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Green Digital Marketing in 5.0 era: Today, *State-of-The-Art* and Future Research Trends

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Abstract. The Society 5.0 era is transforming green digital marketing into a smart, human-centered, and ethically oriented strategy. This study aims to map the current state, *state-of-the-art*, and future research trends through a systematic literature synthesis for the 2019–2024 period. The findings show that the implementation of disruptive technologies delivers measurable results: AI achieves 98.7% accuracy in environmental attitude classification through *green nudging*, while Blockchain improves supply chain visibility by up to 50%. Furthermore, Digital Twins can reduce operational costs by 15–30% through accurate life cycle assessments (real-time LCA). The study also highlights the crucial role of *Multi-Criteria Decision Making* (MCDM) methods such as AHP, ANP, and ISM in aligning complex economic and sustainability criteria. Despite significant technical advances, research gaps remain on AI ethical frameworks, consumer data privacy in the IoT ecosystem, and the lack of standardized KPIs for the digital circular economy. The study concludes that transparent and ethical technology integration is key to building sustainable brand equity in the Society 5.0 era.

Keywords: Green Digital Marketing, Society 5.0, Artificial Intelligence, Blockchain, Circular Economy

I. Introduction

The global transition towards Society 5.0 has brought about a paradigm shift in the interaction between technology, society and the environment (T. Kaur, 2023). The concept of Society 5.0, rooted in Japan's strategic vision, proposes a super-intelligent society where the integration of cyber and physical space aims not only for industrial efficiency, but also to improve human well-being and environmental sustainability holistically (Negi et al., 2024; Oshadi Karunanayaka et al., 2024a). In this landscape, green digital marketing is evolving beyond just basic digital initiatives (Chygryn et al., 2026). Green marketing in this era is transforming from the operational approach of Green Marketing 4.0, which focuses on scalability through social media and websites, to the Green Marketing 5.0 paradigm which is human-centered, ethically oriented, and driven by stakeholder values (Bakator et al., 2024; Chatterjee & Dun, 2025).

The main driving force behind this evolution is the adoption of disruptive technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data, and Blockchain (Gonchar et al., 2026; S. Kumar et al., 2025; Sagar et al., 2026; Soni & Bala Kaushik, 2026). These technologies enable organizations to optimize resources in real-time and create more personalized and in-depth consumer engagement. For example, the use of AI in green nudging strategies has demonstrated up to 98.7% accuracy in classifying consumers' environmental attitudes, enabling more precise and effective ecological messaging (Arslan et al., 2025a; Naim, 2025a; Sohaib et al., 2025a). Additionally, the integration of Blockchain and IoT in the global supply chain has increased operational visibility by 50%, significantly reducing traceability errors and waste in the distribution process (Camel et al., 2024a; Usharani et al., 2026).

However, the integration of these advanced technologies also presents complex ethical and operational challenges. The use of AI in marketing often faces the risk of algorithmic bias and a lack of transparency, which in turn can fuel digital greenwashing and undermine consumer trust (Benjelloun & Kabak, 2024; Naim et al., 2024). In addition, the massive collection of environmental data through IoT devices raises serious concerns regarding consumer privacy and data security, especially under evolving regulatory frameworks such as GDPR and the EU AI Act (Erdemir et al., 2020; Frank & Kuijper, 2020). These challenges demonstrate that technological innovation alone is not enough; a robust and transparent governance framework is needed to ensure that sustainability goals are not sacrificed for digital advancement.

Despite rapid progress in technology implementation, current literature shows a significant gap in the standardization of Key Performance Indicators (KPIs) to measure the impact of the digital circular economy on long-term brand equity (Agarwal et al., 2025; Martín-Cervantes et al., 2025; Strycharz et al., 2025). Most theoretical frameworks are still fragmentary and require empirical validation across cultural contexts and emerging markets (Naraločnik, 2025). In this environment of uncertainty, multi-criteria decision-making (MCDM) methods such as AHP, ANP, and ISM become crucial instruments for decision-makers

to balance often conflicting economic, social, and environmental criteria (Anil Kumar et al., 2025a; Prasad & Chakrabarty, 2024a; Veale et al., 2018).

This study aims to provide a comprehensive overview of the current state of green digital marketing in the 5.0 era, dissecting state-of-the-art technological advancements, and identifying pressing future research trends. By synthesizing recent developments from the Scopus AI database, this paper offers an integrative perspective that links technological efficiency with ethical responsibility. By mapping research gaps and proposing a future agenda, this work is expected to serve as a strategic guide for academics and practitioners in building a marketing ecosystem that is not only digitally intelligent but also substantially sustainable.

II. Literature Review

The evolution of green digital marketing towards the era of Society 5.0 represents the convergence of advanced digital technologies, sustainability imperatives, and human-centered innovation. Society 5.0 envisions a smart society where digital transformation and social innovation are integrated to address complex environmental challenges. In this context, green digital marketing is no longer simply about using basic digital tools for operational efficiency, but is shifting to a more ethical and transparent paradigm.

2.1 Paradigm Evolution

From Green Marketing 4.0 to 5.0 Green Digital Marketing 4.0 focuses on operational scalability and the use of basic information technology tools such as social media to convey environmental messages (D. Kumar et al., 2025; Nabivi, 2025; Toichieva et al., 2025). However, the transition to the 5.0 era brings a strategic shift toward a human-centric approach that leverages intelligent technology to create a sustainable, interactive marketing ecosystem. The primary focus in this era is on stakeholder value creation, cultural sensitivity, and the integration of sustainable development goals (SDGs) (Uikey, 2026).

2.2 Disruptive Technologies in Green Marketing

Implementation of state-of-the-art technology is redefining a company's ability to promote sustainable behavior:

1. *Artificial Intelligence* (AI) and *Green Nudging*

   AI uses predictive analytics and machine learning to predict consumer behavior and personalize targeted ecological messages. Algorithmic nudging techniques such as gamification and default options have been shown to increase purchase intentions for sustainable products, with environmental attitude classification accuracy reaching 98.7% (Arslan et al., 2025b; Naim, 2025b; Sohaib et al., 2025b).

