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Systematic Review

The Environmental Impact of Major Sport Events (Giga, Mega and Major): A Systematic Review from 2000 to 2021

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Abstract: In the context of the Sustainable Development Goals interest and concerns about the environmental impact of major sporting events have become increasingly widespread, voiced not only by organizers, but also spectators and residents of affected areas, as well politicians and institutional representatives of the host territories. There are multiple studies of the economic, social, and legal impacts of major sport events. Although several studies have pointed to a range of environmental impacts, there is no clear consensus on the effects that a major event can have on the natural environment. Thus, the aim of this article is to carry out a systematic review of the state of the art. Following the steps proposed by the PRISMA protocol, a selection of scientific articles from between 2000 and 2021 was made. The overall analysis shows that the negatives outweigh the positives, as only 32.91% of the effects described in the articles are deemed to be positive, with 62.03% deemed to be negative, and finally, 5.06% found to be inconclusive. With varying degrees of success, organizers and promoters of major events are already attempting measures to reduce negative impacts and enhance positive ones.

Keywords: mega-events; sustainability; systematic review; environmental; impact

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1. Introduction

It is evident that all human activities have consequences for the environment that surrounds us [1]. Historically, this human impact came about as a consequence of cultural evolution, as land and other forms of natural capital have been appropriated to enhance and support the human habitat [2]. The effects that human beings have on the ecosystem, whether positive or negative, take time to manifest themselves, which makes it difficult to respond effectively if we are not able to anticipate and foresee them [3].

Major sporting events, as a large-scale human activity, inevitably have an impact on the environment [4–6]. Given that land and nature are finite resources, measures have to be put in place to minimize the negative environmental impact of major sporting events [1,7,8] and to reinforce the effects viewed as positive for the host territory [9]. Since 2000, there has been exponential growth in the number of major events, and the continued boom in the mega-event industry, as well as the recent expansion into emerging markets and non-democratic states, has left it facing an array of new and often poorly understood dangers. Over the next decade, the Olympics and the Football World Cup will be held in a number of emerging states against a backdrop of ever-changing global risks [10].

Since the 1990s, there has been an exponential increase in the research on major events [11]. Studies have often examined the short-term impact of these events and the longer-term legacy they leave behind. For example, a number of researchers [12–14] have published guides and articles in reference to events' environmental impact and legacy.

There is some disagreement about how best to define the word sustainability, but most interpretations of the term involve a focus on human needs and values and an emphasis on the future [15]. The concept of sustainability has its origins in German forestry literature as the principle of "Nachaltigkeitsprinzezip" [16,17]. Sustainability is not necessarily a fixed destination, but rather a set of characteristics intended to describe the functioning of some future system [18]. This perspective frames the concept in a more realistic and actionable fashion, in that it allows for a view of sustainability as a "prediction" of what will endure in a manner sensitive to both time and spatial variability [19].

Sustainability, as a theory of human development, has a high degree of linguistic ambiguity, which makes it difficult both to formulate the method and to clarify the approach needed [20]. Sustainability theory seeks to explain the reciprocal relationship between degraded environmental processes resulting from human activities and the vulnerability of those activities to a degraded environment [2].

The meanings of the concept of sustainability have evolved, and individual professions have attempted to develop definitions that make sense in the context of their respective areas of expertise [21]. It is worth noting that, according to the three-pillar conceptual model of sustainability, the economic and social parts of systems are constrained by the environment, which imposes limits on the degree of intensity with which these systems can function [2]. The model illustrates the codependent relationship the environment has with the social and economic spheres and the role the it plays in underpinning human subsystems.

The triple bottom line (TBL) theory highlights the non-market and non-financial areas of corporate performance and responsibility, specifically considering economic, environmental, and social impact [22]. The TBL is used as a framework to report on company performance and measure it against economic, social and environmental parameters [23]. One widely adopted definition of sustainable development comes from the World Commission on Environment and Development [15], which defines the term as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Environmental sustainability is essentially a natural science construct that seeks to apply biophysical principles to define appropriate conditions of balance, resilience, and interconnectedness between human society and the supporting ecosystem [21]. Elsewhere, authors have emphasized the longstanding, intimate connections between the environment and development. Countries consider economic development a top priority, and developing countries have sometimes believed that environmental considerations could limit or impede their development, even desiring pollution as a symbol of industrialization [24].

