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Protecting Ecosystems from Degradation from the Perspective of the Fifth Generation of the Industrial Revolution (A Marketing Reading of the Scene)

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Abstract:

This research paper addresses a contemporary marketing issue whose importance derives from the value and status of environmental sustainability, which essentially means protecting ecosystems from degradation. However, the study's unique approach is that it approaches this phenomenon against the backdrop of the dawning of the fifth wave of the industrial revolution, or Industry 5.0, and the revolutionary emerging technologies it entails, characterized by green responsibility. The research concludes that sustainable marketing, based on environmentally conscious cyber-physical systems and environmentally committed digital innovations, plays a pivotal role in combating carbon emissions and global warming, and is instrumental in containing the climate change crisis.

Keywords : Green Marketing; Sustainability; Industry 5.0; Clean Technologies
Jel Classification Codes : M30; M31; M37

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1. INTRODUCTION

The contemporary international financial and business environment is witnessing numerous radical transformations and profound developments, occurring at an unprecedentedly rapid and dynamic pace, and is expanding in an irreversible manner. These emergency situations have had a significant and tangible impact on the operations, decisions, and agendas of production institutions and industrial facilities. Among the most prominent flashpoints resulting from the administrative and organizational mobilization of stakeholders are topics and concerns of critical importance, such as Corporate Social Responsibility (CSR), Business Ethics, Corporate Governance and Citizenship, Sustainable Development, Quality of Life (QoL), etc. Among the issues emerging from the previous theses are those related to the environmental identity and natural capital of the organization. This is due to concerns about the threats of depleting natural resources, the horrific dangers of Climate Change, and fears of the damage caused by industrial waste, Global Warming, Carbon Emissions, greenhouse gases, air and water Pollution, etc. The dire consequences of these terrifying disruptions on human societies, vegetation cover, wildlife, and biodiversity, as well as the shrinking forest area, and the increase in desertification and drought. All of this is due to the greed and misuse of multinational corporations, and their perpetration of atrocities and crimes against the environment.

In this regard, many companies in countries leading in social development and economic growth have excelled in developing theories and applying them to field reality, adapting to the conditions dictated by the facts and circumstances related to Environmental Pollution. Among the clearest examples of these human innovations, which are aligned with improving Corporate Environmental Responsibility (CER) and harmonizing with the fortification of Ecosystems, we find: environmental management systems, the Circular Carbon Economy (CCE) to reduce emissions, Cleaner Production, waste Recycling, renewable and clean energy, etc. What has increased the value and priority of environmental protection for business decision-makers are those international efforts that have helped address conscience and create Environmental Awareness, such as the contributions

of the United Nations Environment Programme. In addition, the tasks assigned to it by the International Organization for Standardization (ISO), which sets strict quality standards and precise technical specifications for environmental safety. Furthermore, the civilizing role played by environmental protection and consumer rights associations, which are informal pressure groups, seek to preserve the beauty and pristine nature from the corruption and depravity of capitalist corporations, which claim and assert CER.

In this context, and without a doubt, the variables of the marketing industry are concerned with the inevitability of adapting to new developments and changes in global markets, as it is an open system that affects and is affected by the environment in which it operates. Accordingly, Sustainable Marketing was developed with its mechanisms, methodologies, and methods. It is a cumulative cognitive link in the chain of development of marketing philosophy and thought. While Green Marketing, derived from the green economy, specializes in addressing environmental problems and dilemmas, Sustainable Marketing expands to address the three dimensions of Sustainable Development (social justice, profit and wealth, and environmental protection) within the framework of CSR and Business Ethics. The marketing system faces major challenges in the field of comprehensive Sustainability in general, and Environmental Sustainability in particular. The green performance of marketing and sales activity has become at stake, so efforts and attempts have been directed towards re-engineering policies and strategies for environmentally friendly marketing and logistics mixes, and diligent work to formulate and implement green initiatives to achieve a Sustainable Competitive Advantage (SCA), especially since the transition from traditional (offline) marketing to digital (online) marketing has occurred at record speed, with qualitative leaps, and in a short period of time..

Recently, discussions have begun about the precursors to the emergence of a Fifth Generation Industrial Revolution (5.0), based essentially on advanced, hyper-digital information systems and the coexistence and integration of physical and cyberspaces. Its core and foundation are human beings, not robots, and robots are collaborative. That is, humans and machines will work in the same loop; indeed, humans are

now front and center of the production process. This aims to recalibrate the course of the Fourth Industrial Revolution, which overemphasized automation and the replacement of humans with machines. This has emboldened manufacturers and producers to rely excessively on algorithms, software, and computer hardware to increase returns on investment, maximize profit margins, and generate additional sales. This has resulted in huge social and environmental costs, depleted natural resources, and exacerbated the global climate crisis. It is imperative to rectify the trend, restore the balance between human and economic development, and explore radical solutions to social and environmental issues. Green Sustainability is one of the priorities of this critical digital juncture and decisive revolutionary turning point.

Amid this digital transformation stemming from Industry 5.0, powered by computers and IT, the adoption of AI and IoT and the embrace of other digital innovations and technologies with their tremendous potential bring significant gains, as well as significant challenges and threats. These include, but are not limited to : Generative AI, Deep Learning (DL), Natural Language Processing (NLP), Chatbots, Virtual Assistants (VA), Industrial Internet of Things (IIoT), Cloud Computing (CC), Quantum Computing (QC), 3D Printing (Additive Manufacturing), Augmented Reality (AR), Virtual Reality (VR), Blockchains (BC), and many others. These technologies have contributed significantly to the smooth transition from Quality 4.0 to Quality 5.0, from Society 4.0 to Society 5.0, and from Marketing 4.0 to Marketing 5.0. These technologies have positive effects and positive repercussions if properly utilized during this critical situation, by containing critical environmental issues and addressing complex climate crises.

The purpose of this research paper is to identify the benefits of harnessing clean and safe digital technologies, enhanced by AI and IoT, to improve the outcomes, results, and initiatives of Sustainable Marketing. Sustainable Marketing is a crucial issue today, where environmentally responsible and Sustainable Marketing can seize the opportunities available to us by Industry 5.0, which has a distinct environmental dimension. This can be achieved by introducing eco-friendly products, green brands, and customizing the experiences of environmentally literate customers who are

inclined toward green purchasing and sustainable consumption. This original paper can thus provide a theoretical framework and conceptual model from which researchers can build their academic and professional studies. This model will have a practical impact, promoting changes in consumer behavior and the purchasing decision process, with the goal of creating a more conscious and sustainable society, which will have a dramatic impact on the quality of Ecosystems. Below are the most important basic elements of the phenomenon under study and the factors influencing it.

2. Green Marketing Ambitions as A Vital Tributary to Overcoming the Constraints of Sustainability and Achieving the Aspirations of CER Amidst the Requirements of Governance and QoL

There is no doubt that the phenomenon of CSR is not a new phenomenon. Rather, it has intellectual roots deep in modern history. However, it has not matured intellectually and philosophically until recent decades (ISO 26000 standards). CSR is one of the safe administrative and organizational approaches, and distinguished panoramic methods, which aspires to help establishments voluntarily carry out and advance their humanitarian role, their cultural commitment, and their participation related to benevolence towards the environment, its geography and terrain, and the components of the natural world, and their contribution to biological, plant and animal diversity, and the quality of climate and weather, along with serious consideration of upgrading and developing competitiveness, and ensuring the generation of revenues and financial income, enhancing cash flows, and reaping material profits, i.e. economic feasibility, which is an absolute necessity and a top priority for the growth of wealth and the continuity of activity, in a balanced, consistent, and harmonious manner, and in a thoughtful, planned, and organized manner. Therefore, CSR is rooted in the blending and integration of social and relief concerns, commitments to environmental efficiency standards, and increased commercial returns and investment benefits, all of which melt into one melting pot. It is worth noting that all these interactions and connections must be considered by business boards and CEOs when measuring operational and strategic

performance, both in the short and long term. This is to prioritize the human interest of society first, then to meet stakeholder expectations, align the demands of relevant parties, and strengthen ties and connections with them, such as shareholders, donors, employees, owners, investors, the public, government, pressure groups, etc.

