Green sports supporting a low-carbon society: inspiration from Japan

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Abstract: Global warming, mainly due to anthropogenic greenhouse gas emissions, has a devastating effect on our living planet. To combat it and foster a low-carbon society, contributions from the sports community are needed. Accordingly, the concept of ‘green sports’ has emerged, calling for green performance of sports infrastructure, green production in sports manufacturing, and green awareness of sports community. In this respect, Japan, as a leader in both Asian sports and worldwide sustainable development, has valuable experiences, including widespread stakeholders’ participation, substantial efforts, and outstanding achievements. Inspired by Japan’s examples, this study not only summarises mainstream recommendations for the development of green sports, but also presents two innovative proposals – linking green sports with market-based flexibility mechanisms and promoting environmental education through sports celebrities – and the prospects for these approaches. This article could be used by worldwide sports community as reference for making contributions to the establishment of a low-carbon society.

Keywords: green sports; low-carbon society; green performance; green production; green awareness; Japan; 2020 Tokyo Olympic Games; sports community; sustainable development; flexibility mechanism; environmental education.


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1 Introduction

Sports are commonly defined as including all forms of competitive activities that involve using, maintaining, or improving human beings’ physical capabilities and skills, thereby entertaining the participants as well as spectators (Council of Europe, 2015). Through casual or organised participation in sports, people are even searching for the meaning of life. Types of sports activities range from individual sports such as jogging and gymnastics to those requiring a pair of participants (tennis and boxing) or teams (soccer and basketball). The relationship between sports and our living environment is quite complex (Lenskyj, 2000, 2002; Jarvie and Thornton, 2012). Sports can have a positive influence on the natural environment, particularly outdoor sports such as mountaineering and canoeing arouse people’s love for the greatness of nature and their concern for
environmental conservation and improvement. However, sports can also play a detrimental role. For instance, to construct golf courses or motor racing speedways, large areas of land must be cleared, and in many cases, the facility replaces fertile farmlands or thriving forests. Additionally, major international sports events entail negative environmental impacts far beyond those of normal sports activities and events. Most notably, the establishment of necessary infrastructure for each Olympic Games or World Cup soccer tournament often means intensive utilisation of natural resources, high consumption of energy, and significant generation of waste. Even after these major sports events, dire environmental influences persist. Frequently, the stadiums and other facilities are abandoned or destroyed. Moreover, the resulting environmental pollution and degradation often spawn irreversible and chronic problems.

In 1987, the World Commission on Environment and Development (WCED) proposed the concept of sustainable development, i.e., “development that meets the need of the present generation without compromising the ability of future generations to meet their own needs”. Since then, the idea has grown into an emphasis on achieving a fully sustainable society. This concern has encompassed three main components: less carbon footprint (the focus of this article), harmony with nature, and sound material cycle (Nakagami, 2010). The notion of sustainability has also been introduced into the Olympic Charter, as the International Olympic Committee (IOC) was keenly aware of its important obligation to support the pursuit of a sustainable society and hence, was eager to replace the poor environmental image of the Olympic Games with positive examples. Along with the IOC and its 204 National Olympic Committees, many sports-related organisations around the world, such as the Global Sports Alliance (GSA), are also devoting themselves to this admirable campaign.

Can the entire sports community become an impetus for achieving sustainable development? In response to this question, the concept of ‘green sports’ has come into being. As described by the US Environmental Protection Agency (USEPA, 2015a), this goal calls for environment-friendly behaviours by all sports participants, such as “saving energy, cutting waste, and cleaning up pollution”. It is hoped that contributions from green sports, along with those from many other sectors, will make the idea of a sustainable society a reality.

In this study, fundamental theories and guidelines about achieving a sustainable (low-carbon) society are presented first, followed by general descriptions of the mission of green sports and the major relevant organisations involved in putting low-carbon notions into practice. The current status of green sports in Japan is then presented through case studies. In particular, along with aiming to hold a ‘green’ 2020 Olympic Games and simultaneously building a sustainable (low-carbon) metropolis, the Tokyo Metropolitan Government has comprehensively upgraded its long-term urban development strategies lately. Finally, as one of the main objectives and highlights of this study, further proposals for the development of green sports toward building a low-carbon society are
put forward, and their prospects are discussed. This article features the widespread stakeholders’ participation, substantial efforts and outstanding achievements of Japan as a trailblazing nation in sustainable development.

2 Creating a low-carbon society through green sports

2.1 The importance of and guidelines for building a low-carbon society

The term ‘climate change’ refers to significant variations in the statistical distribution of weather patterns over decades, centuries, and even millions of years. Climate change on Earth results from many factors, some of which human beings have no ability to control, such as biotic processes, change in solar radiation, and tectonic plate movement. However, certain human activities that emit what are known as anthropogenic greenhouse gases (GHGs) are widely considered the primary driver of global warming in the past century. Just as its name implies, ‘global warming’ is an unequivocal and continuing trend of increases in the average temperature of the earth’s climate system (IPCC, 2013). Some worrying phenomena have already happened because of rising temperatures, such as accelerated ice melt at the Earth’s poles and consequent rising sea levels, increases in worldwide precipitation, and the abnormal extinction or boom in certain species. If these patterns continue, dramatic changes will probably occur. Extreme weather events may increase significantly in frequency, and eco-catastrophes may prevail across the globe (IPCC, 2013). Sports events, arguably, are adding fuel to the fire. For instance, major sports events emit incredibly high amounts of GHG into the atmosphere over a short period of time. During the 2004 Athens Olympic Games, approximately half a million tons of GHG carbon dioxide were generated in two weeks, which is almost equal to what a city of one million people could release within the same period (Schmidt, 2006).