2. *Blockchain and Transparency*

   Blockchain provides an immutable record for secure tracking of goods within a circular supply chain. This integration enables real-time environmental monitoring and compliance automation through smart contracts, significantly increasing stakeholder trust and reducing the risk of greenwashing (Ansari & Zaman, 2025a; Camel et al., 2024b; Saxena & Chiu, 2023).

3. *Digital Twins (DT) for Life Cycle Assessment*

   DT replicates physical systems with real-time data to support dynamic sustainability decision-making. The use of DT in marketing enables credible verification of environmental claims through dynamically verified environmental data, thereby improving the accuracy of product life cycle assessments (LCAs) (Aouani et al., 2024; Santos et al., 2026).

2.3 Multicriteria Decision Making (MCDM) Framework

In facing the complexity of the Society 5.0 era, the MCDM method is essential for prioritizing green marketing strategies (Anil Kumar et al., 2025b; Prasad & Chakrabarty, 2024b; Sánchez-Garrido et al., 2022). Methods such as the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) are often combined with fuzzy logic to handle uncertainty and ambiguity in expert judgments regarding sustainability criteria (Demircan & Kurtul, 2025; Kahraman et al., 2023; G. Kaur et al., 2025). In addition, Interpretive Structural Modeling (ISM) and Delphi methods were used in a hybrid manner to identify key drivers of sustainability and build expert consensus on future social impacts (Shanmuga & Rithvik, 2025).

2.4 Digital Circular Economy and Equity

Brands Integrating circular economy principles into digital marketing strategies aims to reduce waste and increase resource efficiency (Paiva, 2025). Digital platforms facilitate consumer

engagement through co-creation processes that enhance long-term brand loyalty and reputation (Muhammad Sukarsono et al., 2025; Rosário & Dias, 2025; Zeng et al., 2026). However, current research still shows that there are barriers in the form of consumer skepticism and a lack of standardized key performance indicators (KPIs) to measure the impact of circularity on brand equity across the ecosystem (Agarwal et al., 2025; Martín-Cervantes et al., 2025).

III. Research Method

This study uses a qualitative approach with a *systematic literature review* and *meta-synthesis* to map the development of green digital marketing in the Society 5.0 era. The units of analysis in this study are scientific articles, empirical case studies, and cross-sector reviews published in reputable international journals. **The data selection procedure** was carried out through a search of the Scopus database with a focus on the publication period between 2018 and 2026. This timeframe was chosen to cover the development of post-GDPR regulations as well as the most recent conceptual evolution of Society 5.0. Inclusion criteria included studies discussing the integration of disruptive technologies such as *Artificial Intelligence (AI), Blockchain, and Digital Twins* in the context of sustainable marketing. **Data collection techniques** were carried out through metadata extraction covering key findings, technological benefits, key challenges, and measurable sustainability outcomes. To analyze future research trends, this study specifically evaluated literature that applied *multi-criteria decision-making (MCDM) methodologies, including the Analytic Hierarchy Process (AHP), the Analytic Network Process (ANP), Interpretive Structural Modeling (ISM), and the Delphi method.* **Data analysis techniques** involve meta-analyzing empirical research findings to determine the state-of-the-art in technology effectiveness, such as the accuracy of consumer behavior prediction and operational efficiency. Data validation is performed through triangulation of findings from various disciplines, including Marketing Management, Information Systems, Supply Chain Management, and Environmental Engineering, to ensure the objectivity and comprehensiveness of the resulting synthesis.

The research stages are as follows: **Research Stages: Green Digital Marketing in the 5.0**

Table 1. Research Stages

No.	Research Stages	Description	Target	Output
1	**Identification and Scope Determination**	Defining the evolution of marketing from the 4.0 to the human-centered 5.0 era.	Identifying theoretical gaps and current sustainability challenges.	Problem formulation and research limitations (2018–2026).
2	**Data Collection (Literature Search)**	A systematic search on the Scopus database using the keywords AI, Blockchain, and Digital Twins.	Collecting journal articles, empirical case studies, and cross-sector reviews.	A reputable international article metadata dataset.
3	**SOTA Synthesis & Technology Analysis**	Conducting a meta-analysis on the effectiveness of disruptive technologies in green marketing.	Evaluate measurable outcomes such as behavioral accuracy (98.7%) and supply chain visibility (50%).	Comparison matrix of the impact of technology 5.0.
4	**Methodological Analysis (MCDM)**	Evaluating the application of AHP, ANP, ISM, and Delphi methods in marketing strategies.	Determining priority sustainability criteria and expert consensus.	Hybrid Decision Framework.
5	**Formulating a Future Research Agenda**	Identifying ethical issues of AI, data privacy (GDPR), and standardizing digital circular KPIs.	Provides recommendations for longitudinal studies and cross-cultural validation.	Green digital marketing research roadmap for the 5.0 era.

IV. Results and Discussion

4.1 Results

a. Evolution of Marketing Paradigms

The evolution of green digital marketing reflects a broader societal shift toward sustainability, driven by the convergence of digital transformation and environmental imperatives. Research findings indicate that this paradigm has evolved from basic digital initiatives to a highly integrated approach in the era of Society 5.0 (Chygryn et al., 2026; Ramírez-Márquez et al., 2024).

Green Marketing 4.0 is characterized by the integration of basic digital tools such as information and communication technology (ICT), web, and social media to expand the reach of environmental messages and improve operational efficiency (D. Kumar et al., 2025; Nabivi, 2025; Toichieva et al., 2025; Uikey, 2026). At this stage, marketing efforts often remain siloed with limited personalization and transparency. The primary focus is on operational scalability and reducing the environmental footprint through digital tools. The transition to Society 5.0 marks a shift toward Green Marketing 5.0, where marketing becomes a strategic imperative that leverages advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Big Data, and Blockchain. Society 5.0 emphasizes the fusion of cyber and physical spaces to create a super-intelligent society that prioritizes human well-being and sustainability (Chygryn et al., 2026; Hashimova, 2024). In the 5.0 paradigm, better consumer engagement is achieved through real-time data collection, predictive personalization, and greater supply chain transparency.