A range of models have been used to assess sustainability. Firstly, there is the three-pillar model, which includes the environmental, social and economic dimensions [23,25,26]. Secondly, the four-pillar model encompasses institutional, social, economic and environmental dimensions [27]. There is also the model of cosmic interdependence [28] and, finally, the model of the circles of sustainability [29].

There are also a number of methods and measurement models intended to assess environmental sustainability. One such approach is a flexible tool to assess buildings hosting major sport events [30]. Another one is a case-study methodology [31] that uses the life cycle assessment method to evaluate major sporting events. The ecological footprint (EF) method has also been used in some studies [32], as have environmental input–output analysis (ENVIO) and many others [4]. The qualitative and quantitative information collected in these studies is analyzed and detailed in the subsequent tables. It has been considered that the type and magnitude of the impact of sport events differs according to the size of the event. The literature has proven that the impacts and legacy of events of different sizes can vary, and that they should be assessed with this in mind [33–35]. A classification system for these events is used in this systematic review to obtain more accurate information.

Sporting events can be classified according to their size, visitor appeal (based on the number of tickets sold), audience reach (based on the cost of broadcasting rights), total cost, and transformational impact (capital investment) [35]. An index has been created by awarding a range of values for each variable, according to which events scoring between 1 and 6 points will be considered major-events, while those that score between 7 and 10 will be called mega-events, and those that score between 11 and 12 will be labelled giga-events, as can be seen in Table 1.

Table 1. Sporting events scoring matrix second measurement.

Size	**Visitor Attraction**	**Mediated Reach**	**Cost**	**Transformation**
	Number of Tickets Sold	**Cost of Broadcasting Rights**	**Total Cost**	**Capital Investment**
XXL (3 points)	>3 million	>2 billion	>10 billion	>10 billion
XL (2 points)	>1 million	>1 billion	>5 billion	>10 billion
L (1 points)	>0.5 million	>0.1 billion	>1 billion	>1 billion

As the negative environmental impacts of major sporting events has come to light, research and work has been carried out in various contexts in attempts to reverse these harmful environmental impacts and reinforce the beneficial ones.

The increasing concern about negative impacts has put pressure on the major organizers of events to move towards a more sustainable way of doing things.

In light of the large number of articles published on the environmental impact of major events in recent years and the wide range of topics they cover, it was considered useful and necessary to carry out a systematic review of the literature on the environmental impacts of major sporting events in order to ascertain the state of the art.

2. Materials and Methods

To analyze the environmental impacts generated by major sporting events and to be able to categorize these events, a qualitative systematic review was carried out.

2.1. Literature Identification

A systematic literature search was carried out using the following databases: Ebscohost, eBook Collection (EBSCOhost), E-Journals, GreenFILE, Sales & Marketing Source, SportDiscus. Web of Science, Web of Science Core Collection, CABI, Current Contents Connect, BIOSISCitation Index, BIOSIS Previews, MEDLINE, Zoological Record, KCI-Korean Journal Database, Derwent Innovations Index, SciELO Citation Index, Russian Science Citation Index and Scopus. The search was limited to scientific articles published between 2000 and January 2021. It was based on the PRISMA methodology [36] of identification, selection, choice and inclusion. We decided on the period from 2000 to 2021, since no systematic review or meta-analysis covering this time frame was found. There is an increasing need for transfer of knowledge from academia to society from the point of view of environmental sustainability, especially when it comes to major sporting events.

The search string is shown in Table 2, and is made up of four parts: (1) sport, as the focus of the research, together with (2) events, which places us in a specific space and time when a planned event takes place; (3) impact, effect, influence, outcome, result or consequence, referring to all the effects of the sporting event; (4) major, mega, large, big or giga or Olympic, to focus on the object of study; (5) and, finally, to focus on the type of impact on which the study focuses, environment or ecological.

Table 2. Keywords for the creation of the English search string.

Sport(1)	AND	Event (2)	AND	Impact OR effect OR influence OR outcome OR result OR consequence (3)	AND	Major OR Mega OR Large OR Big OR Giga OR Olympic (4)	AND	Environment OR ecologic (5)

The search string is detailed in Table 3.

Table 3. Search String.