International leaders have called for creating a low-carbon society to prevent global warming before the situation can become too severe to reverse. A low-carbon society is defined as one that minimises emission of GHGs, primarily carbon dioxide (CO₂). Through maintaining and restoring environmental prosperity, it is proposed, a low-carbon society can coexist with nature in a harmonious way (Japan Ministry of the Environment, 2007). To work out a roadmap for a low-carbon society, dynamic framework is needed to integrate the changes from demographic, technological and economic aspects, including commercial sector, residential sector, industrial sector, transportation sector, etc. (Shimada et al., 2007). As a pioneering country in the low-carbon movement, Japan launched its ‘Low-Carbon Society’ project about a decade ago, with the ultimate goal of reducing 70% of CO₂ emissions by 2050 compared to 1990 levels (NIES et al., 2008). Subsequently, ‘a dozen actions’ to foster a low-carbon society were proposed (see Table 1). In a comprehensive and concise manner, these recommended actions function as guidelines for all sectors of society and for all countries in the world.
Table 1  A dozen actions toward low-carbon society

<table>
<thead>
<tr>
<th>Name of action</th>
<th>General explanation</th>
<th>Corresponding sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Comfortable and green built environment</td>
<td>Efficiently use of sunlight and energy-efficient design of the built environment; intelligent buildings.</td>
<td>Commercial and residential sectors</td>
</tr>
<tr>
<td>2 Appliances appropriate anytime and anywhere</td>
<td>Use of the top-runner and appropriate appliances; initial cost reduction by rent and release system resulting in improved availability.</td>
<td></td>
</tr>
<tr>
<td>3 Promoting seasonal local food</td>
<td>Supply of seasonal and safe low-carbon local foods for local cuisine.</td>
<td></td>
</tr>
<tr>
<td>4 Sustainable building materials</td>
<td>Using local and renewable building materials and products.</td>
<td>Industrial sector</td>
</tr>
<tr>
<td>5 Environmentally enlightened business and industry</td>
<td>Businesses aiming at creating and operating in a low-carbon market; supplying low-carbon and high-value-added goods and services through energy-efficient production systems.</td>
<td></td>
</tr>
<tr>
<td>6 Swift and smooth logistics</td>
<td>Networking seamless logistics systems with supply chain management, using both transportation and information and communication technology (ICT) infrastructure.</td>
<td>Transportation sector</td>
</tr>
<tr>
<td>7 Pedestrian-friendly city design</td>
<td>City design requiring short trips and containing pedestrian- and bicycle-friendly system, augmented by efficient public transportation.</td>
<td></td>
</tr>
<tr>
<td>8 Low-carbon electricity</td>
<td>Supplying low-carbon electricity through large-scale use of renewables, nuclear power, and fossil- and biomass-fired plants equipped to engage in carbon capture and storage (CCS).</td>
<td></td>
</tr>
<tr>
<td>9 Local renewable resources for local demand</td>
<td>Enhancing local use of renewable energy sources, such as solar, wind, biomass, and others.</td>
<td>Energy transmission sector</td>
</tr>
<tr>
<td>10 Next-generation fuels</td>
<td>Development of carbon-free hydrogen- and/or biomass-based energy supply systems with the required infrastructure to support them.</td>
<td></td>
</tr>
<tr>
<td>11 Labelling to encourage smart and rational choices</td>
<td>Publicising of energy use and CO₂ cost information enabling smart choices of low-carbon goods and services by consumers, and public acknowledgement of such consumers.</td>
<td>All sectors</td>
</tr>
<tr>
<td>12 Low-carbon society leadership</td>
<td>Human resource development for building a low-carbon society and recognising extraordinary contributions.</td>
<td></td>
</tr>
</tbody>
</table>

Source:  NIES et al. (2008)
Green sports supporting a low-carbon society

2.2 Green sports and low-carbon society

2.2.1 The mission of green sports

In the modern world, sports play an integral role in almost every individual’s lives. A majority of the world participates in and/or watches sports and thus is a member of a sports community. As the global warming alarms continue to ring, the emergence of green sports offers the sports community the chance to become an indispensable catalyst for positive changes. Given the many possible ways to reduce energy consumption and waste generation or to solve pollution problems, everyone ought to seek for their own ‘green’ marks.