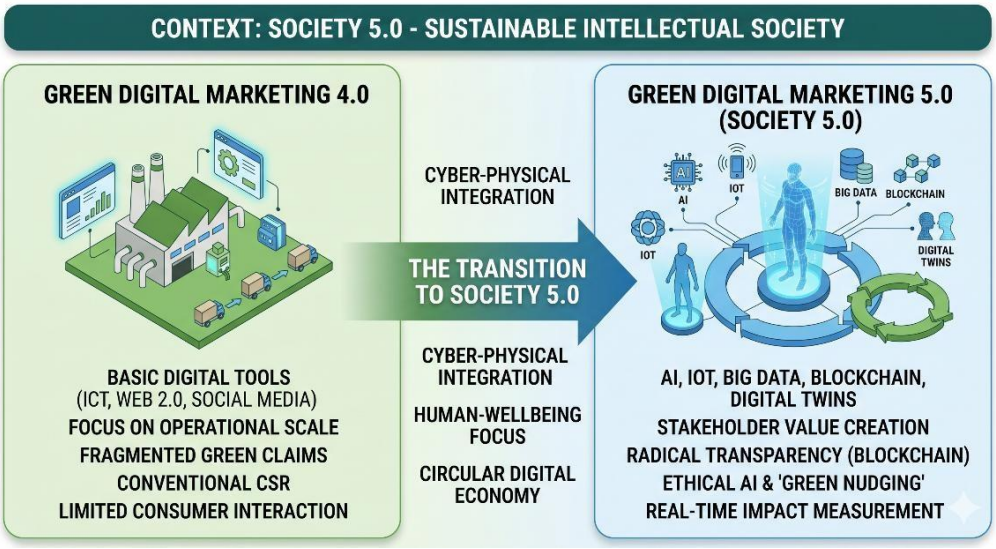

Figure 1. Evolution of Marketing Paradigm 4.0 to 5.0

The fundamental difference between these two paradigms lies in their strategic orientation. While Green Marketing 4.0 focuses on scalability and operational eco-innovation, Green Marketing 5.0 places greater emphasis on human-centered values, digital ethics, and stakeholder value creation (Movahed et al., 2024; Soni & Bala Kaushik, 2026). In addition, transparency in the 5.0 era has been supported by Blockchain technology, which allows real-time supply chain tracking compared to basic reporting in the previous era (Ansari & Zaman, 2025a; Chibaro et al., 2026).

Systematically, the evolution of this paradigm is summarized in the following table:

Table 1. Comparison of Characteristics of Green Marketing 4.0 and 5.0

Dimensions	Green Marketing 4.0	Green Marketing 5.0 (Society 5.0)
Technology Focus	Basic digital tools such as ICT, web and social media.	Advanced technologies include AI, IoT, Big Data, Blockchain, and AR/VR.
Strategic Orientation	Operational scalability and eco-innovation.	Human-centric, ethical, and stakeholder value-driven.
Consumer Engagement	Basic digital interaction and personalization.	Predictive, real-time, emotional, and immersive.
Transparency & Traceability	Limited to basic reporting.	Blockchain based with high supply chain transparency.
Ethical & Cultural Dimensions	Focusing on CSR and environmental responsibility in general.	Emphasizes digital ethics, cultural sensitivity, and alignment with the SDGs.
Sustainability Metrics	Fundamental carbon and waste reduction.	Measurable, real-time, multidimensional metrics.
Governance and Risk	Greenwashing risks and basic compliance.	Focus on data privacy, ethical AI, and strong governance

The synthesis of these findings suggests that the evolution from Green Marketing 4.0 to 5.0 is not simply the adoption of new digital tools, but rather a strategic transformation that combines technological innovation with ethical responsibility and human values to create measurable environmental impact.

b. Disruptive Technology Performance Marketing

The implementation of disruptive technologies in green digital marketing during the 2019-2024 period demonstrated significant and measurable performance results in supporting sustainability strategies. Based on data analysis, key technology performance can be grouped into three main domains: Artificial Intelligence (AI), Blockchain, and Digital Twins.

1. *Artificial Intelligence (AI) Performance in Green Nudging*

   The application of AI in green marketing strategies has evolved through the use of advanced methods such as Random Forests, Deep Neural Networks, and Reinforcement Learning to predict environmentally friendly consumer behavior (Muduva & Kiwa, 2025). The analysis results show that the AI algorithm is able to achieve an accuracy level of 98.7% in classifying consumer environmental attitudes (Sofia & Hassan, 2025). Additionally, the use of Explainable AI (XAI) through methods such as SHAP and CatBoost has been shown to increase consumer trust by providing interpretable and actionable insights regarding green product recommendations (Panwar et al., 2025). AI-driven personalized ecological messaging has also been reported to increase sustainable purchasing intentions as well as overall brand loyalty.

2. *Blockchain Performance in Supply Chain Transparency*

   Blockchain technology makes a crucial contribution in creating an immutable track record to verify compliance with environmental standards (Ansari & Zaman, 2025b). Empirical data shows that the implementation of Blockchain integrated with IoT has resulted in an increase in supply chain visibility of up to 50% (Sowmya et al., 2024). Furthermore, this technology successfully reduces traceability errors by 35% (Usharani et al., 2026). The use of smart contracts also improves operational efficiency by automating contract execution and sustainability compliance verification, particularly in the food and fashion sectors (Shukla, 2024).

3. *Performance of Digital Twins in Life Cycle Assessment (LCA)*

   Digital Twins have emerged as a powerful tool for conducting real-time product lifecycle assessments. Studies have shown that adopting a Digital Twins-based framework has resulted in a 15% to 30% reduction in operational costs (OPEX). Furthermore, this technology contributes to a 20% reduction in capital costs (CAPEX) through dynamic simulation and resource optimization. In the retail sector, the use of Digital Twins facilitates the creation of zero-waste value chains by providing actionable data for logistics and marketing decisions. This performance directly strengthens the credibility of green marketing communications by providing verified and dynamic environmental data, while also serving as a key instrument in combating greenwashing practices (Ansari & Zaman, 2025b; Shukla, 2024; Sowmya et al., 2024; Usharani et al., 2026).

