THE JOURNAL OF
INTERACTIVE SOCIAL SCIENCES
2025 Vol. 1, No. 2, ISSN 3030-5322

Green Management of Sports Events from a Twin Transformation Perspective: How Digitalization Empowers Sustainable Events

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ARTICLE INFO

Keywords
Twin Transformation
Digitalization
Sustainability
Sport Event Management
Case Study
Fan Engagement
Green Events

Published
8 June 2025

ABSTRACT

Sports event management is increasingly shaped by the pressures of twin transformation, combining the dual imperatives of digitalization and sustainability. While digital technologies such as digital ticketing, AI-driven analytics, and digital twin simulations are widely adopted in the sports industry, their role in empowering green management practices remains underexplored. This study examines how digitalization facilitates sustainable event management through a comparative case analysis of World Athletics 2024 Events and the Formula One 2023 Impact Report. Using official sustainability reports, media coverage, and social media content, the research adopts a mixed qualitative approach involving comparative case study and computational text analysis. The findings highlight how digitalization supports carbon footprint monitoring, resource efficiency, and enhanced stakeholder engagement, but also reveal challenges such as data transparency gaps and unequal adoption across event types. By integrating insights from both institutional disclosures and public perceptions, the study contributes to advancing the theoretical framework of twin transformation in sports management. Practically, the research provides actionable recommendations for event organizers seeking to leverage digital innovation as a catalyst for sustainable and responsible sports events.

1. Introduction

1.1 Background

In recent years, the management of sports events has entered a new era shaped by two overarching global imperatives: digital transformation and sustainable development. The rapid

Citation: Zhang, Y., Song, T., Feng, D., Huang, Z., & Lei, Z. (2025). Green management of sports events from a twin transformation perspective: How digitalization empowers sustainable events. *The Journal of Interactive Social Science*, 1(2), 1-11.

https://doi.org/10.64744/tjiss.2025.23.

adoption of digital technologies such as artificial intelligence (AI), big data analytics, and digital twin modeling has fundamentally altered the way sports events are organized, delivered, and experienced (Wang et al., 2024). In parallel, the urgency of addressing climate change and environmental degradation has brought sustainability to the forefront of event management, with stakeholders increasingly demanding low-carbon, resource-efficient, and socially responsible practices (Glebova & Madsen, 2024; Yilmaz & Karadayi-Usta, 2025).

While both digitalization and sustainability are critical individually, contemporary management discourse emphasizes their integration through the concept of twin transformation, the concurrent pursuit of digital innovation and sustainable development strategies (Aagaard & Vanhaverbeke, 2024). This perspective suggests that digital technologies are not merely tools for operational efficiency but can also act as enablers of green event management, amplifying efforts to reduce environmental impact, improve transparency, and foster stakeholder engagement (Segedinac, 2024). In sports events, where visibility and scale magnify both environmental footprints and societal expectations, understanding this relationship has become essential (Cuicui & Shuhong, 2024).

1.2 Research Significance

The intersection of digitalization and sustainability in sports event management is an emerging yet underexplored domain. Existing scholarship has tended to treat these domains separately: studies on digitalization focus on fan engagement, immersive technologies, and data-driven decision-making (Jover & Sempere, 2025), while sustainability research emphasizes environmental footprints, legacy planning, and social responsibility. However, few studies have systematically examined how digitalization actively empowers sustainability in practice (Burinskienė & Nalivaikė, 2024).

This gap is particularly salient given the role of major sports events as laboratories for innovation and societal influence. When international federations and high-profile competitions adopt digital-green strategies, they not only transform their own operations but also set benchmarks for smaller-scale events and broader industries. By exploring concrete cases where digitalization and sustainability converge, this study contributes to both theory and practice in sports management, advancing the twin transformation framework within a sports context.

1.3 Case Selection: World Athletics 2024 and Formula One 2023

This research draws on two high-profile and globally recognized cases: World Athletics 2024 Events and the Formula One 2023 Impact Report.

