GREEN TENNIS

Literature Review Report

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Tennis for a Greener Future

GREEN TENNIS – 101184588

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Green Tennis Literature Review Report

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Introduction

The transition towards environmentally sustainable models represents one of the major challenges for sports organisations in the current context of climate emergency and global ecological transformation. As a cultural, social, and economic phenomenon of great relevance, sport cannot remain detached from the commitments established by the **European Green Deal**, which sets out the path towards a climate-neutral Europe by 2050. Within this framework, the European Commission and the Council of the European Union have highlighted the key role that educational, youth and sports institutions must play in generating environmental awareness and promoting sustainable behaviours across all levels of society.

The sports sector, however, is not only a potential driver of change but also an area with a considerable environmental footprint. Some estimates suggest that sport is responsible for up to 4% of global carbon emissions, mainly due to mobility, energy consumption in facilities, material usage, and waste generation during events. Tennis is no exception. Its ecosystem —comprising clubs, training centres, tournaments, and a diverse community of players, coaches, families, and fans— requires a renewed perspective that combines sport's traditions with the sustainability demands of today.

The **GreenTennis project** (*Tennis for a Greener Future*), framed within the Erasmus+ Sport 2024 Key Action 2, is a timely and innovative response to this need. Its goal is to enhance environmental sustainability in **National Tennis Centres (NTCs)** and their events by providing resources, tools, and training for technical, administrative, and facility staff. Furthermore, GreenTennis seeks to promote a cultural shift in the sector by raising awareness among young players, coaches, grassroots clubs, families, and fans regarding the impact of climate change and the role tennis can play in building a greener Europe.

Specifically, the project promotes sustainable practices in areas such as transportation, energy use, food consumption, and waste reduction, and it also includes the development of a mobile application to help players, coaches, and fans **measure and reduce their personal carbon footprint** within the context of tennis.

In this context, the present document aims to provide a **rigorous analysis of good practices and environmental sustainability strategies**, applicable specifically to **historic tennis clubs**, many of which are over a century old. These clubs represent not only the sporting heritage of their communities but also cultural assets that must be preserved. Due to their age, architectural typology, and location within urban settings, such clubs face unique challenges when attempting to meet modern environmental standards.

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This report, developed under **Work Package 2 (WP2) of the GreenTennis project**, combines an official policy review of key European and international strategies with a systematic review of scientific literature focused on sustainability practices in sport. The findings will serve as the foundation for the design of the upcoming **Sustainability Toolkit**, training itineraries, and environmental assessment and communication strategies that GreenTennis will deploy in its next phases. The ultimate goal is to **build a more sustainable, informed, and committed tennis ecosystem that contributes to the future of the planet**.

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1. Theoretical and Conceptual Framework

1.1. Environmental Sustainability in Sports Settings.

Environmental sustainability in sports settings refers to the integration of ecological practices within sporting activities in order to reduce their impact on the environment, while simultaneously ensuring the conservation of natural resources for future generations. This concept has gained increasing attention within the international academic community, where it is recognised that sporting activities—particularly major events and the construction of facilities—can generate significant adverse effects on the natural environment.

Various studies have emphasised the direct connection between sport and environmental sustainability. Ahmet E. Atalay (2021) argues that sport, being linked to mass production and consumption, infrastructure construction, and event organisation, can accelerate environmental degradation if not managed responsibly. In this regard, he suggests that reducing the environmental impact of sport will contribute not only to the sustainability of sporting practices but also to the overall protection of the natural environment.

From the perspective of sports facility management, Timothy B. Kellison (2014) found that many sports facilities in the United States have incorporated recycling programmes and energy-efficient technologies. However, these actions face considerable obstacles, such as a lack of financial resources, trained personnel, and knowledge about environmental sustainability. This suggests that, despite the interest in sustainability, its implementation is not yet universal or systematic.

International sporting events have also become relevant platforms for promoting sustainability. For example, the Sydney Olympic Games in 2000 were notable for incorporating ecological principles into their planning and execution, earning them the nickname "Green Games." Similarly, Qatar's proposal for the 2022 FIFA World Cup included the construction of dismantlable and reusable stadiums, representing a new vision of how sporting events can minimise their ecological footprint (Fuss, Subic & Mehta, 2010; Kiani & Nazari, 2021).

At an organisational level, the study by Daddi et al. (2021) on football stadiums in Europe reveals that environmental practices in sport can be analysed on two levels: operational and governance. The former includes waste management, energy and water use,

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while the latter addresses strategic planning and the allocation of responsibilities within the organisation. The study underlines that, although positive initiatives exist, many are adopted voluntarily, reflecting a lack of maturity in institutional structures regarding sustainability.

Finally, Trendafilova et al. (2014) highlight that despite the growing interest in sustainable practices, challenges such as poor communication, resource scarcity, and the need for strategic alliances between sports organisations and sustainability experts persist. Nevertheless, sport is increasingly recognised for its potential as a powerful tool to raise environmental awareness and promote sustainable behaviours within society.

Therefore, there is a broad international academic consensus that environmental sustainability in sport must be addressed through a combination of operational and management measures aimed at mitigating the ecological impact of sporting activities. In this way, sport will not only be able to develop more responsibly but will also serve as a vehicle for promoting environmental awareness at a global level.

1.2. Triple Bottom Line: A Tool for Sustainability in Sports Settings

The **Triple Bottom Line (TBL)** approach, also known as the “triple bottom line accounting,” is a widely adopted model for evaluating the sustainability of organisations and projects, including those related to the sports sector. Initially proposed by John Elkington in 1994, the TBL posits that the success of an organisation should not be measured solely by its economic profits but also by its impact on the environment and society. Thus, the three dimensions comprising this approach are: economic, environmental, and social.

Applying the TBL approach to sports facilities involves analysing and managing these spaces from a comprehensive perspective.

Firstly, from the **economic dimension**, the goal is for facilities to be financially viable in the long term, promoting resource efficiency, generating sustainable revenue streams, and achieving a return on investment through sports, cultural, and recreational activities. This includes investment in technologies that reduce operational costs, such as solar energy systems or energy-efficient lighting and climate control systems.

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Secondly, the **environmental dimension** of the TBL is critically important given the significant ecological impact that sports facilities can have. This includes water and energy consumption, waste generation, and land use. The implementation of sustainable practices, such as the use of recyclable materials, rainwater harvesting systems, proper waste management, and obtaining environmental certifications such as **LEED (Leadership in Energy and Environmental Design)**, helps to mitigate these impacts and actively contributes to the conservation of the environment.

Finally, the **social dimension** refers to the role that sports facilities play in community well-being. A sustainable sports facility should not only be accessible and inclusive but should also generate social value by promoting health, community cohesion, education, and equal opportunities. This can be reflected in the development of sports programmes targeting vulnerable groups, the universal design of spaces to allow access for people with disabilities, and the creation of local employment opportunities.

Several studies in the field of sports management have highlighted the usefulness of the TBL approach as a tool for strategic decision-making in sports facilities. According to Trendafilova et al. (2014), many sports organisations are beginning to adopt the TBL framework to align their operations with the growing social and regulatory expectations regarding sustainability.

This integrated vision not only strengthens the institutional legitimacy of these organisations but also enables them to generate positive impacts within their communities and natural environments.

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2. Methodology

2.1. Analysis of Official Technical Documents

In order to contextualise the GreenTennis project within the framework of existing policies and strategies on environmental sustainability in sport, a review of key official documents was carried out.

This review encompassed a total of 12 technical documents, sourced from international organisations such as the European Commission, the International Olympic Committee (IOC), the European Union, the International Tennis Federation (ITF), and UEFA, as well as relevant European projects such as Green Sports Hub Europe.

