

Looking Forward to The Future Olympic Games

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Abstract. Since its inception in 1896, the modern Olympic Games have evolved into a global platform that celebrates athletic achievement and fosters international unity. As new sports emerge and the number of total events rises, ensuring that the selecting or removing sports, disciplines, and events (SDEs) aligns with the International Olympic Committee's (IOC) evolving priorities has become increasingly challenging. This study conducted a literature review of the IOC's criteria and chose the Analytic Hierarchy Process (AHP) as a multi-criteria decision-making tool. We identified 11 criteria that reflect the IOC's evolving focus on sustainability, youth engagement, and cultural representation while balancing traditional Olympic values. The AHP model reveals the top five SDEs are Athletics, Basketball, Football, Diving, and Badminton. Three new projects—Cricket (2028), Breaking (2024), and Coastal Rowing (2028), and three longstanding projects—basketball, weightlifting, and diving demonstrate high fairness, and benefits, and are aligned with the evolving goals and values of the Olympic Games. This highlights the validity and robustness of our model, as well as Olympics's accurate consideration of IOC Criteria when screening SDEs. We also recommend the permanent inclusion of Breaking and Chess in the 2032 Games and the consideration of eSports for the 2036 Games.

Keywords: Analytic Hierarchy Process; Olympic Games; Evaluation; IOC criteria.

1. Introduction

The Olympic Games are the world's premier multi-sport event held every four years, with more than 400 events and over 200 countries participating. The first Olympic Games took place in 776 BC in ancient Greece, and they were dedicated to Zeus. Originally, only men could compete. In AD 394, Byzantine Emperor Theodosius banned the Olympics, but they were revived in 1896 by French educator and sportsman Pierre de Coubertin. The first modern Olympics, still an all-male event, were held in Athens. The 1900 Paris Games introduced female competitors. Since then, women's participation has grown significantly, from 8.4% in the 1936 Berlin Games to 48.7% in the Tokyo 2020 Olympics. The 2024 Paris Olympics sets a milestone as the first Olympics to achieve full gender parity with numerical gender parity on the field and assure the separate representation of male and female athletes. Besides, The Paris 2024 Olympics are pioneering environmental sustainability using Eiffel Tower iron for medals and recycled materials for furniture and décor.

The International Olympic Committee (IOC), a non-governmental organization, holds ultimate authority over the Olympics. It aims to promote sports, enhance integrity, and safeguard athletes' interests across all genders and races. The IOC's action program states the responsibilities of the Olympic Movement's constituency in promoting environmental and sustainable governance, sporting communities should be contributing their utmost to adopt more sustainable practices for a greener future. The IOC emphasizes the importance of safety, fair play, and respect in sports. Selecting sports, disciplines, or events for the Olympics involves a rigorous evaluation process to align with IOC standards, which consider quantitative factors like global participation and qualitative aspects like cultural diversity and social responsibility. However, there is a lack of homogenous standards to identify which SDE should be included. A scientific and comprehensive SDE evaluation model that considers determinative and random perspectives is needed to support decision-making.

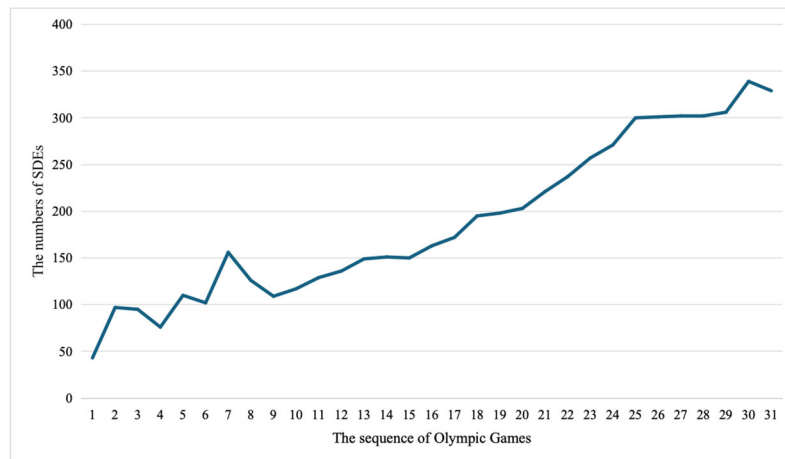


Fig.1 The changing trend of total SDEs in the Olympic Games

In this study, we developed a mathematical model to assess Sports Disciplines and Events (SDEs) in the Olympic Games and address the following questions. (1) What are the key factors in determining the inclusion or exclusion of sports? (2) How can these factors be modeled through both quantitative and qualitative analysis? (3) Which SDEs should be considered or excluded in the 2032 Summer Olympics?