World Athletics 2024 Events: Under the "Athletics for a Better World" (ABW) framework, World Athletics systematically evaluated events against a sustainability standard encompassing carbon management, waste reduction, environmental quality, and community engagement. Several events in 2024, including elite competitions such as the World Indoor Championships and the Bislett Games, disclosed detailed sustainability assessments. These reports not only provide insight into green management practices but also highlight the use of digital monitoring systems and standardized data collection.

Formula One 2023 Impact Report: Formula One (F1) has positioned itself at the forefront of sustainability discourse in motorsport through its annual impact reporting. The 2023 report

outlined progress towards the sport's 2030 Net Zero Carbon target, detailing initiatives in logistics optimization, renewable energy adoption, and sustainable fuels. Importantly, F1 leverages advanced digital systems for carbon accounting, operations monitoring, and performance benchmarking, making it a particularly rich case for analyzing the interplay of digitalization and sustainability.

The selection of these two cases enables comparative analysis across different event formats-an international federation's multi-event calendar versus a global motorsport series-providing diverse perspectives on how digital innovation can drive sustainable outcomes.

1.4 Research Questions

Building on the theoretical framework of twin transformation and the selected cases, this study addresses the following research questions:

(1)How do sports events integrate digital technologies into their sustainability strategies? (2) What mechanisms link digitalization to green management outcomes such as carbon reduction, resource efficiency, and fan engagement? (3) How do institutional reports and public discourse converge or diverge in their evaluation of digital-sustainability initiatives? (4) What lessons can be drawn for sports event organizers aiming to implement twin transformation strategies?

1.5 Contributions

This study makes three primary contributions:

1.5.1 Theoretical: It extends the twin transformation framework into the domain of sports event management, illustrating how digital technologies act as enablers of sustainability rather than parallel innovations.

1.5.2 Empirical: Through comparative case analysis of World Athletics 2024 and Formula One 2023, it provides empirical evidence of diverse digital-green strategies in practice.

1.5.3 Practical: By incorporating both official disclosures and public perceptions (via media and social media text analysis), the study generates actionable insights for event organizers and policymakers seeking to balance technological innovation with environmental responsibility.

2. Theoretical Perspectives

2.1 Twin Transformation in Management Research

The concept of twin transformation (TT) refers to the simultaneous pursuit of digitalization and sustainability as complementary strategic priorities. In management literature, TT is increasingly seen as essential for organizations aiming to achieve both operational excellence and long-term environmental responsibility. Hammerschmidt et al. (2025) emphasize that TT fosters synergistic benefits by embedding digital tools into sustainability initiatives, allowing firms to track emissions, reduce waste, and engage stakeholders more effectively.

Within sports management, the TT approach is emerging as a framework for integrating technology and sustainability. Wang et al. (2024) highlight that TT encourages sports organizations to align digital initiatives such as smart ticketing or virtual fan platforms with green

objectives like carbon-neutral event management. However, while the concept is widely discussed in corporate and SME contexts, empirical evidence in sports events remains scarce. This study aims to bridge this gap by applying TT to two high-profile event contexts.

2.2 Digitalization in Sports Event Management

Digitalization has transformed sports events across multiple dimensions, from spectator engagement to operational efficiency. Technologies such as digital twin simulations are increasingly used for venue management, allowing organizers to model logistics, optimize energy use, and create virtual spectator experiences. Similarly, AI-driven analytics improve crowd flow, ticketing, and security while simultaneously reducing resource consumption.

Recent scholarship also highlights how digitalization is reshaping sports fandom. Sherif et al. (2025) note that blockchain-based technologies and tokenization are creating new avenues for fan participation while offering traceable and transparent sustainability metrics. Meanwhile, studies on digital transformation in sports organizations reveal that technological adoption can stimulate green innovation, for example, by facilitating eco-friendly product design and service delivery.

Nevertheless, most of these studies emphasize digitalization's role in enhancing the fan experience or operational convenience rather than its direct contribution to sustainability outcomes. The current research seeks to address this by focusing explicitly on how digital technologies empower environmental management in large-scale events.

2.3 Sustainability in Sports Events

Sustainability in sports events has been extensively studied, with emphasis on carbon footprint reduction, waste management, and social legacy. Mehra et al. (2025) argued that innovation and digitalization have opened new perspectives for sustainable event management in the meeting industry, pointing to parallels with sports where scale and visibility amplify environmental concerns.

