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Retraction

Retracted: Sports Facilities Investment Based on Multi-objective Optimization and Attribute Decision-Making

Mathematical Problems in Engineering

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] D. Guo, "Sports Facilities Investment Based on Multi-objective Optimization and Attribute Decision-Making," *Mathematical Problems in Engineering*, vol. 2022, Article ID 9051076, 12 pages, 2022.

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Research Article

Sports Facilities Investment Based on Multi-objective Optimization and Attribute Decision-Making

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With the development of the social spiritual civilization, people pay more and more attention to physical health. The construction of sports facilities is an important way to improve the national physical quality, which helps to promote the national exercise. So, the demands of sports facilities around the world are in the climax. The blind and crazy expansion of sports facilities can alleviate people's demand for physical exercise to a certain extent, but there are also risks of environmental damage and economic waste. At present, there is still a lack of scientific guiding theory for the investment decision-making of sports design. In order to improve the quality and efficiency of the sports facility's construction, its investment decision-making research was combed. According to the requirements, construction goal, and the restriction of the sports facility's construction, the method of multi-objective optimization and attribute decision was studied and adopted to provide guidance for sports facilities investment decisions-making in this article. And sports facilities construction plan in a given area was taken as a study example to verify the effectiveness of the results studied in this paper. The results showed that the application of multi-objective optimization and attribute decision-making methods to guide the investment and construction of sports facilities can improve its economy and reduce environmental pollution.

1. Introduction

Sports is a purposeful, conscious, and organized social activity carried out by human beings in the process of social development [1, 2]. According to the needs of production and life, following the development law of human body and mind, physical exercise is taken as the basic means to enhance physique, improve sports technology, carry out ideological and moral education, and enrich social and cultural life. It is a special scientific field that has been gradually established and developed with the development of human society. The origin of sports is based on the emergence of human beings, the perfection of human physique and the development of psychology, and the development of human society and closely related to human production, labor, and life practice [3].

With the rapid development of social economy, people are increasingly pursuing spiritual civilization and physical quality [4, 5]. In recent years, China's sports undertakings have developed rapidly, and the construction of sports facilities has also shown a vigorous development trend. The relationship between this phenomenon of urban development and the improvement of the quality and efficiency of sports facilities construction have attracted the attention of many scholars and research institutions at home and abroad.

Like the development of sports, the development of construction and sports facilities in China have also made remarkable achievements. The construction process of sports facilities has also applied the latest scientific and technological achievements. It also has presented a rich and diverse development momentum. At present, the types of sports facilities under construction mainly include stadiums, sports centers, swimming and diving halls, special football fields, water sports centers, ski fields, ice hockey halls, baseball and softball courses, shooting ranges, golf courses, and fitness centers. In most cases, these sports facilities can meet the needs of various sports competitions and daily training at all levels [6, 7].

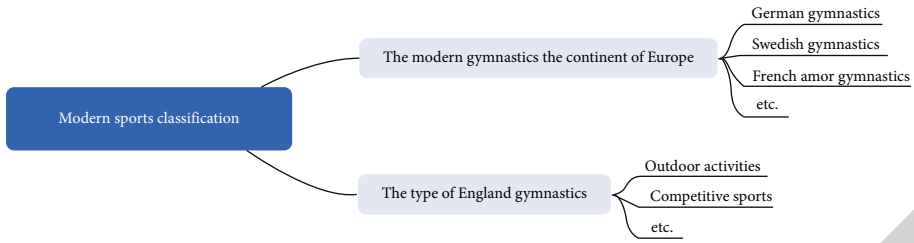

Figure 1: Classification of modern sports.

Modern sports originated in the late 19th century and the beginning of the 20th century. The rise and development of the modern Olympic Games have greatly promoted the self-development of sports and its popularization in the world and made modern sports move towards comprehensive sports. Modern sports mainly include three parts, namely, competitive sports, mass sports, and school sports. Among them, competitive sports are the cutting-edge part of modern sports, representing the highest development level of modern sports. Mass sports is the most important part of modern sports and the foundation of competitive sports. School sports [8, 9] is a part of modern physical education and school education. It aims to cultivate students' physical quality and promote their all-round development. From the perspective of its essential characteristics, physical education is a kind of physical education and social and cultural activities in human society. It takes physical exercise as a means to develop the body, enhance the physique, promote the all-round development of people, and serve the social development.

Now, sports education has become an important part of the culture education, an important symbol to measure the development and progress of a country and society, and an important means of diplomacy and cultural exchanges among countries [10]. The development level of a country's sports can be measured from the following aspects: the degree of the people's physique level, the degree of sports popularization, the level of scientific theory of sports and the status of sports facilities, the level of sports technology, and the best sports performance.

The development status of modern sports and sports facilities construction is combed in this paper. Relevant characteristics and requirements of sports construction investment are analyzed. The method of application of multi-objective optimization and attribute decision-making methods to assist sports facilities investment decision-making is studied, which is used to improve the quality and efficiency of sports facilities construction and maximize the social effect with a limited sports construction resource.

2. Related Works

Sports is an important way to improve the national comprehensive quality, its construction, and development attracting more and more people's concern and attention [11, 12]. Sports development is an important sign of social development and progress of a country or region. It is also one of the important means of cultural communication among different regions.

2.1. Development of Modern Sports. The development history of sports [13, 14] is similar around the world, which has undergone a very rich history. The development of sports directly influences the sports culture of countries. The ancient Greeks regarded sports as education, which is an important and necessary for military base. It founded the famous ancient Spartan education system and education system in ancient Athens. Many statesmen, strategist, and philosopher in western countries continued the thought and attached importance to physical education. For instance, the great philosopher Plato conducted in-depth research on gymnastics and pointed out that "mound soul music, gymnastics exercise," his successors promoted the thought of beauty, intelligence, and physique full scale development education [15, 16].

Since the 1870s, after continuous exploration, debate, and development, European modern sports have gradually formed two basic types, namely, modern gymnastics in the European continent and British sports.

Figure 1 shows the classification of modern sports.

