the baseline model in terms of direction and significance. The results of the above tests of instrumental variables indicate that the effect of mixed integer planning applications on rural residents' sense of social governance efficacy still holds true after accounting for endogeneity problems caused by reverse causation and omitted variables.

Table 7. The combination integer programming application affects the effectiveness of governance

Variable	IV-2SLS	
	Rural social governance efficacy	
	Model 8	Model 9
	The first stage	The first stage
Mixed integer programming applications	-	0.514**
		(0.248)
Rural mixed integer programming Application mean (instrumental variable)	0.815***	-
	(0.059)	
Control variable	Control	Control
Regional fixed effect	Control	Control
Sample size	1936	1936
R^2	0.948	0.105

Cragg-Donald Wald F	-	204.348

4.3.3. Robustness Tests. Since the six constituent variables of the dependent variable sense of governance efficacy are discrete and ordered variables, with reference to related studies, this paper here adopts the ordered probit modeling method as a robustness test, Table 8 shows the robustness test results, as can be seen from the regression model, the estimation results of the core variables are basically consistent with the estimation results of the benchmark regression model, with the estimation results of 0.145, 0.348, respectively, 0.428, thus indicating that the results of the benchmark regression of the mixed integer planning application on rural residents' sense of efficacy in social governance are robust.

Table 8. Robustness test results

Variable	The sense of effectiveness of rural social governance		
	Model 10	Model 11	Model 12
Mixed integer programming	0.145***	0.348***	0.428***
	(0.024)	(0.064)	(0.124)
Control variable	Control	Control	Control
Regional fixation effect	Control	Control	Control
Sample size	1936	1936	1936
R^2	0.024	0.097	0.105

5. Strategies for improving the effectiveness of social governance in the era of big data

5.1. Continuously strengthen the leadership role of grass-roots party organizations in villages

To enhance the effectiveness of rural governance and modernize rural governance, it is necessary to place the construction of grass-roots Party organizations in rural areas at the core, further strengthen and enhance the leadership role of grass-roots Party organizations in rural areas, and firmly grasp the correct political direction of socialist construction with Chinese characteristics. First, resolutely implement the Party's leading role in the process of rural governance, and deeply promote the implementation of the central government's comprehensive and strict governance of the Party's various initiatives in the countryside at the grassroots level when it comes to Party organizations. Second, effectively strengthen the construction of rural grass-roots party organization leaders. Focus on the selection of good cadres of both virtue and talent, excellent style, training and promotion of ideal, can act, dare to bear the countryside grass-roots Party members and cadres, to stimulate the leading cadres of the grass-roots Party organizations of the vitality of the entrepreneurial spirit, to the grass-roots Party organizations to lead the countryside governance. Once again, the establishment of rural grass-roots party members and cadres purity mechanism, to promote the construction of grass-roots party organizations by comprehensively strictly governing the party, to create a positive and healthy rural grass-roots party organization ecology, to create a clean and efficient high-quality rural grass-roots leadership cadres, to enhance the internal driving force of the party to improve the effectiveness of rural governance under the leadership of the party.

5.2. Promoting the effectiveness of rural governance through collective economic revitalization

The high-quality development of the collective economy is an important guarantee for the realization of socialist common wealth. Without the revitalization of the collective economy, the superiority of socialism cannot be brought into play, the common wealth cannot be realized, and the goal of rural governance is naturally even more difficult to put into practice. Strengthening the strength of the collective economy is the only way to revitalize agriculture in poor areas, and the revitalization of the collective economy is an important foundation for promoting the effectiveness of rural governance. The family-based small farm economy has an insurmountable blindness and lag, and it is difficult to bear the price fluctuations of agricultural products and resist various types of disasters and other risks, and various forms of rural collective economy, including rural cooperatives and rural shareholding cooperative markets, is an indispensable and important force in the strategy of rural revitalization. In order for the rural collective economy to gain significant development, it is first necessary to give good play to the leading demonstration role of the rich leaders, and absorb elites with high political quality, strong management ability and new development concepts into the grass-roots party organizations, so that they can shoulder the responsibility and power of leading the development of the collective economy. Secondly, it is necessary to deeply explore the effective realization forms and development modes of the rural collective economy, encourage the leasing of assets, resource integration, land transfer, cooperative management and other forms, give full play to the advantages of location, service advantages and industrial characteristics, reasonably allocate all kinds of resources, and further release the vitality of the rural collective economy. Once again, it is necessary to strengthen the management of the financial system of the rural collective economy, enhance the supervision of collective assets through system construction, innovate the management and development mode, revitalize the industrial support fund and other financial funds in impoverished areas, and promote the preservation and appreciation of the value of the rural collective assets. Secondly, the rural collective economy should develop differentiated development paths according to local conditions, focus on deep integration and synergistic development with the county and municipal economies, and strengthen the supervision of and services for the rural collective economy from a macroscopic perspective.