(sport) AND (event) AND (impact OR effect OR influence OR outcome OR result OR consequence) AND (major OR mega OR large OR big OR giga OR Olympic OR mega-events) AND (environment OR ecologic)

2.2. Selection and Data Extraction

Combining the results from all databases, a total of 1801 records were identified. Once the duplicates had been removed, the total number of records was reduced to 1570, which were then screened for inclusion or exclusion. To reduce bias, a double check by title and abstract was performed. A total of 222 articles were accepted to be filtered through full-text reading. Finally, after the elimination of articles that did not meet the established criteria as they did not refer to major sporting events or did not address their environmental impact, 49 articles were included in the systematic review (Figure 1).

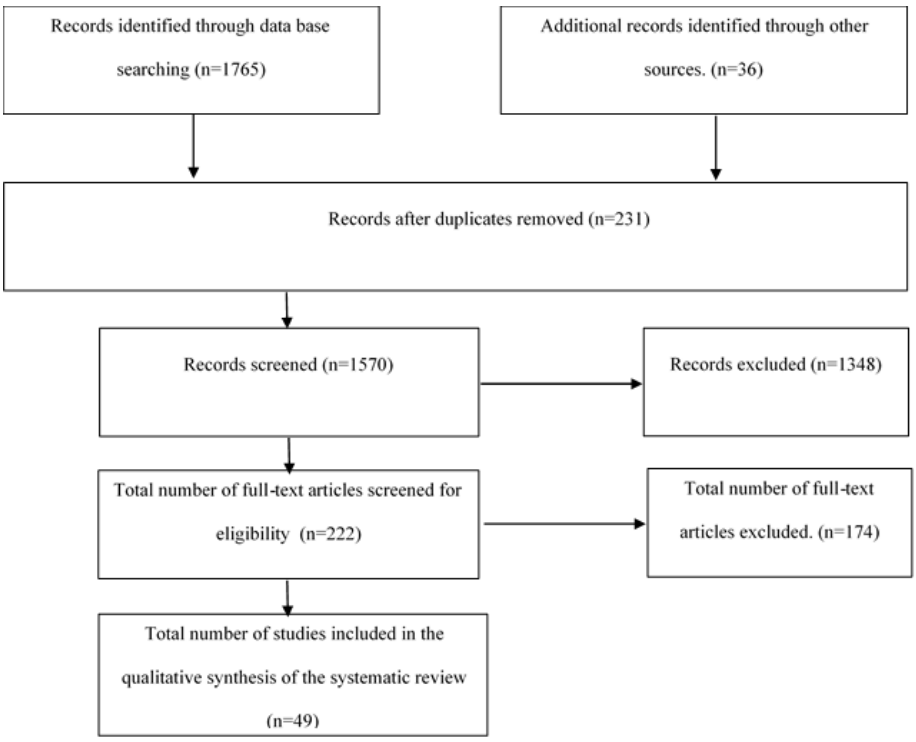

Figure 1. Selection and data extraction.

3. Results

Overall, 49 studies were selected and analyzed. All the studies were in English. The studies employed a number of different methods of analysis, as shown in Table 4. Cross-sectional studies represent the majority, with a total of 28 studies or 57.14% of the total. The second most common were longitudinal studies, of which there were 13, representing 26.53%. In third position, there were five theoretical studies and/or policy statements,

representing 10.20% of the total, and, finally, we found three non-systematic literature reviews, 6.12% of the total, as can be seen in Table 4.

Table 4. Types of methods used by the studies.

