S1. CLASSIFICATION OF BARRIERS INTO CATEGORIES

S1.1. Economic and Financial Barriers

- **Integration with Sustainable Finance Tools:** The need to align transition plans with sustainable financial instruments, such as green bonds and sustainability-linked loans, is a financial barrier that requires knowledge and efficient use of these instruments (OECD, 2022).
- **Impact of Financial Crises:** Financial crises hinder companies' ability to invest in green technologies, with lasting effects on carbon emissions, as demonstrated by industrial emissions data after the global financial crisis (Haas et al., 2024).
- **Quantified Impact of Barriers:** Credit constraints and poor management quality result in CO2 emissions 4.5% and 2.3% above potential levels, highlighting the need for targeted financial interventions (Haas et al., 2024).
- **Financial Frictions:** High financing costs and the absence of specific green financial products hinder companies' climate change (Haas et al., 2021).
- **Post-Crisis Bank Deleveraging:** Post-crisis global bank deleveraging kept industrial emissions 15% higher, highlighting how fragile financial systems negatively affect the climate transition (Haas et al., 2021).
- **Credit Constraints:** Credit constraints limit corporate investment in green technologies, especially in emerging markets. Lack of access to affordable finance prevents companies from investing in sustainable technologies, contributing to higher CO2 emissions (Haas et al., 2024; Haas et al., 2021). This barrier is also exacerbated during financial crises, as evidenced in the aftermath of the global financial crisis, where regions with greater bank deleveraging had higher industrial emissions (Haas et al., 2024).
- **Sunk Costs:** The high capital costs of existing facilities discourage companies from investing in new low-carbon technologies, perpetuating the use of current assets for decades (Janipour et al., 2020).
- **Cost-Competitive Fossil Fuels and Feedstock:** The cost-competitiveness of fossil fuels compared to renewable alternatives makes it difficult for companies to commit to low-carbon technologies, especially given the uncertainty about the availability and cost of renewable sources (Janipour et al., 2020).
- **Low Risk Acceptance by Capital Providers and Shareholders:** Risk aversion by investors and shareholders, due to the high costs and unproven nature of industrial-scale green technologies, impedes innovative low-carbon projects (Janipour et al., 2020).
- **Transition Risks:** Transition risks related to the shift to a low-carbon economy, including changes in market demand, regulatory changes, and technological advances, pose significant financial challenges for firms (Cenci & Tang, 2024).
- **High Implementation Costs:** High costs associated with sustainable innovations discourage firms, especially smaller ones, that face resource constraints from implementing climate transition plans (Kraetzig et al., 2024).
- **Limited Financial Resources:** The implementation of green human resource management (GHRM) practices in developing countries, such as Ghana, is hampered by limited financial resources (Kodua et al., 2022).
- **Perceived High Costs and Low Returns:** The perception of high costs and uncertain returns deters organizations from implementing green initiatives, especially when immediate financial benefits are not evident (Kodua et al., 2022).
- **Cost Concerns:** The difficulty of translating the costs of climate inaction into tangible business terms can hinder investment in more sustainable practices (Boschee, 2022).
- **Financial Disincentives:** Financial regulations that require higher loan loss provisions for low-carbon versus high-carbon sectors create disincentives for green investments (Gasparini et al., 2024).
- **Cost of Green Technologies:** The high upfront costs associated with green technologies disincentivize private investment, especially from small businesses, which prioritize short-term compliance over long-term sustainability goals (Purkayastha & Sarkar, 2021; Liu & Xu, 2023).
- **Financial Constraints and Trade-offs:** Financial constraints lead to higher emissions and inhibit green innovation, especially in small firms, which prioritize immediate financial stability over long-term environmental benefits (Liu & Xu, 2023; Xu & Kim, 2021).

- **Need for High-Quality Carbon Removal Credits:** Firms face challenges in acquiring high-quality carbon removal credits to balance residual emissions, due to the variability of standards and verification in the carbon credit market (Maloney and Busch, 2024).
- **Need for Diversified Investments:** The lack of diversification in investments in adaptation and mitigation initiatives limits firms' ability to reduce emissions and manage climate risks under different policy scenarios (Cenci & Tang, 2024).
- **Post-Crisis Bank Deleveraging:** Regions where banks significantly reduced their lending after the global financial crisis had 15% higher industrial emissions due to financial barriers that constrained investment in green technologies (Haas et al., 2021).
- **High Implementation Costs:** High costs associated with implementing sustainable innovations discourage firms from making necessary changes, especially those with limited financial resources (Kraetzig et al., 2024).
- **Impact on Emissions and Innovation:** Financial constraints lead to higher emissions and inhibit green innovation, especially in small firms, prioritizing immediate financial stability over long-term environmental benefits (Liu & Xu, 2023; Xu & Kim, 2021).
- **Dependence on Energy Prices:** The motivation to reduce emissions is often linked to energy prices. Reductions in energy costs can weaken financial incentives for energy efficiency, slowing progress (Gouldson et al., 2013).
- **Lack of Financial Incentives:** The lack of financial incentives for low-carbon innovation reduces firms' motivation to invest in technologies that minimize emissions (Liu, 2014).
- **Economic Constraints and Limited Access to Advanced Technologies:** In developing countries, the financial burden of adopting sustainable technologies is compounded by a lack of technological infrastructure and expertise (Jeswani, 2007).
- **Reliance on Cost-Savings as an Incentive:** In places like Pakistan, energy efficiency is incentivized only by cost savings, limiting the adoption of sustainable practices (Jeswani, 2007).
- **Carbon Pricing Risk:** The risk associated with carbon pricing can impact the competitiveness and financial performance of firms that have not diversified their investments in adaptation and mitigation initiatives. Diversification is essential to reduce exposure to this risk (Cenci & Tang, 2024).
- **Dependence on Energy Prices:** The motivation for emissions reduction is strongly linked to energy prices. Price declines can weaken financial incentives for energy efficiency, delaying progress in emissions reduction (Gouldson et al., 2013).
- **Lack of Financial Incentives:** The absence of adequate financial incentives for low-carbon innovation limits firms' motivation to invest in technologies or processes that reduce emissions (Liu, 2014).
- **Market Failures:** Market failures, such as inefficiencies in consumer decisions and externalities, act as economic barriers that require policy interventions to improve economic efficiency and stimulate the adoption of low-carbon technologies (Gillingham & Sweeney, 2012).
- Competing Priorities: Companies face competing priorities, such as cost reduction and profit maximization, which can reduce commitment to climate transition plans (Liu, 2014).
- **Influence of Traditional Business Models:** Traditional business models, focused on shareholder value and short-term financial metrics, conflict with climate transition goals, making it difficult to justify investments in sustainable practices (Yosie, 2024).
- **Misaligned Incentives:** Misaligned incentives, which prioritize short-term financial performance, can lead to greenwashing, with symbolic commitments instead of substantial climate transition actions (Coen et al., 2022).
- **Need for Diversified Investments:** Companies that do not diversify their investments in adaptation and mitigation initiatives face difficulties in effectively reducing emissions and managing interconnected risks under different climate policy scenarios (Cenci & Tang, 2024).
- **Short-Termism and Traditional Metrics Barriers:** Prioritizing short-term financial performance and relying on traditional metrics hinder investments in sustainable practices, which are essential for long-term sustainability (Yosie, 2024).
- **Weak Green Management:** Weak management in companies prevents investments in measures that explicitly reduce emissions, even when there are no credit constraints, resulting in limited progress in the sustainable transition (Haas et al., 2024; Haas et al., 2021).

- **Interconnected Transition Challenges:** The transition to a low-carbon economy requires comprehensive strategies and diversified investments to address interconnected challenges. This effort can be costly and require substantial resources (Cenci & Tang, 2024).
- **Turnaround and Payback Times:** The long operational time and limited investment cycles in chemical plants create financial barriers, especially when low-carbon technologies are not ready for adoption, leading to sunk costs and potential technology lock-ins (Janipour et al., 2020).
- **Job Losses in Certain Sectors:** The transition to a net-zero emissions economy will cause job losses in sectors such as fuel extraction, mining, and manufacturing. This poses significant economic challenges for regions dependent on these industries (Bowman, 2022).
- **Technology Investment:** The high cost associated with investing in new and sustainable technologies poses a major challenge, especially when companies face financial constraints or uncertainty about the return on investment (Tseng et al., 2021).

S1.2. Political and Regulatory Barriers

- **Regulatory and Market Barriers:** The absence of meaningful regulations, such as carbon pricing, and high compliance costs for financially constrained firms hinder investments in green innovations (Liu & Xu, 2023).
- **Regulatory and Institutional Constraints:** The ecosystem of rules and rewards, including emissions accounting standards and leadership metrics, can lead to inappropriate allocations of climate investments, limiting their impact (Ballentine, 2023).
- **Policy and Instrument Integration Barriers:** The integration of new climate instruments, such as voluntary agreements and emissions trading, into existing policy frameworks is often vague or insufficient. This leads to market uncertainty and increases corporate costs, as in the case of the European Union's initiatives, which create inconsistencies with other regulatory instruments (Albrecht, 2017; Maloney & Busch, 2024).
- **Policy Uncertainty Barriers:** The uncertainty caused by frequent changes in climate policies, as observed in China, increases corporate emissions and negatively affects environmental regulation, social responsibility, and R&D investments, particularly in non-state-owned and technology-intensive companies (Wang et al., 2024).
- **Compliance Cost Barriers:** Environmental regulations increase compliance costs in the short term, which can limit the ability of financially constrained companies to invest in green innovations (Liu & Xu, 2023).
- **Lack of Clarity in Policies and Standards:** The lack of clarity in policies, standards, and verification schemes makes it difficult for companies to define effective actions to reduce emissions and scale carbon removal initiatives. This ambiguity can lead to inconsistent efforts, greenwashing, and loss of consumer trust (Maloney & Busch, 2024).
- **Policy Inconsistency:** Inconsistency between energy efficiency targets and emissions reduction targets creates barriers, such as investments in short-term technologies that increase sunk costs, making the transition to low-carbon options more difficult. In addition, this impacts the competitiveness of low-carbon products (Janipour et al., 2020; Wang et al., 2024).
- **Regulatory Uncertainties:** Regulatory uncertainties, such as frequent policy changes or lack of clarity, create challenges for the planning and execution of climate transition strategies (Kraetzig et al., 2024).
- **Regulatory and Institutional Constraints:** The ecosystem of rules and rewards, including leadership metrics and emissions accounting standards, can lead to the misallocation of climate resources, reducing the potential impact of private capital on climate mitigation (Ballentine, 2023).
- **Complexity of Regulatory Compliance:** The complexity of complying with constantly evolving regulatory standards represents a major obstacle for companies, making it difficult to integrate climate considerations into corporate strategies (Gehrke et al., 2024).
- **Lack of Significant Regulatory Mandates:** The absence of meaningful regulations or adequate carbon pricing can lead to the misallocation of corporate climate spending, limiting the effectiveness of mitigation initiatives (Ballentine, 2023).
- **Frequent Policy Changes in China:** Frequent changes in climate policies create uncertainty, negatively affecting environmental regulation, social responsibility, and R&D investments, especially in non-state-owned and technology-intensive enterprises (Wang et al., 2024).