The selection of documents was based on the following criteria:

- Originating from internationally or European recognised organisations.
- Published between 2014 and 2024 to ensure relevance and up-to-date information.
- Explicit focus on environmental sustainability, energy efficiency, water management, sustainable mobility, conservation of sports heritage, or carbon footprint reduction.
- Direct or adaptable applicability to the context of historic sports clubs.

Each document was analysed to extract strategic principles, evaluation tools, action guidelines, and examples of good practices that would serve as a basis for the design of the Toolkit and the methodology of the GreenTennis project.

2.2. Systematic Literature Review Adapted to the PECO Model

In parallel, a systematic literature review adapted to the PECO model was conducted, with the aim of identifying applicable practices and relevant experiences in the field of sustainability in sport.

The methodological strategy was structured around the PECO model, where:

- P (Population / Problem): Tennis clubs, sports facilities, sporting events.

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- E (Exposure): Implementation of environmental sustainability strategies or programs.
- C (Context): Urban environments or historic facilities.
- (Outcome): Carbon footprint reduction, energy efficiency, water management, sustainable mobility, environmental awareness, conservation of heritage.

Search Strategy

The following specialised databases were consulted:

- UCAM Library
- SportDocs
- Scopus
- Science Direct
- Web of Science (WOS)
- PUBMED
- Olympic World Library (OWL)
- SportDiscus
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A total of 40,906 initial results were retrieved. After applying inclusion criteria (thematic relevance, practical applicability, publications between 2010 and 2025), a first refinement process reduced the pool to 241 documents.

Finally, 30 articles were selected for analysis as they were directly applicable to the objectives of the GreenTennis project.

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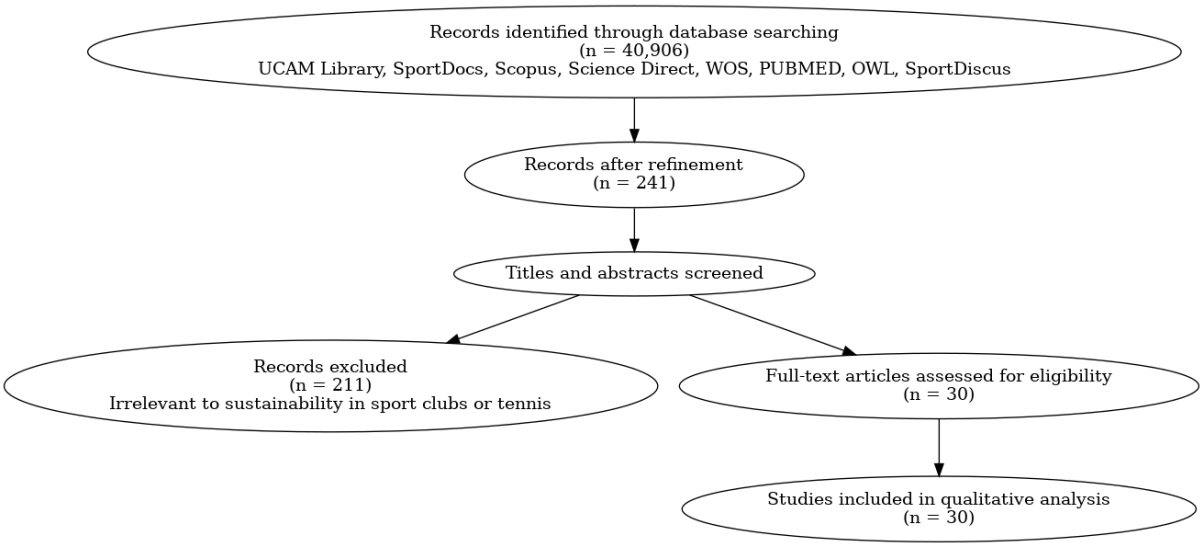

The distribution of the selected articles was as follows:

Database	Selected articles
UCAM Library	1
SportDocs	3
Scopus	9
Science Direct	2
Web of Science (WOS)	0
PUBMED	0
Olympic World Library (OWL)	3
SportDiscus	12

Each selected publication was individually analysed to extract:

- The design and sample of the study.
- Relevant variables aligned with the categories defined in GreenTennis (energy efficiency, renewable energies, water management, carbon footprint, sustainable mobility, environmental awareness, conservation of heritage).
- Main objectives of the study.
- Main findings obtained.

This dual methodological approach (analysis of official technical documents + systematic literature review adapted to the PECO model) provides a robust and systematic

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foundation for the identification of good practices, the detection of sectoral gaps, and the formulation of strategic recommendations for the GreenTennis project..

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3. Review of Scientific and Technical Literature

3.1. European and International Regulatory Frameworks and Strategies

Delivering the European Green Deal

The **European Green Deal** is the European Union's roadmap to transform its economy into a climate-neutral system by 2050. This plan aims to decouple economic growth from the use of natural resources, protect the environment, and improve the quality of life of European citizens, while simultaneously promoting innovation and green employment.

At its core lies the **European Climate Law**, which establishes the binding commitment to achieve climate neutrality by 2050 and to reduce greenhouse gas emissions by at least **55% by 2030** compared to 1990 levels. To achieve this, the European Commission has designed a comprehensive set of sectoral policies and reforms, affecting areas such as energy production, mobility, industry, and land use.

One of the key pillars is the **reform of the Emissions Trading System (EU ETS)**, which will be extended to sectors like transport and construction. Additionally, the creation of the **Social Climate Fund** seeks to offset the effects of the transition on households and regions most vulnerable to change.

In terms of infrastructure, the EU plans to carry out the **energy renovation of 35 million buildings by 2030**, including sports facilities. This fact is particularly relevant for the GreenTennis project, as it opens a window of opportunity to incorporate historic tennis clubs into national or local strategies for sustainable refurbishment. This translates into actions such as improving thermal insulation, replacing conventional lighting systems with LED technology, and integrating renewable energy sources such as solar panels.

Mobility is also a strategic axis. The use of non-polluting means of transport, such as bicycles and electric vehicles, is being promoted, which can be encouraged within sports clubs through incentives, appropriate facilities, or more sustainable access routes. The **circular economy** also gains prominence through regulations aimed at reducing waste, promoting recycling, and encouraging the reuse of materials—elements that can be incorporated both into daily sports activities and into events organised by clubs.

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Regarding governance, the **European Commission** promotes the **European Climate Pact**, an initiative that allows organisations of all types (including sports entities) to actively participate in climate action through voluntary commitments, the exchange of good practices, and access to technical resources.

The key data of the European Green Deal for the 2030 horizon are summarised in the following table:

Strategic Indicator	2030 Target
Reduction of GHG emissions	-55% (compared to 1990 levels)
Renovation of buildings	35 million
Renewable energy share in final energy consumption	42.5%
Estimated additional annual investment	520 billion euros

For **GreenTennis**, this strategy represents a solid foundation upon which to design, justify, and align all its actions. The ecological renovation of historic clubs, the inclusion of energy efficiency criteria, the development of training methodologies, and the promotion of sustainable sport are all perfectly consistent with the European Green Deal and can position the project as a model initiative within European sport committed to ecological transition.

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EU Work Plans for Sport (2021–2027)

The **EU Work Plans for Sport** are the European Union's main tool for political coordination and strategic guidance in the field of sport. Adopted by the **Council of the EU** in cooperation with the **Directorate-General for Education, Youth, Sport and Culture (DG EAC)** of the European Commission, these plans define shared priorities and actions aimed at enhancing the social, economic, educational, and environmental value of sport across all Member States.