Type of Methods	Total (n = 49)	Studies (n = 49)
Cross-sectional studies	28 (57.14%)	Dolles and Söderman, 2010 [37], Chen et al., 2013 [38], Collins et al., 2012 [4], Crab, 2018 [5], Tziralis et al., 2008 [6], Chappelet, 2008 [7], Gaffney, 2013 [8], Ermolaeva, 2016 [39], Jones, 2008 [40], Gold and Gold, 2013 [41], Rupf-Haller and Locher Oberholzer, 2005 [42], Karaczun, 2012 [43], Death, 2011 [44], Shokri et al., 2013 [45], Fairley et al., 2011 [46], Aragón-Pérez, 2019 [47], Otto and Heath, 2009 [48], Abdel Azim Ahmed, 2017 [49], Collins et al., 2007 [50], Huang et al., 2012 [51], Bama and Tichaawa, 2015 [52], Collins and Flynn, 2008 [53], Konstantaki and Wickens, 2010 [54], Jin et al., 2011 [55], Boonsiritomachai and Phonthanukitithaworn, 2019 [56], Johnsen et al., 2004 [57], Govender et al., 2012 [58] and Kim, 2013 [59].
Longitudinal studies	13 (26.53%)	Zhang et al., 2016 [9], Ventura et al., 2019 [60], Bono et al., 2010 [61], Locke, 2019 [62], Yang, 2019 [63], De La Cruz et al., 2019 [64], Ma and Kaplanidou, 2017 [65], Cai et al., 2017 [66], Shen et al., 2011 [67], Pfitzner and Koenigstorfer, 2016 [68], Beig et al., 2013 [69], Vilani and Machado, 2015 [70] and Cai and Xie, 2011 [71].
Theoretical articles or policy statements	5 (10.20%)	Yeh and Huang, 2018 [72], Zhang, 2018 [73], Meza Talavera et al., 2019 [74], Boykoff and Mascarenhas, 2016 [75] and Fermeglia, 2017 [76].
Non-systematic literature reviews	3 (6.12%)	Ross and Leopkey, 2017 [1], Drummond and Cronje, 2019 [77] and Thomson et al., 2017 [78].
Total	49 (100%)	

Grade: n = 49. SD = Standard desviation.

3.1. Event Identification

The 49 selected articles study a total of 50 events: 21 of the papers (42.85%) refer to the Olympic Games, 9 (18.36%) to the FIFA Football World Cup, 2 (4.08%) to the 2003–2004 FA Cup Final, 2 (4.08%) to the 2003 World Ski Championships in St. Moritz, 9 (2.04%) to a single event other than the above, and the remaining 7 (14.28%) make a general analysis of major events without referring to any specific event As mentioned above, these results are shown in Table 5.

The events included in the systematic review have been classified according to their size, in accordance with the system defined by Müller, as detailed in Table 6. Data from previous studies on events have been used to develop this classification [35,79,80]. Thus, we have a total of five giga-events (21.74%), nine mega-events (39.14%) and nine major events (39.13%).

3.2. Identification of Impacts Associated with the Events

Overall, the results show a greater prevalence of detrimental impacts than of beneficial ones. As can be seen in Table 7, a total of 26 impacts were considered positive, representing 32.91% of the total. A total of 49 negative impacts were identified, or 62.03% of the total. Lastly, there are four inconclusive impacts, which have no perceptible effect on the environment, accounting for a total of 5.06%. The table shows the number of studies (n) that refer to each event.

Table 5. Number of studies by type of event.

Event	Total	%	Studies (n = 50)
Olympic Games	21	42.85	Chappelet, 2008 [7], Ross and Leopkey, 2017 [1], Aragón-Pérez, 2018 [47], Tziralis et al., 2008 [6], Bono et al., 2010 [61], Zhang et al., 2016 [9], Yang, 2019 [63], Cai et al., 2017 [66], Shen et al., 2011 [67], Jin et al., 2011 [55], Cai and Xie, 2011 [71], Gold and Gold, 2013 [41], Konstantaki & Wickens, 2010 [54], Shokri et al., 2013 [45], Kim, 2013 [59], Ermolaeva, 2016 [39], Ventura et al., 2019 [60], Gaffney, 2013 [8], De La Cruz et al., 2019 [64], Vilani and Machado, 2015 [70] and Boykoff & Mascarenhas, 2016 [75].
FIFA World Cup	9	18.36	Dolles & Söderman, 2010 [37], Drummond & Cronje, 2019 [77], Death, 2011 [44], Otto and Heath, 2009 [48], Govender et al., 2012 [58], Crabb, 2018 [5], Pfitzner & Koenigstorfer, 2016 [68], Meza Talavera et al., 2019 [74] and Ermolaeva, 2016 [39].
General	7	14.28	Yeh and Huang, 2018 [72]., Ma & Kaplanidou, 2017 [65]., Chen et al., 2013 [38]., Boonsiritomachai and Phonthanukitithaworn, 2019 [56]., Fermeglia, 2017 [76] and Thomson et al., 2017 [78]
2003/2004 FA Cup Final	2	4.08	Collins et al., 2007 [50] and Collins and Flynn, 2008 [53].
2003 World Ski Championships in St. Moritz	2	4.08	Rupf-Haller and Locher Oberholzer, 2005 [42] and Johnsen et al., 2004 [57]
2013 AFCON	1	2.04	Bama and Tichaawa, 2015 [52].
2010 Commonwealth Games	1	2.04	Beig et al., 2013 [69].
2012 Eurocup	1	2.04	Karaczun, 2012 [43].
2009 Australian Gran Prix	1	2.04	Fairley et al., 2011 [46].
2016 Hail International Rally	1	2.04	Abdel Azim Ahmed, 2017 [49].
2009 World Games in Kaohsiung	1	2.04	Huang et al., 2012 [51].
Major League Baseball 2010–2016 seasons	1	2.04	Locke, 2019 [62].
2007 Tour de France	1	2.04	Collins et al., 2012 [50].
2004 Rally World Championship 2004	1	2.04	Jones, 2008 [40].

