

Carbon Neutrality to Zero Waste: The Three-Tier Evolution of Sports Sustainability

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Abstract

The global sports industry, long celebrated for its unifying power, has in recent decades emerged as a significant and increasingly visible contributor to environmental degradation, generating substantial greenhouse gas emissions, single-use plastic waste and resource-intensive infrastructure demands. This paper traces the conceptual and operational evolution of sports sustainability through three successive tiers of ambition, charting a trajectory from carbon neutrality toward net-zero decarbonization and ultimately, the circular economy ideal of zero waste. The first tier, carbon neutrality, represents the industry's initial response to climate accountability. Grounded in the logic of measurement and offsetting, this phase saw governing bodies and event organizers quantify emissions and compensate for unavoidable impacts through carbon offset projects, exemplified by FIFA's carbon-neutral World Cup commitments and the United Nations Sports for Climate Action Framework. The second tier, net-zero decarbonization, marks a decisive shift from offsetting to abatement. Here the emphasis moves to absolute emission reductions across scopes, renewable energy procurement and efficiency retrofits, sustainable transport and mobility planning and supply-chain engagement. World Athletics' carbon-reduction guidance and the Seattle Kraken's Climate Pledge Arena illustrate how venues and federations are embedding reduction targets, monitoring, and reporting into bid, tender and contractual processes, signalling a maturation from symbolic neutrality to structural change. The third and most recent tier, zero waste, extends sustainability beyond the carbon lens to embrace the full material metabolism of sport. Rooted in circular-economy principles, this phase prioritizes waste avoidance and source reduction, reuse, recycling, and composting, and responsible disposal of residual waste, alongside plastic neutrality and the elimination of landfill diversion. These three tiers are not merely sequential milestones but a deepening hierarchy of ambition, each expanding the boundary of responsibility from atmospheric carbon to the full life cycle of materials and from organizational accounting to systemic, stakeholder-engaged transformation. In short, the evolution from carbon neutrality to zero waste signals a fundamental reconceptualization of sport's environmental role, positioning the industry not as a passive emitter requiring compensation but as an active agent of regenerative and circular practice, with significant implications for policy, governance, and the long-term resilience of the sector.

Keywords: Sports Sustainability, Carbon Neutrality, Net-Zero Emissions, Zero Waste.

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INTRODUCTION

The relationship between sports and the environment has become an increasingly important area of sustainability research and policy. Although sport is widely regarded as a source of social cohesion, health, cultural identity and economic development, its operations are associated with considerable environmental pressures (Cerezo-Esteve *et al.*, 2022). International competitions, professional leagues and community-level events require extensive travel, energy-intensive venues, construction materials, accommodation, catering, merchandising and waste-management systems (McCullough *et al.*, 2023). These

activities contribute to greenhouse-gas emissions, resource depletion, air pollution and the generation of single-use plastics and other event-related waste (Watanabe *et al.*, 2023; Zafari *et al.*, 2025). The environmental footprint of sport is therefore not limited to the stadium or playing field; it extends across complex global supply chains and the entire life cycle of sporting infrastructure and consumption.

The growing visibility of climate change has encouraged sports organisations to move beyond conventional corporate social responsibility and to adopt more systematic environmental strategies. The United Nations Sports for Climate Action Framework

calls upon sports organisations to promote climate awareness, reduce emissions, educate stakeholders and use their influence to encourage wider climate action (UNFCCC, 2020). This development reflects the distinctive position of sport as both an environmental impact-producing sector and a powerful communication platform capable of influencing athletes, spectators, sponsors, governments and local communities. Thus, this paper traces the conceptual and operational evolution of sports sustainability through three successive tiers of ambition, charting a trajectory from carbon neutrality toward net-zero decarbonization and ultimately, the circular economy ideal of zero waste.