2. Methods

2.1 Key Assumptions and Evaluation Criteria of SDEs

We introduced three fundamental assumptions that support the evaluation of Sports Disciplines and Events (SDEs).

Assumption 1: Popularity is a key factor that determines the extent of global appeal to Olympic sports.

Justification: Prevailing sports are more likely accepted by the audience, promoting television audience rating, ticket sales, and sponsorship cooperation, which are crucial for the Olympic Game's financial sustainability. Traditional and widely accessible sports like soccer, basketball, and Ping-Pong have consistently drawn global attention. Sports such as surfing and skateboarding, introduced at the Paris 2024 Olympics, are popular among young people. Data from various social media platforms can quantify the popularity and engagement of the sports.

Assumption 2: Gender Equity and Inclusivity are non-neglectable factors for SDE selection.

Justification: The International Olympic Committee (IOC) underscores inclusivity and equity. Sports that are incapable of providing equal opportunities for men and women would risk exclusion from the IOC. The IOC requires that sports played in at least 75 countries on four continents be included in the Olympic Games. Sports like cricket, which is England's national summer sport, particularly played in Australia, India, and Pakistan, expand global participation and enrich cultural multiformity.

Assumption 3: Innovative sports increase youth participation.

Justification: The high popularity of innovative sports such as breakdancing and rock climbing reflects the progress of society and the shifting interests in modern sports. The development of the Internet has led to the maturation of virtual and e-sports, attracting more young audiences to join in and raising the competition spirit. The IOC points out relevance and innovation in the criteria for adding SDEs, which highlights the long-term role of the Olympic Games in global cultural exchange and the stabilization of international relationships.

Based on the IOC's guidelines, we identified 11 key criteria (Table 1), which are organized in a hierarchy to guide our evaluation process and ensure an objective assessment of each SDE's compatibility with the Olympic values.

Table 1. The factors selected to evaluate the SDEs

IOC Criteria	Factors	Reasons
Popularity and Accessibility	Number of people watching the sport	Assess the global number of views of the SDE's official social media accounts, indicating its broad appeal and participation potential.
	Number of athletes	Assess the SDEs' global participation rate.
Gender Equity	Gender ratio of athletes	Assess whether the SDE provides equal opportunities for men and women.
	Carbon emissions of the SDEs	Assess the sustainability of the SDE based on carbon emissions data. SDEs are divided into three categories (low, medium and high) and scored.
Sustainability	Number of participating countries	The number of participating countries must meet the IOC standard of 75, indicating the cultural diversity of the SDE.
	The attention of young people	Evaluate the number of followers of the official Instagram account as a representative of young people's attention.
Relevance and Innovation	When the sport first appeared	Reflect the innovativeness of SDEs
	Whether it did not appear in the competition	Indicate the uniqueness and innovation of the SDE.
Safety and Fair Play	Injury rate of athletes	Evaluate whether the SDE is safe or too risky through the data on the probability and severity of injuries to athletes.
	Probability of doping	Assess fairness and equity through doping utilisation rates.
	False positive rate	Assess whether the SDE has a false positive rate, indicating its fairness

2.2 AHP Model Foundation

We have developed a structured framework (Figure 2) for assessing Sports Disciplines and Events (SDEs) in the Olympic Games. To test this framework, we chose six SDEs from the HiMCM_Olympic Data table as case studies which include three recently added sports (cricket (2028), breakdancing (2024), and coastal rowing (2028)) and three long-standing Olympic sports (basketball, weightlifting, and diving). The case studies assess the adaptability of our model across modern and traditional sports, thus confirming its validity in analyzing SDEs.

Each chosen SDE is meticulously evaluated against 11 specific criteria, ensuring a consistent and transparent assessment process (Table 1). For instance, we measured "Popularity" by global participation rates and "Sustainability" by the environmental impact of sports. We offered a standardized, data-driven framework aligned with the Olympic This replicable and adaptable assessment tool for SDEs provides scientific underpinning for IOC decision-making while facilitating the development of current priorities and future global expectations.