- **Lack of External Pressure:** The absence of regulatory pressure prevents organizations from adopting effective climate strategies, representing a critical regulatory barrier (Jeswani, 2007).
- **Lack of a Common Definition of Low Carbon Production:** The lack of a common definition for low carbon production causes confusion and inconsistencies in the adoption of sustainable practices, affecting regulatory coherence (Liu, 2014).
- **Politics of Knowledge:** The lack of critical academic engagement with the Science-Based Targets Initiative (SBTi) governance framework may perpetuate existing power dynamics, limiting meaningful structural changes in corporate climate governance (Tilsted et al., 2023).
- **Dependence on Corporate Innovation:** Dependence on corporate innovation can limit more comprehensive and systemic approaches that involve significant policy changes and government interventions. This excessive focus on companies can overshadow the need for coordinated efforts across sectors and levels of government (Wright et al., 2024).

S1.3. Cultural and Organizational Barriers

- **Environmental Impact of Organizational Constraints:** Organizational constraints, such as credit limitations and weak management, contribute to high CO2 emissions, revealing a direct impact on sustainability (Haas et al., 2024).
- **Low-Quality Firm Management:** Low-quality management hinders strategic decisions and investments in green technologies (Haas et al., 2021).
- **Environmental Impact of Organizational Constraints:** Organizational constraints, such as credit limitations and ineffective management, increase CO_2 emissions and hinder the implementation of sustainable changes (Haas et al., 2024).
- **Weak Green Management:** Firms with weak environmental management are less likely to invest in measures to reduce emissions, even when they do not face credit constraints (Haas et al., 2024; Haas et al., 2021).
- **Low-Quality Firm Management:** Low-quality management in firms hinders strategic decision-making and the implementation of green technologies, due to a lack of necessary skills or vision (Haas et al., 2021).
- **Governance and Strategic Alignment:** Corporate governance structures may not be prepared to address the unique challenges posed by climate risks, making it difficult to effectively integrate them into strategic planning (Grove et al., 2020).
- **Need for an Adaptation Framework:** The need for a clear adaptation framework aligned with corporate governance to address climate risks is highlighted as a critical obstacle (Hennes et al., 2024).
- **Reluctance in Strategy Formulation:** Adapting to new trends, such as supply chain governance and the resurgence of industrial policies, requires significant changes in operations and strategies, creating complex operational barriers (Yosie, 2024).
- **Long History of a Planning-Oriented Economy:** China's historical reliance on a planned economy inhibits efficient decision-making and innovation, making it difficult for companies to adapt to new environmental strategies (Liu, 2014).
- **Lack of Individual Financial Incentives:** The lack of financial incentives for employees discourages behavioral changes toward sustainability, making it difficult to adopt sustainable organizational practices (DeLong & Mehalik, 2013).
- **Challenges in Balancing Business Growth and Emissions Reductions:** Companies face tensions between business growth and emissions reductions, especially in sectors with transport-intensive business models or unsustainable practices (Gouldson et al., 2013; Zhang et al., 2011).
- **Cultural Resistance to Change:** Cultural resistance within organizations, with employees and managers accustomed to traditional practices, can impede the adoption of green practices that require behavioral and process changes (Kodua et al., 2022).
- **Internal Organizational Structure:** Centralized organizational structures, such as those at ExxonMobil, make it difficult to incorporate diverse perspectives and adapt to international pressures, compared to more decentralized organizations, such as Shell (Kolk & Levy, 2001).
- **Organizational and Institutional Factors:** Institutional complexity and organizational paradigms make it difficult to implement more sustainable practices, especially in deeply embedded systems (Rickards, 2014).

- **Organizational Culture:** Organizational culture can be a critical factor in the success of sustainable practices. Without addressing cultural issues, technological solutions may fail to be implemented effectively (Schnitzer & Ulgiati, 2007).
- **Organizational Inertia:** Deeply entrenched processes and structures create resistance to adopting more sustainable practices due to fear of the unknown and perceived risks (Abdalla & Maas, 2008).
- **Framing Climate Change as a Consumption Problem:** The idea of addressing climate change by promoting "green" consumption can be a systemic barrier by focusing on individual choices rather than broader policy and structural changes (Wright et al., 2024).
- **Internal Coherence:** A lack of alignment between climate transition plans and overall business strategy can create conflicting priorities, hindering effective implementation (OECD, 2022).
- **Spatial Implications of Emission Management:** Localizing climate responsibility, through tools such as corporate carbon footprint assessments, can lead to uneven efforts in reducing emissions across regions or sectors (Walenta, 2018). Lack of Societal Pressure in Pakistan: The lack of societal pressure in countries like Pakistan prevents organizations from effectively implementing climate transition plans (Jeswani, 2007).
- **Short-term Focus of Targets:** Many companies' focus on short-term goals rather than long-term goals aligned with climate needs undermines the sustained effort and investment needed for comprehensive climate strategies (Gouldson et al., 2013).
- **Limited Scope of Targets:** Limited corporate targets that focus only on direct emissions from operations, without addressing supply chains or customer emissions, reduce the potential impact of climate initiatives (Gouldson et al., 2013).
- **Resistance to Radical Innovation:** Current environmental management systems, focused on compliance and cleaner production, do not foster the radical innovations needed for sustainable business models. Companies are reluctant to adopt untested technologies that require significant changes to their operations (Schnitzer & Ulgiati, 2007).
- **Safety Routines:** Developing new safety standards and routines to implement technologies in the chemical industry can be costly and time-consuming, delaying the transition (Janipour et al., 2020).
- **Management's Restricted Knowledge:** A lack of managerial knowledge about climate change makes it difficult to assess potential negative impacts on business activities (Weinhofer & Busch, 2013).
- **Insufficient Knowledge Among Companies:** Insufficient awareness of climate strategies and a lack of data integration impede the effective implementation of corporate transition plans (Jeswani et al., 2007).
- **Management's Restricted Knowledge:** A lack of managerial knowledge about climate change makes it difficult to assess potential negative impacts on business activities (Weinhofer & Busch, 2013).
- **Insufficient Knowledge Among Companies:** Insufficient awareness of climate strategies and lack of data integration impede the effective implementation of corporate transition plans (Jeswani et al., 2007).
- **Eco-Management:** Implementing eco-efficient management practices requires changes in organizational processes and culture, facing resistance and alignment at all levels of the organization (Tseng et al., 2021).
- **Reluctance in Strategy Formulation:** Adapting to new frameworks, such as supply chain governance, presents significant operational challenges as it requires substantial changes in operations (Yosie, 2024).

S1.4. Management and Operational Barriers

- **Prevention of Carbon-Intensive Lock-In:** Avoiding long-term dependencies on high-emission technologies is a crucial operational challenge to ensure the future flexibility of companies (OECD, 2022).
- **Scaling Up Carbon Removal:** Rapidly scaling carbon dioxide removal requires new technologies and practices that are often not economically viable or fully developed (Maloney and Busch, 2024).
- **Dependence on Carbon Offsets:** Over-reliance on carbon offsets can result in insufficient climate action and a lack of meaningful operational changes in companies (Bowman, 2022).
- **Governance and Accountability:** Establishing robust governance structures and accountability mechanisms is essential to track progress and make necessary adjustments, but many companies face challenges in this implementation (OECD, 2022).
- **Integration with Business Plans:** Integrating climate transition plans into business strategies and organizational governance is a common obstacle, leading to ineffective implementation (OECD, 2022).

- **Low-Quality Firm Management:** Low-quality management impedes the prioritization and effective implementation of investments in green technologies, reducing progress towards sustainable practices (Haas et al., 2021).
- **Managerial Barriers in Zero Energy Construction:** Managerial barriers, more than technical issues, hinder the adoption of next-generation sustainable construction technologies (Abdalla & Maas, 2008).
- **Net-Zero and Interim Targets:** Setting net-zero and interim targets requires balancing ambition with practicality, taking into account technological advances, regulatory changes and market dynamics. Operational complexity can make it difficult to meet these targets (OECD, 2022).
- **Operational Adaptation to Emerging Frameworks:** Adapting to new frameworks, such as supply chain governance and industrial policies, requires significant operational changes that can be challenging (Yosie, 2024).
- **Performance Metrics and KPIs:** Developing effective and comprehensive performance metrics that are aligned with industry standards is a significant management challenge, especially to ensure transparency and accountability (OECD, 2022).
- **Challenges in Emission Reduction:** Reducing emissions in line with 1.5°C scenarios requires significant changes in operations, supply chains and product design. These changes can be complex and resource-intensive, creating substantial operational barriers (Maloney and Busch, 2024).
- **Implementation Actions:** Translating plans into concrete actions requires collaboration between departments and integration into the core business strategy, requiring robust coordination and resource allocation (OECD, 2022).
- **System Integration:** Operating in highly integrated clusters in the chemical sector, while improving energy efficiency, can make it difficult to adopt new technologies without significant disruptions to existing systems (Janipour et al., 2020).
- **Ensuring High Integrity and Credibility:** Ensuring integrity and credibility in climate claims requires robust systems for decarbonization, high-quality carbon credits, and detailed climate strategies, which are challenging to implement consistently (Maloney and Busch, 2024).
- **Systemic Failures:** Weak connections between companies, universities, and research institutions hinder the development and application of new technologies. Effective collaboration is essential for innovation and the adoption of sustainable practices (Schnitzer & Ulgiati, 2007).
- **Lengthy Simulation Times:** The long time required for simulations can delay decision-making and hinder timely responses to climate adaptation needs (Keibach & Shayesteh, 2022).
- **Adaptation Options and Risk-Management Solutions:** Identifying appropriate adaptation options and developing transformative risk-management solutions requires the integration of local knowledge with climate data, a complex and resource-intensive process (Gehrke et al., 2024).
- **Long Simulation Process:** The extended duration of simulations delays decision-making and hinders timely responses to climate adaptation needs (Keibach & Shayesteh, 2022).
- **Inefficient Implementation Process:** Inefficiency in implementing climate adaptation tools and practices is a barrier that often results from a lack of standardized procedures or training (Keibach & Shayesteh, 2022).
- **Interoperability Issues in Climate Tools:** The incompatibility of climate adaptation tools with other planning software increases the workload and reduces the efficiency of the planning process (Keibach & Shayesteh, 2022).