Figure 1 shows that modern sports can be divided into continental Europe type modern gymnastics and British sports two types while they can be divided into several basic content of sports patterns. For example, modern gymnastics in the European continent can be divided into continental Europe type sports gymnastics and British sports, and British sports can be divided into outdoor activities, competitive sports, and other basic sports [17, 18], respectively.

The modern Olympic Games is a sports pageant, also a grand festival of people all over the world, which encourages the athletes to compete [19, 20]. Figures 2 and 3 show that the rankings of the Olympics and number of medals won by Chinese athletes since 1984, respectively.

According to Figures 2 and 3, it shows that (1) since the reform and opening up, China participates in the Olympic Games the world-class sports event actively and shows a good image of country. (2) Since the 1990s, China's Olympic performance has been steadily improving. The results of ranking and the number of Olympic medals have always been ideal. (3) In 2008, China hosted the Olympic Games and achieved the best results in this Olympic Games. (4) The enthusiasm of the Chinese government and the whole people for sports have also continued to improve. With the active

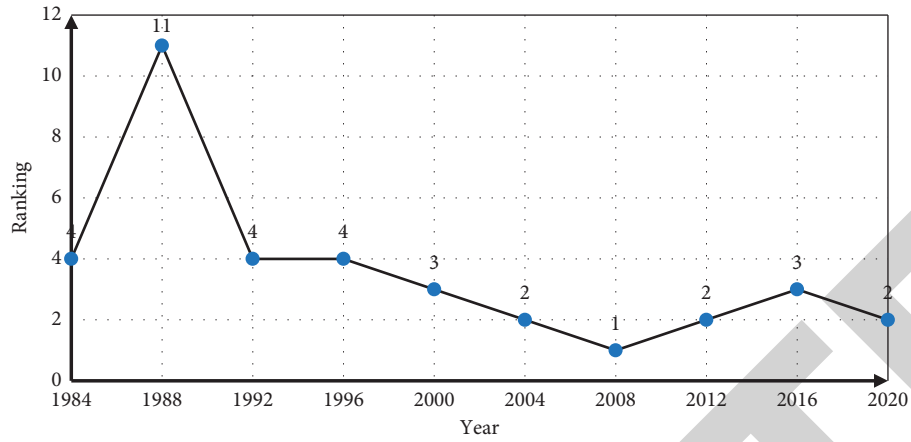

Figure 2: Rankings for the Olympics of China since 1984.

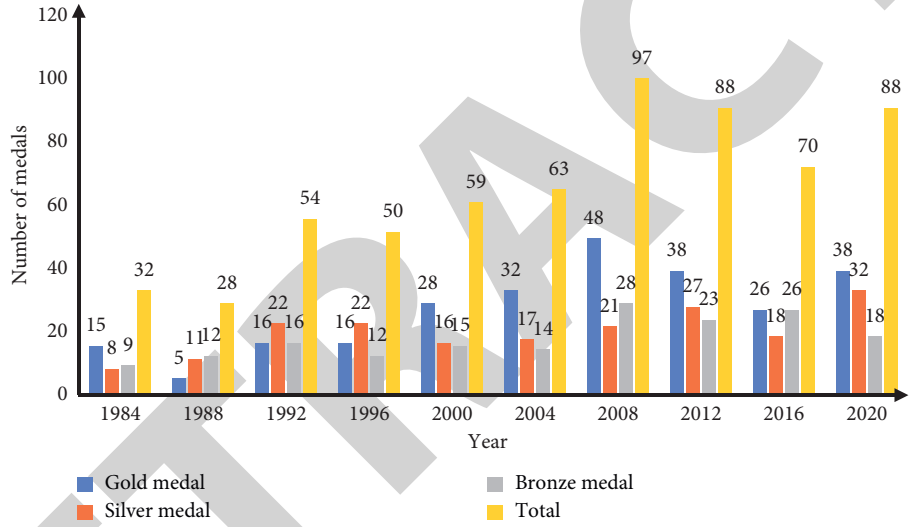

Figure 3: Win medal number of China since 1984.

participation of all sectors of society in sports, the national physical quality has continued to improve.

2.2. Compositions and Characteristics of Modern Sports. Modern sports is a complex system, and Figure 4 shows the structure of the modern sports system.

Figure 4 shows that the modern sports contains mass sports, competitive sports, and school sports while competitive sports, mass sports, and school sports are, respectively, composed of several subsystems [21]. For example, competitive sports includes four organic parts: the athletes selecting, sports training, sports competition, and management of competitive sports. Public sports contains sports fitness, sports entertainment, and so on. School sports contains physical education, physical exercise, extracurricular sports activities, and so on.

They also have their own characteristics:

(1) The characteristics of competitive sports are high technical requirements and highly competitive. In accordance with the strict and unified rules of competition, athletes' achievements can be recognized by the society. It mainly includes track and field, football, basketball, volleyball, tennis, table tennis, diving, gymnastics, weightlifting, fencing, wrestling, judo, skating, and skiing.

(2) The characteristics of the mass sports are facing the whole society. It is mainly for the masses to entertain themselves. There are certain rules of the game, but they are not strict. Almost all competitive sports can be used as mass sports. However, mass sports focus on participation and entertainment. It has some popular items, such as aerobics, roller skating, Wushu, table tennis, qigong, mountaineering, walking, chess and cards, and darts.