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The **EU Work Plan for Sport 2021–2024** was adopted at a critical transitional moment following the COVID-19 pandemic, focusing on the recovery and resilience of the sports sector. It emphasised five priority areas: the promotion of health-enhancing physical activity (HEPA), the safeguarding of the integrity of sport (addressing doping and match-fixing), the promotion of gender equality, the recognition of the economic contribution of sport, and the strengthening of sport's role in environmental sustainability. The plan also encouraged synergies between sports organisations, public authorities, and the education and health sectors.

Building on this foundation, the **EU Work Plan for Sport 2024–2027**, in force since July 2024, continues to integrate sport into the broader political priorities of the EU, such as the green transition, digitalisation, and public health. It highlights the role of sport in achieving the **European Green Deal** and the **United Nations Sustainable Development Goals (SDGs)**, particularly through the adoption of environmentally responsible practices by clubs, events, and facilities.

Of particular relevance to the **GreenTennis project**, the latest EU Work Plan explicitly promotes the implementation of sustainability strategies within sports organisations, including actions on energy efficiency, carbon footprint reduction, sustainable mobility, and responsible resource management. This vision reinforces the project's mission to support the green transformation of historic tennis clubs in urban environments, combining environmental impact mitigation with cultural and architectural preservation.

From an analytical perspective, these EU policy frameworks provide a legitimising foundation and strategic coherence for GreenTennis. The project not only responds to the political imperatives set by European institutions but also serves as a pilot model for the practical application of sustainability principles in heritage sports facilities. By aligning itself with the EU's current priorities, GreenTennis can enhance its visibility, scalability, and potential impact within the European sports landscape, significantly contributing to the continent's green transition through sport.

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IOC Sustainability Strategy

The **Sustainability Strategy of the International Olympic Committee (IOC)**, published in 2017, is framed within the implementation of the Olympic Agenda 2020 and is

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directly aligned with the United Nations Sustainable Development Goals (SDGs). This strategy aims to integrate sustainability into all IOC operations and to act as a catalyst for sustainable action across the entire Olympic Movement, including National Olympic Committees, federations, and local sports entities.

The strategy is built upon five fundamental principles: incorporating sustainability into all key IOC decisions, leading sustainable action in sport in collaboration with stakeholders, respecting planetary and social boundaries, committing to continuous improvement and accountability, and using sport as a platform to drive sustainable development. These principles are materialised into five key areas of action that offer a clear basis for the practical application of the GreenTennis project.

The first area is **infrastructure and venues**. The IOC promotes the design and management of sports facilities under international sustainability standards, such as **ISO 20121**. Energy efficiency, low water impact, and minimisation of the carbon footprint are strongly encouraged. It is also recommended that venues are planned with a legacy approach, allowing for their reuse, conversion, or dismantling after events. This line of action is especially relevant for GreenTennis, as it supports the sustainable modernisation of historic clubs while respecting their heritage value.

Regarding **resource and supply management**, the IOC strategy highlights the importance of responsible procurement, efficient use of materials, waste minimisation, and the promotion of recycling. For GreenTennis, this involves promoting a transition towards recyclable materials in equipment, reducing single-use plastics, and applying circular economy criteria to internal club operations.

The third priority area is **mobility**. The IOC advocates for the planning of sustainable transport both for events and for the daily operations of sports facilities. Measuring emissions associated with transport and promoting non-polluting modes of mobility are key components. In this respect, GreenTennis can apply these guidelines by incentivising the use of bicycles, public transport, or electric vehicles for the travel needs of members, staff, and visitors.

With regard to the **workforce**, the IOC promotes continuous training in sustainability and the creation of an organisational culture that respects the environment. It also promotes fair working conditions, social inclusion, and gender equity. GreenTennis can integrate these values through specific training programmes, inclusive policies, and the implementation of best organisational practices.

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Finally, the strategy directly addresses **climate and the environment**, with the IOC's commitment to reducing its own greenhouse gas emissions, achieving climate neutrality, and protecting biodiversity. It promotes the constant evaluation of the environmental impact of sports operations and the adoption of corrective or compensatory measures. GreenTennis can adopt this framework as a guide for the implementation of carbon footprint audits in tennis clubs and the design of progressive environmental improvement plans.

The strategy also underlines the importance of monitoring, evaluation through specific indicators, and collaborative governance. The IOC is committed to working with multiple stakeholders, including governments, sports organisations, businesses, universities, and civil society.

This approach is fully compatible with the spirit of the GreenTennis project, which is conceived as an international and collaborative initiative with a transformative vocation and the ambition to become a reference in sports sustainability.

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IOC STRATEGY AREA	IOC RECOMMENDATIONS	APPLICATIONS FOR GREENTENNIS
Infrastructure and venues	Efficient design, low water and energy impact, planned legacy	Modernise clubs with LED lighting, thermal insulation, and solar panels while respecting their heritage value
Resource and supply management	Responsible procurement, use of sustainable materials, recycling, and circular economy	Review suppliers, implement recycling of sports materials, reduce single-use plastics
Mobility	Sustainable transport, emission measurement, and promotion of active mobility	Provide bicycle parking, incentives for public transport use, and electric charging stations
Workforce	Training in sustainability, fair conditions, inclusion, and equity	Train staff in sustainable practices, develop inclusion policies, and promote social responsibility
Climate and environment	Emission reduction, climate neutrality, environmental protection	Conduct carbon footprint audits, establish environmental improvement and offset plans

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Environmental Sustainability Protocols of the ITF

The commitment of the International Tennis Federation (ITF) to environmental sustainability has undergone significant structural advancement since 2022, with the publication of its first Operational Sustainability Report and the update of the World Tennis Tour (WTT) Organisational Requirements.

These documents represent not only an exercise of institutional responsibility but also a strategic turning point by integrating international standards such as the Greenhouse Gas Protocol, the guidelines of the Task Force on Climate-related Financial Disclosures (TCFD), and the United Nations Sustainable Development Goals (SDGs).

From an analytical perspective, the ITF's strategy is structured around two major lines of action:

- The measurement and reduction of its own carbon footprint (including Scopes 1, 2, and 3).
- The dissemination of sustainable practices across its global federative structure, encompassing 210 national associations and six regional associations.

This dual dimension (international and operational) provides a valuable reference framework for initiatives such as GreenTennis, as it reinforces the need to act at both the governance and direct execution levels within clubs and events.

Furthermore, the incorporation of sustainability criteria into tournament organisational requirements introduces a regulatory precedent within the tennis ecosystem.

By requiring sustainable practices in transportation, accommodation, energy consumption, and resource management, the ITF sets minimum standards that anticipate a stricter environmental regulatory future within professional sport.

This regulatory evolution strengthens the relevance of projects such as GreenTennis, which seek to anticipate these trends and become models of good practice in historic sports clubs.

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Another relevant aspect is that the ITF has successfully consolidated, within a few years, a sustainability narrative that goes beyond the reduction of emissions, incorporating biodiversity, resource efficiency, and social responsibility.

This integrated vision provides GreenTennis with an additional justification to propose interventions not solely focused on carbon footprint reduction but also encompassing environmental education, accessibility, and the social legacy of the clubs.

The ITF's progress in sustainability not only provides top-tier sectoral support for the GreenTennis project but also imposes a challenge: adapting and transferring these global principles to specific local and heritage contexts, such as historic urban tennis clubs, combining sporting tradition with environmental innovation..

