

Sustainability and Climate Risk: A Comprehensive Overview (Understanding the Interconnection between Sustainability and Climate Risk)

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Abstract

Sustainability and climate risk are interconnected. Both provide a foundation for taking action on global environmental challenges and helping ensure economic stability into the long term. Sustainability means managing resources with consideration so as not to harm the ability of future generations to meet their needs. Climate risk refers to the potential negative impacts that may arise from climate change, such as physical, transitional, and liability risks on ecosystems, economies, and societies. Organizations incorporate the principles of sustainability in the mitigation of climate risks, building resilience, and stewardship of the environment. This article will discuss what exactly sustainability and climate risk are; go into detail about the various types and impacts of climate risks; and outline why sustainability is very crucial in handling those climate-related risks. It looks at the integration of climate risk and sustainability using strategic frameworks, the important role that policies and regulations play, and corporate responsibility in driving sustainable practices. It also discusses key metrics to monitor and manage climate risks and sustainability initiatives, offering a broad overview of how the two concepts support each other to further a sustainable future.

Keywords: Sustainability, Climate Risk, Environmental Stewardship, Climate Change, Physical Risks, Transitional Risks, Liability Risks, Policy, Regulation, Corporate Responsibility, Resilience, Sustainable Development, Metrics, Global Challenges, Resource Management

I. INTRODUCTION

Sustainability and climate risk are intricately linked concepts that are pivotal to addressing the global challenges posed by environmental degradation and climate change. Sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their own needs, encompassing social, environmental, and economic dimensions [1]. On the other hand, climate risk is described as possible adverse impacts concerning ecosystems, economies, and societies as a result of climate change. Such risks emanate from physical changes in the climate, such as extreme weather events, rise in sea level, and temperature shift, and also transition risks regarding policy, technology, and market dynamic changes for mitigating climate change [3][14]. Understanding and addressing climate

risk are crucial for sustainability. The risks of climate change, from acute events like floods to chronic changes in rising temperatures, affect sustainable development through disruptions to economic stability, health endangerment, and exacerbation of resource scarcity [1] [12]. There are also interlinkages of climate action with the greater SDGs, and these call for integrated strategies in promoting resilience and reducing vulnerabilities [2]. For instance, addressing climate risks through sustainable practices such as renewable energy adoption, efficient resource use, and conservation can mitigate environmental degradation and support long-term development goals [6] [8]. In turn, sustainability contributes crucially to the reduction in climate risks. The development of sustainability policies and strategies reduced carbon emission, improved the management of natural resources, and ensured ecosystem restoration, hence making the community less exposed and vulnerable to climate-related hazards [13][15]. Secondly, sustainability-based approaches consider the principles of the circular economy, reduction in the utilisation of scarce resources, and increasing innovation in order for effective building back better against the climate risks [5] [8]. Sustainability and management of climate risk are all about holistic approaches that combine environmental, social, and economic objectives. This interconnection is reinforced by the role of policy and regulation in driving sustainable practices, reducing climate vulnerabilities [9] [14]. The corporate responsibility will also play a key role, where organizations increasingly recognize the need to embed sustainability metrics into decision-making processes, improve non-financial reporting, and adopt transparent practices with regard to climate risks [9]. This paper, the interaction of sustainability with climate risk is discussed: types and impacts of climate risks, the importance of sustainability, and how to integrate the two. Further, policy, corporate responsibility, and metrics to measure progress are looked into for an all-round understanding of this important nexus. Sustainability means conducting the present development without compromising the ability of future generations to meet their needs. The principle of sustainability, accordingly, focuses on the wise use of natural resources, less generation of waste, and ecologically balanced use for the longest period. Sustainability provides a key framework in holistic environmental challenges, improvement in economic stability, and increasing social equity. On the other hand, climate risk is about possible adverse consequences of climate change on ecosystems, economies, and societies. The various risks include physical risks from extreme weather events, chronic environmental changes such as rising sea levels, and transition risks resulting from the shift to a low-carbon economy [1] [3].