Grade: n = 50.

Table 7 shows the positive impacts of the analyzed events. The studies included in the systematic review highlight a total of 12 positive impacts. In the case of events in which two or more studies reflect the same impact, we counted each one as a separate impact. For example, in the case of the 2008 Beijing Olympics, where three of the six articles agreed on the decrease in air pollution, we counted this three times.

Although a similar number of studies analyzed events of each of the three dimensions (19 looked at giga-events, 15 at mega-events and 18 at major-events), the giga-events clearly outperform the other categories in terms of the positive impacts identified in the literature, as can be seen in Table S1. The most frequent positive impacts are the decrease in air

pollution, the improvement of the host city's livability and improvements in the ecological civilization index. Table S1 is available in the Supplementary Materials.

The negative or adverse impacts are shown in Table S2. In this case, the impacts of mega-events were greater in number than those of major events. The former had 18 identified impacts, while the latter had 14, and giga-events had only 13 identified impacts. The most frequent negative impacts are the increase in air pollution, the poor formulation of the environmental sustainability program, and the omission of environmental responsibility on the part of the organizers and promoters.

Only three events were found not to have generated any definite impact (Table S3), or, in other words, had an inconclusive impact. Firstly, this is the case of the future Football World Cup to be held in Qatar in 2022, which aims to have neutral emissions. Secondly, it was the case of the 2003 St. Moritz World Ski Championships, about which the two articles underlined the importance of the planning phase to achieve the environmental sustainability objectives. Lastly, no impacts are defined in the article covering the England Football Cup Final of the 2003–2004 season, which also reinforces the importance of the planning phase.

Table 6. Dimensions of the events.

Event	Dimension	%
1992 Barcelona Summer Olympic Games 2004 Athens Summer Olympic Games 2008 Beijing Summer Olympic Games 2012 London Summer Olympic Games 2016 Rio de Janeiro Summer Olympic Games	Giga-events	21.74
2006 Winter Olympic Games Torino 2014 Winter Olympic Games Sochi 2010 Commonwealth Games 2012 Eurocup 2006 Football World Cup 2010 Football World Cup 2014 Football World Cup 2018 Football World Cup 2022 Football World Cup	Mega-events	39.13
AFCON 2013 2009 Australia GP F1 2003/2004 FA Cup Final 2016 Hail International Rally 2009 World Games in Kaohsiung Major League Baseball 2010–2016 seasons 2007 Tour de France 2004 Rally World Championship 2003 World Ski Championships in St. Moritz	Major events	39.13

3.3. Impacts Associated with Events According to Their Dimension

The giga-events were found to have 15 (53.57%) positive impacts and 13 (46.43%) negative impacts, a total of 28. The mega-events had 5 (20.83%) positive impacts, 1 (4.17%) inconclusive impact and 18 (75%) negative impacts, a total of 24 impacts. The major events had a total of 3 (15%) positive impacts, 3 (15%) inconclusive impacts and 14 (70%) negative impacts, a total of 20 impacts. Finally, there were impacts that were not associated with any specific event, specifically, 3 (42.86%) positive impacts and 4 (57.14%) negative impacts, a total of 7.

3.3.1. Positive Impacts

In the case of the 1992 Barcelona Summer Olympic Games, environmental education initiatives were identified. These programs were intended to improve society's knowledge

of the importance of the environment and to raise awareness of the measures taken in connection with the Games. For example, there were some restorative initiatives, such as the planting of trees to offset carbon emissions during the preparation and execution of the games [47].

Table 7. Type of impact per event according to its classification and type (events n = 52).