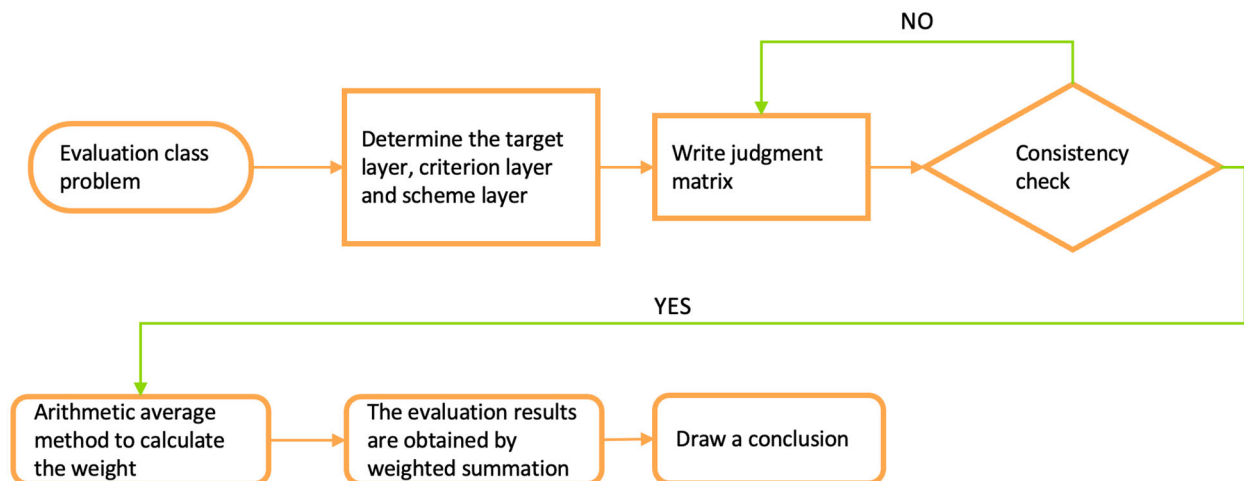


Figure 2. AHP model foundation

Below are some important mathematical notations used in this paper (Table 2).

Table 2. Notations used in this paper

Symbol	Description
A1	Number of people watching the sport
A2	Number of athletes
A3	Gender ratio of athletes
A4	Carbon emissions of the SDEs
A5	Number of participating countries
A6	The attention of young people
A7	When the sport first appeared
A8	Whether it did not appear in the competition
A9	Injury rate of athletes
A10	Probability of doping
A11	False positive rate
w_i	The weight of the criterion i
s_{ij}	The score of the SDE j on the criterion i
O_j	Overall score for the SDE j
n	The number of criteria ($n=11$)

We constructed the Analytic Hierarchy Process (AHP) model using a multi-criteria decision-making approach to assign weights to various factors and compute a composite score for each decision alternative (in this case, each sport).

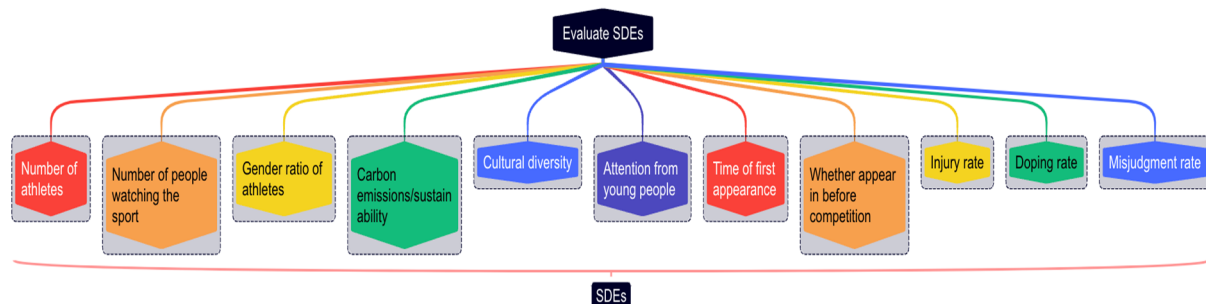


Figure 3. The AHP model structure

We created pairwise comparison matrices to evaluate how important one criterion is compared to another at each level. Expert experience determines the importance of each criterion, usually on a scale of 1 to 9.