The quality of Business Ethics, or good ethical responsibility for companies in general, and for marketing and sales in particular, is not an emerging topic or a newly emerging concept. Rather, it is deeply rooted in the literature that addresses the influence of religious and spiritual motivations and professional conscience on the good behaviors and actions of employees and workers, enabling a business organization to achieve its goals and objectives, both quantitatively and qualitatively. It is a comprehensive system of guidance and direction within educational considerations and conventions, and it places great importance on the cultural contexts that influence human resource management and desirable organizational behavior. It avoids reprehensible traits and prohibits violations. Rejecting and abhorring deviant practices that deviate from the ethical standard and behavioral quality in business is a necessity dictated by instinct, Sharia, faith, belief, and sound reason, as they distort and harm the good reputation of the brand, such as fraud, deception, misleading, fraud, deception, etc. If subordinates' Ethics flourish, this will lead to enhanced moral capital, which will automatically improve job performance. This will be directly and tangibly reflected through word-of-mouth marketing on the organization's reputation and the brand's reputation among the public. It is no surprise that effective and efficient ethical marketing contributes to combating and combating the widespread Greenwashing and addressing all ethical issues and challenges related to protecting the earth and preserving natural resources from vandals, saboteurs, and destroyers of the beauty and pristine nature. This is especially true considering the increasing production of non-biodegradable waste, the hazardous content of materials and products, and other environmental diseases and epidemics resulting from human activity, the primary enemy of the environment.

While governments' focus has been on social development and the relentless pursuit of accelerating economic growth, government attention is shifting to environmental issues, formulating environmental policies to

reward and penalize companies, tracking their green performance based on their adherence to and compliance with environmental standards, enacting environmental laws and regulations to protect the planet from the harmful effects of pollutants, and establishing bodies dedicated to combating Environmental Degradation. All the above would not have been possible without the pressures and concerns emanating from the binding recommendations and agreements of the United Nations Environment Program (UNEP), and the follow-up, reviews, and audits of the International Organization for Standardization (ISO). Furthermore, environmental scientists warn humanity of the consequences and dangers of Environmental Pollution from all over the world, and the repeated calls and distress calls of Ecosystem protection associations and movements, working tirelessly to spread and instill Environmental Awareness, vigilance, and culture among individuals and institutions. Accordingly, considering these tense circumstances, in addition to the complex turmoil of Climate Change, the CER of companies in general, and marketing and sales management in particular, have emerged. This is a subsystem that emerged from the heart of the objectives of CSR and professional Ethics, primarily as it deals professionally with the threat of environmental problems, such as: the excessive use of fossil fuels and plastics, and the Pollution of groundwater, soil, and air, etc. In this context, adopting a socially and ethically responsible marketing approach towards natural capital, which applies environmental principles and laws, yields many important gains, at the forefront of which is building sustainable brands enhanced by Cleaner Production, leading to the acquisition and attraction of new customers, and enriching the experiences of existing customers, i.e. satisfaction, loyalty, and then a customer for life, which ensures the success of the organization in environmentally responsible entrepreneurship and achieving a lasting Green Competitive Advantage.

Discussions about comprehensive development in its three dimensions (social, economic, and environmental) are inseparable from Sustainability and continuity. The relationship is interdependent, and the bond is purely interactive. The goals and noble objectives of Sustainable Development are not merely theoretical, given their impact and repercussions on the QoL, prosperity, and flourishing. It is worth noting that human civilization is

currently facing enormous and dangerous challenges that hinder and obstruct the aspiration for development and put societal, living and health well-being at stake. At the forefront of these challenges are the pressures of Climate Change, Pollution and Environmental Degradation, which have become more global than ever before, both in terms of causes and consequences. This is due to the harm and damage inflicted by expansionist companies on the Ecosystem through the waste and toxins of carbon factories, the chaos of Greenhouse Gas Emissions, and other shortcomings and repercussions of the environmental crisis that is exacerbating it. They are, in fact, predatory and environmentally savage companies, especially multinational companies that, through their impulsive industrial behavior, seek to achieve savings in mass production and maximize net profits, regardless of their social responsibility, moral duty and environmental commitment towards planet Earth. Therefore, governments and United Nations bodies are called upon more than ever to sound the global alarm and to be strict in holding accountable, questioning and criminalizing their abusive practices, especially since the magnitude of the loss to Green Sustainability has become striking, clear, and tangible.

In the context of the previous theses, the systems and models of the green or environmental economy are aligned and interconnected with aspirations for agricultural, industrial, and service growth, and Ambitions for the sustainable use and consumption of resources and wealth in all sectors. They enhance the potential of projects and the ability of environmentally committed companies to cooperate and contribute to creating a greener, more nature-friendly world, which is being distorted, vandalized, and over-exploited. Countries that care about supporting natural capital, biodiversity, and Waste Management, and participate in the maintenance and security of complex Ecosystems, placing them at the top of their priorities and seriously, and in the forefront of their business agendas, are described as environmentally conscious economies that support clean manufacturing, Renewable Energy, and Recycling. This green transformation and the trend driven by Sustainability and protecting and fortifying the planet have fueled competition among countries. This has led to the monitoring, diagnosis, tracking, and evaluation of excellence based on environmental standards, the extent of attention paid to Climate Change and

Environmental Degradation, and the serious effort to transform and adjust the economic cycle to become more sustainable and low-carbon, and to avoid harming nature and its components, including water, air, and soil. This has also led to the establishment of the necessary controls and measures to engineer, design, and market environmentally friendly products and goods with superior competitiveness, instead of traditional products that cause environmental disasters.

In the same context, there are many international bodies interested in the green economy, which issue periodic reports and rankings:

- Green Future Index.
- Global Green Economy Index (GGEI).
- Forest Landscape Integrity Index (FLII).
- United Nations Convention on Biological Diversity (CBD).
- United Nations Convention to Combat Desertification (UNCCD).
- United Nations Framework Convention on Climate Change (UNFCCC).
- ... etc.

From a social and economic perspective, and from a point of view of environmental psychology and environmental safety, QoL is at the top of the United Nations' plans and visions in its protocols and conferences. It also occupies a significant position for countries where human development receives utmost attention and well-thought-out strategic thinking. This is due to the strong links between the quality of healthcare and medical care and Ecosystems, as well as between the education sector and environmental education, and finally, between a comfortable and happy standard of living (known as food and water security) and environmental impact. Consequently, any disruption, stress, or destruction of nature that mars its beauty and strips it of its virginity results in unsatisfactory outcomes in terms of QoL and tranquility. Governments, particularly in developed countries and emerging economies, continue to exert their utmost efforts and energies, allocating budgets and spending vast sums of money to achieve happiness, well-being, and luxury for their societies, which are thirsty and yearning for a peaceful and secure life. They have long faced, and continue to face, difficulties, obstacles, impediments, and frustrations related to Environmental Pollution and Carbon Emissions. Therefore, adopting

environmentally literate and insightful marketing, whether in the public or private sectors, is a crucial tool and an effective means to help build an ambitious, dynamic economy, characterized as low-carbon and with limited Greenhouse Gas Emissions. This will accelerate the achievement of desired Sustainable Development Goals (SDGs) and promote progress toward better QoL, the achievement and realization of the desired good QoL goals. Consequently, we conclude that there is a congruence and compatibility between Green Sustainability management and improving societal outcomes in terms of positive QoL. Companies and projects should be vigilant and aware of this duality when restructuring and redesigning their competitive strategies, reinforced by an Environmental Culture.