Event	Positive Impacts	Negative Impacts	Inconclusive Impact
Giga-events (n = 19)	15	13	0
Summer Olympic Games (n = 19)	15	13	0
Barcelona 1992 (n = 1)	*2*	*0*	*0*
Athens 2004 (n = 1)	*2*	*0*	*0*
Beijing 2008 (n = 6)	*5*	*1*	*0*
London 2012 (n = 4)	*3*	*6*	*0*
Rio de Janeiro 2016 (n = 6)	*3*	*5*	*0*
Multiple editions (n = 1)	*0*	*1*	*0*
Mega-events (n = 15)	5	18	1
Football World Cup (n = 9)	2	14	1
Germany 2006 (n = 1)	*1*	*0*	*0*
South Africa 2010 (n = 4)	*0*	*9*	*0*
Brazil 2014 (n = 2)	*0*	*5*	*0*
Russia 2018 (n = 1)	*1*	*0*	*0*
Qatar 2020 (n = 1)	*0*	*0*	*1*
Winter Olympic Games (n = 3)	2	1	0
Torino 2010 (n = 1)	*0*	*1*	*0*
Sochi 2014 (n = 1)	*1*	*0*	*0*
Multiple editions (n = 1)	*1*	*0*	*0*
Games of the Commonwealth de 2010 (n = 1)	0	1	0
Eurocup 20,122,012 (n = 1)	0	2	0
Universiade Kazan 2014 (n = 1)	1	0	0
Major events (n = 18)	3	14	3
2003 World Ski Championships in St. Moritz (n = 2)	0	0	2
FA Cup Final 2003/2004 (n = 2)	0	5	1
2004 Rally World Championship (n = 1)	0	1	0
2013 AFCON (n = 1)	2	0	0
2007 Tour de France (n = 1)	0	1	0
World Games of the Kaohsiung 2009 (n = 1)	1	2	0
Australia GP F1 2009 (n = 1)	0	2	0
Major League Baseball 2010–2016 seasons (n = 1)	0	1	0
Rally International of Hail 20,162,016 (n = 1)	0	2	0
no event specified (n = 7)	3	4	0

Grade: n = 79 impacts identified.

It is clear that some events have helped to improve the infrastructure of the cities and territories that host them. In the case of the Athens Summer Olympic Games in 2004, the city's metro system grew by a factor of 1.74 [6]. The improvement of motorways is also a clear example, as during the 2004 Olympic Games in Athens, motorways were upgraded [6]. A report on the World Games held in Kaohsiung in 2009 shows that residents, especially women, value major events positively as long as they are linked to improvement in the city's landscape and facilities [51]. Some authors also challenge governments to improve the quality of cities so that residents will be more willing to host sporting events [51,56].

The reduction of air pollution is one of the impacts that appears most frequently in studies on giga-events. In the case of the Athens Summer Olympics in 2004, the Beijing Summer Olympics in 2008, and the Rio Summer Olympics in 2016, all studies show that emissions of different particulate pollutants such as ozone (O3), carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO2) and sulfur dioxide were reduced (SO2) [6,9,60,64,67,71].

However, it should be noted that in the case of the 2008 Beijing Summer Olympics, pollution levels returned to normal levels after the Games were over [9,67,71].

A couple of papers state that the 2008 Beijing Summer Olympics increased the score on the ecological civilization index, improving the urban thermal environment thanks to the increase in the areas with permeable surfaces, which made the city more livable [63,66]. Other studies show the effect of major sporting events in Russia, focusing on the cases of the 2013 Universiade held in Kazan, the 2014 Winter Olympics held in Sochi and the 2018 Football World Cup. These studies found that after the events, citizens became more environmentally friendly and lived a greener lifestyle, changes that could be linked to the increased accessibility of green infrastructure, such as the widespread implementation of recycling bins, the creation of green ways for cyclists, and the environmental certification of products and services [39].

One of the most important positive environmental and economic effects for the host of the Olympic Games is the development and improvement of the transport industry [45].

In preparation for the London 2012 Summer Olympics, nearly 2 million tons of contaminated soil was cleaned up for reuse in the Olympic Park [45].

Growing concern for the environment is driving cities to apply environmental criteria in the design, planning and implementation phases, leading to an increase in sustainable construction, the use of recycled materials, the use of renewable energy, and the protection of ecologically vulnerable areas and endangered species [38]. The plan for the 2012 London Summer Olympics called for 42% recycled material to be used, and thousands of plants, trees and bulbs to be planted [45].