Tier One: Carbon management and the pursuit of neutrality

Under the concept of carbon neutrality, organisations measure their greenhouse-gas emissions, implement reduction measures and compensate for residual emissions through credible offsetting mechanisms. Carbon neutrality consequently provided sports bodies with an entry point into climate governance by making emissions measurable and creating institutional responsibility (Ahmet and Demir, 2024). FIFA, for example, initially committed to measuring, reducing and compensating for emissions associated with its World Cups after joining the Climate Neutral Now campaign (FIFA, 2021). Similarly, World Athletics established a sustainability strategy aimed at achieving carbon neutrality by 2030 through annual emission reductions, renewable-energy use, sustainable procurement and improved travel policies (Crawford, 2020).

- **The numbers that shocked the industry:** London 2012, long promoted as the “greenest Games” of its era, generated an estimated 3.3 million tonnes of CO₂ equivalent (Hayes and Horne, 2011); Rio 2016 followed with 3.6 million tonnes (Olympic and Paralympic Games, 2016). Tokyo 2020, held without spectators during the pandemic, produced approximately 2 million tonnes (Ito *et al.*, 2022). These figures encompassed everything from stadium construction to athlete travel, but they were far from complete. Many events excluded spectator travel entirely - a convenient omission that would later prove catastrophic for credibility. For football, the picture was equally sobering. About 3.63 million tons of carbon dioxide equivalent were produced during the Men's World Cup in Qatar in 2022. 52% of the emissions (1.89 million) came from transportation, while 20% came from lodging (728,404). Together, temporary (162,556) and permanent (654,658) facility/venue building made about 23% of the total. Logistics, media, supplies and products, venue operations, energy, heating and cooling were further important aspects (Konyn, 2025).
- **The global frameworks take shape:** In response to these mounting numbers, three global

frameworks emerged to guide sports toward lower carbon emissions. The UN Sports for Climate Action Framework (UNSCAF), launched at COP24 in 2018 by the UNFCCC in partnership with the International Olympic Committee, established five core principles for signatories (UNCC, 2018). By 2021, the Framework had adopted ambitious new targets: reducing greenhouse gas emissions by 50 per cent by 2030 at the latest, and achieving net-zero by 2040 (UNCC, 2021). Signatories, including the IOC, FIFA, the Premier League and Formula E, committed to submitting annual progress reports. Alongside UNSCAF, ISO 20121 emerged as the operational standard for sustainable event management (ISO, 2024). Originally developed in the run-up to London 2012, the standard provides a framework for limiting carbon emissions and waste, managing venue biodiversity, and respecting human rights. It was revised in 2024 to align with the UN Sustainable Development Goals and the Paris Agreement. World Athletics achieved recertification to ISO 20121:2024 after a rigorous two-day audit.

- **Paris 2024: The carbon reduction benchmark:** No event better exemplifies the carbon management tier than Paris 2024. The organising committee vowed to halve the carbon footprint of London 2012 and Rio 2016. The final ex-post assessment, published in April 2025, estimated the Games generated approximately 2.085 million tonnes of CO₂, roughly half the London/Rio average. More significantly, Paris achieved a 54.6 per cent reduction in greenhouse gas emissions compared to the average of those earlier Games. Of 35 venues, only two were purpose-built. Approximately 95 percent of venues were pre-existing or temporary, with the remainder constructed using low-carbon methods. The aquatics centre incorporated seats made from recycled local plastic waste and wood throughout construction. The IOC's methodology divided emissions into three spheres. Sphere 1 (direct operations) totalled 16%; Sphere 2 (permanent infrastructure) accounted for 19%; and Sphere 3 (indirect emissions, primarily travel and accommodation) represented a staggering 65% of the total footprint. On average, a visitor to the Games emitted 0.52 tCO₂e, compared with 0.92 tCO₂e for the Rugby World Cup 2023 (IOC, 2024a).