Prior to putting forward the comprehensive strategies for building a low-carbon society through green sports, key aspects and low-carbon features involved in sports context are summarised in Figure 1. Firstly, there is a demand for green performance in infrastructure, such as sports venues and facilities. Besides, manufacturing industry is a leading producer of GHG, and green production in sports can hence make substantial contributions to GHG reduction. Moreover, sports community is composed of various stakeholders, and their green awareness underpins the entire low-carbon cause (Ratten, 2010; Salome et al., 2013). In a word, to establish a low-carbon society, what we expect from green sports can be interpreted as green performance, green production and green awareness. Correspondingly, detailed elucidation and recommendations are provided in Section 4 of this article, for which the ‘a dozen actions’ shown in Table 1 are used as valuable references.

![Figure 1](link-to-image)

**Figure 1** Key aspects and low-carbon features involved in the context of sports (see online version for colours)
2.2.2 Major organisations promoting green sports

Many organisations within the sports community, from local to international levels, are exerting considerable efforts to advance the notion of green sports. Two leading promoters with great influence deserve particular attention: the International Olympic Committee and the Global Sports Alliance.

As the highest authority in the modern Olympic movement, the IOC takes the leading role in promoting Olympism throughout the world. According to the goal of Olympism, sports should be placed “at the service of the harmonious development of humankind, with a view to promoting a peaceful society concerned with the preservation of human dignity” (IOC, 2013). Obviously, the notion of green sports supporting a low-carbon society is consistent with Olympism, and the issuance of the IOC Guide to Sport, Environment and Sustainable Development and the Manual on Sport and the Environment reflects the organisation’s strong determination to guide the sports community into tangible green actions. Highlighting the slogan “think globally, act locally”, the IOC Guide to Sport, Environment and Sustainable Development analyses the environmental impact of different parties involved in sports, especially Olympic sports, and then offers methodologies and practical tools based on the principles of sustainable development (IOC, 2007). The Manual on Sport and the Environment (IOC, 2005) is another far-reaching resource showing how the sports community can help to build a sustainable society. In this manual, key concepts and issues relevant to sports and the environment are presented, followed by a description of environmental recommendations and the IOC’s environmental policies and actions.

The GSA is an official partner of the United Nations Environment Programme (UNEP), a veteran in the sports sustainability movement. The GSA aims to establish a global network of sports enthusiasts committed to preserving a healthy environment for future generations. This non-profit organisation has its headquarters in Tokyo, Japan, and has regional centres and 172 local teams distributed in 57 countries around the world. The GSA advocates ‘ecoplay’ as an indispensable component of sportsmanship through the so-called ‘ecoflag movement’, the core of which includes enriching nature, saving energy, and reducing material consumption (GSA, 2015a). By this March, 11,591 ‘ecoflags’ have been distributed worldwide, and 177 teams from 58 countries have answered the call and moved into ‘ecoplay’ actions (GSA, 2015b). Through a series of colourful sports-related activities and events on all continents, this influential organisation is evoking more and more people’s environmental awareness, as well as teaching them how to take substantial green measures as competent ‘ecoplayers’.

3 The current situation of green sports in Japan

As a leader in both Asian sports and worldwide sustainable development, Japan has been actively flying the green sports flag. Following the success in winning the right to host the 2020 Olympic Games, it is eagerly expected that the country’s entire sports community will support fostering a low-carbon society. In terms of its development of green sports, Japan has numerous case studies worth sharing.
3.1 Government’s action

As host city for the 2020 Olympics, Tokyo aspires to show the world a model of a ‘sustainable metropolis’ (IOC, 2012). The Tokyo Metropolitan Government (TMG) recently launched a new set of urban development strategies looking toward and beyond 2020, called The Long-term Vision for Tokyo, in which the goal of creating a low-carbon and ‘smart energy’ city is clearly stated (TMG, 2015a). The planning and preparation for the 2020 Olympic Games fully conform to this document’s provisions, and the ‘Tokyo 2020 Sustainability Strategy’ was proposed as the primary approach for the environmental management of the Games. Emphasising the philosophy of ‘Tokyo 2020 Games with a top priority on the environment’, this sustainability strategy consists of three pillars: a ‘minimal impact Games’ (achieving a carbon-neutral Games through reduced consumption of energy and resources, decreased carbon emissions, boosting utilisation of renewable energy, using public transportation and low-energy vehicles, and implementation of zero-waste policies); ‘green urban plans’ (forging harmony between human life and nature through bridging venues with green areas and corridors, and establishing downtown Tokyo as a green place rich in biodiversity); and ‘sustainability through sport’ (raising environmental awareness within the general public and promoting relevant actions through the impact of the 2020 Games) (TOCOG, 2013a). Based on these principles, various measures are being taken to fulfil Tokyo’s ‘green Games’ commitment to the world.