Parallel to some events, a series of green initiatives are generated. This happened in London 2012 and the 2006 Football World Cup in Germany [37,45]. Over time, event promoters and organizers are increasingly incorporating green initiatives and sustainability principles into their plans [78].

Some events have been moved away from protected areas, thus favoring a better use of the heritage sites and avoiding some of the environmental impact of these events, as in the case of various Winter Olympic Games [6].

Visitors to the 2013 Africa World Cup of Nations did not believe that the event would increase pollution in the area, nor that the environment would degrade in the area where the event was held [52].

3.3.2. Negative Impacts

Other papers reviewed show residents' perceptions of environmental impact, often finding that respondents tended to support green events, but not major events such as the Olympic Games [55].

Several studies point to the increase in air pollution linked to major sporting events, such as the 2006 Winter Olympics in Turin, the 2010 Commonwealth Games in Delhi, the English Football Cup Final in 2003–2004, the 2004 Rally World Championships, the stages of the Tour de France that passed through the UK, the 2009 Australian Formula 1 Grand Prix and the Major League Baseball in the United States [4,40,46,50,53,61,62,69]. The 2009 Australian Formula 1 Grand Prix saw the surrounding ecosystem disrupted by increased pollution and other issues [46].

Residents' perceptions of adverse environmental effects have also been closely observed [54], and it has been noted that residents aged between 33 and 55 associate major events with increased pollution and increased traffic congestion, specifically in a study of the 2012 London Summer Olympics. Residents' perceptions of increased pollution and increased waste are also shared with other studies [51].

Visitors to the 2010 Football World Cup in South Africa recognized that the event had adverse environmental effects such as increased pollution, increased waste, high water consumption, noise pollution, destruction of natural habitats and loss of biodiversity [58]. Meanwhile, a study of the 2016 Hail International Rally shows that environmental damage

is very important to the local population, and the researchers urge organizing committees to consider all possible procedures to reduce the adverse side effects on the environment [49].

The lack of communication from promoters and organizers to residents was evident in the London 2012 Summer Olympics [54].

Poor formulation of the sustainability program, omission of responsibility and minimization of adverse environmental effects caused by the event were common to the following events: (a) London 2012 Summer Olympics; (b) Rio 2016 Summer Olympics; (c) the 2012 edition of the European Football Championship; and (d) the 2010 World Cup in South Africa [1,5,41,43,48,68].

Especially noteworthy is the case of the 2014 World Cup held in Brazil, as the stadium was certified as carbon-neutral, yet the certificate was issued thanks to a program that envisaged planting 1.4 million trees in the area, to reverse the adverse effects of the construction. In the end, only 70,000 trees were planted, and the nursery was abandoned after achieving only 5% of the planting required to determine a positive impact. This program was clearly poorly formulated, and there was a clear omission of environmental responsibility and a failure to enforce the agreements that had been defined [5]. Other authors [76] have observed that major sporting events have adverse effects on biodiversity and natural resources. Indeed, environmental and climate safeguards were introduced into FIFA's bidding procedure for the years 2018 and 2022. These requirements call for the hosts to adopt ambitious climate policies and regulations to reduce their carbon footprint, yet climate change does not appear to feature prominently in the substantive and material provisions included in the bid. In fact, it is not even a major part of their program.

Elsewhere, related authors have found no positive effects of the hosting of the megasport event on four quality of life domains of the residents themselves [68]. The individual perception of changes in quality of life varies, and does not necessarily correspond with what has been foreseen in the program.

Before the London Summer Olympics of 2012, it was been pointed out that 6.5 million people would attend the London 2012 Summer Olympics, which would generate more than 3300 tons of food packaging waste [45].

From an ideological point of view, and with reference to the 2016 Summer Olympic Games in Rio de Janeiro, the academic consensus seems to be coalescing around the notion that large sporting events such as the Olympics are incongruent with sustainability [75].

Some events have led to environmental degradation and the destruction of protected areas, such as the 2016 Olympic Games in Rio de Janeiro [8,45,70]

Poor or nonexistent coordination has also been pointed out [44,68,77] in the cases of the 2010 World Cup held in South Africa and the 2014 World Cup held in Brazil.