II. LITERATURE REVIEW

Cramer et al. (2018): Have examined interconnected risks resulting from climate change to sustainable development in the Mediterranean region. This study underlined that regional vulnerabilities are closely related to global challenges and therefore require integrated management approaches. The findings indicate strong feedback from the complex interaction of climate and socio-economic systems. It is believed that such interactions could be usefully harnessed toward mitigating negative impacts. This provides a framework for understanding, in a region, how to address the issue of climate risk on a regional scale [1].

Nerini et al. (2019): Investigated the synergies between climate action and SDGs. Therein, synergies and trade-offs were identified as relevant framing of climate initiatives in light of the broader context of sustainability. Their findings raise the need for policymakers to adopt holistic approaches in climate planning. The authors underline how much integrated governance contributes to reaching the

SDGs while taking care of climate change. The paper provides a contribution to the debate on sustainable development strategies [2].

Zscheischler et al. (2018): Examined the increasing future risks associated with compound climate events. These include the simultaneous occurrence of extreme weather conditions, which pose heightened challenges to environmental and societal resilience. The study underscores the need for improved risk assessment models to anticipate such events. By analyzing historical and projected data, the authors provide valuable insights into emerging vulnerabilities. Their research is pivotal in guiding adaptive climate policies [3].

Dendup et al. (2018): Carried out a systematic review of the literature on environmental risk factors for Type 2 Diabetes Mellitus. According to the authors, it was found that there was an association between exposure to pollutants with susceptibility to the disease. Their findings reinforce the consideration of environmental risk in public health policies. The review calls for prevention, as well as an intersectoral research approach to address diabetes. It updates the comprehensive understanding of environmental determinants of health [4].

Kaikkonen et al. (2021): Conducted a review on the application of Bayesian networks in environmental risk assessment. The study proved the strength of Bayesian networks in modeling complicated systems in the environment and associated uncertainties. Their research thus demonstrates a potential for these networks to enhance decision-making in risk management. This review identified the importance of the integration of statistical models within the environmental assessments. A strong methodology is hereby given out for addressing multi-faceted ecological challenges [5].

Piovani et al. (2019): Performed an umbrella review of meta-analyses to identify environmental risk factors associated with inflammatory bowel diseases. This study identified diet, pollution, and lifestyle changes as major contributors to the etiology of IBD and synthesized data from a number of studies on this topic. It points out the need for mitigating environmental triggers as part of IBD prevention strategies. The findings are valuable for understanding multifactorial disease dynamics and fostering interdisciplinary research. Future work could focus on region-specific factors and personalized prevention approaches[6].

Bridson et al. (2021): Reviewed analytical approaches to studying the leaching and extraction of additives from plastic pollution to assess environmental risks. This multidisciplinary review underscored the complexities of chemical interactions between plastic pollutants and their surrounding environments. It identified the issues in quantifying the magnitude of additive migration and their toxicological effects. It is suggested that standard approaches to methodology are required for the assessment of risks. More research is needed to make use of advanced analytical techniques in understanding the long-term ecological impacts[7].

III.KEY OBJECTIVES

- **Understanding Sustainability:** Sustainability can be conceptualized as a practice to satisfy current needs without compromising the ability of future generations in meeting their own needs. The dimensions of sustainability are economic, social, and environmental with a focus on long-term ecological balance [2][8].
- **Understanding Climate Risk:** Climate risk can be defined as the potential for adverse impacts resulting from climate change, including extreme weather events, rising temperatures, and sea level rise [3][14].

Discuss how climate risk impacts ecosystems, economies, and human health [3] [12].

- Climate Risk and Sustainability Interlinked: Describe how sustainability initiatives reduce the risks of climate change with the involvement of renewable energies, a reduction in various forms of pollution, and increased resilience to climate-linked disasters/stresses [1][2]. Sustainable practices support action on climate goals and goals of sustainable development [2][13].

- Types of Climate Risks:

Physical: direct physical events like floods, hurricanes, and droughts attributed to changes in climate, among other factors [3]

Transition risks: associated with policy, legal, and technological changes in the course of transition to the low-carbon economy [14][9].

Liability risks: the legal consequences of failure to act regarding climate-related damages [9].