(3) The characteristics of school physical education are as follows: it is a component of school education and has the education function. For students of different ages and levels, organize teaching according to students' physiological and psychological

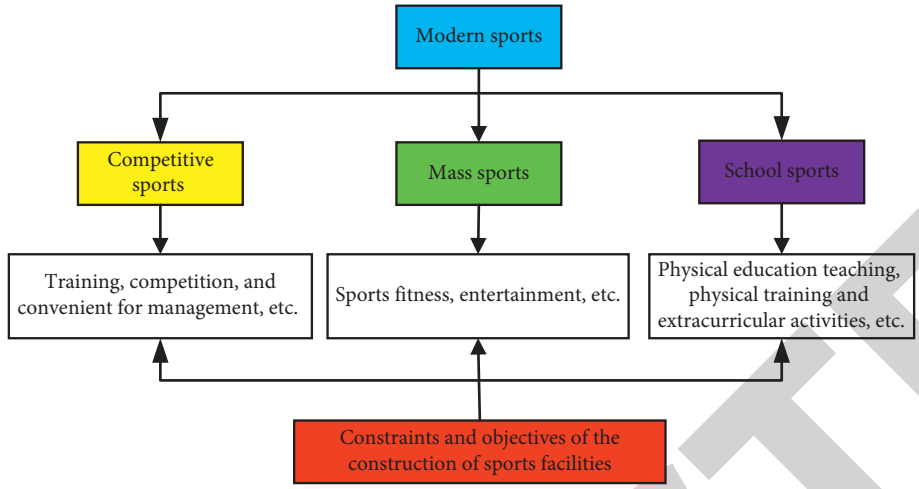

Figure 4: Structure of the modern sports system.

characteristics, which has a certain requirements for teaching methods. The content of school physical education is set up according to the requirements of the school education system, which generally includes physical education teaching, physical exercise, and entertainment games [9, 22].

With the rapid development of economic and social, the process of urbanization is continued to speed up around the world. The demand of sports facilities investment is becoming stronger and stronger.

2.3. Modern Sports Facilities. Sports facilities is a relatively broad and inclusive stronger concept, which refers to the general name of sports buildings, venues, outdoor facilities, and sports equipment as sports competition, sports teaching, sports entertainment, and physical exercise. Modern sports facilities are the basic guarantee for carrying out various sports activities and the material carrier of sports culture. According to the counterpoint relationship with modern sports, modern sports facilities can be divided into competitive sports facilities, mass sports facilities, and school sports facilities [23, 24]. Each type of sports facilities can be divided into several subcategories (subsystems). Most sports facilities are compatible with a variety of sports and have multiple functions, so their classification contains a certain degree of comprehensiveness. Of course, sports facilities continue to develop with the development of modern sports. Stadiums are generally outdoor, but with the progress of science and technology, some stadiums in developed countries have set open and closed roofs, which can be called indoor stadiums. Sports facilities can be further classified according to the type of application. Taking competitive sports facilities as an example, they can be divided into various types according to the sports undertaken by competitive sports facilities, indoor and outdoor, whether there is a grandstand or not.

Figure 5 shows the composition and classification of the modern sports facilities.

Figure 5 shows that (1) according to the different application occasions, the modern sports facilities can be mainly divided into competitive sports, mass sports, and school sports facilities. (2) Different types of sports facilities can be further classified according to the users and structural characteristics. (3) The difference between public sports facilities and the school sports facilities is not clear, and without scientific classification, this problem deserves further study.

2.4. Multi-objective Optimization and Attribute Decision Theory. In 1896, the French economist Pareto multi-objective optimization model was put forward in the first time. It transforms several essentially incomparable goals into a single optimal goal [25].

The mathematical model [26, 27] of multi-objective optimization problem can be described as follows: suppose that there are m goals, n decision variables, and l constraints in the multi-objective optimization systems. It can be described as the following formula:

$$\begin{cases} \min f(x) = \min\left[f_1(x), f_2(x), \cdots, f_m(x)\right], \\ \text{s.t. } g_i(x) \geq 0 \quad i = 1, 2, \cdots, l \\ x = \left[x_1, x_2, \cdots, x_n\right]. \end{cases} \tag{1}$$

In the formula, $f_1(x)$, $f_2(x)$, ..., $f_m(x)$ are the m objective functions of the multi-objective optimization model. $g_i(x)$ is a bound variable, $i = 1, 2, \cdots, l$. $x_1, x_2, \cdots, x_n$ are the decision variables. Solving the multi-objective model of the solution is to find a feasible solution set $\mathbf{X}$, i.e., all decision variables satisfy the constraint conditions, then eliminate the feasible solution concentration, and find out the pareto solutions.

The solution methods of multi-objective optimization problems mainly include the following [28, 29]:

(1) Linear weighted sum method is a commonly used method of multi-objective optimization. That is, according to the importance of m objectives in the multi-objective optimization problem, they are given a weight value w_j, $j = 1, 2, \ldots, m$. w_j satisfies the following formula:

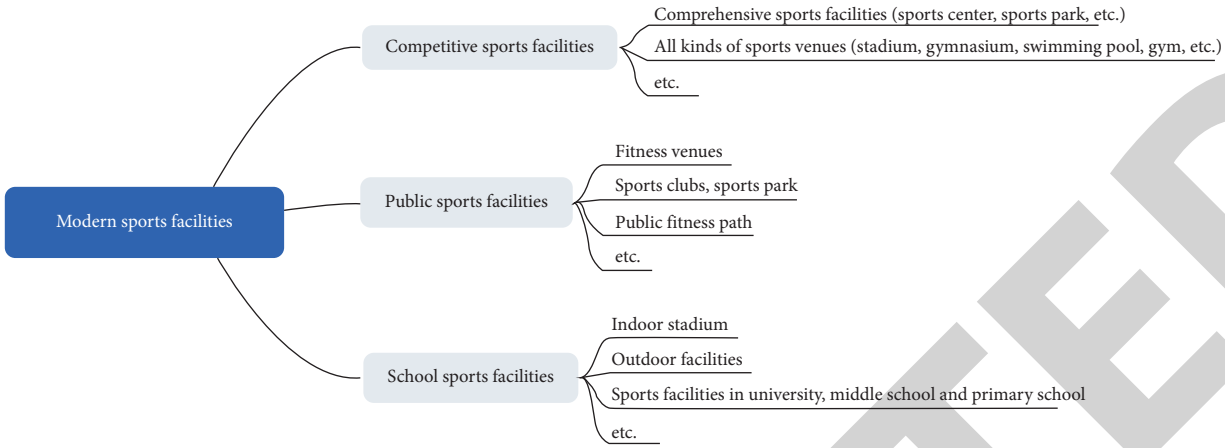

Figure 5: Composition and classification of the modern sports facilities.

$$\sum_{j=1}^{m} w_j = 1, \tag{2}$$

w_j corresponds to each objective function one by one. After determining the weight value of each objective function, the multi-objective optimization model can be transformed into a single objective problem by using formula (3).

$$\min F(x) = \sum_{j=1}^{m} w_j \times f_j(x). \tag{3}$$

(2) Fuzzy algorithm: the optimization objectives of multi-objective optimization problem are often incompatible contradiction and contradictory, and the sum weighted method inevitably has the influence of human subjective factors, so it is often unable to give a clear weight value. The fuzzy algorithm can solve this kind of problem by fuzzy processing.

