REPUBLIC OF TÜRKİYE
YALOVA UNIVERSITY
INSTITUTE OF GRADUATE EDUCATION

DEPARTMENT OF BUSINESS ADMINISTRATION
BUSINESS ADMINISTRATION (ENGLISH) PROGRAM

THE IMPACT OF CLIMATE CHANGE AGREEMENTS ON INTERNATIONAL TRADE

MASTER'S THESIS

ZAINEB BOUSTATA

SUPERVISOR: ASSIST. PROF. DR. ALPEREN AKKAYA

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T.C.
YALOVA ÜNİVERSİTESİ
LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

İŞLETME ANABİLİM DALI
İŞLETME (İNGLİZCE) BİLİM DALI

THE IMPACT OF CLIMATE CHANGE AGREEMENTS ON INTERNATIONAL TRADE

YÜKSEK LİSANS TEZİ

ZAINEB BOUSTATA
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YALOVA
TEMMUZ 2025

ETHICAL DECLARATION

I hereby declare that in this thesis titled "**Impact of Climate Change Agreements on International Trade**", which I have prepared in accordance with the Thesis Writing Rules of the Graduate School of YalovaUniversity; I have obtained the data, information, and documents presented in the thesis within the framework of academic and ethical principles, that I have presented all information, documents, evaluations, and results in accordance with the rules of scientific ethics and integrity, that I have properly cited and referenced all the works I have benefited from, that I have not made any alterations to the data used, and that the work I present in this thesis is original. I hereby declare and undertake that I accept all legal responsibilities that may arise in the event of any contrary determination.

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Zaineb Boustata

ETİK BEYAN

Yalova Üniversitesi Lisansüstü Eğitim Enstitüsü Tez/Proje Yazım Kuralları'na uygun olarak hazırladığım "**Impact of Climate Change Agreements on International Trade**" başlıklı bu tez çalışmasında; tez içinde sunduğum verileri, bilgileri ve dokümanları akademik ve etik kurallar çerçevesinde elde ettiğimi, tüm bilgi, belge, değerlendirme ve sonuçları bilimsel etik ve ahlak kurallarına uygun olarak sunduğumu, tez çalışmasında yararlandığım eserlerin tümüne uygun atıfta bulunarak kaynak gösterdiğimi, kullanılan verilerde herhangi bir değişiklik yapmadığımı, bu tezde sunduğum çalışmanın özgün olduğunu bildirir, aksinin tespiti halinde doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi taahhüt ve beyan ederim.

İmza

Zaineb Boustata

ÖNSÖZ

Öncelikle tez danışmanım Dr. Öğr. Üyesi Alperen AKKAYA'ya en derin şükranlarımı sunarım. Uzmanlığı, sabrı ve sürekli desteği bu araştırma yolculuğu boyunca bana rehberlik etti. Değerli görüşleri ve teşvikleri, düşüncemi geliştirmeme ve hem akademik titizliği hem de gerçek dünya ile bağlantıyı korumama yardımcı oldu.

Yalova Üniversitesi'ndeki öğretim üyeleri ve idari personele de teşekkür ederim. Yıllar boyunca verdikleri eğitim ve mentorluk, akademik temelimi şekillendirdi ve uluslararası politika ile çevresel adalete olan tutkumun güçlenmesine ilham verdi.

Aileme ve yakın arkadaşlarıma, özellikle tereddüt yaşadığım anlarda bana duyduğunuz sarsılmaz inanç için minnettarım. Duygusal desteğiniz ve anlayışınız bu tezin tamamlanmasında hayati rol oynadı.

Ayrıca, en çok ihtiyaç duyduğum zamanlarda değerli tartışmalar, araştırma önerileri ve motivasyon paylaştıkları için sınıf arkadaşlarıma ve meslektaşlarıma özel teşekkür ederim.

Son olarak, dünyanın dört bir yanında iklim değişikliğinin yükünü taşımaya devam eden sayısız birey ve topluluğu saygıyla anıyorum. Deneyimleriniz bu çalışmada yalnızca birer veri değildi; bu çalışmanın neden önemli olduğunu güçlü bir şekilde hatırlattı.