5.3. Innovative concepts and methods of rural grassroots social governance

First, it is necessary to stimulate the enthusiasm and creativity of villagers to participate in rural affairs and to respect their subjective position in rural governance. Relying on the strengths of community-based social organizations, such as civil mediation, red and white wedding ceremonies, public welfare and charities, and village professional associations, the fundamental role of farmers in rural governance should be better utilized. Institutionalize village decision-making and supervision of village affairs, promote openness in village and government affairs, improve the multi-level grass-roots consultation system and the efficiently functioning democratic supervision mechanism, and effectively safeguard the democratic rights of the grass-roots people. Secondly, attention should be paid to the pivotal role played by social organizations in village governance. As important participants in rural governance, people's groups, enterprises and public welfare organizations are not only grass-roots governance units connecting the masses, but also play a key role in areas such as production and services, greatly expanding governance resources and governance effectiveness. Thirdly, new township sages are encouraged to become leaders and promoters of good rural governance, by enhancing their emotional identity, promoting their culture, strengthening their ties with them and guiding them to transform their local ties into practical actions that actively return to their hometowns.

5.4. Strengthening the institutional basis of self-governance, morality and the rule of law in rural governance

First, it is necessary to actively explore effective forms of realization of villagers' autonomy, focusing on improving the system of mass self-governance at the grass-roots level, and to improve the construction of mechanisms for democratic elections, decision-making and supervision at the grass-roots level. It should clarify the relationship of power and responsibility between county and township governments and villagers' self-governance, promote the downward sinking of administrative power, encourage grass-roots level to explore new forms of rural governance, strengthen the supervision mechanism of power at the township and village levels, and innovate the ways in which villagers can participate in public affairs, so as to truly realize grass-roots level people's self-administration, self-service, self-education and self-supervision. Secondly, we attach importance to the moral edification function of rural rules and regulations, enhance villagers' sense of identity and belonging to the traditional and excellent moral traditions, guide villagers to establish correct moral concepts, and cultivate good moral customs. Once again, all efforts are being made to promote the construction of the rule of law in villages.

6. Conclusion and outlook

6.1. Conclusion

This paper constructs the rural public service facility system, proposes the direction of optimizing the allocation of public facility layout, considers the rural public facility layout of asymmetric flow, and uses the mixed integer planning model to realize the optimization of rural public facility layout. A benchmark regression model is used to analyze the improvement of social governance effectiveness by mixed integer planning techniques.

The global spatial autocorrelation Moran's index is used to analyze the degree of spatial correlation of the accessibility of basic public service facilities in a certain countryside, and the values of Moran's I for rural education, medical care, and cultural and sports facilities are 0.89, 0.66, and 0.55, respectively, which are all positively correlated. It indicates that the spatial layout of various types of facilities in a rural area is more concentrated, which can basically meet the basic public service needs of rural residents.

Optimization plans are proposed for the layout of educational, medical, cultural and sports facilities, respectively. In terms of the layout of educational facilities, the number of classes that need to be increased ranges from 1 to 5, corresponding to the implementation of expanding the scale or building a new school. Medical care is in the case of the number of medical staff remains unchanged, enhance the number of services, enhance the number of people in 34 $\sim$ 321 people, on the basis of the existing scale, landscaping the medical environment, can be considered to optimize the management approach and other non-hard conditions. All rural cultural and sports facilities need to increase the scale, the land area of cultural facilities increased to more than 750 m^2, and the land area of sports facilities increased to more than 1,000 m^2.

From the regression results of the sub-variables of governance effectiveness, the application of mixed integer planning has a significant impact on rural residents in terms of human development index, public services, social security, public safety and social participation, with regression results of 0.075, 0.068, 0.125, 0.083 and 0.164, respectively, which are significant at the 1% level.

6.2. Outlook

This paper uses mixed integer programming to optimize the layout of rural public facilities, and applies a multiple linear regression analysis model to evaluate the social governance effectiveness situation, in which there are still some shortcomings. In terms of the dataset of rural public facilities layout, limited to the reasons for the work and the limitation of obtaining data, it mainly focuses on a certain rural area, the sample size and breadth of data in this paper still need to be strengthened, and data samples from other areas can be considered in the future, due to the small number of indicators in the dataset dimension, this paper only chooses six indicators to construct the indicator system of rural governance, and in the future, it is possible to design more indicators to enhance the applicability and precision of the indicator system according to the different situations of different regions. In the future, more indicators can be designed according to the different conditions of different regions to enhance the applicability and accuracy of the indicator system.

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