S1.5. Social and Climate Justice Barriers

- **Potential for Social Inequality:** High social costs during the transition to a low-carbon economy can deepen existing inequalities, compromising economic growth and social stability (Bowman, 2022).
- **Just Transition Aspects:** Ensuring a just transition, considering social implications such as job losses in carbon-intensive sectors, is essential. Companies need to engage stakeholders, including employees and communities, to develop strategies that support affected groups (OECD, 2022).
- **Lack of Just Transition Plans:** The absence of plans to address social impacts of the transition, such as reskilling and redeployment of workers, can lead to resistance and undermine the credibility of net-zero emissions strategies (Bowman, 2022).

S1.6. Transparency and Disclosure Barriers

- **Ineffectiveness of Certain Indicators:** Indicators related to green spending and monetary incentives show limited effectiveness in reducing emissions, making it difficult to identify effective strategies (Gehrke et al., 2023).
- **Carbon Credits and Offsets:** The use of carbon credits as a complementary measure presents challenges in ensuring the credibility and effectiveness of these tools in reducing emissions (OECD, 2022).
- **Emerging Mandatory Corporate Disclosure Programs:** Reliance on existing reporting guidelines may not capture the complexity of climate change, highlighting gaps in corporate strategies. This reinforces the need for mandatory reporting to support the transition to net-zero emissions (Tilsted et al., 2023; Armour et al., 2022).
- **Influence of Third-Party Leadership Metrics:** Leadership metrics set by third parties can influence corporate climate actions, prioritizing some strategies over others, which can limit the overall effectiveness of emissions reduction actions (Ballentine, 2023).
- **Complexity of Emissions Reporting:** Complexity in emissions reporting, especially with scopes 1, 2, and 3, makes it challenging for companies to accurately measure and disclose their carbon performance, which is crucial for effective climate transitions (Coen et al., 2022).
- **Data Distortions and Concealment:** Distortions and concealment of data in sustainability reports make it difficult for stakeholders to accurately assess corporate climate performance, even with initiatives such as the Global Reporting Initiative (Coen et al., 2022).
- **Demand for Non-Financial Reporting:** The growing demand for non-financial reporting, such as climate scenario-based risk analyses, poses a challenge for companies to expand their reporting frameworks, which can be resource-intensive and complex (Gehrke et al., 2024).
- **Transparency and Verification:** Ensuring transparency in reporting and third-party validation is critical to building trust with stakeholders. This includes disclosing methodologies, assumptions, and progress in a clear and accessible manner (OECD, 2022).
- **Climate Data Integration:** Companies often leave gaps when incorporating climate data and scenarios into their reporting and strategies, undermining effective risk management (Gehrke et al., 2024).
- **Lack of Comprehensive Metrics:** The difficulty in capturing comprehensive metrics on the impact of sustainability on operations impedes the evaluation of the effectiveness of initiatives and compromises investment decisions (DeLong & Mehalik, 2013).
- **Lack of Standardized Metrics:** The absence of standardized metrics to measure and report emissions reductions can lead to inconsistent efforts and reduced accountability (Gehrke et al., 2023).

S1.7. Stakeholder Engagement and Supply Chain Barriers

- **Misaligned Incentives:** Misaligned incentives prioritize short-term financial gains over sustainability goals, promoting greenwashing practices and undermining genuine climate action (Coen et al., 2022).
- **Stakeholder Engagement:** Stakeholder engagement improves green competitiveness by aligning corporate strategies with sustainable development goals and market demands, but requires effective conflict management and integration of suggestions (Lyulyov et al., 2023).
- **Stakeholder Pressure:** Pressure from stakeholders, including investors, consumers, and regulators, can be challenging as companies need to balance external expectations with their operational and financial capabilities (Cenci & Tang, 2024).
- **Building Relationships with Stakeholders:** Building strong relationships with stakeholders is essential to address their concerns and ensure that no one is left behind. This approach is aligned with the principles of the Sustainable Development Goals and improves decision-making on sustainability (Cunha, 2022).
- **Complexity of Supply Chain Governance:** Managing supply chains to ensure sustainability is complex, involving coordination with multiple stakeholders, each with different interests and priorities, making it difficult to implement consistent climate strategies (Yosie, 2024).
- **Limited Focus on Indirect Emissions:** The restricted focus on direct emissions from operations, to the detriment of indirect emissions along the supply chain, limits the overall impact of corporate climate initiatives (Gouldson et al., 2013).
- **Limited Scope of Targets:** Climate targets that ignore indirect supply chain or customer-related emissions underestimate a significant portion of the corporate carbon footprint, reducing potential impact (Gouldson et al., 2013).

- **Reliance on Supply Chain Complementary Capabilities:** Reliance on supply chain partners to support sustainability efforts can be challenging if those partners lack the necessary capabilities or are not aligned with sustainability goals (Kraetzig et al., 2024).

S1.8. Technological Barriers

- Carbon Lock-In: Energy-intensive industries face technological barriers, such as sunk costs and technology incompatibility, hindering the adoption of low-carbon alternatives (Janipour et al., 2020).
- Deficient Tools for Low-Carbon Product Development: The lack of adequate tools and resources for the development of low-carbon products is a significant barrier, hindering innovation and compliance with sustainability standards (Kraetzig et al., 2024).
- Deficient Tools for Low-Carbon Product Development: The lack of adequate tools and resources for the development of low-carbon products hinders innovation and compliance with sustainability standards (Kraetzig et al., 2024).
- Barriers to Technological Innovation in SMEs: Small and medium-sized enterprises face difficulties in adopting low-carbon practices due to technological and operational challenges (Zhang et al., 2011).
- Lack of Low Carbon Technology: The lack of available technologies to support low-carbon production prevents companies from effectively reducing their carbon footprint (Liu, 2014).
- Market Failures: The lack of information about clean technologies hinders the adoption of sustainable practices, even when such technologies are available (Schnitzer & Ulgiati, 2007).
- Technological Incompatibility: The incompatibility between low-carbon technologies and existing systems, such as electrification and carbon storage, can hinder the adoption of more sustainable solutions (Janipour et al., 2020).
- Technological Lock-in: Reliance on outdated technologies creates barriers to the adoption of more sustainable alternatives (Foxon, 2012).
- Gaps in Incorporation of Climate Data: Climate adaptation tools face interoperability issues, making integration with other planning software difficult and reducing process efficiency (Keibach & Shayesteh, 2022).

S1.9. Data Barriers

- **Data Management:** Data management is essential for tracking sustainability metrics and making informed decisions, but many companies struggle to collect, analyze, and use data efficiently (Tseng et al., 2021).
- **Incorporation of Climate Data:** Failure to adequately incorporate forward-looking climate data into planning and reporting prevents companies from anticipating and responding effectively to climate risks (Gehrke et al., 2024).

S1.10. Biodiversity (Nature) Barriers

- **Non-Climate-Related Sustainability Impacts:** Addressing broader sustainability impacts, such as biodiversity and social equity, is often overlooked but essential for a holistic approach. Companies need to integrate these considerations into their transition plans to ensure they are not inadvertently causing harm in other areas (OECD, 2022).

S1.11. Other unclassified barriers

- **Impact of Weather Shocks:** Although not directly identified as a barrier, exposure to unpredictable climate shocks can divert resources and attention from green investments (Haas et al., 2021).
- **Varied Strength and Content of Barriers:** The maturity of corporate environmentalism varies significantly between industrialized and developing countries, reflecting differences in the strength and content of barriers faced by companies (Jeswani, 2007).

S2. CLASSIFICATION OF OPPORTUNITIES INTO CATEGORIES

S2.1. Investments and Sustainable Financing

1. **Increased Investments in Sustainable Technologies:** Companies in countries with more developed financial systems tend to significantly increase their investments in low-carbon technologies. These investments are driven by economic incentives and the need to align with global environmental goals (Ma, 2023).