ITF Document	Description	Year	Link
Operational Sustainability Report	First ITF sustainability report measuring carbon footprint and defining its environmental strategy (aligned with GHG Protocol, TCFD, SDGs, and IOC).	2022	https://www.itftennis.com/media/11641/54-operational-sustainability-report.pdf
World Tennis Tour (WTT) Organisational Requirements	Document including environmental requirements for tournament organisation, promoting sustainable practices in transportation, accommodation, and resource management.	2022	https://www.itftennis.com/media/9106/wtt-organisational-requirements.pdf

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Relevant European initiatives in sports sustainability: Green Sports Hub Europe and UEFA

Within the literature review focused on environmental sustainability in sport, several recent European initiatives stand out that address the need to transform the sports sector in line with the commitments of the European Green Deal and the Sustainable Development Goals (SDGs). Among these, the Green Sports Hub Europe (GSHE) project and the Strength Through Unity sustainability strategy developed by UEFA are particularly relevant, both for their scope and for the applicability of their tools and methodologies to the context of traditional sports facilities such as historic tennis clubs.

The Green Sports Hub Europe project (2021–2023), funded by the Erasmus+ Sport programme, brought together a multisectoral network of sports entities, local governments, and environmental organisations with the aim of creating practical tools to assess, plan, and improve environmental sustainability in European sport. One of its main achievements was the development of an environmental self-assessment tool that allows sports organisations to measure their performance, identify areas for improvement, and design customised action plans (Green Sports Hub Europe, 2023). This tool is particularly useful for sports clubs that do not have large technical or financial resources, such as many of the historic clubs targeted by the GreenTennis project.

In addition, GSHE conducted research into the most common barriers to implementing green strategies in sport, highlighting the lack of specialised knowledge, the initial investment costs, and the absence of specific national regulatory frameworks. In response, a European Green Sports Charter was promoted, a voluntary adherence document that enables clubs and federations to progressively commit to specific environmental objectives (European Athletics, 2022).

For its part, UEFA presented in 2021 its ambitious sustainability strategy Strength Through Unity, with a horizon set for 2030. This strategy represents a turning point among international sports federations by integrating environmental, social, and governance (ESG) sustainability principles into all operations and competitions organised by the body (UEFA,

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2021). Among the most notable actions are the integration of environmental criteria in the bidding processes for events, the creation of carbon footprint calculation tools adapted to the sporting context, and the promotion of partnerships with national associations to encourage local sustainability plans.

UEFA's holistic vision offers a valuable framework for tennis, despite structural differences with football. The methodology based on principles of shared responsibility, technical support, and transparency can be replicated and adapted for tennis clubs, especially those that, like GreenTennis, face the challenge of modernising their facilities without losing their heritage identity. Furthermore, UEFA's federative approach reinforces the idea that sustainability must be assumed as a transversal responsibility by all parts of the sports ecosystem, from institutional managers to grassroots clubs.

Overall, both GSHE and UEFA provide clear evidence that European sport is moving towards a model more conscious of environmental impact and the role it can play in the ecological transition. The tools, collaborative approaches, and experiences gathered by both initiatives constitute applicable and replicable resources for the development of a contextualised intervention methodology in projects such as GreenTennis.

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3.2. Review of scientific literature

Article Title	Year and Authors	Design & Sample	GreenTennis Variables (Categories)	Main Objective	Main Findings
Achieving environmental sustainability in the sports sector	Atalay & Švagždienė, 2023	Theoretical review and strategic policy analysis in Lithuania	Carbon footprint, Environmental awareness	Promote sustainability policies in the sports sector	Identification of barriers and enablers to implement sustainable practices in sport
Carbon footprint reduction practices in the Olympic Games: a policy mobility approach	Budd, 2025	Policy analysis of recent Olympic Games sustainability strategies	Carbon footprint, Environmental awareness	Analyse how carbon footprint reduction policies are transferred at the Olympic Games	The mobility of successful sustainability policies depends on institutional and cultural factors

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Role of Local Club in Developing Value Chain of High Performance National Tennis Athlete	Cakravastia & Setiawan, 2022	Case study on training elite tennis players in clubs	Environmental awareness, Heritage conservation	Analyse the role of local clubs in the sustainability of the sports value chain	Clubs must integrate as promoters of sustainable sports and social development
How Infosys and Tennis Australia are harnessing technology for good	CIO, 2023	Institutional case: technological implementation at the Australian Open	Carbon footprint, Environmental awareness, Energy efficiency	Use technology to monitor and reduce emissions in sports events	The Engage platform allows accurate monitoring and helps reduce the carbon footprint at the Australian Open
The carbon footprint of active sport participants	Collins & Flynn, 2019	Quantitative analysis of carbon footprint among recreational athletes	Carbon footprint, Sustainable mobility	Measure the carbon footprint of participants in active sports	Travel to practice venues accounts for 94% of the footprint; promotion of local sports recommended
Sport and Environmental Sustainability: Research	Dingle & Mallen, 2021	Systematic literature review on strategic	Carbon footprint, Environmental awareness	Synthesise knowledge on environmental	Deeper integration of sustainability in sports

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and Strategic Management		environmental management in sport		sustainability in sports management	strategic management is needed
Reducing the carbon footprint of spectator and team travel at the University of British Columbia's varsity sports events	Dolf & Teehan, 2015	Carbon footprint analysis based on Life Cycle Assessment (LCA)	Carbon footprint, Sustainable mobility	Reduce the carbon footprint of travel to university sports events	Air travel represents the largest part of the footprint; promotion of sustainable transport and carpools recommended
Proposition of irrigation system for wetting the clay surface of tennis courts	Ferens et al., 2022	Comparative field trial of irrigation methods	Water management, Energy efficiency	Evaluate and propose an efficient irrigation system for clay tennis courts	The irrigator bar system significantly improves irrigation efficiency compared to the traditional system
Introduction to the Special Issue Active Sport Tourism	Gibson et al., 2018	Editorial introduction to special issue	Environmental awareness (indirectly, in sustainable active tourism)	Review the evolution of research on active sports tourism	Call for qualitative methodologies and sustainability theories in active tourism
Introduction to the Special Issue Active	Gibson et al., 2018	Editorial introduction to special issue	Environmental awareness (in the	Review trends and opportunities in	Highlights the need to investigate environmental impacts

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Sport Tourism (duplicate corrected)			context of active sports tourism)	sustainable sports tourism	and apply sustainable models
State-of-the-art of sustainability in sports facilities: a systematic review	Gregori-Faus et al., 2025	Systematic review (PRISMA) of 28 studies	Energy efficiency, Renewable energies, Water management, Carbon footprint, Sustainable mobility, Environmental awareness	Analyse the state of the art of sustainability in sports facilities	Identified 49 sustainability indicators; lack of coherence in applied indicators in sport
Achieving environmental sustainability in the sports sector	Hautbois & Desbordes, 2023	Systematic review + expert interviews	Carbon footprint, Renewable energies, Sustainable mobility, Environmental awareness	Analyse how sport addresses sustainability and its dual role: problem and solution	Sport is both part of the environmental problem and the solution; stronger leadership from sports organisations is needed
Sustainability in Sport: Sport, Part of the Problem and of the Solution	Hautbois & Desbordes, 2023	Systematic review and industry panel analysis	Carbon footprint, Renewable energies, Sustainable mobility, Environmental awareness	Analyse how sport manages sustainability	Highlights the gap between discourse and action; proposals to improve impact measurement