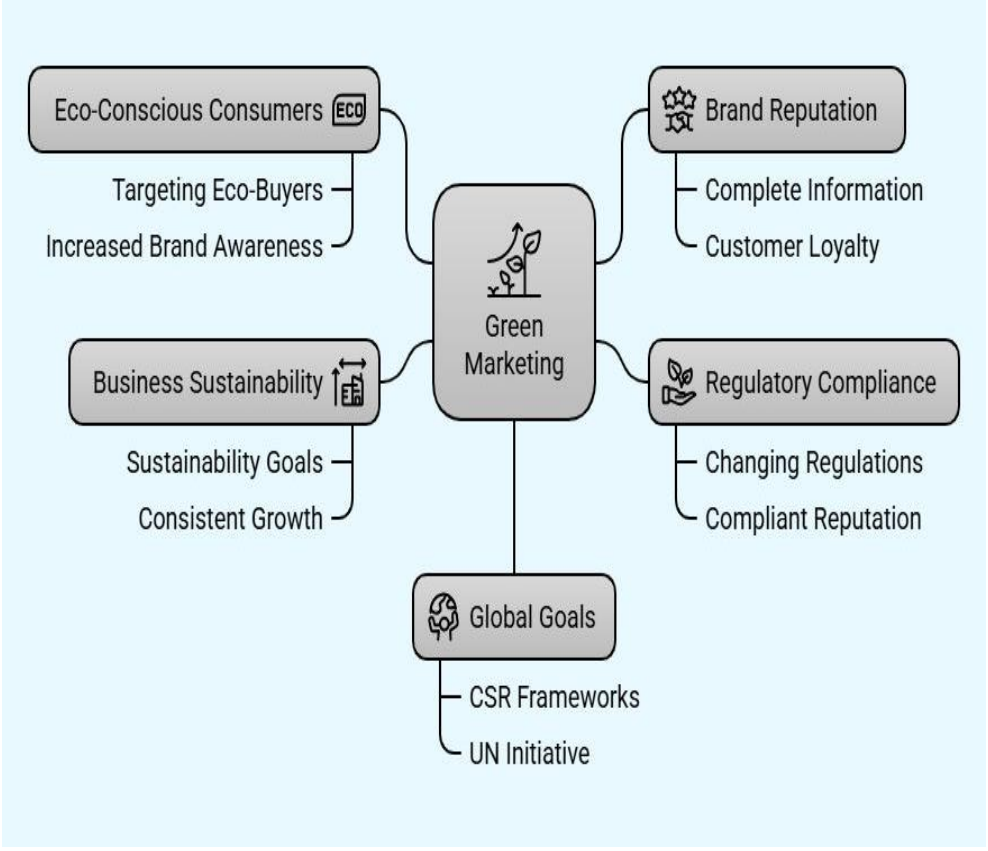
It is no secret to those interested and working in research and studies related to the approach and tools of Green Marketing, and the activation of laws and policies of good governance in their environmental context, that there are statistically significant correlations and effects between sustainable and rational marketing decision-making and the governmental efforts exerted to ensure the implementation of environmental impact governance and green accounting, i.e., the auditing and review of the inputs and outputs of economic and commercial activity in institutions, through a framework based on accountability, transparency, and environmental disclosure. There is widespread agreement on the environmental damage caused and left behind by projects and initiatives, due to the lack of compliance and environmental compliance with the rules and controls of Sustainability supported by governance, i.e., regarding the environmental standards, measures, and indicators that must be considered in manufacturing, storage, marketing, and logistics. Environmentally prudent marketing management and interests should not neglect or overlook comprehensive and regular green governance mechanisms when delineating the roadmap and marketing path with diverse programs. Creating a balance between supporting cash flow and protecting the Ecosystem, and motivating those in charge of sales and customer service, Providing them with attractive incentives for strict and strong environmental commitment, and encouraging customers to report and notify regarding behavior that violates environmental protection, and other things, is a strong competitive advantage based on the optimal exploitation of natural resources, thus providing the professional marketer

with high profit opportunities, especially since there are stakeholders and related parties that tend to deal with actors that pay great attention to internal and external supervision and control of the effectiveness of Environmental Sustainability. It is a coordinating and participatory role, and a solidarity and consultative work, between the CEO of marketing and sales and the rest of the vital functions, in the long-term horizontal and vertical movement towards more sustainable CER and Ethics.

In a related pivotal context, there are many seamless and fluid links and interactions between Green Marketing and Corporate Citizenship. This is particularly true given that today's corporate activity has become focused—voluntarily or involuntarily—on protecting the environment from Pollution and Degradation, due to the pressures and constraints imposed on corporate performance. Therefore, meeting the requirement of sound environmental practices goes hand in hand with other social, economic, legal, and ethical responsibilities. Stakeholders, including shareholders, investors, employees, suppliers, distributors, and others—have become increasingly interested and deeply concerned with topics such as green investment and financing, green human resource management, and sustainable supply chains and networks. Addressing and resolving the intractable dilemmas of environmental and biological systems is a top priority for Corporate Citizenship. From an ecological perspective, Corporate Citizenship represents a crossroads between projects offering a friendly, recyclable, and traditional product. It has become a tactical and strategic victory over competitors for dominance, influence, and supremacy in target markets. Therefore, to ensure the benefits of Green Marketing Citizenship, proactive measures must be taken regarding Sustainability, awareness of rights and duties towards the environment, and the importance of sincerely responding to the calls and cries of environmental protection associations must be highlighted, so that marketing work is exemplary, and environmentally pioneering. Accordingly, enabling marketing Citizenship that is consistent with and aligned with environmental issues and Climate Change constitutes a fundamental drive for achieving a Green Competitive Advantage, given that environmental marketing management reports are part of corporate and entity Citizenship reports in terms of Sustainability.

See: Deshmukh, P., & Tare, H. 2024; Stoian, I. C. 2024; Adae, E. K., et al. 2021; Fallah Shayan, N., et al. 2022; Dahinine, B., et al. 2024; Dahinine, B., et al. 2023; Singh, B., et al. 2025; Galan-Ladero, M. M. 2025; Zrybnieva, I., et al. 2025; Jia, H. M., et al. 2022; Thangam, D., & Chavadi, C. 2023; Mohammed Al-Dulaimi, W. A., & Hassan Al-Taai, S. H. 2021; Zhang, M., et al. 2022; D'Arco, M., & Marino, V. 2022; Agrawal, A., 2022

Fig.1. Importance of Green Marketing for Sustainability



Source: Jacob, K. 2025

3. The Future of Sustainable Marketing considering the Emergence of the Fifth Generation of the Industrial Revolution, the Fifth Wave of

Super-Intelligent Societies, and their Disruptive Technologies

From steam engines and electricity in the traditional industrial revolutions, the first, the second, and then the third electronic wave, which spawned the technological era, to automation and digital transformation in the fourth cyber revolution, a German initiative. We now stand in the new era of industrial progress on the brink of Industry 5.0, announced by the European Commission. It is unmistakable that the features of its formation were spontaneous reactions to correct the process of Industry 4.0 and address the imbalances it produced. While the orbit and backbone of Industry 4.0 was to strengthen the link between automation and digitization, the axis and pole of Industry 5.0 is to strengthen cooperation between humans and smart machines. Therefore, it is the product and creative outcome of the generative and transformative revolutions emerging over time. We can see in it the preparation of each revolution's scenario and the preparation of the groundwork for the next revolution, which are ongoing revolutionary waves. A closer look at Industry 5.0 reveals its distinct and differentiated nature from its predecessors, in that it deepens the collaborative relationship between the human mind and cognitively adaptive learning machines; strengthens the harmonious and synergistic interaction, connection, and communication between humans and automated devices; and promotes the harmonious and integrated fusion of biological and computational forces, maximizing their effectiveness and efficiency. More precisely, humans undertake creative tasks, while robots handle the rest, particularly routine and repetitive tasks. It is worth noting that the transformational wave of the cognitive industrial revolution in the fifth edition seeks to connect people and robots and make them work together, with its human-centeredness, a central element of Industry 5.0. Unlike the previous wave Industry 4.0, which did not prioritize human-machine collaboration—that is, the symbiosis and coexistence of humans and robots in smart manufacturing and critical decision-making—it paid little attention to social responsibility and justice, paid little attention to the ethical use of technology, and paid little attention to Green Sustainability. However, this does not mean that the two generations of recent industrial revolutions are in conflict or contradiction, but rather an extension. Indeed, the fifth wave is inspired by the fourth. It is an improved version, an enhanced edition, and a

modernization model. However, it arose for the purpose of overcoming the limitations and problems, and avoiding the mistakes, lapses, and loopholes found in the previous timeline.