Figure 2  Green concepts thoroughly embedded in planning for the 2020 Tokyo Olympic Games (see online version for colours)

Notes: The photos were taken in January 2015. (a), (b) and (c) even in winter, Tokyo Big Site, the future International Broadcast Centre/Main Press Centre (IBC/MPC) of the Tokyo Games, is surrounded by greenery. (d) near the future Tokyo Olympic Village, the construction of relevant infrastructure is underway, in accordance with the blueprint of creating a network of water and greenery.
Among the 37 planned competition venues, 40% are to be existing ones, and 75% will be situated within 8 km of the Olympic Village (TOCOG, 2013b). The Olympic Village being built is also planned for residential purpose after 2021. Maximum resource utilisation, convenient transportation, and efficient logistics will be applied to minimise the environmental footprint. Giving priority to a blend of comfort and energy efficiency, all Olympic infrastructures and facilities are to be renovated or constructed in compliance with mandatory standards such as the TMG Green Building Program and the Comprehensive Assessment System for Built Environment Efficiency, and all of the building processes will undergo strict Environmental Impact Assessment as well. Moreover, construction for the Olympic Games will take place only on vacant land, rather than at the expense of 377 ha of standing forests in the special-ward area of Tokyo (TMG, 2015a). As one the most important carbon sink on the earth, 1 ha of forests is able to sequester about 3,000 kg of CO2 in a year (USEPA, 2015b). According to the Long-term Vision, a huge network of water and greenery will be further established in Tokyo (TMG, 2015a). In the waterfront area (one of the core areas of the 2020 Olympics), around 98 ha of marine parks with green paths and 88 ha of ‘sea forest’ (forest established on polder) will not only diminish the carbon footprint of the Games, but also bring the future well-being to local residents (TMG, 2015b) (see Figure 2).

Table 2  ‘5R’ model aiming at a zero-waste 2020 Olympic Games

<table>
<thead>
<tr>
<th>Reduce</th>
<th>Maximum utilisation of existing venues to reduce the Games-related construction and consumption.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elimination of disposable containers at venues.</td>
</tr>
<tr>
<td>Reuse</td>
<td>Reuse of existing infrastructures and facilities, and more sustainable operation of newly constructed and renovated buildings.</td>
</tr>
<tr>
<td></td>
<td>Well planned system for the reuse of temporary facilities.</td>
</tr>
<tr>
<td></td>
<td>Promotion of returnable containers at venues.</td>
</tr>
<tr>
<td>Recycle</td>
<td>Well-designed waste sorting system with consistent signage and assistance at venues.</td>
</tr>
<tr>
<td></td>
<td>Green sourcing and purchasing system promoting products made from recycled materials, as well as minimal product packaging.</td>
</tr>
<tr>
<td></td>
<td>Specifically designed waste streams to ensure most efficient recycling.</td>
</tr>
<tr>
<td>Recovery</td>
<td>Generation and utilisation of waste heat from sewerage disposal facilities and biogas from food waste at venues.</td>
</tr>
<tr>
<td></td>
<td>Operation of ‘super eco-town’ for various forms of recycling and recovering.</td>
</tr>
<tr>
<td>Restoration of the natural environment</td>
<td>Establishment of green space in urban region, and implementation of tree-planting programs.</td>
</tr>
</tbody>
</table>

Notes: Tokyo Organising Committee of the Olympic and Paralympic Games (TOCOG) will fully cooperate with the relevant sponsors, licensees, suppliers and concessionaires in applying the ‘5R’ model, especially in respect to the replacement of disposable containers with returnable ones, and the promotion of green sourcing and purchasing system.

Source: TOCOG (2013a)

In terms of urban transportation, Tokyo has already owned world-leading system, while improvements are still underway (TMG, 2015a). The development of the three ring expressways is aimed at facilitating the flow of people and goods during and after the
The Ring Road No. 2 under construction will smoothly link the downtown and the waterfront area of Tokyo in 2020, which functions as the main artery connecting the Olympic Village, Games venues and other relevant areas. All modes of public transportation, including trains, buses and ships, are planned to be improved from the standpoints of convenience and efficiency. The further enhanced transportation network of Tokyo is bound to significantly ameliorate the operation of the Games as well as the reduction of GHG emissions and the mitigation of air pollution (TOCOG, 2013b). In addition, towards 2020 the transportation tools will themselves feature low or no GHG emissions (TMG, 2015a). On the one hand, the use of all-electric, fuel cell, and hybrid vehicles are being expanded in Tokyo, especially in the future Olympic Village. Taking fuel cell vehicle that utilises ‘clean’ hydrogen energy and theoretically emits zero GHG during operation as an example, by 2020 the numbers of fuel cell cars, fuel cell buses and hydrogen stations will reach as many as 6,000, 100 and 35, respectively. On the other hand, the use of bicycles is being greatly promoted. Bicycle lanes on the roads will be extended to 264 km in 2020, doubling that of 2012. Recommended safe cycling routes will be identified in seven districts of Tokyo, including the waterfront area. Meanwhile, regional bicycle sharing system is also being expanded. By doing so, TMG is highly expecting to see a great number of bicycles moving around the 2020 Games venues and the sightseeing spots.

Waste management is also of vital importance, as typically 1 ton of waste sent to the landfill can emit GHGs as many as 3 metric tons of CO₂ equivalents (USEPA, 2015b). With regard to the 2020 Olympics, a target of zero waste has been set, and correspondingly an advanced ‘5R’ model will be implemented (see Table 2).