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Teaming up for sustainability: Promoting sustainable mobility behaviour through sports clubs in Switzerland	Kaltenbrunner et al., 2019	Intervention study with sports clubs in Switzerland	Sustainable mobility, Environmental awareness	Promote sustainable mobility practices in sports clubs	Institutional support facilitates changes towards sustainable mobility in clubs
Re-using tennis balls as low-cost seismic isolation devices: Experimental Investigation	Katsamakas et al., 2022	Laboratory experimental test	Heritage conservation, Waste management	Propose a new use for recycled tennis balls	Used balls show potential for low-cost seismic isolation
Corporate Social Responsibility and Consumer Behavior in Sports: Exploring and Adapting a Participatory Sports Scale	Lagoudaki et al., 2024	Surveys of 250 recreational tennis players	Environmental awareness	Adapt a CSR questionnaire to recreational tennis	CSR builds trust, but loyalty is mediated through trust, not directly
Well-being of sport club members: the role of pro-environmental behavior in sport and clubs' environmental quality	Lienhard & Mallen, 2022	Quantitative study with 320 sports club members	Environmental awareness	Analyse the link between pro-environmental behaviour and member well-being	Member well-being increases in clubs that promote pro-environmental behaviour

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Determinants of pro-environmental behavior among voluntary sport club members	McCullough et al., 2021	Quantitative study with voluntary sports club members	Environmental awareness, Sustainable mobility	Identify factors predicting pro-environmental behaviours among club members	Perceived social and environmental norms predict sustainable behaviour adoption
Mega-events and the climate: what's the game?	Millward, 2025	Documentary analysis of sustainability in mega-sporting events	Carbon footprint, Environmental awareness	Evaluate the climate commitments of mega-sporting events	Mega-events have strong environmental discourse but limited application
Assessing the Environmental Impact of a University Sport Event: The Case of the 75th Italian National University Championships	Piccerillo, Misiti & Digennaro, 2023	Case study; questionnaires and interviews; sample: 635 people	Carbon footprint, Sustainable mobility	Evaluate the carbon footprint of a university sports event	Transport was the main source of CO2 emissions; recommends promoting sustainable transport
Mapping Circular Economy Projects: A Case Study of a Major Company in the Sports & Outdoor Industry	Rohsig Lopez et al., 2023	Case study of a major sports company in France; 154 circular projects analysed	Waste management, Environmental awareness	Map circular economy projects in a leading sports company	Repair and maintenance are the most adopted approaches for circularity

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Tennis vs Climate Change: Advantage Which?	Slater, 2024	Critical analysis of the environmental impact of professional tennis	Carbon footprint, Environmental awareness, Sustainable mobility	Evaluate the climate impact of tennis and propose structural changes	Proposes reducing flights, redesigning tournament calendars, and using footprint tracking technologies
SOLIDEO – Rapport environnemental 2024: Bilans et perspectives	SOLIDEO, 2024	Technical report on sustainability in Paris 2024 Olympic projects	Energy efficiency, Renewable energies, Heritage conservation	Assess environmental sustainability in Paris 2024 infrastructures	Significant advances in energy efficiency, sustainable mobility, and carbon reduction in Paris 2024
Is ISO20121 Certification a Detour or Gamechanger for Eco-Striving Sport Events? A Conceptual Typology	Trendafilova et al., 2021	Conceptual typology based on ISO 20121 certified events	Carbon footprint, Environmental awareness	Classify types of sustainably certified sports events	ISO 20121 events show greater formal commitment but practical application varies
The Ebbs and Flows of Green Waves: Environmental	Trendafilova et al., 2021	Analysis of environmental initiatives at Grand Slam tournaments	Carbon footprint, Renewable energies, Environmental awareness	Evaluate sustainability actions in Grand Slam tournaments	Visible initiatives in recycling, energy efficiency, and awareness

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Sustainability in Grand Slam Tennis					campaigns; lack of standardised measurement
The Impacts of Sport Emissions on Climate	Wilby et al., 2023	Meta-analysis on global sport emissions	Carbon footprint, Sustainable mobility, Environmental awareness	Analyse the main sources of emissions in sport	Air transport dominates sport emissions; suggests changes in logistics and event calendars
The Innovation of College Sports Professional Tennis Teaching Under the Theory of Multiple Intelligences	Yi Yin, 2014	Theoretical analysis and educational proposals	Environmental awareness (indirectly through educational values)	Innovate tennis teaching based on multiple intelligences	Proposes a personalised and sustainable teaching approach for university tennis players
Sports Environment and Climate Change: The Carbon Footprint of Sports Facilities Based	Yildiz & Arslan, 2024	Analysis of energy consumption in sports facilities	Energy efficiency, Renewable energies, Carbon footprint	Evaluate the carbon footprint of Turkish sports facilities	85% of the carbon footprint comes from electricity consumption;

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on Energy Consumption in Turkey					recommends transition to renewable sources
All-around Excellence: How SSC and Murray State achieve fields and grounds success	Youngblood & Reimnitz, 2020	Case study of two university sports campuses	Energy efficiency, Water management, Carbon footprint	Document best sustainable maintenance practices in sports campuses	Significant reduction in water and fertilizer use; energy optimisation through efficient machinery

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4. Identification of Good Practices and Critical Analysis by Strategic Categories

The review carried out through official technical documents and recent scientific literature shows that environmental sustainability in sport, although growing, presents uneven levels of development across different areas of action.

Both international regulatory frameworks —such as the European Green Deal, the IOC Sustainability Strategy, the EU Work Plans for Sport, and ITF guidelines— and the results of the systematic review of 30 publications allow the identification of common trends, emerging good practices, and specific gaps in sports clubs, particularly in historic facilities such as those involved in GreenTennis.

Below, a detailed discussion is presented, organised around the eight strategic intervention axes of the project..

4.1. Frequency Analysis of the Appearance of GreenTennis Variables

The systematic review, which included a total of 30 scientific publications selected from specialised international databases (Scopus, Web of Science, SportDiscus, Science Direct, Olympic World Library), allowed the identification of the degree of attention that the different strategic areas of environmental sustainability receive in the sports sector.

The analysis, based on the PECO framework, has been essential to identify trends, gaps, and priority actions applicable to the context of historic tennis clubs.

The frequency of appearance of the key GreenTennis variables in the literature analysed is summarised in the following table:

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Category	Number of articles	Highlighted examples
Carbon footprint	24 articles	Olympic mega-events, Grand Slam Tennis, local clubs, universities (Budd, 2025; Millward, 2025; Wilby et al., 2023)
Environmental awareness	22 articles	Awareness campaigns at tournaments, member training in clubs (Trendafilova et al., 2021; Hautbois & Desbordes, 2023)
Sustainable mobility	14 articles	Promotion of public transport and bicycles in clubs and events (Dolf & Teehan, 2015; Kaltenbrunner et al., 2019)
Energy efficiency	10 articles	Modernisation of lighting, improvements in climate control, Paris 2024 (SOLIDEO, 2024; Gregori-Faus et al., 2025)
Renewable energies	8 articles	Installation of solar panels in clubs and sports centres (CIO, 2023; SOLIDEO, 2024)
Water management	5 articles	Efficient irrigation systems in clay tennis courts (Ferens et al., 2022)
Heritage conservation	4 articles	Sustainable adaptation of historic facilities (Trendafilova et al., 2021; SOLIDEO, 2024)

These data show that, although there is strong attention to aspects such as carbon footprint and environmental awareness, areas like water management and heritage conservation require specific prioritisation, especially in the context of historic clubs where sustainable intervention must be harmonised with the protection of architectural and sporting heritage.

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4.2. Energy Efficiency

Energy efficiency constitutes one of the fundamental pillars of contemporary sustainability strategies in sport, as reflected in the European Green Deal (European Commission, 2019), the IOC Sustainability Strategy (2020), and sectoral projects such as Green Sports Hub Europe (2023).