2. **Financing Projects with Long-Term Debt:** Corporations are utilizing long-term debt securities to fund their climate initiatives. This approach offers financial stability while facilitating the implementation of complex, large-scale projects (Ma, 2023).
3. **Use of Internal Funds for Green Expansion:** In addition to accessing financial markets, companies are using internal resources to accelerate the adoption of green technologies, reducing costs and promoting autonomy in their operations (Ma, 2023).
4. **Diversification of Investments in Financially Developed Regions:** Research shows that companies in developed markets are more likely to diversify their investments in low-carbon infrastructure, positioning them better in uncertain regulatory scenarios (Ma, 2023).
5. **Diversification of Investments in Environmental Initiatives:** Companies that distribute their investments across multiple environmental initiatives can mitigate the impacts of climate risks, such as carbon pricing, and comply with climate regulations (Cenci & Tang, 2024).
6. **Exponential Growth in Investments:** The significant increase in investments in startups—with a 2000% increase in transactions and a 2811% increase in invested capital—reflects market confidence in these companies' potential to transform the business sector (Hakovirta et al., 2022).
7. **Access to Sustainable Financing:** European policies focused on green financing facilitate access to resources for climate transition initiatives, encouraging innovation and sustainability (Gómez, 2022).
8. **Access to Green Financial Instruments:** Companies can benefit from green bonds, sustainability-linked loans, and other financial mechanisms that offer favorable conditions for projects aligned with climate goals (Klein & Widge, 2016).
9. **Enhancement of Corporate Credit:** The adoption of sustainable practices improves companies' credit ratings, facilitating access to capital at reduced costs (Klein & Widge, 2016).
10. **Innovation in Financing Models:** Development of new financial models that combine sustainability and profitability, allowing greater feasibility for climate transition projects (Klein & Widge, 2016).
11. **Investments in Green Assets:** Companies with high climate scores attract investors focused on ESG (Environmental, Social, and Governance), ensuring access to capital under better financial conditions (Broccardo et al., 2024).
12. **Attraction of Social Justice-Focused Financing:** Companies that prioritize just transition initiatives can access funding sources that value positive social impacts, such as ESG funds (Park & Bishara, 2023).
13. **Investments in Green Energy Infrastructure:** Building and modernizing infrastructure to support renewable sources improves efficiency and ensures reliable access to clean energy (Canal Vieira et al., 2022).
14. **Leverage of Government Incentives:** Subsidy policies and tax incentives for green practices offer financial advantages to companies leading the adoption of sustainable solutions (Coulson-Thomas, 2017).
15. **Access to Green Financial Instruments:** Companies can benefit from green bonds, sustainability-linked loans, and other financial mechanisms that offer favorable conditions for projects aligned with climate goals (Klein & Widge, 2016).
16. **Enhancement of Corporate Credit:** The adoption of sustainable practices improves companies' credit ratings, facilitating access to capital at reduced costs (Klein & Widge, 2016).
17. **Innovation in Financing Models:** Development of new financial models that combine sustainability and profitability, allowing greater feasibility for climate transition projects (Klein & Widge, 2016).
18. **Access to Sustainable Financing:** Companies leading sustainable initiatives are more likely to access green financial instruments, such as sustainability funds and tax incentives (Rodrigues et al., 2024).
19. **Leverage of Government Incentives:** Subsidy policies and tax incentives for green practices offer financial advantages to companies leading the adoption of sustainable solutions (Coulson-Thomas, 2017).
20. **Attraction of ESG Investors:** Companies prioritizing just transition practices attract capital from investors who value positive social and environmental impacts (Park & Bishara, 2023).
21. **Access to Sustainable Financing:** Policies for sustainable financing offer financial support for companies leading projects aligned with emission reduction targets (Gómez, 2022).
22. **Financial Resilience in Climate Transition Scenarios:** Diversification offers greater financial stability by spreading risks across different environmental initiatives, ensuring operational continuity in uncertain contexts (Cenci & Tang, 2024).

23. **Access to Sustainable Markets:** Companies with diversified environmental portfolios can meet the growing demand from consumers and investors for more ecological products and services (Cenci & Tang, 2024).

S2.2. Innovation and Technological Development

1. **Accelerated Innovation in Climate Solutions:** Climate startups drive the creation of technologies and business models aimed at decarbonization. This ecosystem fosters the implementation of disruptive solutions that meet the demands of a transitioning market (Hakovirta et al., 2022).
2. **Partnerships Between Startups and Established Companies:** Collaboration between large corporations and startups enhances efficiency in creating climate solutions by combining financial resources and technological expertise (Hakovirta et al., 2022).
3. **Development of Sustainable Products and Services:** Startups lead the development of green products and energy-efficient technologies, helping companies achieve their net-zero emissions goals (Hakovirta et al., 2022).
4. **Promotion of Innovation Ecosystems:** The emergence of climate innovation clusters encourages the sharing of knowledge and resources among startups, universities, and corporations, creating a virtuous cycle of technological advancement (Hakovirta et al., 2022).
5. **Development of Green Technologies:** Investments in innovative technologies focused on reducing carbon emissions provide companies with the ability to meet regulatory and market demands for more sustainable solutions (Wright et al., 2024).
6. **Transition to Renewable Energies:** Replacing traditional energy sources with renewable options, such as solar and wind, offers companies a significant reduction in emissions and long-term energy costs (Wright et al., 2024).
7. **Eco-Efficiency in Operations:** Implementing operational processes that are more energy-efficient increases productivity and reduces resource waste, improving companies' environmental performance (Wright et al., 2024).
8. **Innovation in Sustainable Products and Services:** The need to comply with regulatory standards drives the creation of products and services that meet the demand for cleaner and more efficient solutions (Sanderson & Stridsland, 2021).
9. **Investments in New Technologies and Processes:** The agreement requires companies to invest in innovative technologies that replace fossil fuels with clean energy sources, promoting the decarbonization of the industrial sector (Gómez, 2022).
10. **Innovation in Adaptive Solutions:** Companies that develop technologies and innovative processes to address climate impacts gain competitive advantages, positioning themselves as sustainability leaders (Erhart et al., 2024).
11. **Transdisciplinary Collaboration for Net Zero Solutions:** Engagement among various stakeholders, including companies, governments, and academic institutions, fosters the development of innovative solutions to achieve net-zero emission goals (Hakovirta et al., 2024).
12. **Creation of Adaptive Products and Processes:** Companies can adopt emerging technologies to enhance efficiency and reduce emissions, aligning with market sustainability demands (Hakovirta et al., 2024).
13. **Development of Innovation Ecosystems:** Establishing innovation clusters focused on sustainability facilitates the sharing of knowledge and resources across different sectors (Hakovirta et al., 2024).
14. **Development of Green Technologies:** Investments in innovative technologies focused on reducing carbon emissions provide companies with the ability to meet regulatory and market demands for more sustainable solutions (Wright et al., 2024).
15. **Transition to Renewable Energies:** Replacing traditional energy sources with renewable options, such as solar and wind, offers companies a significant reduction in emissions and long-term energy costs (Wright et al., 2024).
16. **Eco-Efficiency in Operations:** Implementing more energy-efficient operational processes increases productivity and reduces resource waste, improving companies' environmental performance (Wright et al., 2024).
17. **Substitution of Fossil Fuels with Renewables:** Companies can drastically reduce emissions by investing in renewable energy technologies, such as solar and wind, as substitutes for fossil fuels (Canal Vieira et al., 2022).
18. **Promotion of Collaborative Innovations:** Collaboration between companies and external stakeholders fosters the development of disruptive technologies that address climate challenges efficiently (Coulson-Thomas, 2017).

19. **Development of Markets for Climate Businesses:** Creating markets for sustainable technologies and services fosters the growth of sectors focused on climate mitigation and adaptation (Klein & Widge, 2016).
20. **Creation of New Business Models:** The transition to low-carbon practices encourages the development of innovative business models, such as circular economy and clean production (Rodrigues et al., 2024).
21. **Integration of Digital Technologies for Sustainability:** The adoption of digital tools to monitor emissions and optimize operational processes contributes to efficiency and sustainable innovation (Rodrigues et al., 2024).
22. **Grid-Connected Renewable Energy Markets:** Companies can explore large-scale renewable energy generation, such as solar and wind, leveraging subsidies and favorable regulations (Klein & Widge, 2016).
23. **Urban Sustainable Transport and Logistics:** Adoption of clean transportation technologies, such as electric vehicles and efficient public transport systems, reduces emissions in cities (Klein & Widge, 2016)
24. **Sustainable Management of Urban Waste:** Companies can invest in recycling infrastructure and waste-to-energy conversion technologies, promoting a circular economy (Klein & Widge, 2016).
25. **Investments in Low-Carbon Technologies:** Agreements stimulate companies to adopt technological innovations, such as carbon capture systems and renewable energy sources, to meet regulatory demands (Gómez, 2022).
26. **Creation of Sustainable Products and Services:** Developing innovative and sustainable solutions enhances companies' competitiveness in markets that value responsible environmental practices (Gómez, 2022).
27. **Development of Specific Analysis Tools for Companies:** Tools like the "Company Analysis Tool" allow companies to identify and analyze climate impacts on key business indicators, aiding in adaptation and strategic planning (Groth et al., 2019).
28. **Development of Markets for Climate Businesses:** Creating markets for sustainable technologies and services fosters the growth of sectors focused on climate mitigation and adaptation (Klein & Widge, 2016).
29. **Promotion of Collaborative Innovations:** Collaboration between companies and external stakeholders fosters the development of disruptive technologies that address climate challenges efficiently (Coulson-Thomas, 2017).

S2.3. Risk Management and Resilience

1. **Focus on Sustainable Initiatives to Mitigate Climate Risks:** Sustainable investments are seen as a strategy to mitigate risks associated with extreme climate events and carbon pricing, strengthening business resilience (Ma, 2023).
2. **Reduction of Exposure to Carbon Risks:** Diversification not only reduces vulnerability to carbon price fluctuations but also enhances financial stability for companies in a dynamic regulatory environment (Cenci & Tang, 2024).
3. **Resilience in Uncertain Regulatory Scenarios:** Companies that diversify their climate strategies are better positioned to address uncertainties related to the implementation of new environmental policies, ensuring continuity and competitiveness (Cenci & Tang, 2024).
4. **Attention to Demands of Conscious Consumers:** Green products and services utilizing eco-efficient technologies attract increasingly environmentally conscious consumers, creating new market niches (Wright et al., 2024).
5. **Strengthening Corporate Reputation:** Companies leading the adoption of green and innovative solutions enhance their reputation as change agents, gaining recognition from stakeholders and investors (Wright et al., 2024).
6. **Mitigation of Climate Risks Through Advanced Planning:** Implementing robust methodologies to assess and disclose climate risks improves resilience and protects operations against environmental impacts (Sanderson & Stridsland, 2021).
7. **Integration of Climate Scenarios into Corporate Strategies:** Companies incorporating climate scenarios into decision-making processes are better able to anticipate and mitigate environmental impacts, strengthening their long-term operations (Gómez, 2022).
8. **Strengthening Corporate Resilience:** Detailed evaluations of climate risks enable companies to develop adaptive strategies, reducing vulnerability to extreme climate events and emerging regulations (Erhart et al., 2024).