Table 3 Comparative evaluation of TMG’s measures for a green 2020 Olympic Games

<table>
<thead>
<tr>
<th>Main measure</th>
<th>Requirement for new investment</th>
<th>Short-term environmental benefits (before and during the Games)</th>
<th>Long-term environmental benefits (post-Games)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum utilisation of existing venues</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Compact design of the location of main venues</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Green building reform</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>City greening</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Upgrade of transportation network</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Promotion of both public and private transportation tools (vehicles) with clean energy</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Improvement of bicycling system</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>‘5R’ model for waste management</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Environmental education</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>
Furthermore, TMG is not only developing a specific model for comprehensively monitoring and evaluating the carbon footprint of the 2020 Olympic Games, but also seeking a legacy of long-lasting mitigation of global warming by cultivating the environmental awareness of the next generations and encouraging the involvement of residents and businesses in the Games-related environmental campaigns (TMG, 2015a).

To summarise, a comparative evaluation of TMG’s measures for a green 2020 Olympic Games is also carried out, the result of which is shown in Table 3.

### 3.2 Sports organisations’ practices

In Japan, many sports organisations are also devoted to the low-carbon cause. Yokohama FC, a soccer club in the Japan Professional Football League (J.League), became the first club to acquire ISO14001 certification (in Environment Management Systems) and has taken full responsibility for combating global warming. A solar power generation system has been installed in the club’s facilities. By the end of 2015, the cumulative electric energy outputs reached 32,587 kWh, equivalent to 12,188 kg of CO₂ emission reductions (Yokohama FC, 2015a). More impressively, Yokohama FC has been dedicated to achieving carbon-neutral games. By means of supporting domestic and overseas afforestation projects and purchasing CO₂ emission rights, the CO₂ generated by the crowds present at the team’s home games, as well as by the transportation of team members travelling to away games, has been successfully offset (Climate Change Policy Headquarters of Yokohama City, 2011; Yokohama FC, 2015b). Furthermore, the club is concerned about environmental education for local residents, especially children. An elaborate ‘Yokohama FC Kids’ Book’ and instructional pamphlets have been disseminated to thousands of youths, nurturing their environmental consciousness from an early age (Climate Change Policy Headquarters of Yokohama City, 2011).

### 3.3 Companies’ efforts

Japanese companies also take part in the low-carbon movement, and XEBIO Corporation and Igfy Corporation are two inspiring examples.

As one of the biggest sports goods retailers, XEBIO is very attentive to its obligation to the environment and to society (XEBIO Corporation, 2015). In certain stores, ‘eco-friendly’ concepts are integrated into the design, such as the installation of skylights for natural lighting and solar-powered LED outdoor lights. In addition, plastic shopping bags at all XEBIO stores are manufactured with at least 15% recycled materials, and consequently less CO₂ is emitted in the waste incineration process. XEBIO is also striving for cost-saving and eco-friendly logistics by promoting the utilisation of reusable folding containers instead of wood-consuming cardboard. Furthermore, in alignment with the idea of reducing CO₂ emission through recycling, XEBIO has initiated a ‘One Shoe, One Smile’ activity. Customers are encouraged to contribute their gently worn shoes of passable quality by putting them in collection boxes at the stores. XEBIO then helps to distribute these shoes to poor countries where people, especially children, urgently need them to reduce the risk of infection from tetanus and other diseases.

Meanwhile, Igfy Corporation has taken the practice of green sports to the next level. Following the philosophy proposed by the GSA, Igfy conducts a project called RECYCL’art, which aims to turn old, worn, and broken sports equipment into art (GSA, 2015c; Igfy Corporation, 2015). The project also offers special collection boxes that are
setup at schools, stores, and sports events to collect used sporting goods such as balls, racquets, and shoes for further reuse and recycling (Schmidt, 2006). In this process, people gain a deeper understanding about the spirit of sports, the reuse value of material items, and the meaning of ‘reduce, reuse, and recycle’ (3R). In addition to bridging boundaries between sports, the environment, and art, Igfy Corporation’s efforts express an attitude and a lifestyle that everybody should adopt if we are to achieve a low-carbon society.

4 Proposals for the development of green sports and their prospects

Inspired by the recommended low-carbon actions for all sectors of society (Table 1) and the practices of Japan’s sports community, comprehensive strategies for the development of green sports are presented, together with the discussion about their prospects. As aforementioned in Figure 1, there are three dimensions in the promising future of green sports, i.e., green performance of sports infrastructure, green production in sports manufacturing, and green awareness of sports community. In addition to these mainstream recommendations, two innovative proposals that are lack of discussion and practice in the previous studies are put forward. One emphasises the importance of market-based flexibility mechanisms, and another highlights the influence of sports celebrities on environmental education.