Although the birth and emergence of an industrial revolution in its true sense requires long-term planning and preparation, the advent of Industry 5.0 in a brief flash of time following the fourth generation was considered by specialists and experts to be surprising and astonishing in terms of the economic opportunities and social challenges it presents. This is because long transitional periods between generations of innovative-driven industrial revolutions are common, lasting for considerable periods. This can be attributed to advances in human curiosity and amazing scientific imagination, as well as to the rapid pace of electronic change and technological development, which is expanding and accelerating. Meanwhile, decision-makers were focused on reaping the benefits of Industry 4.0 technologies, where the goal was to reduce human involvement and prioritize process automation. In the context of globalization, knowledge management, and the Internet, the fifth wave of successive industrial revolutions has begun to emerge. Experts in ICT, satellite technology, and the Internet have deemed it a major seismic revolution, a decisive turning point with huge consequences for international trade and e-marketing. It is also a qualitative turning point with global dimensions, addressing the complex issues of Sustainability and governments' SDGs, CSR, individual QoL, and work Ethics. These revolutions have yielded innovative computing systems and groundbreaking cloud technologies, supported by Cyber-Physical Systems (CPS), driven by an unprecedented and deeply rooted exponential dynamic. This means a vital intermingling of the physical world and cyberspace. This fusion of the real and virtual environments has sounded like the whistle for the global industrial transformation, which aims to place the well-being of all humanity at the heart of high-tech digital manufacturing systems.

Amid this massive technological proliferation and growing Environmental Awareness among the global public, the CEO of marketing and sales must have an environmentally conscious background, possess creative and talented individuals who harness advanced technology, and strive to encourage and motivate their team to launch eco-friendly brands

and offer environmentally friendly initiatives and products, whether willingly or reluctantly. This is inevitable given the available data and the intense pressure from relevant authorities and organizations concerned with natural capital. An examination of the evolutionary trajectory of marketing thought reveals that global marketing scholars have recognized the necessity and inevitability of aligning marketers' tools with issues of human concern, given that marketing is a science embedded within the humanities and behavioral sciences. One of the most important hot agendas that marketers must consider is studying the statistical relationship between marketing performance and the environment and adopting the latest digital and smart technologies emerging from computer science. In a related context, the current exploration of Industry 5.0 is still in its early stages and measuring its practical and applied impact on the commercial and sales system is premature, as well as bibliographic research findings are scarce, and require considerable time to mature and clarify the picture. Therefore, the discussion of the close connection between Industry 5.0 and the environmentally oriented marketing approach requires extensive exploration, causal, and survey studies. However, there are numerous justifications, motivations, and reasons that drive environmental management of marketing activity to spare no effort in harnessing the technologies of Industry 5.0 and placing them in the service of strengthening its strategic partnership with the Ecosystem. What is striking, when considering the convergence between Industry 5.0 and the environmentally responsible marketing mix, is that this smart digital revolution is a combination of the username: technology and humanity, and the password: Sustainability and environmental protection.

In parallel, Industry 5.0 focuses on improving overall marketing performance, and environmental performance specifically, through the combined efforts of human creativity, collaborative robot algorithms (Cobots), and computing power. There is a clear difference between the current and previous revolutions. Industry 4.0 relies on the digital use of data, as well as the fourth wave is characterized by structural change based on digital networks. Industry 5.0 relies on the intelligent use of human-centered data, ultimately representing a revolutionary transformation that has resulted in its benefits for growth and Sustainable Development,

particularly in addressing threats related to Climate Change and Environmental Degradation. In fact, one of the reasons for the emergence of Industry 5.0 in the wake of Industry 4.0 is the search for radical and reliable solutions to the Environmental Pollution crisis. It is worth noting that the direct impact of the devices, programs, and applications of Industry 5.0 on Green Marketing and environmentally responsible supply chains is clear in the role of AI algorithms and IoT through interconnected networks designed to communicate with other systems. These two technologies (AI & IoT) are of paramount importance in enhancing the emotional satisfaction of the green consumer, in addition to personalizing their experiences and purchasing journeys, or what is known as green purchasing and sustainable consumption in the long term. What can be observed from the literature review that discussed the topic of Marketing 5.0 strategies in the context of Industry 5.0 is that protecting the environment and preserving nature from Carbon Emissions, in addition to securing a green and sustainable future, by integrating new technologies should be a priority and an urgent need, not maximizing and inflating profits. Therefore, there are brakes and restrictions that prevent economic companies that think in a purely materialistic way.

Undoubtedly, inspired by the pivotal theses, the progress of human civilization and the development of awareness and insight in human society have been driven by a smooth transition from the fourth wave of the industrial revolution, characterized by pure automation and digitization, to the Fifth Wave Industrial Revolution. This revolution emerged from the womb of Industry 4.0, but its unique feature is that it was reinforced by advanced and sophisticated technology, whose cornerstones are human resources, Environmental Sustainability, and ethical standards. This leads to a discussion about transforming marketing for a human-centered future. Accordingly, the marketing landscape has aligned with this dramatic transformation. This is a characteristic inherent in the spirit and essence of marketing philosophy: flexibility—the ability to adapt and adjust to change and transformation in different environments. Green Marketing is reshaping and restructuring its foundations to produce a new theory and contemporary methodology aligned with Sustainable Development. Sustainable Marketing is enhanced by algorithms, supported by smart solutions, collaborative robots, and Big Data Analytics (BDA). Its methodologies are aligned with

the new era's requirements for achieving a Green Competitive Advantage, starting with enhancing enjoyable, unique, and personalized customer experiences through sustainable brand marketing, based on human standards and respect for privacy, and spreading Environmental Awareness among the public. Therefore, the common denominator between marketing Sustainability and the outcomes of Industry 5.0 is the ethical consideration of environmental concerns, where the era of hyper-customization, personalization, targeting, and green consumer psychology play a pivotal role in strategic success in global markets. However, as the researcher previously pointed out, this research is theoretical and requires in-depth studies. Otherwise, the results obtained remain mere predictions and future speculations regarding the expected and estimated impacts of Industry 5.0 on environmentally friendly products and Sustainability. What is certain is that there is a fundamental shift in the way marketing operates, leaning toward sustainable growth and green investment, especially as the rules of commercial competition have become focused on supporting the environment through: safe biotechnology, renewable and alternative energies, combating Greenwashing, Recycling, Waste Management, and Cleaner Production.

The Future Society 5.0 approach, or the Super Smart Society, is a unique and ambitious Japanese panoramic model, which is likely to have promising consequences in addressing social and environmental problems. It has optimistic outcomes from a civilizational and cultural perspective if it is properly applied and exploited. Its advantage is that it is centered around the human being, which is one of the requirements of the age of human imagination, creativity, and digital transformation. The goal of this adopted initiative, which at first glance appears to be very rewarding and generous, is to research ways to embrace cyber innovation, fully utilize electronic development and digital production equipment, achieve a balance between cyberspace and virtual space, and the physical biological element, and integrate cloud technologies and the tremendous technical capacity of computer equipment based on database analysis, which are produced with more advanced tools, and in larger quantities than ever before, such as: AI, Quantum Computing (QC), Blockchains (BC), IoT, Cloud Services, ..., in the joints and aspects of daily life, so that they penetrate all spectrums of

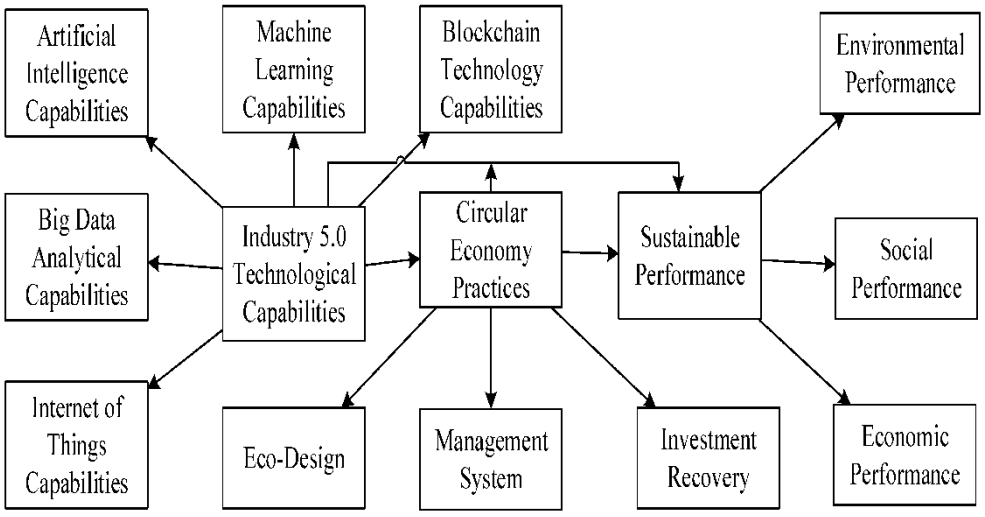
society and seep into Its folds help individuals assess their attitudes and orientations, thus making more accurate, less ambiguous, and timely decisions. This unique society, in its characteristics, is embedded within the context and dynamics of the industrial revolutions of both the fourth and fifth editions. Therefore, the feasibility of activating and operating Society 5.0, specifically aligned with Industry 5.0, is clearly evident in governments achieving their goals and outcomes regarding reaching radical, forward-looking solutions to sensitive and strategic issues, such as: the stakes of human and societal development, the challenges of economic, industrial, agricultural, and service progress, and finally, the gains of protecting the planet and natural capital, and confronting the devastating events resulting from Climate Change and Carbon Emissions. All these goals fall within the category of QoL, and bring new values and improvements to people's livelihoods, work, treatment, education, travel, and enjoyment.