Çınar (2025) stresses that sports events are undergoing a technological transformation where sustainability objectives must align with digitalization processes, leading to more efficient operations and reduced ecological footprints. Furthermore, World Athletics' adoption of sustainability standards and Formula One's commitment to carbon neutrality illustrate how leading organizations frame green initiatives as central to legitimacy and brand value.

Yet, gaps remain in how sustainability efforts are measured and communicated. While impact reports disclose aggregate carbon reductions or recycling rates, less attention has been given to the mechanisms through which digital systems enable these achievements. Bridging this gap requires a twin transformation lens.

2.4 Integration of Digitalization and Sustainability: Towards Twin Transformation in Sports Events

Although sports management research increasingly acknowledges both digitalization and

sustainability, the integration of the two remains underdeveloped. Philp et al. (2025) argue that many studies address either digitalization or sustainability but rarely their intersection, calling for future research that examines how digital tools can serve as sustainability enablers.

The cases analyzed in this study-World Athletics 2024 Events and Formula One 2023 impact Report-offer a unique opportunity to explore this intersection. Both organizations have made substantial commitments to sustainability while employing advanced digital tools for monitoring, reporting, and engagement. By applying a TT perspective, this study examines not only the outcomes (carbon reduction, efficiency gains) but also the processes (data-driven decision-making, transparency, and stakeholder inclusion).

2.5 Conceptual Framework

Based on the reviewed literature, this study adopts a conceptual framework where digitalization serves as both a direct enabler of sustainable practices (e.g., digital ticketing reduces paper use) and an indirect driver by enhancing monitoring, transparency, and stakeholder engagement. The framework positions TT as a mediating construct linking digital inputs (technologies, platforms) with sustainability outcomes (green operations, fan awareness, carbon reductions).

3. Methodology

3.1 Research Design

This study adopts a comparative case study design complemented by computational text analysis. The case study method enables an in-depth examination of how digitalization empowers sustainability within two distinct but globally recognized sports organizations: World Athletics (2024 Events) and Formula One (2023 Impact Report). Comparative analysis allows for the identification of similarities and differences across event formats, thereby uncovering mechanisms of twin transformation. Text analysis of media and social media discourse provides an additional lens, capturing public perceptions of digital-sustainability practices and triangulating findings from institutional reports.

3.2 Case Selection

Two cases were purposively selected based on three criteria: global prominence, availability of sustainability disclosures, and integration of digital systems.

World Athletics 2024 Events: Under the Athletics for a Better World (ABW) Standard, World Athletics conducted systematic evaluations of multiple events in 2024, disclosing sustainability performance across dimensions such as carbon management, environmental quality, and stakeholder engagement. These evaluations incorporate digital monitoring systems, making them highly relevant to twin transformation analysis.

Formula One 2023 Impact Report: Formula One represents a contrasting format, a single global series with centralized sustainability reporting. The 2023 Impact Report outlined initiatives towards the sport's Net Zero 2030 goal, supported by digital technologies for logistics optimization, carbon accounting, and stakeholder reporting.

Together, these cases enable cross-event comparison between a federation managing multiple events and a single series with centralized operations.

3.3 Data Sources

(1) Official Documents: World Athletics 2024 Sustainability Reports (ABW Standard evaluations).Formula One 2023 Impact Report. These documents provide primary evidence of institutional commitments, performance metrics, and digital systems used for sustainability monitoring. (2) Media Coverage: Reports from reputable outlets (e.g., Reuters, BBC Sport, ESPN) were collected to capture independent evaluations of sustainability and digitalization initiatives.(3) Social Media Data: Posts and comments were collected from Twitter/X, Instagram, and Weibo using event-specific hashtags (e.g., #WorldAthletics, #Formula1, #SustainableSport). A sample of approximately 1,000 posts per event was retrieved, ensuring representativeness across stakeholders (fans, athletes, commentators).

3.4 Data Collection Procedures

3.4.1 Document Collection: Official reports were downloaded from organizational websites. Media articles were retrieved using keyword searches ("World Athletics sustainability," "F1 2023 Impact Report," "digital transformation in sports events").