4.1 Recommendations corresponding to green performance, green production, and green awareness

With respect to low-carbon sports infrastructure, efforts toward green performance can be made from at least three aspects, i.e., less and efficient energy consumption, sound waste handling, and sustainable management and operation. As for constructing sports stadiums and arenas, new types of buildings are to meet the goals of energy savings and efficient utilisation (Green Sports Alliance, 2015; USEPA, 2015a). Conventional lighting and space conditioning (heating and cooling) contribute up to 75% of energy use in stadiums and arenas, which can be replaced by state-of-the-art equipment. For example, one stadium with 76,125 seats in Denver, the Sports Authority Field at Mile High has achieved 1.4 M kWh electricity saving by improvement of its lighting system, equivalent to 7% of its annual electricity use. The Toyota Center with 18,300 seats in Houston saved 1.1 M kWh electricity annually, mainly through upgrading its air handler units and lighting system (Dietrich, 2011). Using renewable energy sources in sports facilities, such as solar radiation for heating and wind power for electricity generation, can also reduce consumption of fossil fuel. According to the report (Chard and Mallen, 2013), one quarter of stadiums in Canada have participated in renewable energy projects. Besides, these practices could have a more considerable impact on carbon footprint reduction in the developing world, as the CO₂ intensity of electricity is typically higher in the major developing countries (more than 1 kg CO₂ kWh⁻¹ in both China and India), compared to the developed countries (less than 0.4 kg CO₂ kWh⁻¹ in Japan and EU, and about 0.6 kg CO₂ kWh⁻¹ in the USA) (IPCC and TEAP, 2005). Besides, on-site practice of ‘3R’ in sports venues is another good way to cut waste generation, energy use, and carbon emissions. Furthermore, sustainable management and operation of existing sports venues,
such as repeated use with necessary renovation, ought to be advocated. Cases like the teardown of high-class Wukesong Baseball Field right after the 2008 Beijing Olympic Games need to be avoided, and creative ideas like transforming it into locally popular golf courses for further commercial operation are always welcome (Golf, 2015).

With the rapid development of science and technology, green production in sports manufacturing is no more a daydream. On the one hand, hydrogen and other renewable energy sources can be more fully exploited in manufacturing processes. On the other hand, environment-friendly sporting goods can be promoted and popularised. Products such as high-tech sportswear made from recycled materials can bring about greatly reduced energy consumption and carbon footprint (USEPA, 2015a). By far, the worldwide leading sports corporation Nike has recycled more than 2 billion plastic bottles for producing sports gear (on average 14 bottles unite as one high performance jersey), which cuts down up to 30% of manufacturing energy compared to using virgin polyester (Nike, 2015). Besides, producing table tennis racquets and other wooden sports equipment with recycled wood helps to reduce the consumption of forests and consequently preserve these important carbon sinks. In addition, sports enterprises can seek for the reduction of GHG emissions not only in the manufacturing processes, but also in the entire supply chain. The famous sport lifestyle company PUMA SE (2011) set an ambitious 5-year goal of slashing its GHG emissions by 25% by 2015, and accordingly took the first ever attempt to measure its environmental externalities. The findings revealed that PUMA’s GHG emissions was 717.5 thousand tons of CO₂ equivalents in 2010, the environment impact of which was valued to be 47 million euros. More importantly, the breakdown of GHG emission sources in the supply chain, as well as their respective contribution rates, was clearly determined, i.e., 36% from raw materials tier (cattle ranching and agriculture), 15% from processing tier (energy use and transport of materials), 15% from outsourcing tier (energy use and transport of components), 19% from manufacturing tier (energy use and transport of products), and 15% from final operations (energy use, product distribution and travel). On the way of chasing GHG emission reduction, this type of self-investigation tremendously helps a company gain a more targeted and holistic approach to make sound corporate strategies, wise operational decisions and even innovations in business models.

Although technological and institutional development are fundamental conditions, the green awareness and consequent conducts of sports community are the key to the ultimate success of low-carbon movement. Sports community comprises a variety of stakeholders. Specified in Section 3 of this article, vivid examples of Japan can be followed by sports authorities, organisations and enterprises worldwide. Regarding the recommendations for professionals, particularly sports celebrities, discussion is made in Section 4.3. Here, the main focus is what kinds of attitude and lifestyle the most common members of sports community (the general public) should have, as the backbone of low-carbon cause. For instance, when match day comes, walking or riding a bicycle to sports venue results in zero GHG emissions. When other forms of transportation are needed, convenient public buses or metro and railway systems should be the first choice. Even if one drives private car, hybrid, plug-in hybrid and battery electric automobiles can achieve 13% to 21% of carbon emission reductions in their lifecycles than standard gasoline vehicles (Ricardo, 2015). Meanwhile, other sports event-related campaigns such as tree planting or water and energy conservation can also be strengthened by broad public support (USEPA, 2015a).
4.2 Linking green sports with market-based flexibility mechanisms

Countries around the world have made official commitments and engaged in joint efforts to reduce GHG emissions. There exist many bilateral, multilateral, and international agreements with binding emission reduction targets, among which the best-known are the Kyoto Protocol (‘Kyoto Protocol to the United Nations Framework Convention on Climate Change’, 1997) and its Doha Amendment (‘Doha Amendment to the Kyoto Protocol’, 2012). The signatories, particularly the developed countries with a heavier burden for GHG reduction, can take advantage of several market-based flexibility mechanisms to fulfill their duties. If green sports develop in a manner that accords with these mechanisms, its potential for forging a low-carbon society can be exploited to the fullest.