Figure 2. Disruptive Technology Performance (2019-2024)

A synthesis of the performance results of these disruptive technologies is presented in Table 2 to provide a comparative overview of the benefits and measurable results achieved.

Table 2. Summary of Disruptive Technology Performance (2019-2024)

technology	Measurable Performance Results	Strategic Benefits
Artificial Intelligence (AI)	Environmental attitude classification accuracy 98.7%	Predictive personalization and increased trust through XAI
Blockchain	50% increase in supply chain visibility; 35% reduction in traceability errors	Radical transparency and mitigation of green claims fraud
Digital Twins	15-30% reduction in operational expenditure; 20% reduction in capital expenditure	Real-time LCA accuracy and greenwashing prevention

4. MCDM Methodology Trends

Literature analysis shows that multi-criteria decision-making (MCDM) methods have become essential tools for prioritizing strategies and evaluating green digital marketing performance. There is a clear shift from traditional methods to hybrid models and fuzzy extensions to manage complexity and uncertainty in the Society 5.0 era (Shukla, 2024).

a. Hybridization and Fuzzy Extension

Hybrid models such as AHP-TOPSIS and Fuzzy AHP are the most widely adopted approaches to evaluate sustainability criteria and optimize marketing mix decisions (Anil Kumar et al., 2025a, 2025b; Sánchez-Garrido et al., 2022). The use of fuzzy logic (such as Pythagorean Fuzzy AHP and Spherical Fuzzy AHP) is specifically applied to overcome ambiguity in expert judgment and handle data uncertainty. The Analytic Network Process (ANP) method is also widely used to model interdependencies and feedback between criteria in complex digital ecosystems. Meanwhile, Interpretive Structural Modeling (ISM) is utilized to map hierarchical relationships and prioritize key drivers of sustainability in the supply chain (Demircan & Kurtul, 2025; Kahraman et al., 2023; G. Kaur et al., 2025; Management Association, 2016).

b. Integration of Society 5.0 Technology in the MCDM Framework

Recent trends indicate a growing integration of MCDM methodologies with Society 5.0 technologies such as AI, IoT, Big Data, and Large Language Models (LLMs). The addition of AI and machine learning components to MCDM frameworks enables organizations to perform precise forecasting, optimize resources, and evaluate strategies more efficiently. The use of LLMs is even being explored for AI-based

criteria extraction and context-sensitive expert systems. These hybrid MCDM-AI models support real-time, dynamic decision-making, which is crucial for operationalizing Society 5.0 principles in green marketing (Anil Kumar et al., 2025b; Demircan & Kurtul, 2025; Kahraman et al., 2023; G. Kaur et al., 2025; Sánchez-Garrido et al., 2022).

c. *Delphi Integration for Expert Consensus*

The Delphi method is often integrated with other MCDM methods to achieve robust expert consensus in uncertain environments. Hybrid frameworks such as Delphi-Fuzzy DEMATEL or Delphi-AHP are used to identify, validate, and weight sustainability criteria before the prioritization process is carried out (Aghayari et al., 2022; Zamani, 2023). This integration ensures that the resulting green digital marketing strategy has high contextual relevance and is supported by comprehensive expert validation.

This synthesis of methodological trends suggests that hybridization between traditional decision-making techniques and smart technologies is key to addressing the complexities of future green marketing strategies.

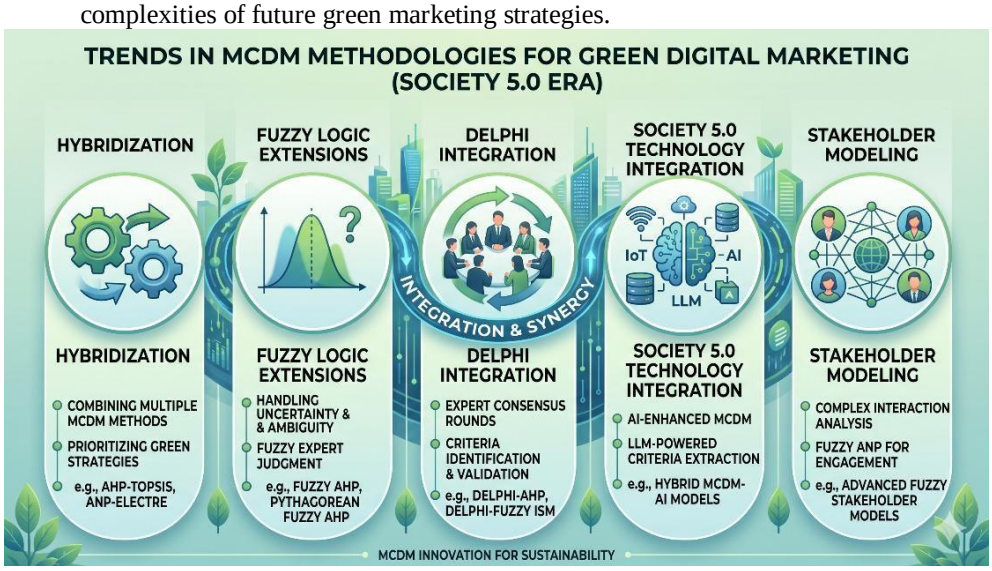

Figure 3. MCDM Methodology Trends in Green Digital Marketing in the Society 5.0 Era

Table 1. MCDM Methodology Trends in Green Digital Marketing

No.	Methodology Trends	Description and Characteristics	Related Methods
1	**Hybridization**	Combining multiple MCDM methods to prioritize green marketing strategies by integrating sustainability criteria and digital transformation criteria simultaneously.	AHP-TOPSIS, ANP-ELECTRE, Hybrid MCDM-Machine Learning.
2	**Fuzzy Logic Extension**	Used to handle uncertainty, ambiguity, and subjectivity in expert judgment, which is crucial in the dynamic digital marketing 5.0 environment.	Fuzzy AHP, Fuzzy ANP, Pythagorean Fuzzy AHP, Spherical Fuzzy AHP.
3	**Delphi Integration**	Involves gathering expert consensus through iterative rounds to identify and validate relevant criteria before weighting strategies.	Delphi-AHP, Delphi-Fuzzy ISM, Delphi-Fuzzy DEMATEL.
4	**Society 5.0 Technology Integration**	Embedding intelligent technologies (AI, IoT, Big Data, LLM) into decision frameworks to improve forecasting accuracy and marketing resource optimization.	AI-Enhanced MCDM, LLM-powered criteria extraction, Hybrid

			MCDM-AI models.
5	**Stakeholder Modeling**	The use of advanced models to analyze complex and dynamic interactions among various stakeholders in the digital marketing ecosystem.	Fuzzy ANP untuk *stakeholder engagement*, advanced fuzzy models.