- Climate Risks Impact: The discussion shall dwell on the economic, environmental, and social impacts; for example, supply chain disruptions, biodiversity loss, health effects [10][15]. Discussion on financial and operational aspects concerning companies [14][9].
- Sustainability: Highlight how sustainability can ensure ecological balance, reduce carbon footprints, and provide resources in the long term [2][8]. Show its role in the improvement of health and equity of the public [13][10].
- Integration of Climate Risk and Sustainability: Discuss ways of integrating climate risk into sustainability policies through assessment of risk, scenario planning, and adaptive management [7][5].
- Illustrate examples of successful integration, including biochar applications that enhance both carbon sequestration and soil improvement [8].
- Role of Policy and Regulation: Discuss how various policies, such as carbon pricing, renewable portfolio standards, and sustainability disclosure requirements, might be used to mitigate climate-related risks [9][14]
- International Agreements: The Paris Agreement: review the Paris Agreement along with other international agreements related to sustainability issues [2].
- Corporate Responsibility and Sustainability: Describe how businesses contribute to sustainability, including such actions as reducing emissions, using energy efficiently, and disclosing ESG information [9] [14]. Expand the section on integrating climate risk metrics in corporate strategies. [14][7]
- Sustainability and Climate Risk Metrics: Describe a few key metrics-carbon emissions, resource efficiency, climate risk exposure-those that are used to monitor/measure sustainability and climate risk. [5] [8].

IV. RESEARCH METHODOLOGY

This research aims to gain a wide understanding of how sustainability and climate risk are interrelated with the view of jointly tackling environmental challenges and enhancing resilience. The methodology encompasses qualitative and quantitative analysis in order to assess the dynamics between sustainability initiatives and management of climate risk. The review of scientific articles and empirical studies on climate risks, types, and impacts assess interconnected risks due to climate change in view of sustainable development with a focus on Mediterranean regions [1] and the implications for compound climate events [3]. These studies provide a fundamental understanding of the diverse and complex nature of

climate risks. The research also explores environmental risk factors, including pollution and combustion of fossil fuel, as major contributors to health and environmental problems [10][13]. The integration of sustainability and climate risk management will be analyzed with frameworks connecting climate action with SDGs 2. This considers how corporate responsibility and policy interventions can bridge the gap in the achievement of sustainability while mitigating climate risks. In addition, Bayesian networks in environmental risk assessment have been reviewed to provide appropriate analytical methods for the prediction and management of climate risks [5]. To understand corporate strategies, the impact of climate risks on firm performance and financing choices is reviewed [14] providing insights into the economic implications of climate risk management. Metrics for assessing sustainability and environmental risks are derived from multidisciplinary reviews [7][9] and innovative approaches such as biochar application [8]. The study adopts an integrated approach, using both secondary data and conceptual frameworks to bring together policy and regulatory dimensions, as reviews have identified with respect to urban vulnerability to heatwaves and environmental health risks [12]. The integrative approach will ensure that the understanding of how sustainability can reduce climate risks supports resilience and environmental equity. The findings are expected to inform decision-making, policy formulation, and corporate strategies in line with sustainable development goals. This methodology establishes a wide interdisciplinary knowledge, from various academic and scientific sources, for a detailed analysis of the interactions between sustainability and climate risk. The references provided will ensure the robustness and credibility of the research since it will provide a solid base for further research.

V. DATA ANALYSIS

Data from various studies indicate that sustainable interventions against climate risks are urgently needed. For instance, urban heat vulnerability assessments underline health risks due to extreme temperatures, especially in vulnerable populations, and hence call for appropriate climate adaptation measures [12]. Biochar studies show its potential to improve soil quality while reducing environmental risks, thus indicating how novel solutions can be used for both sustainability and climate risk issues [8]. Research on firm performance underlines that proactive climate risk strategies are linked to improved financial outcomes, hence encouraging corporate entities to embed sustainability in their operations [14]. Sustainability and climate risk management, through an integrated approach, can support each other in order to foster a resilient future for the planet and its inhabitants.