Excessive use of energy and water, together with high waste generation, were pointed out in connection with the English Football Cup 2003–2004 season [50].

3.3.3. Inconclusive Impacts

The organizers of the Football World Cup to be held in Qatar in 2022 are planning to build the first zero-carbon stadium. Local organizers are applying green technologies and sustainable urban development concepts. They also underline that more needs to be done to reduce adverse environmental impacts [74].

In the case of the study of the 2003 Alpine World Ski Championships in St. Moritz, the importance of the planning phase to eliminate negative influences on the environment is emphasized, and the authors contend that some negative aspects, such as excessive traffic, could be eliminated at the planning stage [42,57]. However, the positive effects envisaged at the planning stage are often linked to the social and economic spheres, relegating environmental effects to the status of a secondary concern [57]. Nonetheless, as observed in connection with the 2003–2004 English Football Cup Final, events of this nature have potentially large impacts on the environment, and there is a need to give these concerns greater consideration in the planning of future events [53].

The environment has become a key factor in the hosting of the Olympic Games, and both residents and visitors often consider events' environmental legacy to be the most important, as their quality of life depends on it. Major events can have a potential impact on local ecosystems, and these effects are difficult to assess quantitatively. Some authors also propose a method for feasibility analysis of sport events based on environmental estimation methods [72].

The quality of life of residents is affected by the legacy of major sporting events. In one study, residents said the environmental legacy was of the greatest importance. The environmental impact and legacy of an event is crucial for the residents [65].

In another study [73], major sporting events are said to demonstrate an improvement in the image of social civilization. The study proposes a quantitative evaluation model based on the quantitative recursive analysis of the ecological environment in sports events, starting from the air pollution index, vegetation cover rate and urban microclimate, as factors of environmental quality evaluation. Once this has been carried out, it suggests a series of actions hosts can take to establish an environmental protection strategy.

4. Discussion

This study focuses on the environmental sustainability of large sports events, examining whether the effects are positive, negative, or inconclusive. The articles have been grouped according to the dimension of the events they cover [35], as it was felt that this classification would be helpful in identifying studies looking at different kinds of events. However, other studies classify events according to other criteria, and this led to a potential bias in the results when comparing them with each other.

We have been able to observe that there is a parity between the positive and negative impacts identified in giga-events, while in the mega-events there are only five positives impacts and 18 negative impacts, and the mayor-events continue with the trend of the mega-events, in this case with three positive impacts identified against 14 negative impacts.

As sustainable development goals become enshrined in sport organizations and public sector bodies, harmful impacts will be reduced, and measures to increase beneficial impacts will be increased [40].

5. Conclusions

This systematic review provides an overview of the environmental impacts of the major events that have been studied. Obviously, the fact that these events have been studied does not imply that they are the only ones, nor that they are more important than others.

Of the total number of impacts studied in the review, 26 (32.91%) were positive impacts, 4 (5.06%) were inconclusive impacts (having no impact or legacy on the territory), and 49 (62.03%) were negative impacts. Even so, if we classify according to giga-event, mega-event, major event and studies not linked to any specific event, we find differences, a finding that reinforces the article's approach of dividing events according to their dimension.

The fact that an event has a greater number of positive impacts does not imply that the total balance is positive; only on the basis of comprehensive studies on all environmental impacts can we come to a final verdict on the environmental impact of an event.

In light of the number of studies published, there is evidence of a growing concern and interest in environmental sustainability on the part of researchers investigating major events and their model of sustainability. From the analysis and review of the articles, we can affirm that progress is being made, since the organizers and promoters of major events have, with varying degrees of success, begun to incorporate more measures to reduce the negative impacts and enhance the positive ones. It is necessary to continue working and establishing measures and methods to reduce the adverse environmental effects of major sporting events and to enhance their positive effects.

Every stakeholder in the world of major sporting events has a key role to play, and should be responsible for ensuring that major events produce positive environmental impacts, including event promoters, host territories, politicians, residents, athletes, con-

sumers... The importance of sustainability education at all levels and for all stakeholders has been demonstrated, as well as the guarantees that ensure compliance with established regulations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su142013581/s1, Table S1: Positive impacts by event according to their classification and type (events N = 52); Table S2: Negative impacts by event according to their classification and type (events N = 52); Table S3: Inconclusive impacts by event-by-event classification and type (events N = 52).

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