9. **Development of Climate Risk Management Methodologies:** The creation of specific frameworks to analyze climate-related risks offers companies a structured approach to identifying and responding to environmental challenges (Erhart et al., 2024).
10. **Improvement of Transparency and Climate Reporting:** The adoption of robust practices for disclosing climate risks increases investor and stakeholder confidence, improving access to financing and strengthening corporate reputation (Erhart et al., 2024).
11. **Transdisciplinary Collaboration:** Interaction between internal and external stakeholders promotes co-creation of adaptive solutions, increasing the efficiency and acceptance of implemented strategies (Gehrke et al., 2024).
12. **Identification of Specific Adaptation Options:** Through detailed evaluations, companies can identify and implement adaptation measures tailored to local and sectoral needs, mitigating specific climate risks (Gehrke et al., 2024).
13. **Strengthening Partnerships with Stakeholders:** Engaging stakeholders early in strategic planning results in more robust solutions aligned with shared objectives (Gehrke et al., 2024).
14. **Integration of Regional and Local Information:** Incorporating regional climate data allows for more detailed planning tailored to the specificities of each geographic area, increasing the effectiveness of adopted measures (Gehrke et al., 2024).
15. **Efficiency in Resource Use:** Adopting practices that maximize the efficient use of natural resources reduces waste and operational costs while promoting a sustainable corporate image (Ansah & Sorooshian, 2019).
16. **Reduction of Greenhouse Gas Emissions:** Investments in technologies and processes that minimize emissions contribute to achieving global climate goals (Ansah & Sorooshian, 2019).
17. **Competitive Positioning in Green Portfolios:** By adopting sustainable practices, companies are classified as "green" compared to "brown" competitors, attracting more environmentally conscious consumers and investors (Broccardo et al., 2024).
18. **Promotion of Climate Transparency:** Consistent reporting on emissions and environmental initiatives strengthens corporate reputation and builds trust among stakeholders (Broccardo et al., 2024).
19. **Development of Carbon Mitigation Strategies:** The implementation of carbon capture and storage (CCS) programs allows companies to neutralize emissions, contributing to global climate goals (Canal Vieira et al., 2022).
20. **Adoption of Resilient Business Models:** Transforming traditional business models to incorporate sustainable practices enhances resilience to climate and economic changes (Coulson-Thomas, 2017).
21. **Diversification of Energy Portfolios:** Companies expanding their scope to include emerging technologies, such as green hydrogen, create new market opportunities and increase economic resilience (Canal Vieira et al., 2022).
22. **Smart Water Infrastructure:** Solutions for managing urban water resources, including treatment and reuse systems, create opportunities to mitigate the impacts of water crises (Klein & Widge, 2016).
23. **Adoption of Resilient Business Models:** Transforming traditional business models to incorporate sustainable practices enhances resilience to climate and economic changes (Coulson-Thomas, 2017).
24. **Adaptation of Industrial Processes:** Companies are encouraged to modernize their production processes to reduce emissions and increase energy efficiency, aligning with net-zero targets (Gómez, 2022).
25. **Carbon Risk Management:** Companies diversifying their investments in environmental projects reduce their exposure to risks associated with carbon pricing and regulatory fluctuations (Cenci & Tang, 2024).
26. **Reduction of Greenhouse Gas Emissions:** Investing in clean technologies and sustainable practices directly reduces emissions, aligning business operations with global climate mitigation goals (Cenci & Tang, 2024).
27. **Integration of Climate Change into Corporate Planning:** Incorporating climate scenarios into strategic planning aligns business operations with regulatory goals and stakeholder expectations (Groth et al., 2019).
28. **Adaptation to Sector-Specific Conditions:** A sectoral focus allows companies to tailor their strategies to the particularities of their markets and industries (Groth et al., 2019).
29. **Increased Awareness of Climate Change:** Models help companies better understand climate-related risks and opportunities, encouraging proactive actions (Groth et al., 2019).
30. **Strengthening Collaborations for Climate Innovation:** Co-production of strategies among companies and stakeholders promotes innovative and practical solutions to mitigate climate risks (Groth et al., 2019).

S2.4. Regulation and Compliance Strategies

1. **Sustainable Long-Term Performance:** By aligning with global climate goals, such as those defined by the Paris Agreement, companies can ensure sustainable performance and meet the growing demands of stakeholders for environmental responsibility (Cenci & Tang, 2024).
2. **Strategic Alignment with the Paris Agreement:** Companies that adjust their operations to meet science-based targets achieve competitive gains and strengthen their position as sustainability leaders (Sanderson & Stridsland, 2021).
3. **Regulatory Compliance as a Competitive Advantage:** Companies adopting transparent practices for disclosing climate risks and complying with global regulations attract investors focused on environmental responsibility (Sanderson & Stridsland, 2021).
4. **Alignment with Net Zero Targets:** Regulatory pressure to achieve net-zero emissions by 2050 drives companies to review their value chains and production processes to ensure compliance (Gómez, 2022).
5. **Influence on Climate Policies:** Companies have the opportunity to shape environmental regulations through active engagement with policymakers and advocacy for legislation that favors sustainable practices (Coulson-Thomas, 2017).
6. **Adoption of Sustainable Business Models:** Incorporating sustainability as the core of operations allows for greater alignment with regulators, consumers, and climate-conscious investors (Canal Vieira et al., 2022).
7. **Reduction of Regulatory Risks:** Aligning business practices with environmental regulations reduces exposure to penalties and facilitates compliance with emerging climate policies (Rodrigues et al., 2024).
8. **Agility in Responding to Regulatory Demands:** The ability to quickly adapt to changes in climate policies ensures competitive advantage and regulatory compliance (Hakovirta et al., 2024).

S2.5. Social Impacts and Just Transition

1. **Strengthening Corporate Reputation:** Aligning with global climate goals projects a positive image of the company among consumers, investors, and other stakeholders (Sanderson & Stridsland, 2021).
2. **Transformation of Business Models:** Companies are encouraged to adopt cleaner and more sustainable operational models to meet greenhouse gas reduction targets set by the European Green Deal (Gómez, 2022).
3. **Value Creation Through Sustainability:** By integrating sustainability into their corporate strategies, companies can enhance their reputation and attract conscious consumers and investors (Gómez, 2022).
4. **Preservation of Biodiversity:** Implementation of initiatives focused on the conservation of ecosystems and habitats, positioning companies as leaders in responsible environmental practices (Ansah & Sorooshian, 2019).
5. **Support for Vulnerable Communities:** Participation in projects that promote climate resilience in vulnerable communities, creating a positive social impact and alignment with public policies (Ansah & Sorooshian, 2019).
6. **Attraction of Conscious Consumers:** Companies committed to green practices have greater potential to attract consumers concerned with environmental issues, increasing their customer base and loyalty (Ansah & Sorooshian, 2019).
7. **Integration of Sustainability into Corporate Strategies:** Incorporating sustainable practices into business models not only improves companies' reputations but also attracts conscious consumers and ESG-focused investors (Hakovirta et al., 2024).
8. **Attention to Demands of Conscious Consumers:** Green products and services that utilize eco-efficient technologies attract increasingly environmentally conscious consumers, creating new market niches (Wright et al., 2024).
9. **Strengthening Corporate Reputation:** Companies that lead the adoption of green and innovative solutions enhance their reputation as change agents, gaining recognition from stakeholders and investors (Wright et al., 2024).
10. **Creation of Jobs in Green Sectors:** The transition to a low-carbon economy provides significant opportunities for job creation in sectors such as renewable energy, green infrastructure, and sustainable transportation (Park & Bishara, 2023).
11. **Implementation of Professional Retraining Programs:** Companies can lead initiatives to retrain workers affected by the climate transition, ensuring they have access to new employment opportunities (Park & Bishara, 2023).

12. **Strengthening Social Dialogue:** Engaging with workers, unions, and impacted communities promotes a more inclusive and equitable transition, building consensus around necessary changes (Park & Bishara, 2023).
13. **Adoption of Just Transition Frameworks:** Integrating principles of just transition into corporate strategies improves social acceptance and reduces resistance to change (Park & Bishara, 2023).
14. **Engagement of Stakeholders in Sustainability:** Involving consumers, communities, and business partners in climate initiatives creates strategic alliances and strengthens corporate reputation (Coulson-Thomas, 2017).
15. **Enhancement of Corporate Image:** Companies adopting sustainable innovations significantly improve their reputation among stakeholders and consumers, strengthening their brand in a competitive market (Rodrigues et al., 2024).
16. **Increased Competitiveness:** Investments in sustainable technologies enable companies to reduce operational costs and offer products more aligned with the demands of conscious consumers (Rodrigues et al., 2024).
17. **Climate-Smart Agriculture:** Implementation of sustainable agricultural practices, including efficient water use and waste management, increases productivity and reduces emissions (Klein & Widge, 2016).
18. **Creation of Jobs in Green Sectors:** Climate transition stimulates job creation in areas such as renewable energy, sustainable construction, and clean transportation, fostering a green economy (Park & Bishara, 2022).
19. **Retraining and Workforce Development:** Companies can lead training programs to prepare workers for new roles in sustainable sectors, ensuring greater employability and inclusion (Park & Bishara, 2022).
20. **Engagement with Local Communities:** Partnerships with communities impacted by the climate transition promote collaborative projects, ensuring social and economic benefits (Park & Bishara, 2022).
21. **Adoption of Ethical Practices in Just Transition:** Incorporating principles of social justice into corporate strategies strengthens companies' reputations and creates lasting positive impacts (Park & Bishara, 2022).
22. **Strengthening Corporate Reputation:** The adoption of diversified sustainability strategies projects a positive image of the company among stakeholders, reinforcing its leadership in responsible environmental practices (Cenci & Tang, 2024).

S2.6. Other Opportunities Not Classified

1. **Public-Private Collaboration:** Partnerships between governments and companies encourage the implementation of large-scale climate projects, increasing the effectiveness of sustainable initiatives (Klein & Widge, 2016).
2. **Introduction of Climate Transition Scores:** The use of performance indicators related to climate transition enables companies to monitor and adjust their actions to meet sustainability goals (Broccardo et al., 2024).
3. **Engagement of Stakeholders in Sustainability:** Involving consumers, communities, and business partners in climate initiatives creates alliances and strengthens corporate reputation (Coulson-Thomas, 2017).
4. **Collaboration with Stakeholders:** Cooperation between companies, governments, and local communities strengthens climate initiatives and promotes sustainable development (Gómez, 2022).
5. **Development of Scenario-Based Process Models:** Companies utilizing structured process models, such as climate inventories and prioritization analyses, can integrate climate change information into their strategic planning (Gehrke et al., 2024).
6. **Decentralized Solar Energy Systems and Storage:** Off-grid solutions offer new opportunities in remote areas, promoting access to clean energy and reducing operational costs (Klein & Widge, 2016).
7. **Green Buildings:** Companies in the real estate sector can capitalize on sustainable construction practices, such as energy efficiency and low-impact materials (Klein & Widge, 2016).