(3) Multi-objective evolutionary algorithm is a multi-objective optimization algorithm based on biological evolution mechanism. It has the advantages of parallel, multiple solutions that can be generated at one time, simple and easy to implement, and no derivation is required. It is an effective method to solve multi-objective optimization problems.

The several multi-objective optimization methods introduced above come out by processing all kinds of complex mathematics and economics multi-objective optimization problems [30]. In order to improve the quality of solving specific multi-objective optimization problems, people have also conducted in-depth research on the abovementioned methods, and the relevant research results also provide convenience and support for solving multi-objective optimization problems.

Figure 6 shows the composition and main steps of the multiple attribute decision-making method.

Figure 6 shows that the multiple attribute decision-making method consists of the two main components of attribute weights determined and multiple attribute decision-making [31, 32]. Main methods to determine the attribute weights are subjective values, the weight method, the subjective objective method, and an interactive method.

Commonly used method for multiple attribute decision-making includes

(1) The approach to ideal solution method ranks the evaluation objects according to the proximity between the evaluation objects and the ideal objectives and evaluates the relative advantages and disadvantages of the existing objects. Its main steps are as follows: the first step is to construct a normalized decision matrix. Assuming that there are m alternative schemes, n targets, and x_{ij} represents the target attribute values of ith and scheme under the jth, the decision matrix $\mathbf{X}$ is constructed as follows:

$$\mathbf{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{21} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} = \left[x_{ij}\right]_{m\times n}, \tag{4}$$

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}. \tag{5}$$

Equation (5) is used for standardized processing of formula (4); the canonical matrix $\mathbf{R}$ is obtained:

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = \left[r_{ij}\right]_{m\times n}. \tag{6}$$

The second step is to calculate the weighted normalized matrix; the weighted matrix $\mathbf{V}$ specification is shown as follows:

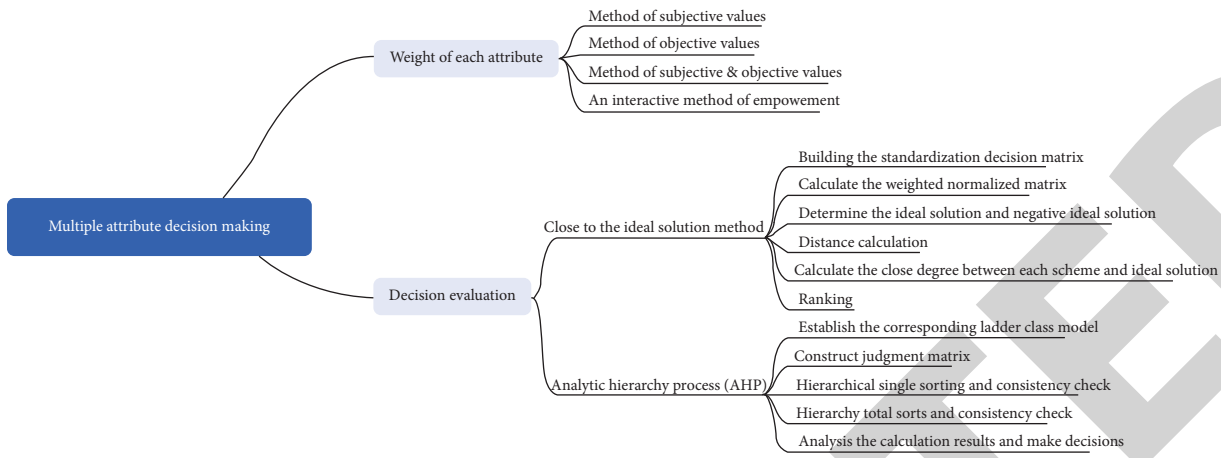

Figure 6: Composition and main steps of the multiple attribute decision-making method.

$$\mathbf{V} = R \times W = \left[r_{ij}\right]_{m\times n} \times \left[w_j\right]^T. \tag{7}$$

The third step is to determine the ideal solution S^+ and negative ideal solution S^-.

$$\begin{aligned} S^+ &= \left[\left(\max v_{ij}\right)\middle| j \in J^+, \left(\min v_{ij}\right)\middle| j \in J^-, |i = 1, 2, \cdots, m\right] \\ &= \left[v_1^+, v_2^+, \cdots, v_m^+\right], \\ S^- &= \left[\left(\min v_{ij}\right)\middle| j \in J^+, \left(\max v_{ij}\right)\middle| j \in J^-, |i = 1, 2, \cdots, m\right] \\ &= \left[v_1^-, v_2^-, \cdots, v_m^-\right], \\ J^+ &= [j = 1, 2, \cdots, r], \end{aligned} \tag{8}$$

where J^+ is the label of benefit target attribute.

$$J^- = [j = 1, 2, \cdots, h], \tag{9}$$

where in J^- is the label of cost target attribute.

The fourth step is to calculate distance. Calculate the distance between the ith scheme and ideal solution and the distance between the ith scheme and negative ideal solution.

$$\begin{aligned} S_i^+ &= \sum_{i=1}^{n} \left(v_{ij} - v_j^+\right)^2, i = 1, 2, \cdots, m, \\ S_i^- &= \sum_{i=1}^{n} \left(v_{ij} - v_j^-\right)^2, i = 1, 2, \cdots, m. \end{aligned} \tag{10}$$

The fifth step is to calculate the distance between each scheme and ideal solution of c_i.

$$c_i = \frac{S_i^+}{\left(S_i^+ + S_i^-\right)}, \quad i = 1, 2, \cdots, m. \tag{11}$$

The sixth step is to obtain the finally satisfactory solutions according to the size of the ci to plan for sorting.