Temmuz – 2025 ZAINEB BOUSTATA

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LIST OF SYMBOLS AND ABBREVIATIONS

CBAM	Carbon Border Adjustment Mechanism
CO_2	Carbon Dioxide
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse Gases
HFC	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally Determined Contribution
UNFCCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization
GATT	General Agreement on Tariffs and Trade
RGGI	Regional Greenhouse Gas Initiative
SWOT	Strengths, Weaknesses, Opportunities, Threats (used in strategic analysis)
€/tonne	Euro per metric ton of CO_2 equivalent
% Percent	Proportional value
IEA	International Energy Agency

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THE IMPACT OF CLIMATE CHANGE AGREEMENTS ON INTERNATIONAL TRADE

ABSTRACT

This thesis is concerned with a comprehensive study of the increasingly complex relationship between global trade and climate change, focusing on how international climate agreements influence trade policy formulation and reshape regulatory frameworks and trends in global markets. The research begins by clarifying the scientific foundations of climate change, by addressing the human factors causing it, and reviewing the environmental repercussions that require urgent political intervention. It then moves on to track the development of multilateral climate governance, by analyzing key agreements such as the Kyoto Protocol, the Paris Agreement, and the Kigali Amendment, which not only set emissions reduction targets, but also contributed to integrating environmental dimensions into the international economic governance structure.

The study highlights the principle of common but differentiated responsibilities between developed and developing countries and also highlights the differences in climate commitments and their implications for trade justice and economic competitiveness. The research discusses in detail the increasing effects of carbon pricing mechanisms, emissions trading systems, and carbon adjustment mechanisms at borders on international trade. While these tools aim to reduce emissions globally, they also pose challenges related to fair market access and regulatory compliance, especially for export-dependent developing countries.

In this context, the thesis reviews the pivotal role played by the WTO in reconciling the objectives of trade liberalization with the requirements of environmental protection. The legal aspects are analysed, especially as provided for in Article XX of GATT, which allows certain environmental derogations, together with a discussion of recent cases of dispute which show the growing tension between environmental obligations and the principles of free trade.

The study aims mainly to assess the extent to which climate policies, especially those adopted by the European Union and major industrialized countries, affect the general structure of global trade, investment flows, and supply chains. It also seeks to anticipate the future of trade blocs and economic alliances by analyzing the level of compatibility or discrepancy between climate and trade agendas. It assesses the effectiveness of instruments used to link trade issues with environmental sustainability, such as the Carbon Border Adjustment Mechanism, in promoting sustainable trade without harming competitiveness.

The thesis also includes an analytical review of previous literature and studies using the bibliometric approach, along with a review of relevant international policies, with the aim of monitoring research and governance developments in this field. To give the analysis a practical nature, the study examines an applied case in the transport and logistics sector, which is one of the sectors most affected by trade-related climate regulations. This part of the study focuses on how companies respond to requirements such as emissions disclosure, carbon accounting, and cross-border regulatory coordination, providing a deeper understanding of the industrial sector's readiness to integrate climate and trade requirements, and highlighting best practices and policies that need further development to ensure a just transition.

Keywords: Climate change, international trading, CBAM, WTO, The climate policy.

DEĞİŞİKLİĞİ ANLAŞMALARININ
ULUSLARARASI TİCARET ÜZERİNDEKİ ETKİSİ

ÖZET

Bu tez, küresel ticaret ile iklim değişikliği arasındaki giderek karmaşıklaşan ilişkiyi kapsamlı biçimde incelemekte; uluslararası iklim anlaşmalarının ticaret politikası oluşturma süreçlerini nasıl etkilediğine ve küresel piyasalardaki düzenleyici çerçeveleri ile eğilimleri nasıl yeniden şekillendirdiğine odaklanmaktadır. Araştırma, iklim değişikliğinin bilimsel temellerini netleştirerek, buna neden olan insan kaynaklı etkenleri ele almakta ve acil siyasi müdahale gerektiren çevresel sonuçları gözden geçirmektedir. Ardından, Kyoto Protokolü, Paris Anlaşması ve Kigali Değişikliği gibi kilit anlaşmaları analiz ederek çok taraflı iklim yönetişiminin gelişimini izlemektedir. Bu anlaşmalar yalnızca emisyon azaltım hedefleri koymakla kalmamış, aynı zamanda çevresel boyutların uluslararası ekonomik yönetişim yapısına entegrasyonuna da katkı sağlamıştır.

Çalışma, gelişmiş ve gelişmekte olan ülkeler arasındaki "ortak ancak farklılaştırılmış sorumluluklar" ilkesini öne çıkarırken, iklim taahhütlerindeki farklılıkları ve bunların ticaret adaleti ile ekonomik rekabet gücü üzerindeki etkilerini de vurgulamaktadır. Araştırma, karbon fiyatlandırma mekanizmalarının, emisyon ticaret sistemlerinin ve sınırda karbon düzenleme mekanizmalarının (CBAM) uluslararası ticaret üzerindeki artan etkilerini ayrıntılı biçimde tartışmaktadır. Bu araçlar küresel ölçekte emisyonları azaltmayı hedeflerken, özellikle ihracata bağımlı gelişmekte olan ülkeler için adil piyasa erişimi ve düzenlemelere uyum bakımından çeşitli zorluklar da doğurmaktadır.