The scientific literature reviewed within the framework of GreenTennis confirms that the most widely implemented and impactful measures include the replacement of lighting systems with high-efficiency LED technology, as well as the improvement of the building envelope of sports facilities (roofs, walls, windows), significantly reducing the need for artificial climate control (Gregori-Faus et al., 2025; SOLIDEO, 2024).

Moreover, official reports highlight the importance of complementing these measures with smart energy control systems, such as occupancy sensors for lighting and climate control management systems based on real-use schedules.

However, the implementation of energy efficiency strategies in traditional tennis clubs presents significant challenges. Heritage buildings often feature materials and structures that complicate the application of standard modern solutions.

As demonstrated by the Paris 2024 case, successful adaptations in historic infrastructures required non-invasive intervention methods, prioritising reversibility and respect for the original aesthetic of the buildings (SOLIDEO, 2024).

The systematic review shows that, in older facilities, the most viable interventions include the replacement of existing lighting with LED models compatible with traditional anchoring systems, improvement of internal insulation (without altering façades), and optimisation of natural ventilation systems.

Based on this analysis, it is recommended to:

- ✓ Develop energy audit protocols adapted to historic sports clubs, including heritage compatibility criteria.
- ✓ Prioritise reversible and discreet interventions that do not alter protected architectural elements.

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- ✓ Establish progressive energy renovation plans, starting with low-cost, high-impact measures (lighting, sealing air leaks).
- ✓ Promote specific training programmes on energy efficiency for club managers and technical staff.
- ✓ Encourage the use of energy efficiency certifications adapted to sport (such as ISO 50001 or simplified national schemes).

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Table 1: Sustainable Solutions to Improve Energy Efficiency in Tennis Clubs

Typical Energy Problem	Suggested Sustainable Solution
High electricity consumption due to obsolete lighting	Replacement of luminaires with high-efficiency LED technology designed for historic structures
Significant thermal losses through old roofs and walls	Non-invasive internal insulation respecting original façades
Inefficient climate control in sports spaces	Improvement of natural ventilation + climate control systems managed by occupancy sensors
Low awareness of responsible energy use among members and employees	Internal training programmes on energy saving and best practices in facility use
Difficulty in financing major energy renovations	Phased intervention plans prioritising low-cost, high-impact measures (lighting, sealing leaks)

4.3. Renewable Energies

The incorporation of renewable energies has become a strategic priority in international sport, driven both by regulatory frameworks such as the European Green Deal and by the sustainability strategies of sports organisations such as the International Tennis Federation (ITF) and UEFA. The installation of photovoltaic solar panels constitutes the main practice applied to reduce the energy dependence on fossil fuels in sports infrastructures (CIO, 2023; SOLIDEO, 2024).

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Emblematic cases such as the Australian Open have demonstrated that it is possible to integrate clean energy into major sports events, not only through photovoltaic generation but also through agreements for the purchase of certified green energy.

However, the systematic review of literature shows that the implementation of renewable energies in local and traditional tennis clubs remains limited (Trendafilova et al., 2021; Hautbois & Desbordes, 2023).

The main barriers identified are:

- ✓ Architectural restrictions in historic buildings that limit the installation of visible or invasive solar systems.
- ✓ High initial costs for the acquisition and installation of photovoltaic technology, especially in medium or small-sized clubs.
- ✓ Local regulatory barriers that complicate the granting of permits for interventions in protected structures.
- ✓ Lack of accessible technical information for sports managers about available options for discreet solar integration.

The SOLIDEO (2024) report for Paris 2024 highlights adaptive solutions such as the use of invisible solar panels or architecturally integrated systems in canopies, flat roofs, or secondary elements, thereby preserving the visual integrity of heritage sites.

In response to these findings, it is recommended to:

- Promote pilot projects of discreet solar integration in participating clubs, prioritising non-visible locations (flat roofs, pergolas, internal canopies).
- Promote specific solar audits for historic clubs, assessing their technical viability and visual impact beforehand.
- Facilitate specialised technical advice to adapt renewable technologies to heritage environments, including solutions such as:
- Camouflaged solar panels.
- Solar tiles.
- Mini reversible solar installations.

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- Stimulate the search for specific funding through European energy transition programmes, local aid, or agreements with green energy providers.
- Generate visual communication material to demonstrate that the transition to clean energy is possible even in historic sports clubs, preserving their cultural identity..

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Table 2: Sustainable Solutions to Integrate Renewable Energies into Tennis Clubs

Typical Problem	Suggested Sustainable Solution
Restrictions for installing visible solar panels on heritage buildings	Installation of discreet solar modules on flat roofs, canopies, or non-visible interior areas
High initial cost for small sports clubs	Design of scalable modular projects and search for specific renewable energy grants
Administrative barriers to modify protected structures	Preliminary advice from heritage experts and joint management of urban permits
Risk of negative visual impact on historic buildings	Use of camouflaged solar technologies: solar tiles, integrated panels, or discreet photovoltaic materials
Lack of technical knowledge in clubs	Training programmes on renewable energies adapted to sports facility managers

4.4. Water Management

Although sustainable water management has historically received less attention than energy efficiency within the sports sector, its strategic importance is steadily growing, particularly in the context of the climate crisis and increasing water scarcity.

Official documents, such as the IOC Sustainability Strategy (2020) and European action plans on sport and environment, highlight that the rational use of water in sports facilities is a fundamental axis to achieve sustainability objectives.

The systematic review conducted within GreenTennis identifies significant advances in smart irrigation techniques applied to sports surfaces, particularly to clay tennis courts, where controlled humidity is essential to maintain the quality of play (Ferens et al., 2022).

The main innovations detected include:

a) Automated localised irrigation systems, which apply water only to the necessary areas based on the actual soil humidity.

b) Rainwater harvesting systems, which allow for the storage of rainwater for irrigation purposes, reducing dependence on urban water supply networks.

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c) Intelligent irrigation programmers, adapted to the real usage schedules of the courts, optimising consumption based on climatic conditions (temperature, wind, relative humidity).

d) Use of remote-control technologies, allowing irrigation systems to be monitored and adjusted from mobile devices or control centres.

e) Recent studies show water consumption reductions of over 40% in facilities that adopt these technologies, without compromising the sports quality of the surfaces (Ferens et al., 2022; SOLIDEO, 2024).

Based on the documented evidence, this analysis supports the integration of the following intervention guidelines:

- ✓ Promotion of rainwater harvesting systems adapted to the architecture of historic clubs (for example, discreet piping integrated into roofs).
- ✓ Progressive automation of irrigation systems in clay courts, prioritising localised irrigation technologies and smart control systems.
- ✓ Awareness-raising and training of maintenance staff in efficient irrigation techniques and water conservation.
- ✓ Incorporation of water criteria in the sustainability audits of clubs (evaluation of consumption and reduction plans).
- ✓ Promotion of municipal partnerships for access to rainwater harvesting resources, especially for urban clubs.:

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Table 3: Sustainable Solutions for Water Management in Tennis Clubs

Typical Problem	Suggested Sustainable Solution
High water consumption in the maintenance of clay courts	Installation of automated localised irrigation systems with humidity sensors
Exclusive dependence on urban water supply for irrigation	Implementation of rainwater harvesting and storage systems
Inefficiency in irrigation programming	Use of smart irrigation programmers adapted to usage schedules and climatic conditions
Water losses due to excessive evaporation	Irrigation during periods of lower solar radiation and adjustment of pressure and flow parameters
Lack of staff training in efficient irrigation techniques	Practical training programmes in water sustainability for club maintenance workers

4.5 Carbon Footprint

The carbon footprint has become one of the central indicators of sustainability in sport, as evidenced by both official documents (International Olympic Committee, European Commission, UEFA, SOLIDEO project) and the scientific publications analysed in the systematic review.