(2) Analytic hierarchy process (AHP): it is a method of combining quantitative and qualitative. Firstly, related factors in the decision-making problem are classified into objectives, criteria, objects, and so on. Secondly, according to the membership relationship, the corresponding hierarchical structure is established, and the importance of a certain criterion in each level is compared, the judgment matrix is constructed, and the weight is calculated. Finally, the weights of the lowest level elements to the highest level system objectives are calculated and sorted.

Figure 7 shows the multiple attribute level decision-making model.

Figure 7 shows that when applying the method of AHP to multiattribute decision-making, the decision-making problem is divided into three levels: target level, criterion level, and scheme level. Among them, (1) the target layer is the highest level, which represents the overall target of problem. (2) The criteria layer is the middle layer, which represents various criteria, factors, and strategies involved in the realization of goals. (3) The scheme layer is the bottom layer, which represents several feasible schemes and measures to achieve the goals.

2.5. Analysis of Sports Facilities Investment. The process of "shortage-wanton expansion-operational loss-return to rationality" seems to have become a "strange circle" in the development of many industries [33, 34]. Only after the huge loss of wanton investment can we return to the rational track. At present, China is in an era of shortage of large-scale public sports facilities. Since the Olympic Games was held for the first time in China, the rapid development of the sports industry and the arrival of the era of sports and leisure indicate that China will set off a large-scale upsurge of investment in large-scale public sports facilities. Many economists and environmentalists have also warned against this situation: blind investment in large-scale public sports facilities and unscientific decision-making will bring a series of problems such as waste of funds and resources, and the decision-making

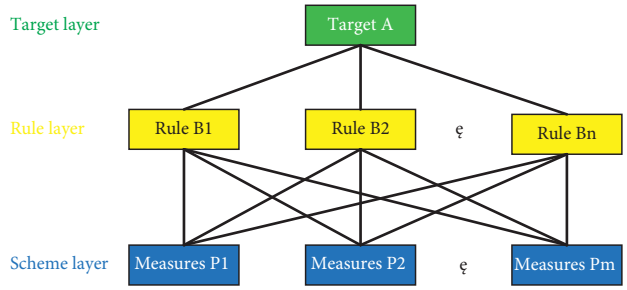

Figure 7: Multiple attribute level decision-making model.

government will also pay the price for unscientific sports facilities investment. In order to avoid the occurrence of the above early warning situations, we should study scientific decision-making methods and rational investment, strengthen the macro-control of fixed asset investment in the sports industry, improve the scientific level of decision-making of large-scale public sports facilities, guide and promote the rational allocation of sports and related resources, optimize the investment structure in the sports field, and reduce and avoid risks.

At present, the commonly used investment estimation model mainly contains the following:

(1) *Net Investment Estimation Model.* For some projects, the project benefits and external costs have been considered in the initial investment. In the selection of subsequent projects, only the costs to be invested need to be considered, and the costs and benefits do not need to be considered. Therefore, the net investment estimation model can be expressed by the following formula:

$$N = \sum_{i=1}^{n} \left[(C_i - B_i) \times \frac{1}{(1+r)^2} \right], \tag{12}$$

where B_i is the gained income from project in the ith year; C_i is investment for the project in the ith year; N is net investment; r is the social discount rate; and n is the project life cycle.

(2) *Comprehensive Benefits and Net Investment Ratio Model.* The ultimate goal of project evaluation is to sort the advantages and disadvantages of different projects for project selection. Suppose P represents the score of comprehensive benefit evaluation of public sports facilities, and the ratio of comprehensive benefit to net investment S can be expressed as follows:

$$S = \frac{P}{N}. \tag{13}$$

According to the comprehensive score S, different projects or different solutions of the same project can be sorted on.

(3) *Investment Benefit Model of Comprehensive Evaluation.* Comprehensive evaluation can be generally divided into four links: first, set up a comprehensive evaluation index system; second, quantitative indicators; third, give the weight value to the index; and fourth, index data synthesis. In the above four links, except the first link, the other three links have different ways of realization and expression.

It is precisely because of the different methods of index quantification, weight distribution, and index synthesis that different comprehensive evaluation methods are formed. At present, comprehensive evaluation mainly includes comprehensive scoring method, principal component analysis method, grey comprehensive evaluation method, and fuzzy comprehensive evaluation method.

In order to make reasonable investment decisions on sports facilities, it is necessary to combine the characteristics of sports facilities investment before investment decisions. (1) Make statistics and classification on the sports facilities already built in the region, analyze the main demand points of regional sports facilities construction and the number of various sports to be invested, and build a multi-objective optimization model for sports facilities investment in the region. (2) Based on the determined investment objectives of sports facilities, the multi-objective optimization algorithm is applied to generate various investment alternatives. (3) Select a reasonable investment estimation model, evaluate and rank the alternatives, and finally form an investment decision.

3. Sports Facilities Investment Optimization Examples

Based on the multi-objective optimization and attribute decision-making theory studied above, the characteristics of sports facilities investment and related investment assessment model are combined. An example of sports facilities investment in a certain region is analyzed in order to verify the scientific and effectiveness of the sports facilities investment decision-making method studied in this paper.

3.1. Sports Facilities in a Given Area. A certain area has moderate economic development, and the construction of sports facilities also belongs to the medium level, which is highly representative. The sports venues in this region cover a total area of 13.21 million square meters, including 12.13 million square meters of standard venues, 1.08 million square meters of nonstandard venues, and 1.7 square meters of per capita sports venues.

According to the classification of sports facilities in Section 2.2, Figures 8 and 9 show the number and proportion of various sports facilities in the region.

Figures 8 and 9 show that there are a total of 4560 various kinds of sports facilities in the region; there are 196 athletics sports facilities accounting for 4.298%, 2485 school sports facilities accounting for 54.496%, 1352 public sports facilities accounting for 29.649%, and 527 other sports facilities accounting for 11.557%.