Table 3. The pairwise comparison matrices

Factors	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	1	0.33	0.25	0.33	0.2	0.2	0.25	0.2	0.2	0.2	0.2	0.2
A2	3	1	0.33	3	0.25	0.33	0.25	0.25	0.25	0.25	0.2	0.2
A3	4	3	1	3	0.33	1	1	0.33	0.2	0.25	0.33	0.33
A4	5	4	3	4	1	2	0.5	1	0.5	1	2	3
A5	4	3	1	3	0.5	1	1	0.5	0.25	0.33	4	4
A6	4	3	1	3	2	1	1	0.5	0.25	0.33	4	4
A7	5	4	3	4	1	2	2	1	0.5	1	2	3
A8	5	4	5	5	2	4	4	2	1	1	2	4
A9	5	4	4	4	1	3	3	1	1	1	3	1
A10	5	5	3	3	0.5	0.25	0.25	0.5	0.5	0.33	1	1
A11	5	5	3	3	0.33	0.25	0.25	0.33	0.25	1	1	1

Furthermore, we checked the model consistency for multibed times until the CR = 0.098.

$$CI = (max_eigenvalue - n) / (n - 1) \quad (1)$$

$$CR = CI / RI \quad (2)$$

Where n is the order of the matrix A, max_ eigenvalue is the maximum eigenvalue of matrix A, RI=1.51.

We also used the Eigenvalue method to calculate the relative weights of each criterion based on the pairwise comparisons (Table 4). Firstly, we computed the eigenvectors V and eigenvalues D of the matrix A. Then, we identified the largest eigenvalue and its corresponding index position from the diagonal of the eigenvalue matrix D. The associated eigenvector was normalized by dividing each component by the vector sum to obtain the relative weight of each criterion.

Table 4. The weights for 11 factors selected

Criteria	Weight
Number of people watching the sport	24.94%
Number of athletes	18.60%
Gender ratio of athletes	11.69%
Carbon emissions of the SDEs	8.13%
Number of participating countries	10.17%
The attention of young people	9.30%
When the sport first appeared	2.18%
Whether it did not appear in the competition	2.78%
Injury rate of athletes	5.26%
Probability of doping	4.96%
False positive rate	2.00%

The overall score O_j for the SDE j is given by:

$$O_j = \sum_{i=1}^n w_i \times s_{ij} \quad (3)$$

Where w_i is the weight of the criterion i, s_{ij} is the score of the SDE j on the criterion i, n is the number of criteria (n=11), w_i is derived from the pairwise comparison matrix and normalized to ensure $\sum_{i=1}^n w_i = 1$. If the criteria scores are on different scales or units, s_{ij} should be normalized or standardized.

2.3 Data Availability

To obtain enough data to verify the effectiveness of the model, we collected detailed data on the above 11 factors from multiple sources and websites (<https://olympics.com/en/olympic-games/rio-2016>, <https://zh.wikipedia.org/wiki>, et al.). Detailed data can be obtained by contacting the corresponding author.

3. Results

3.1 The Top Five SDEs

According to the results, we found that the top five SDEs were Athletics, Basketball, Football, Diving and Badminton. The ranking of Sports Disciplines and Events (SDEs) such as Athletics, Basketball, Football, Diving, and Badminton as the top five using the AHP can be attributed to several key factors that align with the criteria established in the AHP model.

(1) Athletics

Athletics is a cornerstone of the Olympic Games, including various events from sprints to marathons and field events like long jump and shot put. Its universal appeal stems from its simplicity and the direct competition of human speed, strength, and endurance. Due to its inherent drama and diverse representation of different countries, athletics is a traditional Olympic sport and one of the most globally inclusive sports.

(2) Basketball

Basketball is one of the most popular sports worldwide, marked by its dynamic and fast-paced gameplay. It consistently attracts large audiences during the Olympics with its high-scoring nature and the participation of globally recognized athletes. This sport benefits from strong organizational support and a widespread professional infrastructure, which fosters a massive following and drives its success on the international stage.