Tier two: Circular economy and the zero waste imperative

Circular economy has become a significant framework for rethinking the environmental impacts of contemporary sport. Unlike the conventional linear model of “take, make, use and dispose,” the circular approach seeks to retain the value of materials, products and resources for as long as possible through reduction, reuse, repair, refurbishment, recycling and recovery. In

the sporting sector, this transition is particularly important because tournaments, leagues and stadiums depend on large quantities of food, packaging, textiles, sporting equipment, construction materials, water and energy. Without systematic intervention, these activities generate substantial volumes of single-use plastics, discarded food, damaged infrastructure, promotional materials and post-event waste. The United Nations Environment Programme has noted that a major sporting event can generate up to 750,000 plastic bottles, illustrating the scale of the material challenge confronting sports organisers (UNEP, 2018).

The zero-waste imperative therefore represents more than an effort to improve recycling facilities. It requires sports organisations to prevent waste at the design and procurement stages, rather than managing it only after disposal. Event planners must assess the full life cycle of materials, from extraction and manufacturing to transport, use and end-of-life treatment which involves replacing disposable products with reusable alternatives, eliminating unnecessary packaging, providing refill stations, introducing digital ticketing and documentation and ensuring that food and beverage services operate with durable or compostable tableware. Surplus food can be redirected to community organisations, while organic waste can be processed through composting or anaerobic digestion. These measures reduce landfill dependence while also lowering emissions associated with the production, transport and disposal of materials.

Circularity also requires changes in stadium construction and event infrastructure. Temporary structures, seating, signage, exhibition materials and equipment should be designed for modularity, disassembly and future use. Existing venues can be renovated rather than demolished, thereby conserving embodied energy and reducing construction waste. At the Hangzhou Asian Games, the zero-waste approach included retaining existing seats, maximising available venue space, adopting paperless ticketing and encouraging a “bottle-free action” (Ecns wire, 2023). Such practices demonstrate that zero waste can be integrated into both event operations and long-term infrastructure planning. International sports bodies are increasingly formalising these principles. UEFA’s Circular Economy Event Checklist promotes waste prevention, recycling, energy efficiency, sustainable sourcing and stakeholder participation across football competitions (Coliseum, 2022). Its wider circular-economy guidelines recommend assigning institutional responsibility, analysing environmental impacts, defining measurable targets, prioritising solutions, monitoring performance and publicly reporting progress. This governance structure is essential because ambitious zero-waste claims require transparent definitions, reliable data and independent verification. “Zero waste” should not simply mean that waste is transferred from landfill to incineration or exported

elsewhere; it should prioritise prevention, material recovery and responsible treatment of unavoidable residuals.

- **Defining zero waste in sport:** The concept of zero waste in sporting events typically means diverting at least 90 percent of event-related waste from landfill. This requires comprehensive systems: waste segregation, composting, recycling, reuse, and often, a fundamental rethinking of procurement. Wimbledon provides a compelling case. None of the Championships’ day-to-day business or event waste goes to landfill (Zajmi, 2024). Recyclable materials are separated, with general waste generating electricity for the National Grid. The tournament promotes a culture of reuse, providing reusable cups for all drinks and eliminating single-use plastic. In 2024, evian introduced a natural mineral water refill system for spectators—the first of its kind at the tournament (Briggs, 2025).
- **The Hangzhou Asian games: Zero carbon and zero waste combined:** The Hangzhou 2022 Asian Games (held in 2023) received the OCA Sports and Environment Award for hosting a zero carbon-emission Asian Games and the first-ever Green Asian Games (OCA, 2023). The achievements were multifaceted: digital fireworks replaced traditional displays, methanol fuelled the cauldron and 107 million people participated in the “Going Green for a Carbon-neutral Asian Games Campaign”. But it was the waste innovations that distinguished Hangzhou. The Athletes’ Village collected 57 tons of paper lunch and milk boxes and 92 tons of low-value waste, processing them into 89.34 tons of raw paper for bags and fans. Toothbrush cups and clothes hangers were made from biodegradable wheat straw. These were not symbolic gestures; they represented systemic material management at scale.
- **Food: The frontier of zero waste:** Paris 2024 doubled the proportion of plant-based ingredients available to spectators and workforce compared to London and Rio, sourcing 80 percent of ingredients from local agricultural production (IOC, 2024b). Place de la Concorde, hosting urban sports, served exclusively vegetarian food - a significant departure in a nation synonymous with steak tartare. Over 13 million meals were provided, making it the largest catering event in the world. The Games pledged 100 percent recovery of unconsumed food, redistributing it to charities, converting it to animal feed or composting.