3.4.2 Social Media Scraping: Data was collected using API-based tools and keyword queries. To ensure ethical compliance, only publicly available posts were included, and personal identifiers were anonymized.

3.5 Analytical Techniques
3.5.1 Content Analysis (Official Reports)

Reports were coded deductively based on a framework of digitalization practices (e.g., smart ticketing, carbon tracking software) and sustainability outcomes (e.g., emissions reduction, waste management). Cross-case comparison identified convergences and divergences in strategies.

3.5.2 Text Analysis (Media and Social Media)

Sentiment Analysis: Posts were classified as positive, negative, or neutral toward digital-sustainability initiatives. Topic Modeling (LDA): Themes were extracted to identify dominant public concerns (e.g., environmental legitimacy, digital convenience, skepticism).Triangulation: Findings from public discourse were compared with institutional narratives to reveal perception gaps. Comparative Framework: A matrix was constructed to compare cases across three dimensions. Digitalization inputs (technologies adopted).Sustainability outputs (carbon reduction, waste minimization, renewable energy).Stakeholder perceptions (media and fan discourse).

3.6 Validity and Reliability

Data Triangulation: Multiple sources (official reports, media, social media) were used to validate findings. Coding Reliability: Two independent coders conducted content analysis; intercoder reliability exceeded 0.80 (Cohen's Kappa).Transparency: All documents and datasets are archived and available upon request to ensure replicability.

3.7 Ethical Considerations

This study complies with ethical guidelines for secondary data research. Official documents were publicly available. Media articles were cited appropriately. Social media data were anonymized, and only content in the public domain was analyzed. No personal or sensitive information was collected.

4. Findings

4.1 World Athletics 2024 Events

The 2024 season of World Athletics marked a significant advancement in aligning event operations with the Athletics for a Better World (ABW) Standard. Events such as the World Indoor Championships and the Bislett Games disclosed detailed sustainability metrics, highlighting reductions in single-use plastics, waste diversion rates exceeding 65%, and the adoption of digital ticketing platforms that replaced paper-based entry systems (Yilmaz & Karadayi-Usta, 2025). These digital systems reduced administrative costs and contributed to measurable decreases in paper consumption.

Digital monitoring tools also enhanced the accuracy of carbon accounting. For instance, travel-related emissions were tracked using standardized calculators, enabling more precise assessments of athlete and spectator mobility patterns (Tan et al., 2025). While progress was evident, challenges persisted in harmonizing reporting practices across different host cities, with variations in data quality and transparency limiting cross-event comparability (Romanova, 2024).

4.2 Formula One 2023 Impact Report

The Formula One 2023 Impact Report provided evidence of the sport's strategic embrace of sustainability within a high-emission context. F1's commitment to achieving Net Zero Carbon by 2030 was supported by a suite of digital innovations, including logistics optimization software that reportedly reduced freight emissions by 12% year-on-year, and smart sensors monitoring fuel efficiency during races (POGGI, 2023). Moreover, the integration of blockchain-based fan engagement initiatives was positioned as both a commercial and environmental innovation, as blockchain systems like Tezos NFTs claim to be significantly less energy-intensive than traditional digital assets (Malamas et al., 2024).

Despite these advances, critical evaluations of F1 have questioned whether such measures constitute substantive sustainability or are instances of greenwashing. Sturm et al. (2025) argue that while reporting transparency has improved, contradictions remain between F1's partnerships with fossil-fuel sponsors and its sustainability rhetoric. This tension underscores the difficulty of achieving genuine twin transformation in resource-intensive sports.

4.3 Comparative Analysis

A cross-case comparison reveals both convergences and divergences in the digital-sustainability nexus.

Convergences:

(1) Both organizations employ digital monitoring tools for carbon accounting and performance evaluation.
(2) Both leverage digital platforms for fan engagement, with sustainability messaging embedded in communication strategies.
(3) Both cases illustrate the potential for twin transformation, where digitalization enables measurable environmental outcomes.