(3) Football

Football, known as soccer in some countries, commands the globe's attention with its profound cultural and emotional connection to worldwide fans. Its inclusion in the Olympics brings together diverse nations, showcasing a blend of styles and talents. The sport's widespread popularity and accessibility contribute to its significant presence at the Olympics, appealing to a broad demographic of viewers and participants alike.

(4) Diving

Diving combines grace, precision, and athletic skill, capturing the attention of Olympic viewers with its visually captivating performances. Competitors execute complex maneuvers from varying heights, making it a thrilling spectator sport. Diving scores well in terms of safety, sustainability, and appeal, bolstered by stringent training and judging standards that emphasize technical prowess and artistic execution.

(5) Badminton

Badminton is celebrated for its accessibility and the rapid pace of play, which demands quick reflexes and strategic thinking. Popular particularly in Asia, it has a growing global audience due to its competitive nature and the excitement of rallies. Badminton's inclusion in the Olympics highlights its status as a sport requiring minimal equipment and space, promoting widespread participation and sustainability.

3.2 New additions or reintroductions for the 2032 Olympics

Three new projects are Cricket (2028), Breaking (2024), and Coastal Rowing (2028), and three longstanding projects are basketball, weightlifting, and diving. We conducted detailed data retrieval and collection for each SDE, and the results are as follows (Table 5).

Table 5: The detailed data for identified six SDEs

Factors	New additions SDEs			Continuous existences SDEs		
	Cricket 2028	Breakdanci ng 2024	Coastal Rowing 2028	Basketb all	Diving	Weightl ifting
Number of Viewers (highest viewership)	16.3 billion	240 thousand	15 thousand	35.89 million	67.45 million	9.57 million
Number of Athletes	2.5 billion	10 thousand	703 thousand	450 million	450 thousan d	50 million
Sustainability (Carbon Emissions)	high	low	low	middle	middle	low
Gender Ratio of Athletes (female: male)	3:7	1:10	1:1	17.4: 82.6	4:5	53:73
Cultural Diversity (Participating Countries)	108	16	159	212	211	193
Youth Engagement (social media fans)	31.33 million	3 million	0.228 million	89.04 million	1.443 million	184 thousan d
First Appearance Year	1877	1970	1980	1891	1880	1905
Previously Unseen in Competitions	yes	no	no	yes	yes	yes
Athlete Injury Rate	12.50%	95%	17%	15%	22.20%	15.80%
Misjudgment Rate (standard 8%)	26%	50%	10%	50%	3%	0
Doping Rate	1	0	0	1	1	1

Based on the Analytic Hierarchy Process (AHP) calculation with the provided data and weights, the results are as follows. Cricket scores the highest with a final score of approximately 0.607, significantly benefiting from its massive global viewership and a large number of athletes. Diving came in second with a score of around 0.667, likely helped by its participation rates and moderate sustainability ratings. Basketball follows closely with a score of 0.891, supported by its strong global presence and cultural diversity. Weightlifting scores 0.676, benefiting from its historical presence in the Olympics and consistent participation across countries. Coastal Rowing scores about 0.243, performing well due to its balance across several factors including sustainability and gender ratio. Breaking scores the lowest at nearly 0.210, limited by its relatively low viewership and smaller athlete base. Besides, the number of participating countries is smaller than 75. The inclusion of three new sports disciplines (Cricket (2028), Breaking (2024), and Coastal Rowing (2028)) is highly justified and beneficial. Similarly, the continued inclusion of longstanding sports (Basketball, Weightlifting, and Diving) effectively meets the International Olympic Committee's (IOC) criteria, aligning with the evolving goals and values of the Olympic Games. The integration of new and longstanding sports disciplines in the Olympics not only preserves the traditional values of the Games but also incorporates innovative and modern elements that resonate with current global trends. This balance ensures that the Olympic Games remain relevant, diverse, and engaging for worldwide audiences, fulfilling the IOC's criteria of inclusivity, sustainability, and global appeal. These strategic additions and continuations are essential for the Olympics' evolution as a leading sporting event.

We recommend that Breaking be reintroduced as a permanent discipline by the 2032 Olympic Games. This decision is informed by its unique appeal to a younger audience, its embodiment of modern urban culture, and its potential to bridge traditional Olympic values with contemporary entertainment forms. Breaking, characterized by its dynamic and visually engaging performances, not only captivates a wide audience but also promotes a diverse and inclusive sporting environment.