4.2 Discussion

a. Implications of Human-Centricity

The concept of human-centricity in green digital marketing in the 5.0 era signifies a fundamental shift from a focus on pure industrial efficiency to improving human well-being and holistic social sustainability. The findings of this study indicate that the integration of advanced technologies such as AI and IoT is no longer merely aimed at operational optimization, but rather at creating authentic engagement through innovations that mimic human interaction and strengthen emotional intelligence in marketing campaigns. The main implication of this approach is the transformation of marketing strategies, which must radically shift from a product-centric model to a more inclusive approach to creating value for all stakeholders (Chygryn et al., 2026; Ramírez-Márquez et al., 2024).

The implementation of a human-centric framework demands high levels of algorithmic transparency through Explainable AI (XAI). This is crucial for rebuilding consumer trust, often eroded by opaque digital marketing practices in the past. By providing understandable explanations of how green product recommendations are generated, organizations can mitigate the risk of skepticism and accusations of greenwashing. Therefore, human-centricity forces marketers to shift from manipulative tactics to consumer empowerment, where technology is used to provide more environmentally conscious choices without compromising individual autonomy (Arslan et al., 2025a; Humer et al., 2024; Yang et al., 2025). Furthermore, data dignity and consumer privacy are fundamental pillars in marketing ethics 5.0.

Figure 4. Implications of Human-Centricity in green digital marketing in the Society 5.0 era

The global shift towards the use of zero-party data demonstrates a greater respect for individual rights rather than simply pursuing invasive hyper-personalization (Humer et al., 2024). In the context of Society 5.0, privacy should be viewed as a strategic value-add that strengthens a brand's integrity in the public eye. By prioritizing data protection, organizations can foster long-term relationships based on principles of fairness and social accountability (Arslan et al., 2025b). Overall, the implication of this human-centricity is the imperative for companies to align digital innovation with broader social needs in order to achieve true sustainable brand equity.

Table 3. Strategic Implications of Human-Centricity in Green Digital Marketing 5.0

Implication Dimension	Strategic Description	Impact on Stakeholders
Shift in Value Orientation	The transition from a product-centric approach to human-centered value creation and social welfare.	Increase long-term loyalty and brand value through alignment with sustainable development goals (SDGs).
Empathy-Based Interaction	The use of AI technology that mimics human interaction to enhance emotional intelligence in consumer engagement.	Creating more immersive, personal, and contextually relevant customer experiences.
Radical Transparency and Ethics	Implementation of Explainable AI (XAI) and Blockchain to provide full accountability for environmental claims.	Building deep consumer trust and mitigating the risk of skepticism due to greenwashing practices.
Data Sovereignty and Dignity	Adopting the principle of Data Dignity, where personal data is treated as an extension of human identity.	Giving consumers greater control over their data through a user-centric privacy management system.
Cultural Inclusivity	Adjusting marketing algorithms to ethically respect cultural diversity and local preferences.	Ensuring green campaigns are inclusive and effective across demographic backgrounds and global regions.
Consumer Empowerment	The transparent use of Green Nudging to help consumers make environmentally friendly decisions without coercion.	Encourage voluntary, information-based, sustainable behavior change.

The explanation in this table emphasizes that in the Society 5.0 era, the success of green digital marketing is no longer measured solely by technical metrics, but rather by the extent to which the technology is able to humanize digital interactions and uphold universal ethical values.

b. The Paradox of Technology and Privacy

The integration of disruptive technologies into green digital marketing creates a strategic dilemma known as the data privacy paradox, where consumers' desire for relevant personalization contradicts their concerns about personal data protection. In the era of Society 5.0, the use of artificial intelligence (AI) for green nudging and predictive analytics relies heavily on the collection of massive, often real-time, consumer data through IoT devices. While this personalization can increase purchase intentions for sustainable products, it also increases the risk of privacy breaches, algorithmic bias, and unwanted data surveillance (T. Kaur, 2023; Oshadi Karunanayaka et al., 2024b).

The implementation of stringent regulations like GDPR and CCPA has fundamentally changed the landscape of green data collection by establishing stringent requirements regarding consent and transparency. This regulatory pressure has led to a decline in the availability of third-party data, which has in turn pushed companies to shift to first-party or zero-party data strategies, which are voluntarily shared by consumers. However, this transition creates new challenges, as marketers must balance effective personalization with compliance with consumers' autonomy and information rights. Regulatory uncertainty, particularly in emerging markets, often hinders the adoption of more transparent technologies like blockchain for privacy management (Bentotahewa et al., 2024; Mollay et al., 2026).