The National Hockey League in North America adopted one creative initiative to expand the earth’s carbon sink, as 50 trees were donated to Brazil’s Atlantic Forest for every ‘hat trick’ (i.e., three goals scored by one player in a single game) scored during the 2012 to 2013 regular season (USEPA, 2015a). This inspiring example of commitment to green sports deserves recognition, even though it cannot be replicated universally. In the fight against global warming, we cannot always rely on such voluntary actions instead of market-oriented measures. One important market-oriented mechanism is emissions trading, where one ‘carbon credit’ can be defined as equal to one metric ton of CO₂ or other GHGs. Based on this definition, a ‘carbon market’ is formed within which carbon emissions can be tracked, verified, and traded like a common commodity. The development of such emissions trading mechanism allows an entity (e.g., a country or an organisation) to sell its ‘created’ amount of carbon removal and reduction or its ‘unused’ permitted emission capacity to other entities that are still generating GHGs or have already exceeded their emission limits.

The aforementioned Yokohama FC soccer club attempts to offset its CO₂ emissions through a variety of approaches enabled by the carbon market: financially supporting the afforestation project of Oguni-machi in Kumamoto Prefecture under the J-VER scheme of domestic offset credits, purchasing domestic carbon credits created through others’ emission reduction measures under the J-Credit scheme, and paying for assigned amount units (AAUs) of emission rights generated by New Zealand’s forest carbon sink project under the Kyoto Protocol framework (Climate Change Policy Headquarters of Yokohama City, 2011; Yokohama FC, 2015b). Based on rough calculation, the expense of offsetting the 147 kg of emitted CO₂ from all the J2 League home games in 2013 season only accounted for approximately 0.1% of the total operating cost of the entire club, which fully reflects the financial feasibility of these endeavours (Osawa, 2013; J.League, 2015; Yokohama FC, 2015b). This idea regarding emissions trading mechanism takes advantage of the way in which carbon markets can link the demand side and supply side with motivation, fairness and credibility, offering a bright future for new green sports initiatives. For example, with reliable verification by a third party, the organisers of and participants in sports events can calculate the exact costs required to offset the associated GHG emissions and be prepared to pay for these. Individual sports fans can buy credits to compensate for GHG emissions related to their lives and activities. In addition, sports-related manufacturers and companies will be encouraged to view steps against global warming as business opportunities, because any innovation leading to less GHG emissions in the supply chain can be rewarded, and may even bring about increased
revenues for the company. The emissions trading mechanism and subsequent carbon markets have created new flows of capital, information, and technology aimed at building a low-carbon society.

Sports are a fosterer of communication and cooperation between countries, so is another type of flexibility mechanism for mitigating global warming. In the Kyoto Protocol, the clean development mechanism (CDM) was introduced. Under this mechanism, to help meet their emission reduction or limitation targets, developed countries are allowed to implement relevant projects in developing countries, and they earn credits for the reductions achieved. These credits can be counted toward the fulfilment of the developed country’s Kyoto commitment or even traded in the carbon market. Even though not all countries with large amounts of GHG emissions have ratified the Kyoto Protocol or the Doha Amendment, this kind of environmental investment and credit mechanism also exists in many other bilateral or multilateral anti-GHG agreements. This instrument gives green sports an unprecedented development opportunity.

In recent years, there has been a trend among major sports events to extend their reach to the developing world. For example, the past two World Cup soccer tournaments were held in South Africa in 2010 and Brazil in 2014; following the success of the 2008 Beijing Olympic Games, the 2016 Summer Olympics and 2022 Winter Olympics will return to developing countries, i.e., Brazil and China, respectively. On one hand, this phenomenon can be attributed to the developing countries’ social progress, economic prosperity, and subsequent acceptance by the international community. On the other hand, most of these countries, as well as their neighbours in the same region, are still not at a high level of development. When it comes to hosting a low-carbon sports event, they may not possess advanced ideas, let alone sufficient financial and technological reserves. These deficiencies of the developing world are the reason why developed countries are offered the chance to meet their respective GHG emission reduction targets in a cost-efficient manner. For example, by operating projects based on CDM-like mechanisms, Japan can export its valuable ideas and experience in urban planning, as well as energy-saving and new energy technologies for establishing event-related infrastructures and facilities (stadiums, athletes’ villages, specific transportation tools, etc.), to developing countries like Brazil. According to the study of Homma and Akimoto (2013), in Japan, the marginal abatement cost of CO₂ emissions was estimated to be $500 per ton of CO₂, which can vary by a certain margin due to different types of non-fossil fuel energy utilisation. However, the capital investment costs are usually less than $200 per ton of CO₂ in many cases of CDM projects (Kirkman et al., 2012). Apparently, for Japan the cost of achieving GHG reduction overseas could be significantly less than cutting the same amount of emissions at home. On the other hand, developing countries such as Brazil can meanwhile profit from the foreign investment and technology transfer. Thanks to such forms of cooperation, the idea of holding a ‘low-carbon sports event’ is not just an unrealistic catchphrase anymore. From the viewpoint of building a low-carbon society through global efforts, CDM-like mechanisms pave the way for cooperation between developed and developing countries by simultaneously stimulating enthusiasm and satisfying the development desires of both sides. Low-carbon sports events are just one of many possible starting points; the goal of win-win cooperation for a low-carbon future can eventually be extended to every aspect of society, economy and environment.
Existing market-oriented mechanisms are not limited to those described above. With the progress of a low-carbon society, more innovative proposals and corresponding manifestations will continue to emerge. Green sports can provide remarkable strength to the low-carbon cause if it advances in accordance with these promising flexibility mechanisms.