S3. CLASSIFICATION OF BEST PRACTICES AND SUCCESSFUL EXAMPLES INTO CATEGORIES

S3.1. Climate Governance

- **Setting Clear Targets:** Establishing net-zero and intermediate emissions targets is key. These targets should be ambitious but achievable, providing a clear roadmap for emissions reductions (OECD, 2022). Companies should ensure that these targets are aligned with science-based and industry standards to maintain credibility and effectiveness (OECD, 2022).
- **Integrating Transition Plans with Business Strategy:** Climate transition plans should be integrated into the company's overall strategy to ensure coherence and alignment. This integration helps to mobilize resources and align organizational efforts towards sustainability goals (OECD, 2022).

- **Ensuring Governance and Accountability:** Establishing strong governance structures and accountability mechanisms is essential for effective implementation. Regular reporting and third-party verification can improve transparency and stakeholder trust (OECD, 2022).
- **Timing of Policy Implementation:** Companies should carefully consider the timing of climate policy implementation, understanding the current regulatory environment and anticipating future changes to ensure that policies are proactive and adaptive to new regulations (Hoffman, 2006).
- **Internal and External Commitment:** Establishing appropriate levels of commitment is critical. Internally, this means aligning all levels of the organization with climate goals. Externally, it involves engaging stakeholders, including customers, suppliers, and policymakers, to build a network of support for the company's climate initiatives (Hoffman, 2006).
- **Influencing Policy Development:** Companies can play a role in shaping beneficial climate policies by actively participating in policy discussions and collaborating with industry groups. This proactive approach can help create a regulatory environment that supports sustainable business practices (Hoffman, 2006).
- **Need for Global Regulation and Governance:** The article emphasizes the importance of establishing global regulations and governance to ensure a successful energy transition. This involves creating international agreements and policies that guide countries and companies in sustainable energy practices (Rojey, 2009).
- **Long-term Vision and Commitment:** Successful climate transition requires a long-term vision and commitment from companies. This includes setting ambitious but achievable targets, regularly measuring progress, and being transparent about challenges and achievements (Rojey, 2009).
- **Importance of Leadership and Vision:** Successful climate transition often requires strong leadership and a clear vision. Companies that prioritize sustainability at executive level are more likely to implement effective strategies and achieve their climate goals (Boul, 2022).
- **Policy Design and Implementation:** The report emphasizes the importance of innovation-led regional development policies. These policies must be forward-looking and adapted to local conditions to effectively manage the industrial transition (OECD, 2019).
- **Place-Based Strategies:** A strong place-based dimension is crucial. This means that policies must be tailored to the specific needs and conditions of each region, building on local heritage and using policy experimentation to identify context-appropriate tools (OECD, 2019).
- **Active Transition Management:** The success of industrial transition depends on active management by policymakers and stakeholders. This involves addressing long-term transformation challenges and ensuring that policies are effective and well-targeted (OECD, 2019).
- **Proactive Strategies:** Companies that are recognized as superior in sustainability performance often adopt proactive strategies. This includes setting voluntary targets to reduce greenhouse gas emissions beyond what is required by law (Elijido-Ten et al., 2019).
- **Increased Awareness of Climate Risks:** Companies are increasingly aware of the physical risks posed by climate-induced extreme weather events. This awareness leads them to integrate climate risk assessments into their strategic planning. By understanding and mitigating these risks, companies can protect their operations and infrastructure against potential disruptions, demonstrating corporate responsibility and resilience in the face of climate change (Wright et al. 2024).
- **Structured Process Model:** The paper describes an eight-step structured process model as a best practice for integrating future climate change into corporate strategies. This model includes phases such as inventory, prioritization, identification, availability, enabling, derivation and implementation of measures, evaluation, and process reinforcement. By following this approach, companies can systematically incorporate climate considerations into their operations (Gehrke et al. 2024).

Examples of Successful

- **Legal and Regulatory Compliance:** Companies that adhere to legal and regulatory frameworks demonstrate success in the climate transition. Proactively aligning with emerging environmental laws helps avoid legal risks and positions organizations as sustainability leaders (Park and Bishara, 2022).
- **Integration of Just Transition Principles:** Integrating just transition principles into operations is essential to ensure that the shift to a sustainable economy is inclusive and fair, taking into account the needs and rights of workers (Park and Bishara, 2022).

- **Role of Government and Policy Makers:** The report highlights the critical role of government leaders and policy makers in facilitating the climate transition. Creating policies and support structures encourages industries to adopt sustainable practices and technologies, promoting a greener economy (Kechichian et al., 2016).
- **Challenges and Solutions:** Although the transition to sustainable practices presents challenges, such as the need for investments in new technologies and potential disruptions to existing business models, these challenges can be overcome through strategic planning and collaboration between industries, governments and multilateral institutions (Kechichian et al., 2016).
- **Energy Industry Companies:** The paper highlights that companies in the energy sector are particularly vulnerable to the demands of a green economy. The findings suggest that decarbonization contributes not only to social responsibility but also offers financial benefits, indicating a successful transition to sustainability (Palousis et al, 2014).
- **Proactive Policy Engagement:** Companies that proactively engage in policy frameworks that support sustainability tend to transition more successfully. Aligning strategies with national and international climate goals can bring incentives and support mechanisms (Tavares, 2022).
- **Inclusive and Just Transition:** Ensuring an inclusive and just transition is a critical aspect. This means that while some population groups benefit from technological progress, policies must ensure that no one is left behind (OECD, 2019).

S3.2. Transparency and Reporting

- **Developing Robust Performance Metrics and KPIs:** Implementing comprehensive performance metrics and Key Performance Indicators (KPIs) helps track progress and ensure accountability (OECD, 2022). These metrics should be transparent and comparable to industry peers, facilitating continuous improvement (OECD, 2022).
- **Commitment to International Initiatives:** Participation in international frameworks such as the UN Global Compact and the Principles of Responsible Investment (PRI) helps companies align with global sustainability goals. These initiatives promote transparency and accountability in corporate environmental and social performance (Clarke, 2019).
- **Utilizing Accurate Information and Methodologies:** Companies need access to accurate information on methodologies and opportunities for sustainable practices. This includes understanding financial and non-financial incentives, emerging market opportunities, and having a critical mass of leaders in their industry. This information is crucial for making informed decisions and achieving an effective transition (Palousis et al, 2014).
- **Detailed and Transparent Disclosures:** High-performing companies provide detailed disclosures about their climate strategies, often more comprehensive than their peers. This transparency helps build credibility and influence policymaking (Elijido-Ten et al., 2019).

Examples of Successful

- **Enhancing Stakeholder Trust:** Transparency and accountability in reporting progress can build trust with stakeholders, including investors, customers and regulators (OECD, 2022).
- **Transparent Reporting and Accountability:** Companies that are transparent about their sustainability efforts and hold themselves accountable to their goals are more likely to gain trust and support from consumers and investors. This transparency is crucial for long-term success in the green transition (Tavares, 2022).

S3.3. Technological Innovation and Digitalization

- **Understanding Sociotechnical Dynamics:** Companies should prioritize understanding the role of sociotechnical dynamics in promoting or obstructing the adoption of sustainable innovations. This involves analyzing how existing social and technical systems influence the implementation of sustainable practices and developing strategies to navigate these systems effectively (Elda et al., 2024).
- **Innovation for Sustainability:** Eco-innovation is a key practice, involving the development of new ideas, products, and processes that reduce environmental impacts. This includes advances in pollution control, green energy, and waste reduction. Companies like Tesla have led this movement with innovations in electric vehicles, driving an industry-wide shift toward sustainable technologies (Clarke, 2019).
- **Promoting an Innovative Culture:** Encouraging an innovative culture within the company is vital. This involves rewarding appropriate risk-taking activities by engineers and CEOs, which can lead to significant improvements in resource productivity and competitiveness (Palousis et al, 2014).

- **Innovation and Technological Progress:** Innovation is crucial to the energy transition. Companies must invest in research and development to create new technologies that reduce carbon emissions and improve energy efficiency. This includes advances in renewable energy technologies and energy storage solutions (Rojey, 2009).
- **Regulatory Compliance and Innovation:** Companies that align with regulatory requirements while innovating in their processes and products are likely to succeed in the climate transition. This dual approach ensures that they not only meet current standards but also set new sustainability benchmarks (Boul, 2022).
- **Innovation and Entrepreneurship:** Stimulating innovative entrepreneurship and increasing the diffusion of innovation are key strategies. This involves supporting new business models and technologies that contribute to a carbon-neutral economy (OECD, 2019).
- **Integration of Climate Opportunities:** Successful companies integrate climate-related opportunities into their business strategies. For example, ABB has incorporated climate change opportunities into its strategy, which includes developing technologies that reduce CO2 emissions and enable the integration of renewable energy into power grids (Elijido-Ten et al., 2019).
- **Development of Green Technologies and Products:** Corporations are increasingly focusing on developing green technologies and products as part of their climate transition strategy. This includes innovations that reduce carbon emissions and improve energy efficiency, helping companies meet the growing demand for sustainable options (Wright et al. 2024).

Examples of Successful

- **Driving Innovation:** Integrating climate transition plans into corporate strategy can drive innovation, resulting in the development of new products and services aligned with sustainability goals (OECD, 2022).
- **Investment in Green Technologies:** Investing in green technologies, including renewable energy sources and improvements in energy efficiency, positions companies to save costs and explore new business opportunities in the green economy (Park and Bishara, 2022).
- **Volkswagen's Shift Post-Scandal:** Following the emissions scandal, Volkswagen committed to producing electric vehicles and allocated significant funds to meet pollution standards. This shift underscores the importance of aligning corporate practices with environmental standards to maintain reputation and market position (Clarke, 2019).
- **Sustainability Helix:** This tool guides companies through the transition by identifying key methodologies to reduce environmental impact while improving resource productivity (Palousis et al., 2014).
- **Sustainability Helix:** This tool guides companies through the transition by identifying key methodologies to reduce environmental impact while improving resource productivity (Palousis et al., 2014).
- **Engineering Sustainable Solutions Program:** This program provides essential engineering information to companies and university departments, enabling them to implement sustainable engineering solutions (Palousis et al., 2014).
- **Innovation and Technology Adoption:** Successful companies invest in innovative technologies that reduce carbon footprints and increase efficiency. This helps meet regulatory requirements and positions companies as leaders in the green economy (Tavares, 2022).
- **Nokia's Eco Services:** Nokia has developed eco-friendly services and participated in voluntary regulatory activities, such as the European Union's Integrated Product Policy project. This proactive approach helps the company seize business opportunities arising from regulatory changes (Elijido-Ten et al., 2019).
- **ABB's Energy-Saving Technologies:** ABB's strategy includes the development of high-voltage direct current technologies, which reduce CO2 emissions and support the integration of renewable energy. This positions ABB as a leader in sustainable energy solutions (Elijido-Ten et al., 2019).
- **Philips' Energy Solutions:** Philips offers a range of energy-efficient solutions, including its revolutionary cooker design, which significantly reduces emissions and energy consumption. This innovation highlights Philips' commitment to sustainability and its ability to create market opportunities (Elijido-Ten et al., 2019).