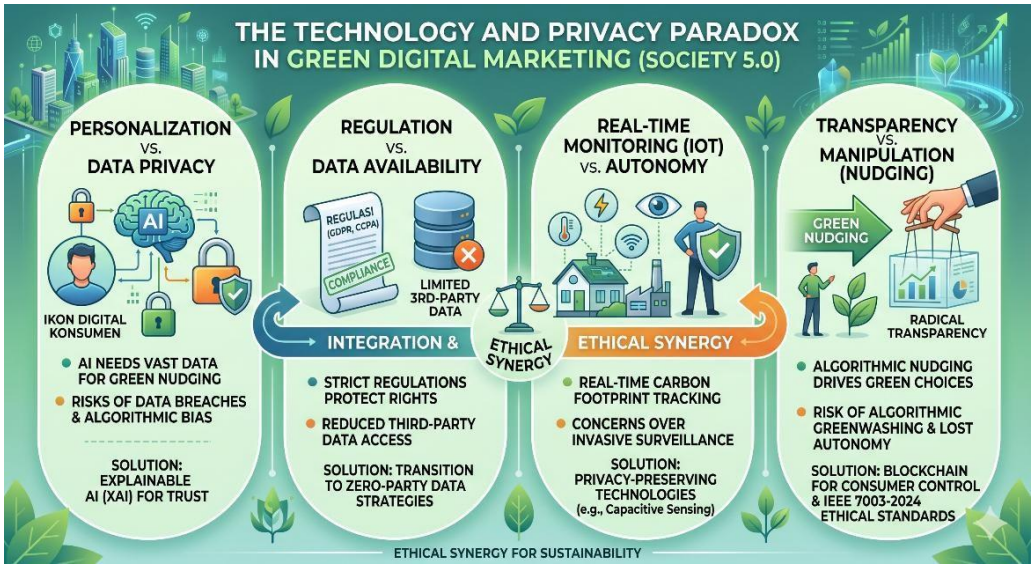

Figure 5. The Paradox of Technology and Privacy in green digital marketing in the Society 5.0 era

To address this paradox, developing a privacy-by-design (PbD) model is crucial but currently relatively rare, particularly for IoT data and real-time environmental data. This data protection by design model must balance privacy as control and privacy as confidentiality, including providing information systems that provide clear digital access rights to consumers. The use of blockchain offers a potential solution by enabling data sharing that complies with standards and is fully controlled by consumers (Veale et al., 2018). Ultimately, consumer trust in green digital marketing in the 5.0 era can only be maintained if companies are able to operationalize algorithmic transparency (XAI) and ensure that privacy is seen as an extension of personal identity, not simply a digital commodity.

Table 4. The Paradox of Technology and Privacy in Green Digital Marketing 5.0

Paradox Dimension	Description and Contradictions	Main Challenges	Future Solutions and Trends
Personalization and Data Privacy	AI's need for massive data to personalize green nudging strategies conflicts with consumers' desire for privacy protection.	The risks of data breaches, algorithmic bias, and invasive digital surveillance.	Implementation of Explainable AI (XAI) for transparency and Privacy-by-Design model.
Regulation vs. Data Availability	Strict regulations (GDPR/CCPA) protect consumer rights but reduce the availability of data for marketing and increase compliance costs.	Limitations of third-party data for accurate behavioral analysis.	The shift to a Zero-Party Data strategy (voluntarily shared data) and a consumer-centric privacy management system.
Real-Time Monitoring (IoT) vs. Autonomy	The use of IoT for real-time carbon footprint monitoring increases efficiency but intensifies privacy concerns in physical spaces.	Lack of mature privacy frameworks for IoT and sensory data.	Use of Privacy-Preserving technologies (such as capacitive sensing) and regular external audits.
Transparency vs. Nudging	*Algorithmic nudging aims to encourage green behavior, but without transparency it can be considered a form of behavioral manipulation.*	The risks of algorithm-driven greenwashing and the loss of consumer decision-making autonomy.	The use of Blockchain integration for consumer data control and AI ethics standards (such as IEEE 7003-2024).

This table shows that the success of green digital marketing in the Society 5.0 era depends heavily on an organization's ability to balance technological innovation with respect for individual privacy rights through an ethical and transparent framework.

c. c. Technology Synergy to Combat Greenwashing

The risk of greenwashing, or misleading environmental claims, remains a major obstacle to building credibility in green digital marketing. This study's findings demonstrate that the synergy between Artificial Intelligence (AI), Blockchain, and Digital Twins creates an integrated framework capable of radically validating sustainability claims. This technological convergence enables companies to shift from static reporting to dynamic, hard-to-manipulate data (Muduva & Kiwa, 2025; Panwar et al., 2025; Sofia & Hassan, 2025). By combining Blockchain transparency with the simulation capabilities of Digital Twins, organizations can provide tangible evidence of their products' environmental impact throughout their lifecycle.

Digital Twins play a crucial role in this discussion by providing a replication of physical systems powered by real-time data for Life Cycle Assessment (LCA). The use of dynamic sensory data enables real-time verification of marketing claims, significantly reducing the risk of unsubstantiated sustainability claims. When data from these Digital Twins is secured on a Blockchain network, the information becomes a permanent and immutable record, ensuring information integrity for all stakeholders (Aouani et al., 2024; A. Kumar et al., 2025; Santos et al., 2026). This synergy enhances the credibility of marketing communications by providing radical transparency that was previously difficult to achieve through conventional audit methods.

Figure 6. Technology Synergy to Combat Greenwashing in green digital marketing in the Society 5.0 era

Furthermore, the role of ethical AI, particularly through Explainable AI (XAI), is crucial in detecting misleading green advertising. Machine learning models can be used to audit marketing claims and compare them with actual environmental performance data. Creative insights from the literature suggest that a future integration of Blockchain, Digital Twins, and AI could serve as a unified green digital marketing platform that bridges the challenges of consumer engagement with supply chain accountability (Bao et al., 2025; Chaudhary, 2024). However, this discussion also emphasized that the success of this technological synergy in combating greenwashing depends heavily on standardizing data interoperability protocols and adhering to global ethical standards.