Meanwhile, modifying and adapting the industrial behavior of countries and companies is indispensable, by adopting green production, environmental monitoring, and the CCE in industrial environments. It is a reliable and dependable building block for the success of the Society 5.0 Sustainability Plan. Diligence and effort in eliminating the environmental damage of carbon dioxide throughout the life cycle of products is necessary, as well as a mandatory approach to creating a sustainable world and establishing a conscious and greener society that lives in the bosom of environmental security and safety. This is a difficult equation to achieve, given the seriousness of Global Warming, ozone depletion, acid rain, greenhouse gases, and the widening circle and scope of Environmental Degradation, which raises panic and terror in threatening the environmental safety of the Earth. However, a glimmer of hope and a spot of light has appeared in this dark tunnel, represented by scientific development and technological progress, which is a unique feature of this digital age, where algorithmic automation has turned the scales upside down, as the strategic alliance between: CPS, intelligence technologies, and IoT algorithms, ..., on the one hand, and CCE Models, Cleaner Production, Ecosystem-Responsible Manufacturing, Waste Management, and Recycling, ..., on the other hand, aim to reduce Pollution and lower carbon by using and mobilizing natural resources in more efficient and effective ways.

Companies today bear civilization and human responsibility for the rise in global temperatures to unprecedented and historic levels. Indeed, there are pioneering countries that have taken bold steps and are now ranked among the strongest Circular Economies, based on a firm conviction from their leadership that taking the necessary measures, procedures, and policies to promote environmental well-being contributes to the desired QoL. Modern technologies play a prominent role in accomplishing this task, by monitoring and storing activities related to data responsible for Pollution and Environmental Degradation. These real-time data can help analyze green or low-carbon data for timely decision-making.

See: Kasinathan, P., et al. 2022; Rejeb, A., et al. 2025; Hu, J. L., 2025; Sharma, A., et al. 2024; Bakator, M., et al. 2024; Kaur, R. 2024; Vettriselvan, R. 2025; Alenezi, A. M., et al. 2024; Andronie, M., et al. 2021; Brennan, R. W., & Lyu, G. 2024

Fig.2. Green Marketing and Industry 5.0 Enhancers considering CCE Model



Source: Shafique, M. N., et al. 2024

4. The Role of Computer in Protecting Natural Capital from Pollution by Adopting Sustainable Marketing Enhanced by Clean Technologies

for Industry 5.0, Such As Green AI And the Eco-Friendly IoT

In recent times, humanity has witnessed an alarming and frightening rise in the global climate crisis, accompanied by rising levels of Pollution and Global Warming. Technology has become a lifeline to escape the hell of these disasters and epidemics that are devastating Sustainability. Therefore, computer technology and electronic innovation dealers and exhibitors are engaged in a fierce, relentless war. This time, distinction and superiority are achieved only by winning battles of a different kind. The arena of combat and engagement takes place in virtual worlds, and the weapons used are computer science algorithms, information and communications technology, the Internet, and cognitive machines from robotics technology. Today's and tomorrow's digital competition between companies and business organizations relies heavily on competitiveness based on the quality of control over tools, applications, and software: AI, IoT, Machine Learning (ML), BDA, 3D Printing (Additive Manufacturing), Blockchains (BC), Web (4.0), Quantum Computing (QC), Cloud Storage, Natural Language Processing (NLP), Chatbots, Virtual Assistants (VA), Augmented Reality (AR), Virtual Reality (VR), etc. These emerging inventions have become an integral part of smart factories, smart cities, and smart cars. They are also part of the lives and culture of many peoples, especially in scientifically advanced and technologically sophisticated nations.

Green technology, enhanced by AI, IoT, and others, are digital innovations on the horizon that are 100% in line with the requirements of Sustainable Development supported by solar, wind, hydroelectric, photovoltaic, and bioenergy. The emergence of Industry 5.0 and Society 5.0, which are primarily based on people and environmental protection, has increased their importance and growing demand. They have emerged as a strategic alternative to traditional technologies, which, according to Climate Change experts, are destructive technologies, as they have caused the destruction of the Ecosystem. For this reason, and because of global pressures to impose Sustainability and prevent Environmental Degradation before it is too late, technology companies have taken the initiative and rushed to assume their civilizational role and CER towards planet Earth, by integrating CPS and fifth-generation collaborative robots in the fields of

manufacturing, supply networks, transportation, and communication. Indeed, the market for clean, environmentally friendly technologies has begun to grow remarkably and flourish at a steady pace, as concerns about the severity of the global climate crisis and the massive decline in biodiversity increase, which is considered Real threats to human societies. The discussion returns to focus on harnessing sustainable technologies to bring comfort to people and combat Pollution, and this is the social and environmental impact of green technology, such as the use of alternative fuels, and technologies that are less harmful to the environment than fossil fuels.

Managing marketing efforts within the cyber-enabled developments resulting from the repercussions of Industry 5.0, under the umbrella of the hyper-intelligent society, and changing rules of competition, must achieve radical, sustainable technological change, not just incremental change. This is embodied by improving the environmental performance of algorithmic marketing based on clean digital innovations and reducing Carbon Emissions. Computer automation of the Sustainable Marketing mix is a competitive advantage and an environmentally friendly strategy enhanced by digital technology, especially in the field of green industry. Modern computer-based marketing approaches promise unprecedented hyper-personalization through technologies such as AI, IoT, and BDA. The latter holds in its fold's innovative solutions to environmental problems and challenges related to marketing activity, which appear in several forms and manifestations: Recycling packaging, quality inspection and control for ISO certification, clean energy production, organic food, green buyers, green brands, Greenwashing, green supply chains, etc. One thing that should not escape marketers is that the green technology market is promising. It is still relatively virgin, capable of expansion, and indicates its future popularity. Indeed, investor interest is increasing significantly. The role of marketing lies in its ability to raise awareness and increase Environmental Culture regarding the negative impacts of Carbon Emissions, industrial waste, and the depletion of natural resources. This is a pivotal and central issue for environmentally responsible marketers to gain a competitive advantage associated with greenery and Sustainability.

Generative AI algorithms, powered by computers and CPS, have

dominated the production and commercial landscape in the contexts of Industry 4.0 and the dynamics of Industry 5.0. The sweep of ML, DL, Artificial Neural Networks (ANNs), and Collaborative Robotics across several vital fields and dynamic areas has led to the automation of complex daily tasks, repetitive and routine work, with astonishing speed of performance and accomplishment, high accuracy, and excellent proficiency in forecasting, estimation, and prediction—known as future management and the industry of tomorrow. The secret behind the incredible power of AI & ML applications within the framework of human-machine synergy advocated by Industry 5.0 lies in their ability to simulate human intelligence and creativity in reasoning, deduction, and induction, as well as in analysis, interpretation, logic, and comprehension, in addition to critical thinking and intelligent handling of rapidly changing situations and realities. This also enables Chatbots, and Virtual Assistants (VA), etc., to make optimal decisions and take desired actions in real time. Therefore, all the above entails the success of industrial companies in achieving their social goals, embodying their societal objectives, and thereby reaching profitability and wealth growth aims.