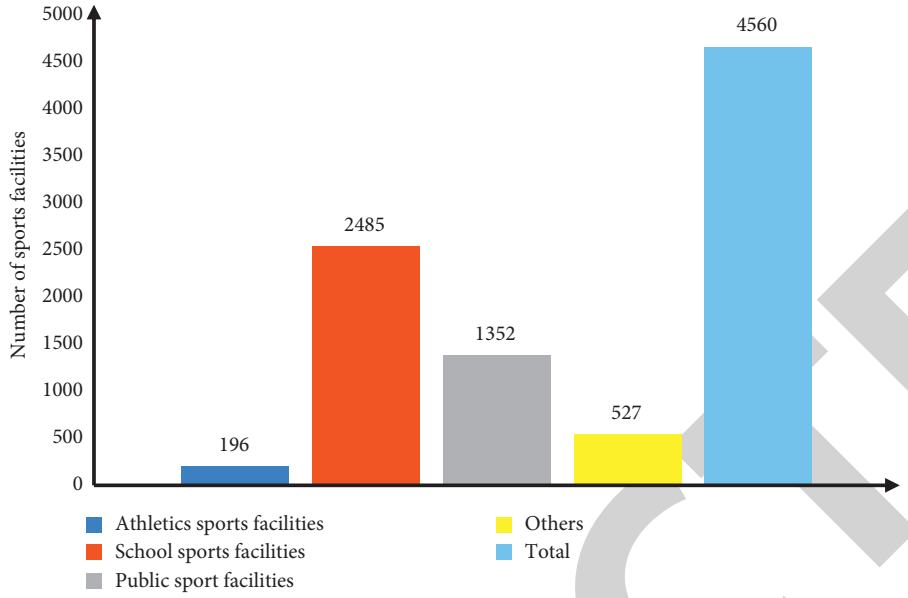

Figure 8: Quantities of all kinds of sports facilities in the region.

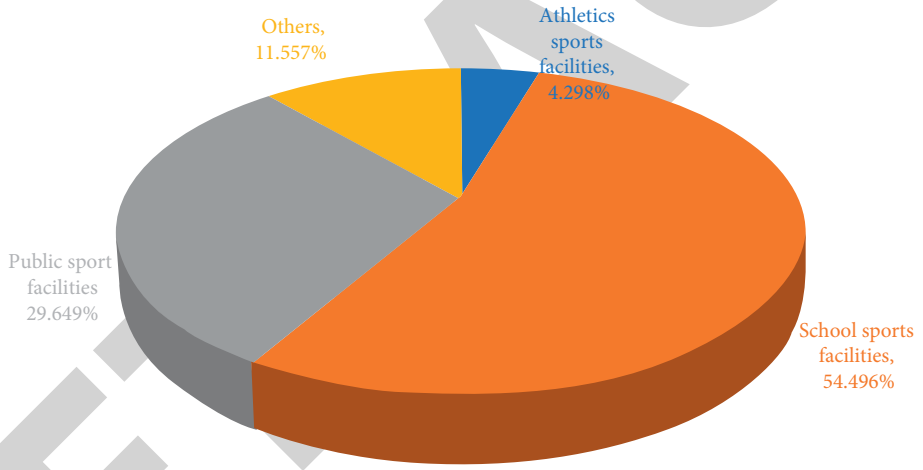

Figure 9: Proportions of all kinds of sports facilities in the region.

3.2. Sports Facilities Investment Optimization. According to the above data, the evaluation concluded that the construction level of sports facilities in the region is at a medium backward level, which is mainly reflected as follows: (1) the scale of competitive stadiums is no longer sufficient to host large-scale sports events; (2) mass sports facilities have gradually failed to meet people's needs for physical fitness and entertainment; and (3) the campus sports facilities are old and the quantity also needs to be supplemented.

In order to improve the backwardness of sports facilities in this area, it is necessary to first analyze the relationship between the cost and benefit of sports investment, the impact of investment on the urban environment, the urban cultural landscape, and the promotion of sports undertakings. Based on the research results in Section 2.4, a multi-objective optimization model for sports facilities investment in the region is established.

Figure 10 shows multi-objective optimization solving process for the investment model of sports facilities in the region.

Figure 10 shows that the optimization goal of sports facilities investment decision-making is not single. In this paper, the intelligent neural network algorithm is used to solve the multi-objective optimization problem of sports facilities investment, and two alternative schemes are obtained.

Figure 11 shows the contrast between the two alternatives and the initial plan.

Figure 11 shows that after the multi-objective optimization, (1) the number of various sports facilities in the two alternative schemes obtained through multi-objective optimization is increased compared with the initial state of the region. (2) In the two alternatives, due to the different functions and demand levels of various sports facilities, their increase quantities are different. Among them, the

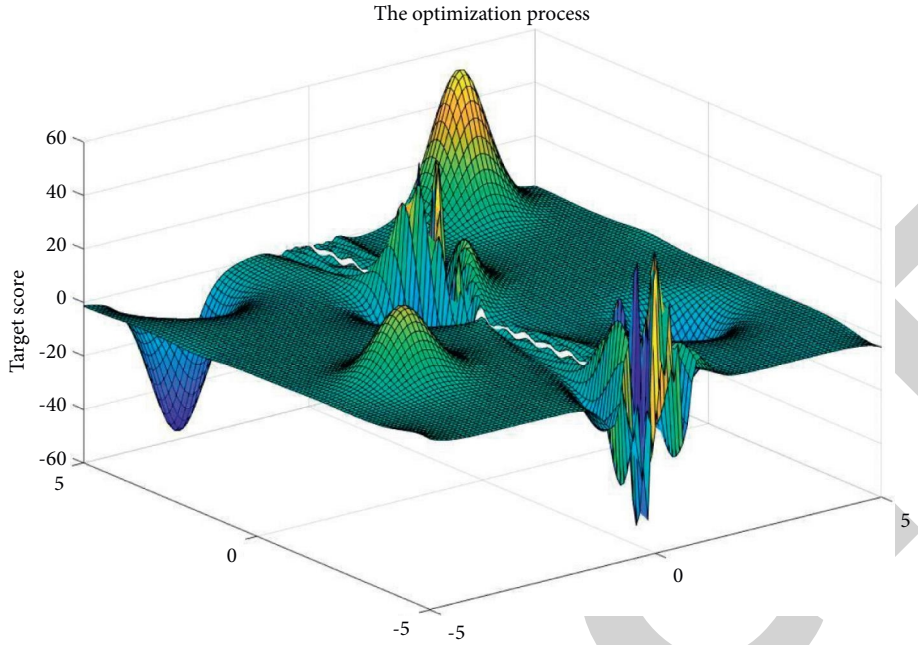

Figure 10: Multi-objective optimization solving process for the investment model of sports facilities in the region.