Table 5. Synergy of Disruptive Technologies in Mitigating Greenwashing

Technology Components	How Greenwashing Works	Impact on Marketing Credibility	Reference
Digital Twins (DT)	Provides dynamic simulation and replication of physical systems using real-time sensory data for Life Cycle Assessment (LCA).	Provides dynamic technical evidence to verify environmental claims accurately and objectively.	Riedelsheimer et al. (2025); Santos et al. (2026)
Blockchain	Creating immutable recordkeeping and using smart contracts for supply chain transparency.	Guaranteeing data integrity from the production stage to the consumer, thereby eliminating the opportunity for unilateral claim manipulation.	Ansari & Zaman (2025); Shukla (2024)
Explainable AI (XAI)	Using transparent machine learning algorithms to detect misleading green advertising and provide the rationale behind product recommendations.	Enables automated auditing of marketing claims and increases trust through open model interpretation.	Arslan et al. (2025); Bao et al. (2025)
Integrated Synergy (DT + Blockchain + AI)	LCA data from Digital Twins is secured in a Blockchain network and automatically audited by AI for validation without human intervention.	Creating a radical transparency platform that bridges operational accountability with trusted consumer engagement.	Naraločnik (2025); Nicolau & Petcu (2026)

This table emphasizes that the fight against greenwashing practices in the Society 5.0 era no longer relies on static manual audit mechanisms, but rather utilizes **technological synergy** to create a transparent, automated, and real data-based evidence ecosystem.

d. KPI Standardization Gap

The findings of this review highlight that while the digital circular economy is seen as a key catalyst for sustainable brand equity, this research field remains highly fragmented theoretically. One of the most crucial research gaps identified is the lack of standardized Key Performance Indicators (KPIs) to measure the tangible impact of circular marketing on long-term brand equity. The absence of uniform metrics often makes it difficult for organizations to validate the business value of their green initiatives, which in turn can fuel consumer skepticism and increase the risk of accusations of greenwashing (Martín-Cervantes et al., 2025; Oshadi Karunanayaka et al., 2024b; Saura et al., 2024). Therefore, the development of objective measuring tools is a strategic imperative to ensure accountability in the Society 5.0 era.

The primary argument for this need for standardization stems from the complexity of integrating digital and circular metrics, which lack a cohesive framework. Most current measurement frameworks remain conceptual or limited to specific case studies, thus lacking cross-industry generalizability. This gap demonstrates that the advancement of disruptive technologies like AI and Blockchain for transparency has not been matched by comprehensive impact measurement tools across the ecosystem (Martín-Cervantes et al., 2025; Oshadi Karunanayaka et al., 2024b; Saura et al., 2024). A systematic effort is needed to align green marketing KPIs with recognized global standards, such as GRI, SDGs, or ISO 59020, to enable comparability of research results and business practices at the international level.

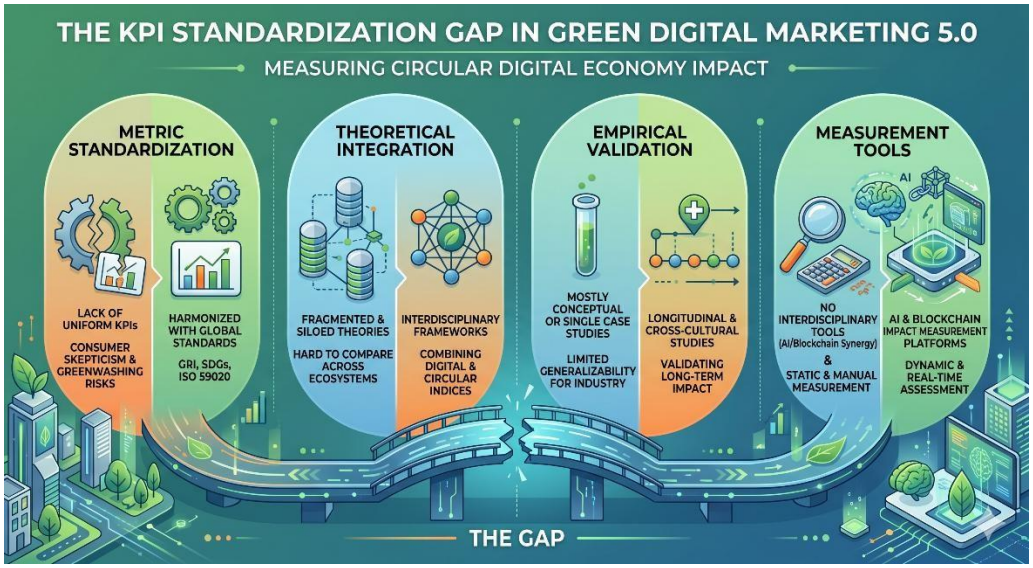

Figure 7. KPI Standardization Gap in Green Digital Marketing in the Society 5.0 Era

Furthermore, there is an urgent need for longitudinal studies capable of tracking the long-term effects of circular marketing strategies on brand loyalty and reputation in a sustainable manner. Future metrics should be able to simultaneously encompass environmental, economic, and social dimensions, including measuring the effectiveness of consumer co-creation through digital platforms. The synergy between real-time tracking technology and a holistic evaluation framework will be key to operationalizing sustainable brand equity that the public can trust (Bogdan et al., 2025; Khedmati-Morasae et al., 2024). By addressing this KPI standardization gap, green digital marketing can transform from mere communication claims to tangible, universally verified sustainability results.

Table 6. Analysis of KPI Standardization Gap in Green Digital Marketing 5.0

Dimensions of Gap	Present condiition	Impact and Risk	Future Recommendations	Reference
Metric Standardization	Lack of uniform KPIs to measure the impact of circularity on brand equity.	The rise of consumer skepticism and difficulties in validating green claims (greenwashing).	Alignment of metrics with global standards such as GRI, SDGs, and ISO 59020.	Agarwal et al. (2025); Ferrante et al. (2025)
Theoretical Integration	Theoretical frameworks remain fragmented and often siloed.	Difficulties in making cross-sector and cross-ecosystem comparisons.	Development of an interdisciplinary framework that combines digital and circular indexes.	Khedmati-Morasae et al. (2024); Martin-Cervantes et al. (2025)
Empirical Validation	Most models are still conceptual or based on single case studies.	Limitations of generalization of research results to large-scale industrial practice.	There is a need for longitudinal studies and cross-cultural validation to measure long-term impacts.	Zeng et al. (2026); Paiva (2025)
Measuring Tools	The absence of interdisciplinary measuring tools to assess technological synergies (AI/Blockchain).	Sustainability impact measurement is not done automatically and in real-time.	Development of an impact measurement platform using AI and Blockchain smart contracts.	Zeng et al. (2026); Paiva (2025)

e. Methodological Contribution

The results of this study provide a significant methodological contribution by highlighting the shift from conventional decision-making techniques to hybrid and intelligent models in the green digital marketing ecosystem. The use of hybrid Multi-Criteria Decision Making (MCDM) methods, such as the integration of AHP-TOPSIS and Fuzzy AHP, proves to be a much more robust instrument for addressing the complexity of overlapping sustainability and digital transformation criteria. The main contribution of these findings is the affirmation that the hybrid approach is able to mitigate the limitations of a single method in addressing criteria interdependence and expert subjectivity, which are key characteristics of the marketing environment in the Society 5.0 era.