Moreover, due to the serious global disruptions and turmoil related to Ecosystem degradation, natural resource depletion, and Greenhouse Gas Emissions, which have harmed the health of humans, animals, plants, and all living organisms, resulting in water Pollution, soil degradation, and atmospheric toxicity, the convergence between digital technologies, represented by AI solutions—particularly Generative AI—and CER, has begun. Today, companies' worthiness lies in the environmental safety and health of their activities and businesses. It is well known that focusing on Sustainability and environmental protection is a fundamental and essential value behind the development of Cleaner Production and green technology towards Industry 5.0. The latter holds many winning cards for the benefit of the planet, by harnessing automation, clean technology, and environmental innovation for QoL, in line with the climate challenges posed by the new cyber age. Therefore, harnessing Industry 5.0 technologies to support Sustainable Development by achieving an optimal balance between human and technical capital through AI and DL has positive implications for managing environmental crises and disasters. Machines that learn by

acquiring knowledge and performing human-like tasks can help reduce the intensive and excessive use of natural resources and improve environmental management for a more sustainable life.

The Fifth Generation of the Industrial Revolution, Green AI, and the rising tide of human-machine interactions offer opportunities to build a more sustainable future, considering the digital and electronic transformation, and at a time when Climate Change and Global Warming have become among the most important issues facing humanity and are disrupting life on Earth. The clear impact of AI algorithms, supported by complex BDA, Cloud Computing (CC), and integration with 5G and 6G wireless networks, on achieving better results in the field of algorithmic marketing automation for CER is evident in several forms, which can be summarized as follows:

 Improving the environmental business outcomes of marketing and sales activities, where information related to environmental protection is collected from robots and automated processing equipment across the network.

 Improving the environmental performance outcomes of marketing and advertising efforts. AI and computer control have enabled the ability to fortify and protect a brand's natural capital.

 Supporting the design and implementation of interventions to promote pro-environmental behavior in communities, i.e., Environmental Awareness, through an integrated promotional communications system enhanced by the power of machine intelligence.

 Increasing the capacity of Green Marketing management to implement the Cleaner Production of a range of environmentally friendly goods and products to a safe, convenient, and professional level.

 Understanding Green Consumer Behavior using Artificial Neural Networks (ANNs), which leads to achieving a competitive advantage from an environmental perspective.

 Enriching personalized customer experiences by combining and blending the capabilities of human and machine intelligence systems to enhance the purchasing journey and provide an enjoyable and superior consumer experience.

 Maintaining environmentally conscious customers at a high level of

satisfaction, trust, and happiness, thanks to AI's skill and prowess in identifying the needs and desires of green buyers and meeting their preferences.

 Improving the retention of responsible and environmentally conscious buyers through hyper-personalization, as extreme care and attention leads to a better experience.

 Embodying strategic relationship management with environmentally minded customers by implementing the principles of Customer Lifetime Value (CLV), enhanced by AI programs.

 Implementing AI-enhanced marketing Ethics to combat Greenwashing, violations of environmental requirements, and non-compliance with environmental standards by industrial institutions.

 Providing comfort and well-being to people's lives through Sustainable Marketing enhanced by AI tools and methods, which aims to respect the environment and strengthen the link to development, growth, and Sustainability.

In this boundless cyberspace, innovative IoT protocols, which fall within the computer science, programming languages, and Industry 5.0 tools, are taking center stage in the field of algorithmic solutions enhanced by CPS, AI, and Blockchains (BCoT). Virtual sensors connected to the Internet with the ability to create private content are experiencing significant and exponential growth in terms of growing interest and increasing demand. It is expected that there will be 25.44 billion IoT devices by 2030. The significant importance of this amazing scientific innovation is attributed to the record spread of digital economies, virtual environments, e-government, smart industries, Cloud Computing (CC), databases, self-driving cars, digital watches, and non-wireless communication networks (such as Wi-Fi, Bluetooth, 5G, and 6G). In this regard, IoT models include interconnected sensors or embedded sensors that manage and share data instantly, using algorithmic methods. It is extremely fast and instantaneous in terms of receiving, collecting, storing, transmitting, exchanging, processing, analyzing, sending, transforming data, etc. In addition, the IoT possesses highly advanced communication programs and very small, low-cost electronic chips to interact with the internal and external environment. It is worth noting that the meaning of things encompasses all material and

sensory resources, as well as non-material elements, including living organisms (humans, animals, plants), and includes equipment, machines, and facilities. In this world, everything has a private Internet Protocol (IP) address, where data reaches servers on computer networks, which study, examine, and understand it, then direct instructions and commands back to those things to act and implement accordingly. Where behavior, response, and decision-making occur without, or with little or no human intervention.

In the same context, and considering the vital benefits and positive impacts resulting from the exploitation of integrated and online IoT systems, this unique and innovative technology has penetrated many areas of life and livelihood, including, but not limited to: the charitable sector, public utilities, government departments, healthcare, educational services, banks, transportation, farms, infrastructure, factories, travel, homes, shopping, stores, warehouses, logistics, Renewable Energy, ... To clarify and illustrate the IoT applications present in people's daily lives, we find: thermostats, e-commerce, smartphones, ATM cards, mechanical workshops, smart cities, smart transportation, gyms, traffic lights, traffic accidents, public lighting, irrigation systems, surgical work, medical devices, shopping baskets, home security, loudspeakers, security surveillance cameras, Pollution control, energy saving, rationalization of consumption, ..., etc. Therefore, IoT devices offer several benefits, the most important of which is QoL. They make daily routines and complex, repetitive tasks easier and more convenient in the world of automation. They proactively help in making better decisions by reducing costs, improving safety, increasing production efficiency, managing time, enhancing customer experience, generating new revenue streams, etc. As for the concerns and risks in the world of IoT software, the question that urgently arises is what if something malfunctions or external interference occurs in the operation of something, such as an internet outage, power outage, or car collision. In addition, there are issues of reliability, credibility, privacy violations, and disclosure of secrets, and therefore it can also be a security nightmare. However, there are significant efforts to correct, restore, and remedy these shortcomings.

IoT, enhanced by sensing networks, represents a qualitative digital shift. It is a new and attractive model that has transformed the traditional way of life into a high-tech lifestyle, especially with the development and

popularity of 5G wireless network, satellites, and hyper-intelligent society. The added value of the emerging IoT revolution lies in the benefits it offers in addressing environmental issues, Climate Change, the destruction of natural resources, and the global ecological imbalance. It also addresses the complexities and challenges of: Greenhouse Gas Emissions, Global Warming, rising temperatures, acid rain, retreating glaciers, more volatile and extreme weather events (floods, droughts, and frosts), the degradation of mountain Ecosystems, soil degradation, water scarcity, etc. The alteration of the Ecosystem and its surrounding atmosphere by various forms of pollutants (chemicals and energy) is called Environmental Pollution. Pollution affects the climate more than anything else. Environmental Pollution and Climate Change have become an international concern due to their impact on the physical and biological components of the environment. Convergence and intersection have emerged between IoT technologies enabled by environmental sensors on the one hand, and Sustainability, Recycling, Cleaner Production, the CCE, energy conservation, energy saving, sustainable mining, etc. on the other. This has given rise to the Green IoT initiatives, which hold a promising future as they incorporate computing engines that support the ecological economy and sustainable communities. They can develop resilient cities that are environmentally, economically, and socially sustainable. Which allows for improving people's QoL and facilitating instant access to useful information and specific services, anywhere and at any time.

Accordingly, given the significant returns generated by ICT supported by G-IoT in protecting the environment from Pollution and Climate Change, it is imperative to highlight its remarkable impact on marketing practices and initiatives from a Sustainability and environmental safety perspective, especially since environmentally responsible marketing activity is concerned with trading in environmentally friendly products and is interested in designing all components of the Green Marketing mix in a way that leads to the preservation of natural capital and care for the Ecosystem through automation and robotics. This framework includes many marketing variables that have a qualitative contribution to Environmental Awareness. The relationship in this approach (MKT & G-IoT) lies in stored databases and information banks resulting from examining and exploring the

conditions of the green market, sounding out the opinions of environmentally conscious buyers, and sensing news from competitors with an environmental orientation, so that the sensing technologies present in smart IoT devices can be harnessed by taking advantage of the analysis of stored data in real time, which is captured from equipment connected to the Internet as data Huge, which contributes significantly to helping marketers:

 Improving prediction accuracy and the quality of forecasting and estimation, which has a statistically significant impact on marketing decisions.

 Providing unprecedented insights into the determinants of Green Consumer Behavior and the process of their purchasing decisions.

 Formulating dynamic pricing policies and methods stemming from the core objectives of preserving a safe environment.

 Personalizing customer experiences, as professional marketers ensure customer empowerment and respect for their privacy.