4.3 Promoting environmental education through sports celebrities

Without sufficient willingness and a sense of social responsibility, any promising proposals to fight global warming could turn out to be less effective or even be stymied by lack of public practices and/or counterproductive behaviours. Only when people fully understand the meaning of ‘eco-participation’, ‘eco-thinking’, and ‘eco-sharing’ can they put ‘eco-learning’, ‘eco-buying’, ‘eco-use’, and ‘eco-disposal’ into daily practice (Japan Ministry of the Environment, 2007). In addition to general environmental education in schools, and both governmental and non-governmental publicity efforts, the enormous influence of sports celebrities must be adequately appreciated. Renowned individual athletes and teams are constantly in the spotlight, and their admiring fans often emulate their words and deeds. There is no doubt that sports celebrities’ devotion to green sports can awake fans’ green awareness and encourage their participation in the low-carbon movement.

At community level, sports stars can set good examples by personally taking environment-friendly actions, such as participating in environmental cleanups (Climate Change Policy Headquarters of Yokohama City, 2011). Hands-on activities such as tree planting can also be carried out together with young people. Moreover, sports celebrities can deliver environmental education directly. The Environmental Athletes Organization (2015) of Japan is an association which about 70 top Japanese athletes have joined forces with. During its periodic ‘environmental classroom’ activities, participating sports celebrities visit local schools and play sports with children outdoors, so that the kids can feel the beauty of nature by themselves. They also teach youths the importance of environmental conservation and a low-carbon society. These stars make deep impressions on youths and their families with their approachable image, and they cultivate environmental awareness in a fruitful way. Through publicity from the mass media, the impact of these events extends beyond the immediate local area and encourages more positive actions nationwide.

When major sports events take place, the increased influence of international sports celebrities can be anticipated. Relevant green sports organisations, especially event organisers and sponsors, ought to seize these opportunities to promote low-carbon notions along with these sports celebrities. For example, during the time period of a major event, famous athletes with healthy attitudes toward the environment could be named ‘Ambassadors for Green Sports’ or ‘Ambassadors for the Environment’ and could participate in a series of low-carbon campaigns with non-profit and/or fan-interactive attributes. Sports- and environment-related enterprises could invite these sports stars to endorse their environment-friendly products and services. When the elite USA men’s basketball team and Brazil men’s soccer team wear elaborate jerseys made from recycled polyester in both commercials and games, not only is this high-tech product advertised but also the positive public image and proper environmental attitudes of the athletes and the brand (Nike) are successfully propagated (Nike, 2015). Furthermore, sports
celebrities can do something significant for the low-carbon cause voluntarily. In this respect, soccer goalkeeper Lutz Pfannenstiel is undoubtedly an environmental role model (UNEP, 2012). As the only person to have played professional soccer for teams on all six continents, he founded Global United FC in 2009, a non-profit soccer club with its distinctive aim displayed on the team logo, ‘Fight climate change’. A number of charity games have been organised all over the world, featuring the participation of legendary soccer players such as Zinedine Zidane (France), Lothar Matthäus (Germany), and Cafu (Brazil). Thanks to these charity events, some projects and scientific studies against climate change have received financial support, and the notion of sustainable development has been promoted as well.

Every athlete’s career will come to an end, but athletes’ legacies for our society and environment can be passed on to future generations. Through their substantial support for green sports in a variety of forms, numerous people can be motivated to participate in a campaign for a low-carbon society.

5 Conclusions

Anthropogenic GHG emission is aggravating global warming, which can further threaten our living planet. In this study, we try to put forward countermeasures from the perspective of green sports. Based on the fundamental theories and guidelines about achieving a sustainable (low-carbon) society, the mission of green sports is summarised in three dimensions, i.e., green performance of sports infrastructure, green production in sports manufacturing, and green awareness of sports community. Correspondingly, mainstream recommendations for the future development of green sports are provided. In addition, two innovative proposals are also considered to be constructive and feasible, i.e., linking green sports with market-based flexibility mechanisms and environmental education through sports celebrities. This article features numerous case studies of Japan, a pioneering country in sustainable development. Relevant contents could be used by worldwide sports community as valuable reference for making contributions to the establishment of a low-carbon society.

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