Tier three: Systemic transformation and Scope 3 accountability

Tier three of sports sustainability represents a movement from isolated environmental initiatives toward systemic transformation, with Scope 3 accountability at its centre. Earlier approaches often

concentrated on direct fuel consumption, purchased electricity, venue operations and waste generated within organisational boundaries. However, these sources constitute only a part of the environmental footprint of sport. The most substantial impacts frequently occur indirectly through travel, construction, procurement, food services, merchandising, broadcasting, sponsorship, accommodation, logistics and spectator behaviour. Scope 3 accounting is therefore essential because it extends responsibility across the entire value chain rather than limiting it to emissions directly controlled by a club, federation, stadium or event organiser (WRI, 2011).

The Greenhouse Gas Protocol classifies Scope 3 emissions into 15 categories, including purchased goods and services, capital goods, upstream transportation, operational waste, business travel, employee commuting, downstream distribution, the use and disposal of sold products, franchises and investments (WRI, 2011). In sport, these categories can be translated into practical areas of responsibility. The manufacture of uniforms, footwear, balls, trophies, promotional merchandise and electronic equipment produces upstream emissions. Stadium construction and renovation generate embodied carbon through steel, cement, glass and other materials. Travel by athletes, officials, media personnel and spectators creates significant emissions, particularly when events attract international audiences. Food production, hotel accommodation, waste treatment and broadcasting infrastructure further enlarge the footprint of sporting competitions.

Scope 3 accountability is difficult because many relevant activities occur outside the direct control of sports organisations. A federation may not own an airline, hotel chain or apparel factory, while a stadium operator may have limited influence over how spectators travel to an event. Nevertheless, indirect control does not eliminate institutional responsibility. Sports bodies shape behaviour through procurement rules, sponsorship agreements, ticketing policies, venue design and event-location decisions. They can require suppliers to disclose emissions, establish environmental criteria in contracts, favour recycled and low-carbon materials and collect reliable data from transport, catering and merchandise partners. The GHG Protocol's Scope 3 guidance provides methods for identifying and calculating these value-chain emissions, even when organisations must initially rely on estimates or sectoral emission factors.

The highest level of Scope 3 accountability also recognises social and distributive dimensions. Climate strategies should protect workers in supply chains, support host communities, respect indigenous and local knowledge, and avoid shifting environmental burdens to less powerful groups. Sport can become a platform for climate education by making sustainable

mobility, responsible consumption and circular procurement visible to millions of people. Tier three therefore redefines sports sustainability as a collective transformation of systems, relationships and incentives. Its objective is not merely to reduce an organisation's reported emissions, but to reshape the wider network through which sport is produced, consumed and experienced. Thus, the third tier represents the most profound shift: moving beyond what organisers can directly control to address the full value chain of emissions and waste - the Scope 3 emissions that dwarf everything else.