 Generating Customer Relationship Management (CRM) results, such as business intelligence for product development and support.

 Measuring and tracking long-term sustainable purchase intentions in sustainable consumption contexts.

 Creating highly targeted marketing campaigns that are environmentally aware through cultural promotion.

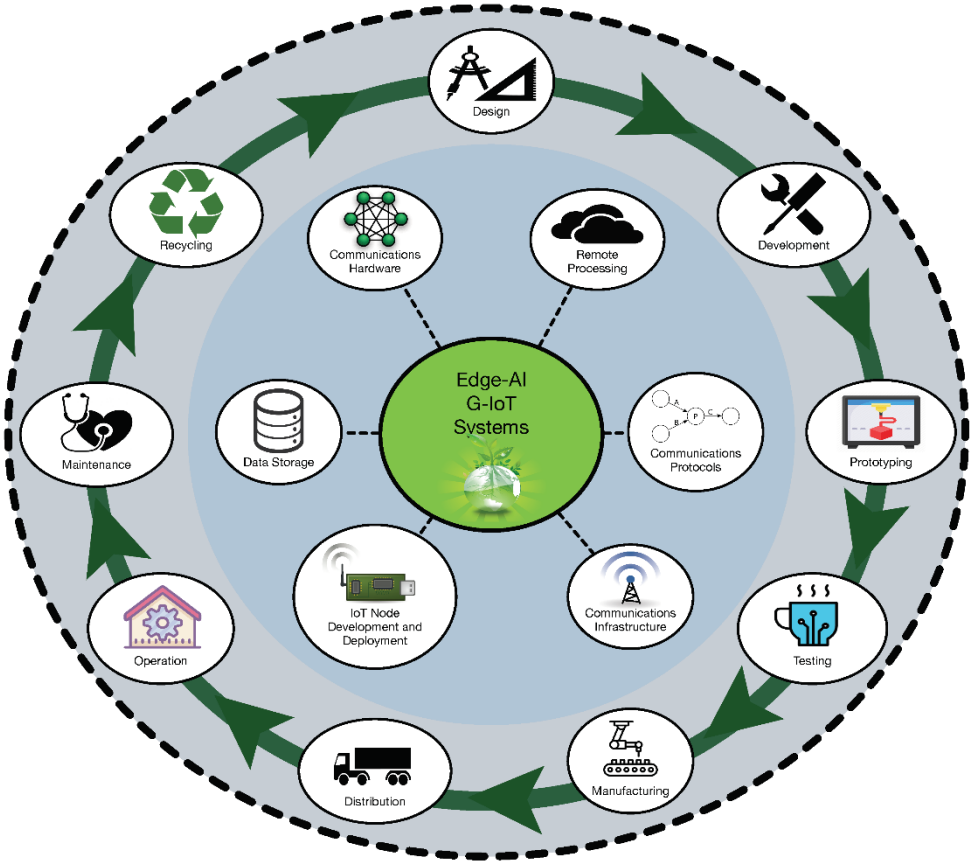
 Establishing distribution channels, supply networks, and logistics services that begin and end with CER and commitment.

 Enhancing the fulfillment of social needs of target audiences, such as disaster relief initiatives.

 Establishing environmental marketing Ethics to combat Greenwashing and other harmful practices.

See: Almalki, F. A., et al. 2023; Yadav, H. 2024; Velrani, K. S., et al. 2025; Islam, M. A., et al. 2025; Kumar, S., et al. 2025; Popescu, S. M., et al. 2024; Omar, H. Y., et al. 2024; Issa, J., 2024

Fig.3. Sustainability from the Perspective of Green AI and Eco-friendly IoT



Source: Fraga-Lamas, P., et al. 2021

4. CONCLUSION

The findings extracted from this research round provide rich and vital information and details that pave the way for future scientific research. Furthermore, they represent an important and inspiring precedent for researchers interested in green responsibility in the marketing industry, supported by AI and IoT, considering Environmental Sustainability and the digital transformation into Industry 5.0. Here are the most important

derivations that emerged from this exciting study.

Environmentally responsible eco-marketing practices are at a crossroads, caught between the hammer of CSR dynamics and the anvil of Sustainable Development. Adapting to these complexities and circumstances has become more urgent than ever, particularly due to environmental concerns and enormous stakeholder pressures. Environmental commitments are a system that stems from the objectives of social and legal responsibility, and the ethical standards of business organizations. There is an interplay between the dimensions of CSR, Business Ethics, and the outcomes of eco-marketing, reinforced by green responsibility and Cleaner Production standards. This is of paramount importance. In a related context, the goals and objectives of Sustainable Development, the radical transformation of the outcomes of the green economy, and environmental QoL, in addition to the philosophy of environmental initiatives and the methodology of Green Marketing in light of the principles and objectives of governance and the commitments and pledges of Corporate Citizenship, are strategic issues and fundamental matters that cannot be ignored or overlooked.

The harbingers of hyper-intelligent societies, dubbed Society 5.0, and the Fifth Industrial Revolution, also known as Industry 5.0, have had dramatic repercussions in terms of the integration between humans and collaborative robots, and they are expanding. Tracing the precursors of the fifth generation of the industrial revolution—whether it is a mutation or a natural and cumulative extension of successive revolutions over time—represents an exciting issue to investigate. Regarding the connection with the marketing system, Industry 5.0 has had a noticeable and significant impact on the marketing industry in general, and green and Sustainable Marketing in particular. Furthermore, the birth and emergence of the hyper-intelligent society and its strong and close ties to the CCE have left a profound impact on the outlook for environmentally conscious marketing, particularly considering the serious Climate Change, severe Pollution, and Environmental Degradation. This necessitates taking the issue seriously and approaching it professionally.

The computer automation of AI and IoT are partners and wings for the sustainable success of the entire marketing Ecosystem. The rise of clean

technologies, the harnessing of Renewable Energy, and the advent of electric vehicles are considered competitive advantages, which are being relied upon as environmentally friendly strategies. In this regard, the momentum of the Green AI revolution and the radical shift towards a more sustainable future, coupled with the opportunities and challenges of the green IoT and its sensor networks in improving the accuracy of Sustainable Marketing, all constitute rich topics for researchers and practitioners seeking to enhance environmental performance in terms of efficiency, effectiveness, and flexibility.

Based on the above data, the researcher sees the necessity and inevitability of companies in today's business world adopting a Green Marketing approach enhanced by digital technologies emerging from the fifth generation of the industrial revolution. This is achieved by understanding the software of environmentally oriented CPS (Green AI and the green IoT) and their potential application to the real world. An important element of an environmental marketing strategy is encouraging the development and adoption of sustainable technologies. One of the most serious challenges facing the contemporary world is combating the negative environmental impacts of human activity, including unsustainable production and consumption. Concern for the environment has a profound impact on building a Green Competitive Advantage, which requires tremendous efforts to acquire and maintain through Sustainable Marketing, which plays a crucial role in achieving this.

5. Bibliography List:

1. Adae, E. K., Kosiba, J. P. B., Hinson, R. E., Twum, K. K., Newman, N., & Nutsugah, F. F. (2021). An Introduction to Responsible Management: A Corporate Social Responsibility, Green Marketing, and Sustainability Management Perspective. In *Responsible Management in Emerging Markets: A Multisectoral Focus* (pp. 1-34). Cham: Springer International Publishing.
2. Agrawal, A., Brandhorst, S., Jain, M., Liao, C., Pradhan, N., & Solomon, D. (2022). From environmental governance to governance for sustainability. *One Earth*, *5*(6), 615-621.