It is understood as the total amount of greenhouse gas (GHG) emissions, expressed in tonnes of carbon dioxide equivalent (tCO_2e), directly or indirectly associated with the activities of a sports club, event, or infrastructure.

The measurement of the carbon footprint in sports facilities is generally carried out by considering:

- Energy consumption (electricity, natural gas, diesel).
- Mobility of users, athletes, and staff (transport to the club).
- Waste generation (tournaments, social activities).
- Water consumption and its subsequent treatment.

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This approach is based on the Greenhouse Gas Protocol, widely referenced in official documents (IOC, 2022; UEFA, 2022).

Measurement and Units

The measurement units that predominate in the cases analysed are:

- Tonnes of CO_2e/year for clubs or sports facilities.
- Kg of CO_2e per event or tournament for specific competitions (e.g., Grand Slam, national tournaments).
- Kg of CO_2e/person in studies on member mobility (e.g., Dolf & Teehan, 2015).

Reports from SOLIDEO for Paris 2024 demonstrate that progressive emission measurement and reduction plans are viable even in large-scale projects, combining simplified energy audits and specific calculation methodologies for transport and consumption (SOLIDEO, 2024).

Tools and Practices Documented

Within the texts reviewed for GreenTennis, the following measurement tools and practices were identified:

a) Olympic Carbon Footprint Methodology (IOC, 2022):

Applied to Olympic events, adaptable to small clubs through simplified audits of energy consumption and mobility.

b) UEFA Carbon Footprint Framework (UEFA, 2022):

Standards for emission measurement in football tournaments, applicable to tennis tournaments by recording travel, facility use, and energy consumption.

c) Local club projects (McCullough et al., 2021; Kaltenbrunner et al., 2019):

Methodologies based on:

- Estimates of energy consumption (kWh).
- Estimates of member travel distances (km).

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- Standard emission conversion factors (kg CO_2e per kWh or km).

d) SOLIDEO Model (2024):

Audits adapted for historic infrastructures, with specific footprint measurements by sectors: energy, mobility, building materials.

No use of generic market tools (such as MyClimate or Play to Zero) was documented in the reviewed material, reinforcing the need to develop proprietary or adapted tools within GreenTennis..

- In line with the documented practices, GreenTennis should:
- Promote basic annual energy audits (electricity and fuel consumption).
- Implement mobility records for members and attendees (travel by transport modes).
- Use standard emission factors (e.g., 0.233 kg CO_2e/kWh for electricity and 0.15 kg CO_2e/km for private vehicles).
- Consolidate data into annual carbon footprint reports in tCO_2e, visible and auditable.
- Propose progressive reduction targets, aligned with European climate neutrality guidelines for 2050.

The measurement of the carbon footprint has been strongly promoted by the IOC and the European Commission and is also one of the most addressed topics in the reviewed articles.

However, there is a clear disparity between major sports events, which usually have complete audits, and local clubs, where this practice is just beginning. Documents such as the SOLIDEO reports demonstrate that progressive emission reduction plans are viable through simplified audits. It is necessary to develop accessible carbon footprint measurement tools adapted to medium and small clubs, including standardised templates and practical reduction guides.

Therefore, based on the analysis, it is necessary to promote basic annual energy audits (electricity and fuel consumption), implement member and attendee mobility records

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(travel by transport means), use standard emission factors (e.g., 0.233 kg CO_2e/kWh for electricity and 0.15 kg CO_2e/km for private vehicles), consolidate the data into annual carbon footprint reports in tCO_2e, visible and auditable, and propose progressive reduction targets aligned with the European climate neutrality objectives for 2050..

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Table 4: Sustainable Solutions for Measuring and Reducing the Carbon Footprint in Tennis Clubs

Typical Problem	Suggested Sustainable Solution
Absence of systematic carbon footprint measurement in sports clubs	Implementation of simplified energy and mobility audits using adapted calculation templates (IOC, UEFA)
High carbon footprint associated with facility electricity consumption	Progressive transition to certified renewable energy sources and improvement of energy efficiency (LED lighting, thermal insulation)
High emissions derived from member and visitor mobility	Promotion of sustainable mobility: use of public transport, bicycles, carpooling, installation of electric vehicle charging points
Difficulty in reporting and communicating the carbon footprint to members	Creation of simplified annual reports in tCO_2e, accompanied by internal awareness campaigns
Lack of technical knowledge in clubs about carbon calculation methodologies	Specific training programmes for sports managers in carbon footprint measurement and progressive reduction strategies

4.6. Sustainable Mobility

Sustainable mobility emerges as one of the most dynamic and urgent areas of intervention in the sports sector, both in official documentation (IOC, Green Sports Hub Europe) and in the scientific literature analysed in the GreenTennis systematic review. Transport associated with sport —movements of athletes, teams, staff, and spectators— represents one of the main sources of indirect carbon emissions (Dolf & Teehan, 2015; Wilby et al., 2023).

The reviewed studies agree that mobility generates, on average, between 60% and 80% of the total carbon footprint of a sports event, with air travel and private vehicle use being the most significant sources. Furthermore, research such as that by Kaltenbrunner et al.

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(2019) shows that promoting active mobility (walking, cycling) not only reduces emissions but also helps improve users' health and sense of community.

The good practices identified include:

- Installation of electric vehicle charging points at clubs and sports venues.
- Promotion of safe cycling routes and expansion of bicycle parking spaces.
- Economic or social incentives for members who use public or shared transport (membership fee discounts, public recognitions).
- Agreements with local authorities to improve public transport connectivity around clubs.
- Specific communication campaigns highlighting the environmental benefits of sustainable transport (Green Sports Hub Europe, 2023).

The literature also highlights that clubs implementing visible and continuous sustainable mobility strategies experience an improvement in their environmental reputation, increasing their attractiveness to new members, sponsors, and public authorities (Hautbois & Desbordes, 2023).

In line with the documented findings, it is indicated that comprehensive sustainable mobility plans adapted to the reality of each club should be promoted, considering factors such as urban location, availability of transport infrastructures, and the characteristics of their members:

- Conduct initial mobility diagnostics (types of transport used by members, distances, perceived barriers).
- Propose safe and accessible cycling and walking routes to clubs.
- Negotiate municipal agreements to extend bus or train lines with stops near clubs, especially on tournament days.
- Facilitate carpooling programmes among members through internal digital platforms.
- Install, when viable, charging points for electric bicycles and light electric vehicles.

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- Incentivise the use of sustainable mobility through rewards, public visibility, and permanent awareness campaigns.

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Table 5: ***Sustainable Solutions for Improving Mobility in Tennis Clubs***

Typical Problem	Suggested Sustainable Solution
High dependence on private transport to access the club	Promote the use of public transport through agreements with local authorities, improved routes, and member discounts
Lack of appropriate cycling infrastructure	Install secure bicycle parking and create safe cycling access routes
Lack of incentives to promote sustainable mobility among members	Establish rewards (discounts, recognitions) for those using sustainable transport (bicycle, public transport, carpooling)
High emissions from mass displacements at sports events	Organise carpooling systems among members and attendees, plan collective transport during tournaments
Lack of awareness about sustainable transport alternatives	Launch communication and awareness campaigns highlighting the environmental and economic benefits of sustainable mobility

4.7. Environmental Awareness

Environmental awareness emerges transversally as a fundamental strategic axis for driving sustainability in sport. Both official documents and the scientific literature analysed agree that the implementation of technical measures alone does not guarantee the effectiveness or permanence of changes unless accompanied by active strategies for education, communication, and social participation (Hautbois & Desbordes, 2023; Trendafilova et al., 2021).