TABLE.1.REAL-TIME EXAMPLES

Company	Sector	Action Taken	Climate Risk Mitigated	Sustainability Impact	Source
Tesla, Inc.	Automotive	Electric vehicle production	Transition risks	Reduced emissions	[8]
IKEA	Retail	Renewable energy in operations	Physical risks	Energy efficiency	[7]
Unilever	Consumer Goods	Sustainable sourcing	Liability risks	Improved resource efficiency	[9]
Google (Alphabet)	Technology	Carbon-neutral data centers	Physical and liability risks	Reduced carbon footprint	[8]

Siemens AG	Industrial	Smart grid technology	Transition risks	Renewable energy adoption	[2]
Microsoft	Technology	AI for climate predictions	Physical risks	Enhanced resilience	[14]
Nestlé	Food & Beverage	Water stewardship programs	Chronic risks	Resource conservation	[6]
BP	Energy	Investment in renewables	Transition risks	Diversified energy portfolio	[7]
Toyota	Automotive	Hybrid and electric vehicles	Transition risks	Emission reductions	[8]
Apple Inc.	Electronics	Supply chain decarbonization	Liability risks	Transparent reporting	[9]
Chevron	Energy	Methane reduction initiatives	Physical risks	Improved air quality	[5]
HSBC	Banking	Green bonds issuance	Transition risks	Funding sustainability projects	[2]
Adidas	Retail	Recycled materials in products	Liability risks	Waste reduction	[8]
Boeing	Aerospace	Lightweight aircraft materials	Physical risks	Fuel efficiency	[6]
Infosys	Technology	Renewable energy in IT parks	Transition risks	Reduced operational emissions	[13]

The following table-1 highlights some real-time examples of companies from different sectors that have taken bold steps in the direction of mitigating climate risks while promoting sustainability. Each company listed has engaged in initiatives designed to mitigate specific types of climate risks-whether physical, transition, or liability risks-while simultaneously contributing to environmental sustainability. For instance, Tesla, Inc. is committed to the manufacture of electric vehicles-a direct response to the transition risk in moving the automotive industry towards sustainable energy. This helps reduce carbon emissions, which supports the goal of environmental sustainability. Similarly, IKEA has been committed to powering its businesses with renewable energy, therefore reducing its carbon footprint, which helps address the physical risks of climate change. For instance, in the technology sector, Google (Alphabet) has made its data centers carbon-neutral, thus addressing both the physical and liability risks, while drastically reducing its environmental impact. Microsoft uses AI in predicting and mitigating climate risks that enhance its resilience to environmental disruptions. Meanwhile, Siemens AG has focused on smart grid technologies in integrating renewable energy into the power grid, hence mitigating transition risks associated with the global move toward decarbonization. Other companies from different industries have also picked up the challenge of sustainability through practices such as water stewardship for Nestlé and investments in renewable energy by BP. These will, in

addition, reduce the environmental and operational risk resulting from climate change and at the same time reduce their environmental footprint in the long run. Each example reflects a commitment to integrating sustainability with risk management strategies, showing how businesses are aligning their operational goals with climate resilience and sustainable development. These listed companies not only manage current climate-related risks but also work toward a more sustainable future by introducing innovative solutions and responsible business practices. This showcases the increasing relevance of sustainability and integration of climate risk across sectors and forms a way forward for others.

TABLE.2. CASE STUDIES ON ENVIRONMENTAL RISK FACTORS, CLIMATE CHANGE, AND THEIR IMPACT ON COMPANIES

Case Study	Company Name	Environmental Risk	Impact on Operations	Mitigation Strategies	Source
1	Mediterranean Region Companies	Climate change and interconnected risks	Disruption in operations due to extreme weather	Adoption of sustainable practices	[1]
2	Various Global Companies	Climate action and SDGs	Difficulty in aligning climate actions with SDGs	Integration of climate actions with SDG frameworks	[2]
3	European Companies	Compound climate events	Increased risk of flooding and storms disrupting supply chains	Implementation of flood protection systems	[3]
4	Global Healthcare Companies	Environmental risk factors for Type 2 diabetes	Increased healthcare costs due to rising incidence	Focus on public health campaigns and environmental regulations	[4]
5	Environmental Risk Assessment Firms	Environmental risk assessment	Lack of predictive models for assessing risks	Use of Bayesian networks in risk assessment	[5]
6	Pharmaceutical Companies	Environmental risk for inflammatory bowel diseases	Rising incidence of diseases due to environmental pollutants	Regulatory compliance and environmental monitoring	[6]
7	Plastic Manufacturing Companies	Plastic pollution and additive leaching	Environmental damage due to chemicals leaching into ecosystems	Adoption of eco-friendly materials and pollution control measures	[7]