3. Alenezi, A. M., Alsmairat, M. A., & Ljepava, N. (2024, February). Integrating the Triple Pillar : AI Marketing's Pathway to Enhancing Industry 5.0 Through Sustainability, Resilience, and Customer Engagement. In *2024 2nd International Conference on Cyber Resilience (ICCR)* (pp. 1-7). IEEE.
4. Almalki, F. A., Alsamhi, S. H., Sahal, R., Hassan, J., Hawbani, A., Rajput, N. S., ... & Breslin, J. (2023). Green IoT for eco-friendly and sustainable smart cities: future directions and opportunities. *Mobile Networks and Applications*, *28*(1), 178-202.
5. Andronie, M., Lăzăroiu, G., Ștefănescu, R., Uță, C., & Dijmărescu, I. (2021). Sustainable, smart, and sensing technologies for cyber-physical manufacturing systems: A systematic literature review. *Sustainability*, *13*(10), 5495.
6. Bakator, M., Ćoćkalo, D., Makitan, V., Stanisavljev, S., & Nikolić, M. (2024). The three pillars of tomorrow: How Marketing 5.0 builds on Industry 5.0 and impacts Society 5.0? *Heliyon*, *10*(17).
7. Brennan, R. W., & Lyu, G. (2024). Towards Sustainable Cyber-Physical Manufacturing Systems. *IFAC-PapersOnLine*, *58*(3), 345-350.
8. Dahinine, B., Laghouag, A., Bensahel, W., Alsolami, M., & Guendouz, T. (2024). Modelling the combined effect of green leadership and human resource management in moving to green supply chain performance enhancement in Saudi Arabia. *Sustainability*, *16*(10), 3953.
9. Dahinine, B., Laghouag, A., Sahel, W., Guendouz, T., & Bennaceur, A. (2023). The impact of green human resource management on green pharmaceutical supply chain management practices. *Uncertain Supply Chain Management*, *11*(3), 893-902.
10. D'Arco, M., & Marino, V. (2022). Environmental citizenship behavior and sustainability apps: An empirical investigation. *Transforming Government: People, Process and Policy*, *16*(2), 185-202.
11. Deshmukh, P., & Tare, H. (2024). Green marketing and corporate social responsibility: A review of business practices. *Multidisciplinary Reviews*, *7*(3), 2024059-2024059.

12. Fallah Shayan, N., Mohabbati-Kalejahi, N., Alavi, S., & Zahed, M. A. (2022). Sustainable development goals (SDGs) as a framework for corporate social responsibility (CSR). *Sustainability*, *14*(3), 1222.
13. Fraga-Lamas, P., Lopes, S. I., & Fernández-Caramés, T. M. (2021). Green IoT and edge AI as key technological enablers for a sustainable digital transition towards a smart circular economy : An industry 5.0 use case. *Sensors*, *21*(17), 5745.
14. Galan-Ladero, M. M. (2025). Social Marketing for Well-Being and Quality of Life. In *Integrated Science to Achieve Sustainable Development Goals* (pp. 13-28). Cham: Springer Nature Switzerland.
15. Ganesh, C., Podila, N., Vamsi, G. B. K., Rao, C. M., & Bhardwaj, N. (2024). AI-enhanced content marketing for sustainability : a theoretical perspective on eco-friendly communication strategies. In *MATEC Web of Conferences* (Vol. 392, p. 01045). EDP Sciences.
16. Hu, J. L., Li, Y., & Chew, J. C. (2025). Industry 5.0 and Human-Centered Energy System: A Comprehensive Review with Socio-Economic Viewpoints. *Energies*, *18*(9), 2345.
17. Islam, M. A., Goldar, S. C., Al Imran, S. M., Halimuzzaman, M., & Hasan, S. (2025). AI-Driven green marketing strategies for eco-friendly tourism businesses. *International Journal of Tourism and Hotel Management*, *7*(1), 31-42.
18. Issa, J., Abdulrahman, L. M., Abdullah, R. M., Sami, T. M. G., & Wasfi, B. (2024). AI-powered sustainability management in enterprise systems based on cloud and web technology: Integrating IoT data for environmental impact reduction. *Journal of Information Technology and Informatics*, *3*(1), 154.
19. Jacob, K. (2025). What is Green Marketing? Definition, Strategies & Examples. https://www.upgrad.com/blog/what-is-green-marketing/
20. Jia, H. M., Wang, Y., Tian, Q., & Fan, D. (2022). Marketing innovations and sustainable development for the future ecosystem. *Journal of Cleaner Production*, *372*, 133295.
21. Kasinathan, P., Pugazhendhi, R., Elavarasan, R. M., Ramachandaramurthy, V. K., Ramanathan, V., Subramanian, S., ... & Alsharif, M. H. (2022). Realization of sustainable development goals

with disruptive technologies by integrating industry 5.0, society 5.0, smart cities and villages. *Sustainability*, *14*(22), 15258.

22. Kaur, R. (2024). Sustainable Food Revolution: The industry 5.0-Permission Marketing Convergence. *International Journal of Multidisciplinary Research in Arts, Science and Technology*, *2*(11), 11-20.
23. Kumar, S., Sharma, C., Mishra, M. K., Sharma, S., & Bhardwaj, V. (2025). Smart, sustainable, and green : the digital transformation of green marketing. *Discover Sustainability*, *6*(1), 388.
24. Mohammed Al-Dulaimi, W. A., & Hassan Al-Taai, S. H. (2021, June). Pollution and its impact on sustainable development. In *IOP Conference Series: Earth and Environmental Science* (Vol. 790, No. 1, p. 012025). IOP Publishing.
25. Omar, H. Y., Abdulqader, D. M., Abdullah, R. M., Ismael, H. R., Rashid, Z. N., & Sami, T. M. G. (2024). A Review on Upshots of Cloud Computing and Web Technology on the Future Green Transformation: AI, IoT, and Secure Enterprise Systems in Fostering Sustainable Work Practices. *Journal of Information Technology and Informatics*, *3*.
26. Popescu, S. M., Mansoor, S., Wani, O. A., Kumar, S. S., Sharma, V., Sharma, A., ... & Chung, Y. S. (2024). Artificial intelligence and IoT driven technologies for environmental pollution monitoring and management. *Frontiers in Environmental Science*, *12*, 1336088.
27. Rejeb, A., Rejeb, K., Keogh, J. G., & Süle, E. (2025). When Industry 5.0 meets the circular economy: A systematic literature review. *Circular Economy and Sustainability*, 1-32.
28. Shafique, M. N., Adeel, U., & Rashid, A. (2024). The Synergy Between Industry 5.0 and Circular Economy for Sustainable Performance in the Chinese Manufacturing Industry. *Sustainability*, *16*(22), 9952.
29. Sharma, A., Dhanka, S., Bansal, R., Kumar, A., & Maini, S. (2024). Industry 5.0 with sustainable development. In *Industry 5.0 and Emerging Technologies: Transformation Through Technology and Innovations* (pp. 347-370). Cham: Springer Nature Switzerland.
30. Singh, B., Chandra, S., & Kaunert, C. (2025). Unleashing

Sustainable Development and Adopting Green Entrepreneurship Practices: Projecting Consumer Protection in the Era of Green Washing. In *Incentives and Benefits for Adopting Green Entrepreneurship Practices* (pp. 341-364). IGI Global Scientific Publishing.

31. Stoian, I. C. (2024). Corporate social responsibility and green marketing: the influence of eco-labelling and ethical certifications on consumer behavior and their impact on sustainable economical development. *ASECU*, *20*, 137-146.
32. Thangam, D., & Chavadi, C. (2023). Impact of digital marketing practices on energy consumption, climate change, and sustainability. *Climate and Energy*, *39*(7), 11-19.
33. Velrani, K. S., Shanthi, T. S., Senthil, T. S., Kavitha, T., Deepa, P., & Muthuvel, S. (2025). A Study on IoT and AI-Integrated Advanced Lightweight Materials for Eco-Friendly Production. In *Innovations in Energy Efficient Construction Through Sustainable Materials* (pp. 1-32). IGI Global.
34. Vettriselvan, R. (2025). Harnessing innovation and digital marketing in the era of industry 5.0: resilient healthcare SMEs. In *The Future of Small Business in Industry 5.0* (pp. 163-186). IGI Global Scientific Publishing.
35. Yadav, H. (2024, April). Advancing Sustainable Development: Harnessing AI for Efficient and Eco-Friendly Customer Support in IoT Solutions. In *International Conference on Sustainable Development through Machine Learning, AI and IoT* (pp. 143-156). Cham: Springer Nature Switzerland.
36. Zhang, M., Chen, Y., Lyulyov, O., & Pimonenko, T. (2022). Interactions between economic growth and environmental degradation toward sustainable development. *Systems*, *11*(1), 13.
37. Zrybnieva, I., Burdyak, O., Venherova, O., Nosachenko, O., & Serhiienko, O. (2025). Sustainable Marketing within the Environmental Responsibility Context: Research and Communication Strategies for Businesses Growth. *Journal of Natural Resources*, *8*(1), 759-776.