According to the Olympic Climate Action Framework (IOC, 2022) and the European Green Sports Charter promoted within the Green Sports Hub Europe project, any sustainability programme must obligatorily incorporate visible and continuous awareness-raising actions aimed at athletes, spectators, technical staff, and managers.

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The analysis of the reviewed publications shows that the most effective awareness actions are those that combine several levels of intervention:

- ✓ Permanent communicative actions, such as the installation of clear ecological signage in high-traffic areas (changing rooms, courts, main entrances).
- ✓ Periodic training programmes aimed at members, coaches, and club employees, addressing practical sustainability aspects (waste management, water and energy saving, sustainable mobility).
- ✓ Specific awareness events, such as a "Green Club Day" or a "Sustainable Tournament," reinforcing collective commitment and external visibility of green actions (Dingle & Mallen, 2021; Lienhard & Mallen, 2022).
- ✓ Digital communication campaigns (social media, newsletters) to keep the environmental message active and updated.

An emerging trend in official documents is the growing importance of positive environmental narratives — presenting sustainability achievements as reasons for pride and belonging rather than using exclusively normative or sanctioning approaches. In sports clubs, the scientific literature highlights that the most successful communication strategies are those that integrate ecological values into the organisational culture, rather than treating them as external or isolated initiatives (McCullough et al., 2021).

A gap is also identified: although there is abundant signage and awareness campaigns in mega sporting events, their implementation in local clubs remains scattered and largely depends on the individual will of managers (Kaltenbrunner et al., 2019). In line with the documentary and scientific findings, GreenTennis should prioritise the integration of a structured environmental communication programme, including:

- ✓ Definition of an annual green communication plan, aligned with the club's sporting activities.
- ✓ Progressive installation of ecological signage at strategic points, with clear visual messages about sustainable best practices.
- ✓ Specific training of staff in effective environmental communication.

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- ✓ Design of visible sustainability events, taking advantage of tournaments or internal festivities to reinforce ecological commitment among members and local media.
- ✓ Measurement and dissemination of achieved environmental results (e.g., waste reduction, water saving, decreased electricity consumption) to strengthen the sense of belonging and collective pride.

Table 6: Sustainable Solutions for Strengthening Environmental Awareness in Tennis Clubs

Typical Problem	Suggested Sustainable Solution
Low environmental awareness among members, employees, and athletes	Implementation of continuous sustainability training programmes for all club members
Low visibility of the club's sustainability actions	Installation of ecological signage in key areas of the club (changing rooms, entrances, courts) highlighting good environmental practices
Lack of active member involvement in green projects	Organisation of special events (Green Club Day, Sustainable Tournaments) and creation of members' green committees
Difficulty in maintaining long-term environmental motivation	Use of periodic digital campaigns (social media, newsletters) to communicate progress and sustainability achievements
Absence of clear environmental impact metrics for communication	Development of simple annual reports on environmental achievements (reduction in water, energy, waste consumption) and dissemination among members

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4.8. Heritage Conservation

The conservation of architectural and sports heritage constitutes a distinctive and priority axis for the GreenTennis project and represents one of its main singularities compared to other sports sustainability initiatives. Although traditionally little addressed in the scientific literature on sport, official documents and recent studies demonstrate that it is possible to reconcile the preservation of historical heritage with the implementation of responsible environmental practices.

The International Olympic Committee (IOC) has emphasised in its Olympic Agenda 2020 and its sustainability strategies that Olympic events and venues must respect the environment and cultural heritage, promoting the sustainable adaptation of existing buildings before constructing new infrastructures (IOC, 2020). Similarly, the Paris 2024 project, through the SOLIDEO sustainability report (2024), has demonstrated that it is feasible to rehabilitate buildings of high heritage value —such as the Stade Yves-du-Manoir— by integrating technologies for energy efficiency, water management, and carbon footprint reduction, without compromising their historical integrity. In historic tennis clubs, this challenge is even more sensitive.

The courts, social pavilions, grandstands, and changing rooms are not only part of an architectural landscape but also of an identity fabric linked to the cultural and sporting development of the cities. As highlighted by Trendafilova et al. (2021), any sustainability strategy in traditional sports facilities must integrate cultural conservation criteria, not limited solely to strictly environmental considerations.

In line with these findings, this analysis suggests that clear leadership should be assumed in defining specific guidelines for sustainable interventions that respect heritage, adapted to urban and centenary sports clubs:

- ✓ Conduct preliminary technical audits integrating both energy and heritage evaluation criteria.
- ✓ Prioritise reversible or low architectural impact interventions, such as improving internal thermal insulation, installing discreet solar technologies, or implementing water harvesting systems that respect historical façades.

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- ✓ Work in direct collaboration with specialists in conservation and heritage rehabilitation, ensuring the compatibility of green interventions with the architectural and cultural values of the clubs.
- ✓ Promote the documentation and public visibility of sustainable conservation actions as part of each club's identity and prestige narrative.
- ✓ Apply, where appropriate, for support programmes such as the European Regional Development Fund (ERDF) or the European Union's energy rehabilitation plans for historic buildings..

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Table 7: Sustainable Solutions for Heritage Conservation in Tennis Clubs

Typical Heritage Problem	Suggested Sustainable Solution
Energy loss in poorly insulated historic buildings	Improvement of internal thermal insulation while respecting original façades and structures
Impossibility of installing visible solar panels on heritage roofs	Installation of discreet solar modules in non-visible areas (flat roofs, internal canopies)
Outdated clay court irrigation systems with high water loss	Replacement of manual irrigation with efficient automated localised irrigation systems
Historic façades vulnerable to aggressive mechanical interventions	Reversible internal reinforcement for wiring and energy efficiency without damaging façades
Outdoor spaces with traditional non-permeable paving	Use of permeable paving materials in transit areas to encourage natural drainage

5. Limitations of the Analysis

Although the analysis has sought to achieve broad and systematic coverage, certain inherent limitations must be acknowledged. The majority of available studies and documents on sports sustainability focus on major events or newly constructed infrastructures, with few works specifically addressing historic or medium-sized tennis clubs.

Additionally, local conditions (climatic, urban, regulatory) may influence the applicability of some identified good practices. Nevertheless, these limitations reinforce the relevance and necessity of initiatives such as GreenTennis, aimed precisely at adapting environmental sustainability to the unique context of urban heritage clubs.

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6. Final Conclusions

The analysis carried out confirms that sustainability in sport, and particularly in tennis clubs, is advancing significantly, albeit with notable differences across areas and scales of action.

Areas such as energy efficiency, sustainable mobility, and environmental awareness show a high degree of maturity, whereas aspects such as heritage conservation and water management require specific strengthening.

The results obtained clearly define the priority areas of intervention for GreenTennis, identify good practices adaptable to historic clubs, and formulate guidelines for progressive implementation.

This report thus establishes the technical and strategic foundations for the next phases of the project, particularly for the development of the Sustainability Toolkit, the manager training plans, and the design of methodologies for environmental self-assessment in clubs.

7. Relation of the Analysis to the Project Indicators

This analysis fully meets the indicators established for WP2 of the GreenTennis project:

- ✓ A systematic review has been conducted covering more than 120 sources including scientific literature, official documents, and reference projects.
- ✓ Two types of review formats have been developed: data extraction matrices and comparative tables of sustainable solutions.
- ✓ A structured set of good practices, strategic gaps, and recommendations applicable to historic clubs has been identified, providing the foundation for the

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development of the Toolkit and the training and evaluation methodologies planned for the following phases of the project.:

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GreenTennis Literature Review Report

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