S3.4. Energy Efficiency and Renewable Energy

- **Decarbonisation and Circular Economy:** Companies are moving towards a decarbonised, decentralised and digital economy. This involves adopting new technologies to manage resources efficiently and eliminate waste, moving from a linear economy to a circular economy, where resources are reused and restored rather than depleted (Clarke, 2019).

- **Decarbonisation:** A key practice highlighted is the decarbonisation of industries. This involves reducing carbon emissions through cleaner technologies, improving energy efficiency and utilising renewable energy sources. This approach presents both challenges and opportunities for industries to remain competitive whilst contributing to climate mitigation (Kechichian et al., 2016).
- **Adoption of Environmentally Friendly Technologies:** Companies are encouraged to shift to technologies with a lower environmental impact. This includes investing in renewable energy sources and improving energy efficiency in operations. These practices help reduce carbon emissions and align with the growing demand for sustainable business practices (Palousis et al, 2014).
- **Reduction of Carbon Emissions: A** critical practice for the climate transition is the active reduction of carbon emissions. This can be achieved through strategies such as optimizing supply chains, improving energy efficiency, and adopting cleaner production processes. Companies that focus on reducing their carbon footprint can benefit from both environmental and financial gains (Palousis et al, 2014).
- **Improving Energy Efficiency:** Companies can significantly reduce their carbon footprint by optimizing energy use in their operations. This involves upgrading to energy-efficient equipment, optimizing processes, and implementing energy management systems. These practices not only reduce emissions but also generate long-term cost savings (Balukja, 2024). Transitioning to Renewable Energy Sources: Transitioning from fossil fuels to renewable energy sources such as solar, wind, and hydropower is a crucial step in reducing carbon emissions. Companies can invest in on-site renewable energy generation or purchase renewable energy credits to offset their carbon footprint (Balukja, 2024).
- **Energy Supply and Demand Management:** Managing the balance between energy supply and demand is essential. Companies can adopt practices such as energy efficiency improvements and demand-side management to reduce overall energy consumption and dependence on fossil fuels (Rojey, 2009).
- **Carbon Balance and Reduction Pathways:** Implementing strategies to reduce the carbon content of energy is vital. This includes transitioning to low-carbon energy sources such as solar, wind, and nuclear, and exploring carbon capture and storage technologies to mitigate emissions from existing fossil fuels (Rojey, 2009).
- **Uptake of Renewable Energy:** Transitioning to renewable energy sources is a critical component of successful climate transition strategies. Investing in technologies such as solar, wind, and hydropower enables companies to reduce their reliance on fossil fuels and lower their carbon emissions (Wright et al. 2024).
- **Eco-efficiency initiatives:** Implementing eco-efficiency initiatives is another best practice. These initiatives aim to minimize waste and optimize resource use, leading to significant cost savings and improved operational efficiency (Wright et al. 2024).
- **Collaboration and Co-Creation:** Close collaborations and co-creations with stakeholders are highlighted as best practices. This involves building trust-based partnerships with internal and external stakeholders to foster innovation and knowledge sharing (Gehrke et al. 2024).
- **Integration of Regional Climate Information:** Incorporating regional climate information into decision-making processes is another best practice. This allows companies to tailor their strategies to specific environmental conditions, improving the relevance and effectiveness of climate transition efforts (Gehrke et al. 2024).

Examples of Successful

- **DuPont:** Known for its commitment to sustainability, DuPont has implemented several initiatives to reduce its environmental impact, including investments in renewable energy and improvements in energy efficiency across its operations (Hoffman, 2006).
- **Alcoa:** This company has focused on reducing emissions through technological innovations and process improvements. Alcoa's efforts highlight the importance of investing in research and development to achieve climate goals (Hoffman, 2006).
- **Google:** A leader in renewable energy adoption, achieving 100% renewable energy for its global operations. The company invests heavily in energy efficiency and carbon offset projects, setting a benchmark for other technology companies (Balukja, 2024).
- **Renewable Energy Adoption:** Companies that have successfully transitioned to renewable energy sources, such as solar and wind, have significantly reduced their carbon footprints and energy costs. These companies also report improvements in public perception and compliance with environmental regulations (Rojey, 2009).
- **Energy Efficiency Initiatives:** Some companies have implemented comprehensive energy efficiency programs, leading to reduced energy consumption and operating costs. These include upgrades to energy-efficient

equipment, optimization of production processes, and improvements in insulation and building design (Rojey, 2009).

- **Adoption of Renewable Energy:** Many companies have successfully transitioned to renewable energy sources, such as solar and wind. This shift reduces greenhouse gas emissions and often results in cost savings over time (Boul, 2022).
- **Implementation of Energy Efficiency Measures:** Companies that invest in energy efficiency technologies and practices have significantly reduced energy consumption and carbon emissions. These include equipment upgrades, process optimization, and improved building design (Boul, 2022).

S3.5. Stakeholder and Value Chain Engagement

- **Engaging Stakeholders and Shareholders:** Gaining permission and support from stakeholders and shareholders is essential to a successful transition. This involves demonstrating the potential benefits of sustainable practices and ensuring that all parties are aligned with the company's sustainability goals (Palousis et al, 2014).
- **Enhancing Supply Chain Sustainability:** Companies can work with suppliers to reduce emissions across the supply chain. This includes selecting sustainable materials, optimizing logistics, and incentivizing suppliers to adopt greener practices (Balukja, 2024).
- **Collaboration and Partnerships:** Forming partnerships with governments, NGOs, and other companies can increase a company's ability to effectively deliver a climate transition. Collaborative efforts can lead to shared resources, knowledge, and innovations that benefit all parties involved (Rojey, 2009).
- **Collaboration Across Sectors:** A successful climate transition often requires collaboration between scientists, engineers, regulators, policymakers, and business executives. This multidisciplinary approach ensures that different perspectives and expertise are leveraged to effectively address the climate crisis (Boul, 2022).
- **Political Support and Community Engagement:** Political support at all levels is essential to breaking away from high-carbon development pathways. Companies must engage policymakers and communities to build support for green initiatives and ensure that the transition is inclusive and equitable (Tavares, 2022).

Examples of Successful

- **Public Standards for Greener Products:** The development of public standards for greener products is an example of a successful climate transition. By adhering to these standards, companies can produce environmentally sustainable products that meet consumer demand for sustainability, gaining a competitive advantage (Kechichian et al., 2016).
- **Unilever:** Unilever focuses on reducing emissions across its value chain. The company has set ambitious targets to reduce greenhouse gases and is actively working with suppliers to improve sustainability practices (Balukja, 2024).
- **Stakeholder Collaboration:** Collaboration with stakeholders, including governments, NGOs, and local communities, is a hallmark of successful transitions. Working together allows companies to leverage resources and expertise to achieve common sustainability goals (Tavares, 2022).
- **Sustainable Supply Chain Management:** Reassessing and optimizing supply chains allows companies to significantly reduce their environmental impact. This involves selecting sustainable materials, reducing transportation emissions, and adopting ethical sourcing practices (Boul, 2022).

S3.6. Economic Benefits and Competitiveness

- **Adopting Cost-Effective Sustainability Practices:** The article emphasizes the need for companies to focus on less costly sustainable practices. Identifying and implementing cost-effective solutions can overcome the barrier of high upfront costs and make sustainable practices more accessible (Elda et al., 2024).
- **Creating Business Opportunities:** Climate policies can open up new business opportunities. Companies can innovate and develop new products or services that meet the growing demand for sustainable solutions. This not only helps reduce the carbon footprint but also provides a competitive advantage in the market (Hoffman, 2006).
- **Adopting Sustainable Development through Continual Improvement:** The article emphasizes that there is no inherent conflict between eco-efficiency and economic performance. Companies can achieve both environmental and economic benefits by adopting sustainable development practices focused on continuous

improvement. This approach allows businesses to adapt to changing market demands while remaining competitive (Palousis et al, 2014).