The application of fuzzy logic extensions (such as Pythagorean Fuzzy and Spherical Fuzzy) within the MCDM framework offers methodological advancements in addressing data uncertainty and ambiguity often encountered in environmental impact assessments. Unlike traditional deterministic approaches, the use of fuzzy logic enables researchers and practitioners to capture the complex nuances of human perceptions of sustainability values. This is particularly relevant in the context of the human-centricity of Society 5.0, where marketing decisions are based not only on financial metrics but also on qualitative estimates of social welfare and digital ethics.

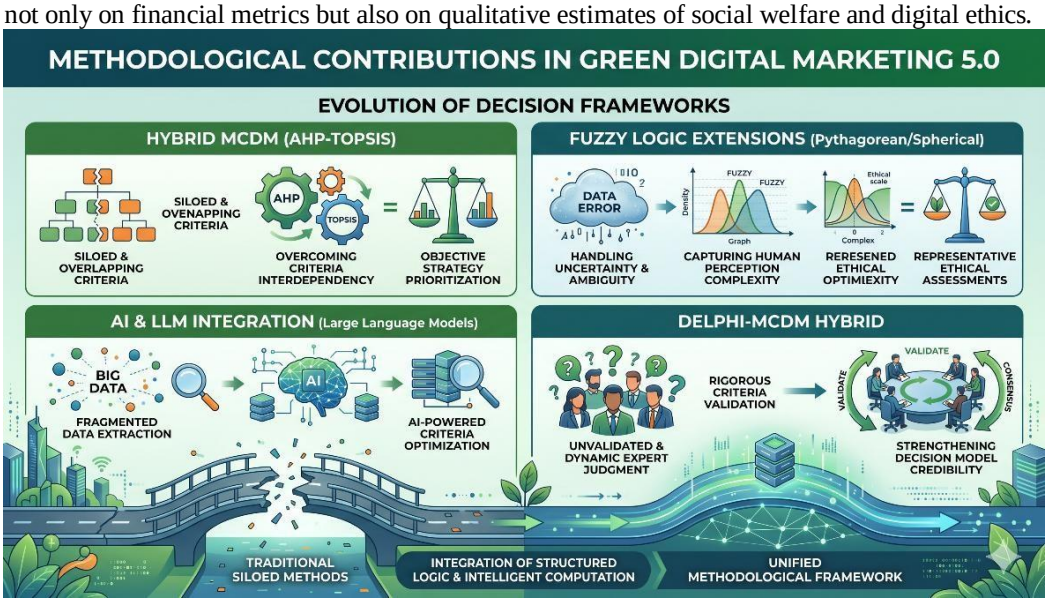

Figure 8. Methodological Contributions in green digital marketing in the Society 5.0 era

The most progressive methodological innovation identified in this study is the integration of Society 5.0 technologies, such as AI and Large Language Models (LLMs), into the MCDM framework. The use of AI for automated criteria extraction and an LLM-based expert system provides unprecedented efficiency in formulating context-sensitive green marketing strategies. This integration bridges the gap between big data analysis and systematic decision-making structures, enabling real-time and adaptive strategy validation.

Finally, the combination of the Delphi method with MCDM (such as Delphi-Fuzzy DEMATEL or Delphi-ISM) contributes to strengthening the validity of expert consensus in a dynamic research environment. This hybrid methodology ensures that key sustainability drivers are hierarchically identified and validated through rigorous iterative cycles before being implemented in marketing campaigns. Overall, these methodological contributions emphasize that achieving accuracy in green digital marketing in the 5.0 era requires a synergy between structured human decision-making logic and intelligent computing power.

Table 7. Methodological Contributions in Green Digital Marketing 5.0 Research

Methodological Innovation	Advantages Compared to Traditional Methods	Impact on Research Quality	Main References
MCDM Hybridization (AHP-TOPSIS/ANP)	Able to model interdependencies and feedback between complex criteria.	Increase the objectivity and sharpness of green marketing strategy priorities.	Kumar et al. (2025); Taherdoost & Madanchian (2023)
Fuzzy Logic Extension	Managing the ambiguity and uncertainty of human judgment mathematically.	Provides more representative evaluation results of consumer ethical perceptions.	Al Lawati et al. (2026); Görçün et al. (2025)
Integration of AI and LLM	Criteria extraction and decision optimization are performed automatically and based on big data.	Enables dynamic, real-time, evidence-based decision making.	Ardebili et al. (2025); Vatin et al. (2024)
Delphi-MCDM Hybrid	Ensuring the validity of expert consensus through a structured iteration process.	Strengthen the logical foundation and credibility of the decision model being built.	Ashour & Mahdiyar (2024); Sánchez-Garrido et al. (2022)

V. Conclusion

This study concludes that the transformation towards **Green Digital Marketing 5.0** in the Society 5.0 era marks a paradigm shift from technical efficiency to a human-centric and ethical approach. The synergy of disruptive technologies such as **AI, Blockchain, and Digital Twins** has been empirically proven to increase behavioral prediction accuracy by up to 98.7% and supply chain transparency by **50%**. Methodologically, the use of a hybrid **MCDM-AI** model provides a more objective and adaptive decision-making framework to future environmental data uncertainty.

The study's primary contribution is the formulation of a sustainability strategy that balances technological sophistication with data dignity and social well-being. However, a critical gap is identified in the standardization of global KPIs for measuring the impact of digital circularity. Managerially, companies are urged to adopt radical transparency based on real-time data to mitigate the risk of greenwashing. Future research should focus on developing universal metrics and cross-cultural longitudinal studies to validate the effectiveness of green nudging. By aligning digital innovation and human values, green digital marketing will become a key pillar in realizing a sustainable, smart society.

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