Divergences

(1) Scale of Operations: World Athletics applies sustainability standards across decentralized events, creating challenges in harmonization. In contrast, F1 benefits from centralized governance, enabling consistent metrics but within a high-emission sport.
(2) Legitimacy and Criticism: World Athletics enjoys relative credibility in its sustainability claims, while F1 faces accusations of greenwashing due to its reliance on carbon-intensive activities.
(3) Technology Integration: F1 demonstrates more advanced digital applications (e.g., logistics software, blockchain fan assets), whereas World Athletics focuses primarily on digital ticketing and standardized reporting.

4.4 Text Analysis of Public Perceptions

Analysis of 2,000 social media posts (1,000 each for World Athletics and F1) revealed notable contrasts in public sentiment.

World Athletics 2024:Positive sentiment (62%) highlighted appreciation for paperless ticketing and recycling initiatives. Neutral sentiment (28%) often consisted of general commentary on event performance rather than sustainability. Negative sentiment (10%) criticized limited transparency, particularly regarding travel emissions.

Formula One 2023:Positive sentiment (48%) focused on digital innovations such as logistics optimization and renewable energy use at circuits. Negative sentiment (35%) strongly criticized sponsorship ties to fossil fuel companies, framing sustainability measures as insufficient. Neutral sentiment (17%) reflected spectator interest unrelated to sustainability.

These findings align with prior research suggesting that digitalization in sports can enhance transparency and fan engagement, but cannot fully compensate for contradictions in sustainability strategy.

4.5 Synthesis

The findings suggest that digitalization is a necessary but not sufficient condition for achieving sustainable outcomes in sports events. While digital tools enable better monitoring, transparency, and fan participation, their effectiveness is mediated by broader organizational and structural factors. For federations like World Athletics, the challenge lies in standardizing reporting across diverse contexts. For high-emission sports like Formula One, the challenge is reputational, where digital innovations are overshadowed by the inherent environmental costs of the sport.

Together, these insights reinforce the relevance of the twin transformation framework, illustrating both its potential and its limitations when applied to global sports events.

5. Discussion

This study examined how digitalization empowers sustainability in sports events through the lens of twin transformation, focusing on World Athletics 2024 and the Formula One 2023 Impact Report. The findings suggest that digital technologies provide important enablers for green management, particularly through more accurate carbon accounting, reduced paper consumption, and logistics optimization. These results are consistent with Hammerschmidt et al. (2025), who highlight the role of digital systems in enhancing efficiency and accountability in sustainability strategies.

However, the comparative analysis reveals that the effectiveness of digitalization is highly context-dependent. For World Athletics, digital measures such as ticketing and standardized calculators were modest but contributed to relatively high legitimacy, with positive public sentiment reaching 62%. In contrast, Formula One deployed advanced tools-including blockchain engagement and smart logistics-but faced significant criticism, with 35% of online commentary highlighting contradictions between sustainability rhetoric and fossil-fuel sponsorships. This aligns with Næss & Tickell (2024), who describe the "green transition paradox" in motorsport, where reputational risks often undermine technological progress.

The divergence between cases underscores that digitalization alone cannot guarantee sustainability. Instead, it operates as a conditional driver: its effectiveness depends on organizational governance structures and the inherent environmental intensity of the sport. For federated organizations such as World Athletics, the main challenge is harmonizing reporting practices across decentralized events. For Formula One, the challenge lies in overcoming structural legitimacy risks that technology cannot resolve. As Sun et al. (2025) argue, transparency through digital systems must be supported by coherent sustainability strategies to avoid accusations of greenwashing.

From a theoretical standpoint, this study extends the twin transformation framework by showing how digitalization functions as both a direct enabler (e.g., paperless operations) and an indirect enabler (enhancing transparency and fan engagement). Practically, the results suggest that event organizers should leverage digital tools strategically: federations should focus on standardized reporting systems, while carbon-intensive sports must address the contradictions that undermine their legitimacy.

In sum, digitalization is a powerful but insufficient mechanism for sustainable event management. Only when paired with credible governance and authentic environmental commitments can twin transformation achieve its full potential in the global sports industry.

Acknowledgments
We are grateful to all respondents who participated in this study.

Funding
There is no fundings for this work.

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