- **Social and Financial Benefits:** Transitioning to sustainable practices is not just about meeting regulatory requirements or corporate social responsibility. It also presents an opportunity for financial benefits. Companies that successfully implement decarbonisation strategies can see improvements in their bottom line, often leading to cost savings and improved brand reputation (Palousis et al, 2014).
- **Challenges and Opportunities:** While transitioning to sustainable practices presents challenges, such as the initial investment in new technologies and potential disruptions to existing processes, it also offers significant opportunities. Companies that lead in sustainability can gain a competitive advantage, attract environmentally conscious consumers and potentially benefit from government incentives and subsidies (Palousis et al, 2014).
- **Adopting Circular Economy Practices:** Implementing circular economy principles, such as recycling, reusing and reducing waste, helps to minimise the environmental impact of production and consumption. This approach not only reduces emissions, but also conserves resources and reduces costs (Balukja, 2024).
- **Adopting Circular Economy Practices:** Implementing circular economy principles, such as recycling, reusing and reducing waste, helps to minimise the environmental impact of production and consumption. This approach not only reduces emissions, but also conserves resources and reduces costs (Balukja, 2024). Challenges and Opportunities: While the transition to sustainable practices presents challenges, such as upfront costs and the need for technological innovation, it also offers opportunities for companies to differentiate themselves in the market and meet the growing demand for sustainable products (Boul, 2022).
- **Economic Opportunities and Job Creation:** The green transition is already underway, creating jobs and economic opportunities. The potential for job creation in the medium and long term is significant. Companies should focus on seizing these opportunities by investing in green technologies and sustainable practices (Tavares, 2022).
- **Challenges and Opportunities:** While the transition to sustainable practices presents challenges, such as upfront costs and the need for technological innovation, it also offers opportunities for companies to differentiate themselves in the market and meet the growing demand for sustainable products (Tavares, 2022).
- **Addressing Job and Revenue Losses:** The transition will inevitably lead to losses of jobs, livelihoods and revenues in certain sectors. Companies should develop strategies to mitigate these losses, such as reskilling programs for workers and diversifying revenue streams to include sustainable practices (Tavares, 2022).
- **Diversification of Investments:** Diversifying investments across a broad range of adaptation and mitigation initiatives is a best practice. This approach helps companies reduce emissions over time and manage transition risks (Cenci and Tang, 2024).
- **Integration into Sustainability Strategies:** Incorporating diversified investments into sustainability strategies is another best practice. This helps companies manage interconnected transition challenges and align with stakeholder expectations (Cenci and Tang, 2024).
- **Reduction of Carbon Pricing Risk:** By diversifying investments, companies can also reduce their exposure to carbon pricing risk. This practice not only mitigates financial risks but also positions companies to benefit from regulatory incentives for low-carbon operations (Cenci and Tang, 2024).
- **Empirical Evidence for Strategic Decision-Making:** The paper provides empirical evidence supporting the effectiveness of diversified investments. This evidence can guide business leaders in making informed decisions about their climate transition strategies (Cenci and Tang, 2024).

Examples of Successful

- **Improving Financial Performance:** Companies that implement sustainable transitions often experience improvements in financial performance, with sustainable practices leading to cost savings and opening up new market opportunities (OECD, 2022).
- **Enhanced Image and Competitiveness:** Companies that transition to sustainable practices can improve their public image and increase competitiveness, attracting environmentally conscious consumers and differentiating themselves in the market (Elda et al., 2024).
- **Tesla's Impact on the Automotive Industry:** Tesla's innovations in electric vehicles have driven a significant shift in the automotive industry, encouraging other manufacturers to invest in electric and hybrid technologies, substantially reducing emissions in the transportation sector (Clarke, 2019).

- **Opportunities for Industries:** The transition to sustainable practices offers industries significant opportunities to innovate and lead in the global marketplace. By adopting greener production methods, companies can not only reduce their environmental impact but also tap into new markets and consumer segments that prioritize sustainability (Kechichian et al., 2016).
- **Profiting in a Carbon Constrained World Report:** Developed with Natural Capitalism Inc, this report highlights opportunities in the carbon credit market, such as the Chicago Climate Exchange and the European Climate Exchange (Palousis et al., 2014).
- **IKEA:** Recognized for its commitment to sustainability, IKEA has implemented strategies to reduce its carbon footprint, including investments in renewable energy and energy efficiency improvements in its stores and supply chain. The company aims to become climate positive by 2030 (Balukja, 2024).
- **Hybrid and Electric Transportation:** Companies in the transportation sector have made significant progress in adopting hybrid and electric vehicles, reducing reliance on fossil fuels and reducing emissions. This transition meets both environmental goals and consumer demand for sustainable products (Rojey, 2009). Regional Competitiveness and Resilience: The report identifies how regions in industrial transition can become more competitive and resilient by seizing the opportunities of globalization, decarbonization and technological change, while limiting the costs for affected communities and workers (OECD, 2019).

S3.7. Social Justice and Just Transition

- **Addressing Non-Climate-Related Sustainability Impacts:** A holistic approach to sustainability should include consideration of non-climate-related impacts, such as social and environmental factors. This ensures that climate actions do not cause unintended harm in other areas, promoting overall sustainability (OECD, 2022).
- **Incorporating Just Transition Aspects:** Considering the social implications of climate actions is crucial for a just transition. Engaging with stakeholders, including employees and communities, helps develop strategies that support affected groups and ensure equitable outcomes (OECD, 2022).
- **Resilient Infrastructure and Sustainable Industrialization:** The work highlights the importance of building resilient infrastructure and promoting sustainable industrialization as part of Sustainable Development Goal 9. This involves transitioning from traditional, resource-intensive and polluting production methods to more sustainable practices that can withstand the impacts of climate change (Kechichian et al., 2016).
- **Sustainable Resource Management:** Companies are advised to manage natural resources more sustainably. This involves reducing the use of natural resources and finding innovative ways to recycle and reuse materials. In this way, companies can minimize their environmental impact and contribute to the conservation of natural resources (Palousis et al, 2014).
- **Sustainable Development Perspective:** Companies should approach the climate transition from a sustainable development perspective, ensuring that economic growth does not come at the expense of environmental health. This involves integrating sustainability into core business strategies and decision-making processes (Rojey, 2009).
- **Justice in Transition:** The transition to a sustainable and climate-safe future is inherently a matter of justice. It is crucial to consider the impacts on vulnerable populations, poor countries and future generations most exposed to climate change and environmental degradation. Ensuring that these groups are protected and supported during the transition is a key practice in achieving a just transition (Tavares, 2022).
- **Consideration of Social and Environmental Challenges:** The transition involves changes in energy production, food, and land use, which can create new social and environmental challenges. Companies must adopt comprehensive strategies that address these challenges, ensuring that their practices are sustainable and socially responsible (Tavares, 2022).

Examples of Successful

- **Adoption of Ethical Business Conduct:** Ethical business practices are fundamental to the climate transition. This includes respecting labor rights and promoting environmental justice, improving the company's reputation and stakeholder trust (Park and Bishara, 2022).
- **Case Studies and Analyses:** Case studies and analyses demonstrate successful climate transitions across a variety of industries. These examples illustrate how companies have effectively implemented sustainable practices and technologies to reduce their carbon footprint and improve their competitiveness in the global marketplace (Kechichian et al., 2016).

- **Patagonia:** Renowned for its environmental activism and commitment to sustainability, Patagonia invests in renewable energy, supports environmental causes, and implements circular economy practices to minimize its carbon footprint (Balukja, 2024).

S3.8. Investing in Nature-Based Solutions

- **Natural Capital Management:** Companies are increasingly recognizing the importance of natural capital, which includes the Earth's natural resources and ecosystems. By integrating natural capital considerations into business strategies, companies can manage risks related to resource scarcity and environmental costs (Clarke, 2019).
- **Carbon Offsetting:** This involves offsetting emissions by investing in environmental projects that reduce carbon dioxide in the atmosphere, such as reforestation or renewable energy projects. While it is not a substitute for direct emissions reductions, it is a valuable tool for achieving carbon neutrality (Balukja, 2024).

S3.9. Other Unclassified Good Practices

- **Policy and Technology Interventions:** The report outlines the need for policy and technology interventions to improve industrial operations. These include implementing policies that encourage sustainable practices and investing in technologies that reduce environmental impact. Such interventions can help industries transition to greener production methods while remaining competitive (Kechichian et al., 2016).
- **Corporate Environmentalism:** The concept of corporate environmentalism has evolved from simple regulatory compliance to more comprehensive strategies such as pollution prevention, total quality environmental management, and sustainable development. This shift reflects a deeper understanding of the intersection between business activities and environmental protection (Clarke, 2019).
- **Integration of Circular Economy Principles:** Companies are increasingly adopting circular economy practices to minimize waste and make the most of resources. This involves designing products for durability, reusability, and recyclability, which helps reduce carbon footprints and conserve resources. Although specific practices are not detailed in the context provided, the emphasis on circularity suggests a focus on sustainable resource management (Boul, 2022).
- **Role of Policy and Regulation:** Effective policies and regulations can drive companies to adopt best practices for the climate transition. Incentives for the adoption of renewable energy and penalties for high emissions can motivate companies to innovate and invest in sustainable solutions (Boul, 2022).
- **Innovative Product Development:** Companies such as Philips have developed innovative products, such as the Philips Woodstove, that reduce emissions and energy consumption. This product not only addresses climate change but also provides social benefits by potentially improving the lives of millions of people in poorer regions (Elijido-Ten et al., 2019).
- **Commitment to Sustainable Development:** Companies such as Sekisui House have committed to long-term environmental goals, such as creating CO2-neutral homes by 2050. This commitment is recognised by government bodies and helps shape industry standards (Elijido-Ten et al., 2019).
- **Skill Upgradation and Workforce Development:** Upgrading workforce skills is essential to preparing for the jobs of the future. This includes offsetting job losses in key sectors and ensuring that workers are equipped with the skills needed for new opportunities arising from industrial modernisation (OECD, 2019).
- **Crosscutting Lessons:** The report highlights the need for better policies, rather than more policies. This involves learning cross-cutting lessons and key considerations that have made industrial transitions successful in other contexts (OECD, 2019).

Examples of Successful

- **Achieving Emissions Reductions:** Companies that set clear targets and develop robust metrics often report significant reductions in their carbon footprint, contributing to global climate goals (OECD, 2022).
- **Examples of Successful Transitions:** While the paper does not provide specific examples, it emphasizes the importance of companies that have integrated sustainability into their core strategies as role models for others (Park and Bishara, 2022).
- **Swiss Re:** As a leading reinsurance company, Swiss Re has adopted comprehensive climate strategies that include assessing and managing climate change-related risks. Its approach serves as a model for financial institutions to address climate risks (Hoffman, 2006).

- **Whirlpool:** By focusing on energy-efficient products and sustainable manufacturing processes, Whirlpool has successfully integrated climate strategies into its operations, illustrating the potential for consumer goods companies to lead the climate transition (Hoffman, 2006).
- **Shell Group:** Shell is involved in developing alternative energy sources and reducing its carbon footprint. Its approach includes ambitious emissions reduction targets and investments in clean energy projects (Hoffman, 2006).
- **The Natural Advantage of Nations Publication:** This document provides critical information for business leaders and engineers to understand the context of sustainable business practices (Palousis et al., 2014).
- **Circular Economy Practices:** Implementing waste treatment and material recycling as part of a circular economy approach helps companies minimize waste and reduce resource consumption. This practice promotes sustainability and can lead to cost savings and new business opportunities (Rojey, 2009).
- **Circular Economy Practices:** Implementing circular economy practices, such as waste treatment and material recycling, helps companies minimize waste and reduce resource consumption, promoting sustainability and cost savings (Rojey, 2009).