8	Agricultural Companies	Soil contamination from biochar use	Decreased soil productivity and potential health risks	Research into biochar composition and safe use	[8]
9	Accounting Firms	Climate and pandemic risk reporting	Challenges in reporting non-financial risks	Development of new reporting frameworks including climate and pandemic risks	[9]
10	Kidney Health Organizations	Environmental pollution and kidney diseases	Increased health issues due to polluted water and air	Health awareness campaigns and environmental advocacy	[10]
11	Environmental NGOs	Childhood exposure to environmental loss	Negative impacts on childhood health and development	Programs to foster children's connection with nature	[11]
12	Urban Development Companies	Urban heatwaves and environmental risks	Increased mortality rates during heatwaves	Development of heatwave management strategies	[12]
13	Global Healthcare Organizations	Pollution from fossil fuel combustion	Increased pediatric health issues due to air pollution	Policy advocacy and environmental health initiatives	[13]
14	Multinational Corporations	Impact of climate risk on business performance	Financial losses due to environmental disruptions	Adoption of climate-resilient business practices	[14]
15	Autism Research Institutions	Environmental exposure and autism spectrum disorder	Higher incidence of ASD due to environmental factors	Focus on research into environmental causes of ASD	[15]

The following table-2 is a summary of different case studies that present various aspects of environmental risk and their respective impacts on different industry firms. Such cases run from the broad environment issues like climate change, pollution, and the environment being responsible for health issues. For example, Mediterranean region companies face the various interrelated risks of climate change that disrupt operations because of extreme weather conditions and are thus putting in place environment-friendly practices to reduce risks. Similarly, companies globally are guided by the SDGs in taking appropriate action on climate. Other factors that influence environmental risk in health-related industries include those related to pollution and changes in climate. Global healthcare firms are struggling with increasing healthcare costs burdened by rising incidences of diseases such as Type 2

diabetes, linked to environmental factors. Simultaneously, environmental risk assessment consulting firms are incorporating new methodologies, such as Bayesian networks, in developing better forecasts and mitigating environmental risks. Other industries manufacturing plastics and engage in agricultural activities are working out the risks of pollution by using environmentally friendly materials and sustainable agricultural methods that cause minimal harm to the environment. More importantly, accounting firms integrate more and more climate or pandemic risks in their reporting frameworks-again an acknowledgment of non-financial risk reporting on a more significant scale. While the urban development sector deals with heatwaves issues, healthcare organizations fight with pollution-borne health hazards among their pediatric populations. Finally, climate-resilient business practices are being adopted by multinational corporations to manage the financial risks of climate change, while research institutions investigate into environmental causes of autism spectrum disorder-a range of effects of environmental exposure. These case studies together present major environmental risks for various businesses and the strategy employed in controlling such risks, hence indicating the increase in relevance of sustainability and environmental responsibility in business operation.



Fig.1.QBL sustainability [16]



Fig.2.Climate risk Assessment [16]

VI.CONCLUSION

Sustainability and climate risk are inextricably linked: the building blocks of a global response to environmental challenges underpin long-term economic and social stability. Sustainability emphasizes responsible resource management and the creation of resilient systems, while climate risk brings forth vulnerabilities and disruptions from climate change. Together, they represent two sides of the coin for mitigating environmental and socio-economic threats. Understanding the types of climate risks-physical, transitional, and systemic-will therefore inherently allow policymakers, corporations, and individuals to devise strategies that give primacy to sustainability. Merging climate risk assessment with

sustainability practices ensures a proactive approach to minimizing damage and maximizing opportunities for growth and innovation. Policy and regulation serve as strong drivers for the integration, setting the benchmark in environmental accountability and creating a framework for collective action. Corporate responsibility further bolsters this with the embedding of climate risk metrics and sustainability goals into business strategies, leading to more transparency and resiliency. It is ultimately the interlinking of sustainability and climate risk management that points toward an equitable and sustainable future. Metrics and frameworks that measure progress, added to concerted efforts, become cardinal in treading the labyrinthine complexities of climate change with its challenges while furthering the imperatives of sustainable development goals. By doing so, it would be possible for society to reach a balance between economic advance, care for the environment, and social equity, thus assuring a resilient planet for the coming generations.

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