Its reintroduction could significantly enhance the cultural relevance and appeal of the Olympics among new generations, aligning with the International Olympic Committee's (IOC) ongoing efforts to innovate and adapt to changing global interests. Additionally, Chess is a globally recognized intellectual sport that has received widespread attention through the Internet and social media in recent years. Its influence is also vast, and now more and more young people are paying attention to it. The possibility of its inclusion in the Olympics is also increasing. We tested the SDEs in our model based on the collected data and obtained promising final scores.

Furthermore, considering the current trends among youth, the inclusion of innovative and technologically driven sports such as eSports should be seriously considered for the 2036 Olympics or beyond. eSports, with its massive global following, professional competitiveness, and substantial youth engagement, stands as a prime candidate for Olympic inclusion. This move would not only adhere to the IOC's criteria by drawing in a younger demographic but also reflect the evolving landscape of international sports. The integration of eSports into the Olympics could serve multiple strategic purposes. eSports can attract viewers who may not be interested in the Olympics' traditional SDEs, thus broadening the global audience. By incorporating eSports, the Olympics can leverage advanced technologies and digital platforms, which are integral to modern sports environments. Besides, eSports provides a platform for participants with different physical abilities and backgrounds, promoting inclusivity. In conclusion, reintroducing Breaking and considering the inclusion of eSports are strategic moves that align with the IOC's mission to evolve with cultural trends while staying true to its core values of promoting excellence, friendship, and respect through sport. These initiatives will ensure the Olympics remain relevant and engaging for future generations, further solidifying its status as the premier global sporting event.

4. Sensitivity Analysis

To evaluate the impact of each input parameter in the model on the total score, we conducted a sensitivity analysis. We found that some parameters (such as playback volume and attention volume) have a significant impact on the results. Since the absolute values of these data are large (for example, the playback volume reaches hundreds of millions), they may have an excessive impact on the model output in the weighted sum, thus dominating the model results. To solve this problem, we took the following measures. Large values (such as "playback volume and attention volume") were scaled, for example, 16,000,000,000 was converted to 1.6 and expressed in "millions". This method significantly reduced the magnitude difference between the data and avoided the situation where a single indicator dominated the results. Based on the scaled data, we further reduced the weights related to "playback volume and attention volume". By reconstructing the judgment matrix and recalculating the weights, we made the impact of these indicators on the total score more reasonable and balanced.

The sensitivity analysis of including various sports in the Olympic Games reveals a robust case for sports like Cricket and Basketball, which maintain top rankings across a variety of criteria weight variations. This stability in their rankings underscores a strong consensus on their value, making them solid candidates for inclusion due to their widespread appeal, and significant global following. In contrast, Breakdancing and Coastal Rowing appear more sensitive to certain criteria. Breakdancing's ranking fluctuates based on the emphasis placed on cultural impact and youth engagement, suggesting that its potential inclusion could be more controversial, hinging on the Olympic Games' strategic goals regarding cultural diversity and attracting younger audiences. Similarly, Coastal Rowing's position improves significantly when sustainability is prioritized, highlighting its appeal as an environmentally sustainable sport.

Since our model is based on the AHP, through the readjustment of weights and consistency tests, the model showed high robustness under different input conditions. Specifically, after adjusting weights and data scaling, the model output results are stable and can maintain the relative ranking order between the various sports.

5. Summary

The proposed model's primary strengths lie in its comprehensive and appropriate inclusion of influencing factors, which ensures a well-rounded evaluation of SDEs. By integrating a wide range of relevant criteria, the model effectively captures the complexity of decision-making scenarios, enhancing its validity. This systematic and invaluable approach utilizing techniques like the AHP allows for clear, understandable, and justifiable decision-making. The primary limitation of this model is data availability. Limited or incomplete data can significantly compromise the model's accuracy and the reliability of its conclusions. Therefore, improving data collection and transparency is crucial. Stronger collaboration with data providers and using advanced data collection techniques can contribute to scientific decision-making. Regular updating of models and stakeholder engagement will also help to refine models and ensure their continued accuracy and validity.

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