- **The Scope 3 reality:** Scope 3 emissions - indirect emissions that occur throughout an event's value chain - include participant and spectator travel, accommodation and supply chain activities. These often exceed the combined impact of Scope 1 and Scope 2 emissions. At Paris 2024, spectator travel alone accounted for 80% of transport-related emissions, despite international visitors comprising only 10% of total attendance. In the 2024 season, MLB, NBA and NFL teams collectively took an estimated 7,502 flights to away games (Del Rosario, 2025). The problem is structural. FIFA's decision to expand the 2026 World Cup to 48 teams across three countries has been projected to generate emissions far exceeding Qatar 2022 (The New Weather Institute, 2025). Thus, hosting group stages in single cities or regions could drastically cut carbon emissions. Instead, the trend is toward dispersal.
- **Offsets under scrutiny:** The carbon offset market, central to Tier One's "neutrality" claims, has faced mounting criticism. FIFA offset the 70,692.76 tCO₂ of controlled emissions from the Women's World Cup 2023 through six different projects, including renewable energy and community initiatives (FIFA, 2024). However, questions like whether such offsets represent genuine emissions reductions or merely "green goodwill" for corporations and events are also present. The Paris 2024 Games, while achieving genuine operational reductions, still relied on carbon offsets to claim neutrality. However, the risk of greenwashing is becoming a reality and questions its credibility.

CONCLUSION

The three-tier evolution from carbon neutrality to zero waste demonstrates that sports sustainability is no longer a peripheral concern but a central requirement for the future legitimacy and resilience of the sports sector. Sport occupies a distinctive position in environmental governance because it is simultaneously a contributor to climate change and a powerful platform for public education, cultural influence and behavioural change. Sporting events mobilise millions of people, generate substantial investment and shape patterns of consumption, mobility and infrastructure development. Consequently, the environmental decisions made by

federations, clubs, venue managers, sponsors and host governments extend far beyond the boundaries of the playing field. The first tier, carbon neutrality, was important because it introduced emissions measurement and climate accountability into sports management. By calculating operational emissions and addressing unavoidable impacts through compensation, sporting organisations began to recognise that environmental performance required institutional responsibility. The second tier, represented by circular economy and zero-waste strategies, broadens the focus from atmospheric emissions to the material foundations of sport. Sustainable events must prevent waste at source, reduce dependence on disposable products, promote reuse and repair, recover valuable materials and responsibly manage unavoidable residuals. Examples from Paris 2024, Wimbledon and the Hangzhou Asian Games illustrate the potential of reusable systems, plant-based catering, food recovery, digital technologies, recycled materials and existing infrastructure to reduce environmental impacts. These initiatives demonstrate that zero waste is not merely a matter of installing more recycling bins; it requires redesigning procurement, construction, catering and consumption throughout the event life cycle.

The third tier, systemic transformation and Scope 3 accountability, represents the most comprehensive stage of this evolution. It acknowledges that the largest environmental impacts of sport may arise from activities outside the direct operational control of organisations, including spectator and athlete travel, accommodation, supply chains, merchandise, construction, broadcasting and sponsorship. The Paris 2024 experience, in which indirect emissions accounted for the majority of the total footprint, illustrates why focusing only on stadium energy use cannot deliver meaningful sustainability. Effective climate governance must therefore include value-chain mapping, supplier disclosure, science-based reduction targets, sustainable transport planning and transparent reporting based on the 15-category Scope 3 framework. The analysis also reveals that environmental transformation must be socially just. Climate strategies should protect workers, respect host communities, include indigenous and local knowledge, improve public transport and ensure that environmental responsibilities are not transferred to vulnerable populations. Sustainable sport must connect ecological integrity with affordability, accessibility, health and community benefit.

Ultimately, the progression from carbon neutrality to zero waste should be understood as a deepening hierarchy of responsibility rather than a set of disconnected targets. Carbon accounting establishes visibility; circular economy practices reduce material waste; and Scope 3 accountability transforms the wider systems that make sporting activity possible. The future of sustainable sport will depend on measurable reductions, credible verification, participatory

governance and long-term institutional commitment. When these principles are embedded in event bids, infrastructure design, procurement, sponsorship, finance and fan engagement, sport can move beyond compensating for environmental harm and become an influential agent of decarbonisation, circularity and ecological regeneration. The true measure of sporting excellence in the coming decades will therefore include not only records, victories and revenues, but also the capacity to protect the environmental systems on which sport and society ultimately depend.

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