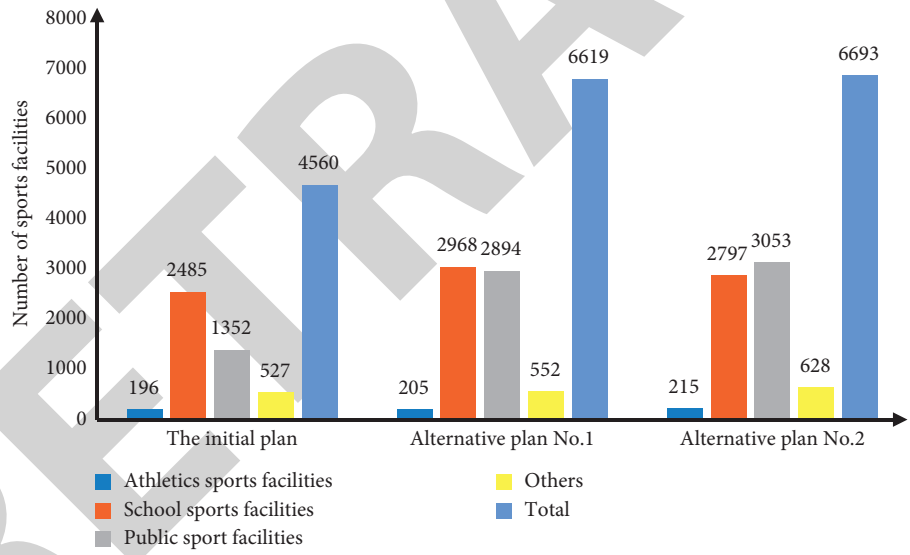

Figure 11: Contrast between the two alternatives and the initial plan.

investment and construction of mass sports facilities are the largest, followed by campus sports facilities. (3) Because the two options have different priorities, the number of sports facilities and the total number of investment and construction of sports facilities are also different.

3.3. Results and Discussion. In Section 3.2, according to the current situation of sports facilities construction and the characteristics of investment demand in an area, a multi-objective optimization model of sports facilities investment in the area is constructed and solved to obtain two alternative sports facilities investment schemes.

Figures 12 to 15 show the proportion of various sports facilities and the proportion of investment in various sports facilities in the region after the adoption of alternative 1 and alternative 2 investment, respectively.

Figures 12~15 show that (1) after adopting alternative 1 to invest in sports facilities in the region, the proportion of competitive sports facilities, campus sports facilities, mass sports facilities, and other sports facilities is 3.097%, 44.841%, 43.723%, and 8.34%, respectively. After adopting alternative 2 to invest in sports facilities in the region, the proportions of the abovementioned facilities are 3.212%, 41.79%, 45.615%, and 9.383%, respectively. (2) The number of investment and construction of various sports facilities in

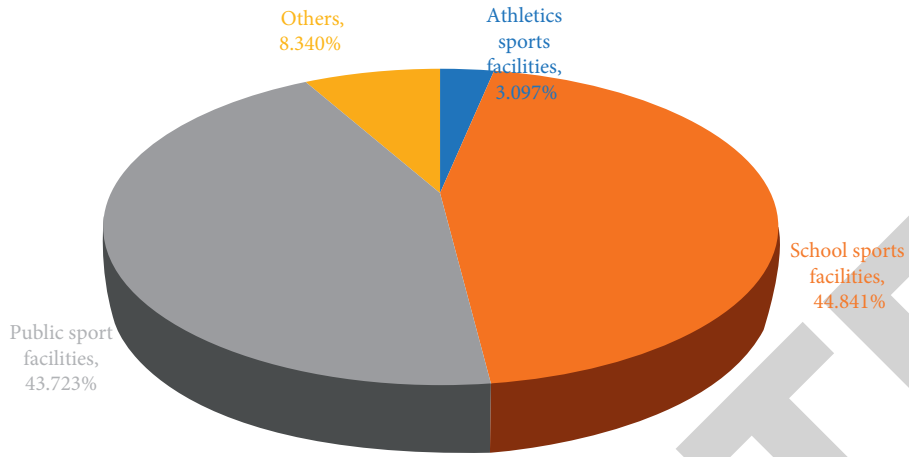

Figure 12: Proportion of each sports facility after using investment alternative No. 1.

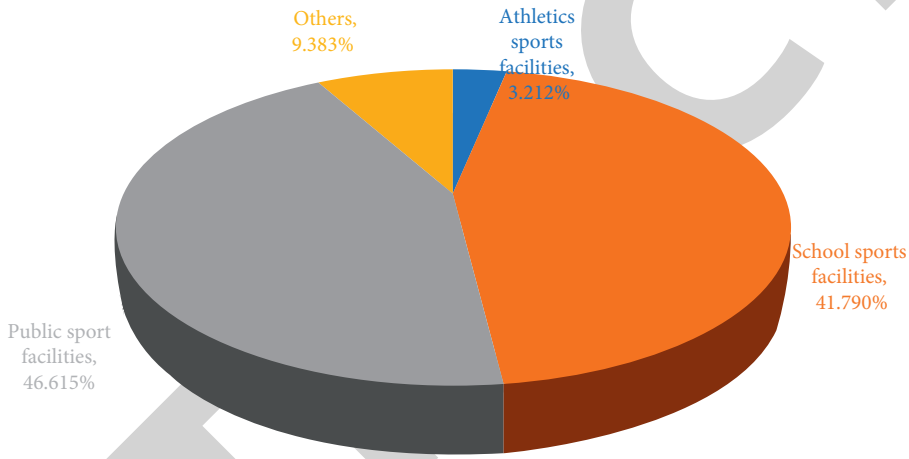

Figure 13: Proportion of each sports facility after using investment alternative No. 2.

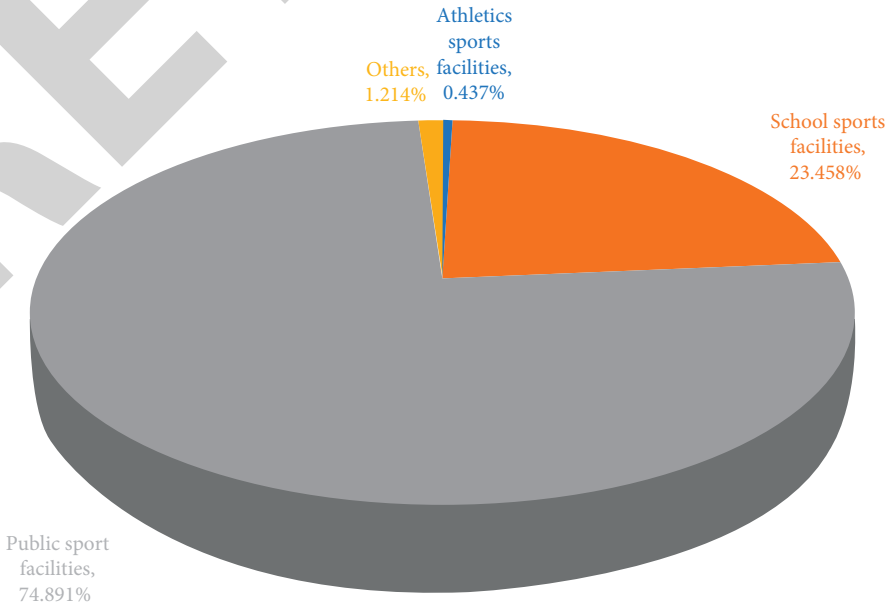

Figure 14: Investment number proportion of each sports facility in investment alternative No. 1.

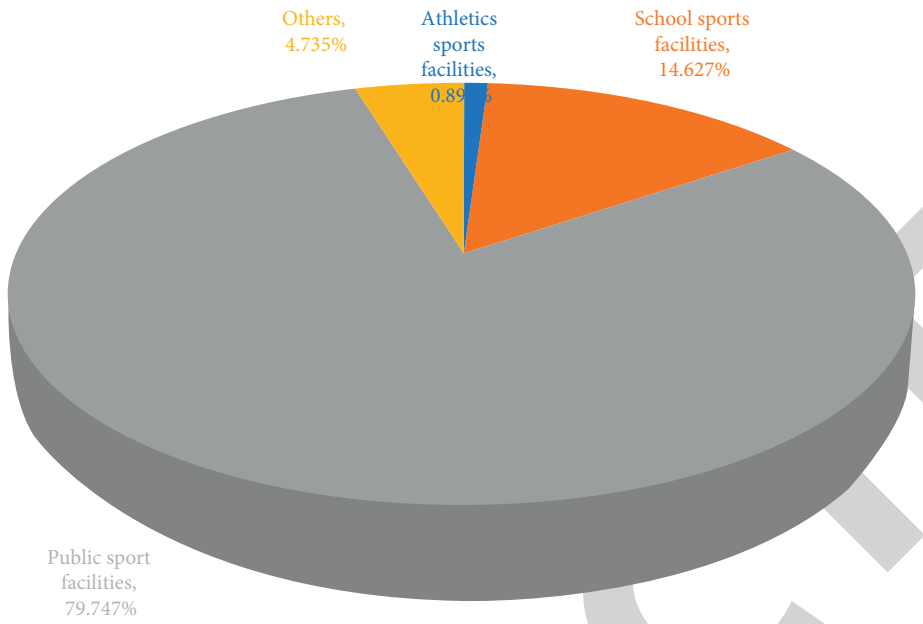

Figure 15: Investment number proportion of each sports facility in investment alternative No. 2.

the region in option 1 is 94831542 and 52, respectively. In alternative 2, the number of investment and construction of various sports facilities in the region is 193121701 and 101, respectively. (3) With the development of economy and society, people's demand for sports and fitness is becoming stronger and stronger. The demand for mass sports facilities in this area is the largest among all kinds of sports facilities. (4) In the two alternatives, the proportion of investment and construction of various sports facilities is roughly similar. The proportion of investment and construction of mass sports facilities is the largest, followed by campus sports facilities. Both two alternatives obtained by optimization can better improve the sports facilities in this area, which is difficult to meet the needs of local people for fitness and the development of sports undertakings.

Finally, according to the comprehensive benefit evaluation and decision-making method studied in Section 2.4, the contributions of the urban construction, cultural landscape, sports facilities, and sports development in the region and enriching people's lives of the two alternatives are analyzed. The investment cost and the pollution degree to the local environment after investment and construction are comprehensively considered. It can be concluded that the score of alternative 2 is higher than that of alternative 1. That is, alternative 2 is better than alternative 1.

4. Conclusions

The current related research status of sports facilities construction investment at present stage is combed in this paper. It concludes that with the rapid development of the current economy and society, people's demand for sports fitness and entertainment is becoming stronger and stronger, so the investment and construction demand for sports facilities around the world is urgent. In order to assist the scientific decision-making of sports facilities investment, a multi-objective mathematical model of sports facilities investment is constructed in this paper. Application of multi-objective optimization and attribute decision-making methods to assist the scientific decision-making of sports facilities investment is studied. Finally, investment of sports facilities in a certain area is taken as an example, the theoretical methods studied in this paper is applied to seek its optimal decision-making scheme, and the effectiveness and correctness of the multi-objective optimization and attribute decision-making methods studied in this paper for the investment decision-making of sports facilities are verified. The results show that AHP and multiattribute decision-making method can effectively guide the investment decision-making of sports facilities construction, which is worth popularizing and applying.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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