Bu bağlamda tez, ticaretin serbestleştirilmesi hedefleri ile çevrenin korunması gerekliliklerini uzlaştırmadaki kritik rolü nedeniyle Dünya Ticaret Örgütü'nün (DTÖ) konumunu ele almaktadır. Özellikle belirli çevresel istisnalara imkân tanıyan GATT'ın XX. Maddesi çerçevesinde hukuki boyutlar analiz edilmekte; çevresel yükümlülüklerle serbest ticaret ilkeleri arasındaki artan gerilimi gösteren yakın tarihli uyuşmazlık davaları da tartışılmaktadır.

Çalışmanın temel amacı, başta Avrupa Birliği ve büyük sanayileşmiş ülkeler tarafından benimsenen iklim politikalarının, küresel ticaretin genel yapısı, yatırım akışları ve tedarik zincirleri üzerindeki etkisini değerlendirmektir. Ayrıca iklim ve ticaret gündemleri arasındaki uyum veya uyumsuzluk düzeyini analiz ederek ticaret blokları ve ekonomik ittifakların geleceğini öngörmeyi amaçlamaktadır. Karbon Sınırda Düzenleme Mekanizması (CBAM) gibi, ticaret meselelerini çevresel sürdürülebilirlikle ilişkilendirmede kullanılan araçların rekabet gücüne zarar vermeksizin sürdürülebilir ticareti teşvik etmedeki etkinliği de değerlendirilmektedir.

Tez ayrıca, bu alandaki araştırma ve yönetişim gelişmelerini izlemek amacıyla bibliyometrik yaklaşımla önceki literatür ve çalışmalara ilişkin analitik bir derleme ile ilgili uluslararası politika incelemesini içermektedir. Analize pratik bir boyut kazandırmak için, ticaretle bağlantılı iklim düzenlemelerinden en çok etkilenen alanlardan biri olan ulaştırma ve lojistik sektöründe uygulamalı bir vaka incelenmektedir. Bu bölüm, şirketlerin emisyon açıklaması, karbon muhasebesi ve sınır ötesi düzenleyici eşgüdüm gibi gerekliliklere nasıl yanıt verdiğine odaklanarak, sanayi sektörünün iklim ve ticaret gerekliliklerini entegre etmeye ne kadar hazır olduğuna dair daha derin bir anlayış sunmakta; adil ve sürdürülebilir bir dönüşümün sağlanması için daha fazla geliştirilmesi gereken iyi uygulamaları ve politikaları öne çıkarmaktadır.

Anahtar Kelimeler: İklim değişikliği, uluslararası ticaret, CBAM, DTÖ, iklim politikası.

1. INTRODUCTION

One of the most urgent worldwide issues of the twenty-first century is generally acknowledged to be climate change (Marks, 2024, p.213). It now has far-reaching effects on political cooperation, international trade, and economic stability in addition to environmental concerns (Grinin & Grinin, 2021, p.181). Resource scarcity, rising sea levels, changing weather patterns, and rising global temperatures have all started to change how countries manufacture, use, and trade goods and services (Cai et al., 2013, p.421). Trade patterns are being impacted by new environmental laws, carbon pricing schemes, and sustainability standards as nations implement more aggressive climate policies to comply with global accords like the Paris Agreement (Leal-Arcas, 2013, p.410). International trade itself has the capacity to both exacerbate and lessen the effects of climate change. The trade also has risks, including carbon leakage (Eichner & Pethig, 2014, p. 1), competitive distortions, and regulatory fragmentation, but it also can promote the spread of sustainable practices and green technologies (Huang et al., 2011, p.12).

Figure 1 presents a conceptual framework that shows how climate change affects global trade through interconnected pathways. This framework explains in a simplified way how climate change affects global trade through a set of interconnected factors. The increase in greenhouse gas emissions causes global warming which leads the international community to establish agreements such as Kyoto and Paris. These agreements aim to reduce emissions using regulatory tools such as carbon pricing, emissions trading systems, and a border carbon adjustment mechanism. These regulatory tools, which directly influence trade policies, prompting governments and companies to adjust their trade strategies. These adjustments lead to changes in global trade flows, especially in high-emission sectors such as energy, industry, agriculture, and transportation. As a result, global supply chains need to be reorganized to align with new sustainability standards.

The framework also highlights the role of the World Trade Organization in regulating the relationship between environmental protection and trade liberalization, through legal tools such as Article XX of the GATT, which allows some environmental exceptions. The framework highlights that these overlapping interactions are pushing international trade towards more sustainable models and encouraging the integration of environmental considerations into global trade policies.

Diverse shapes have been used in the illustration (such as circles, squares, and polygons) to represent different categories such as causes, organizational responses, institutions involved, and economic outcomes, making it easier to understand this complex system in an organized and visual way.

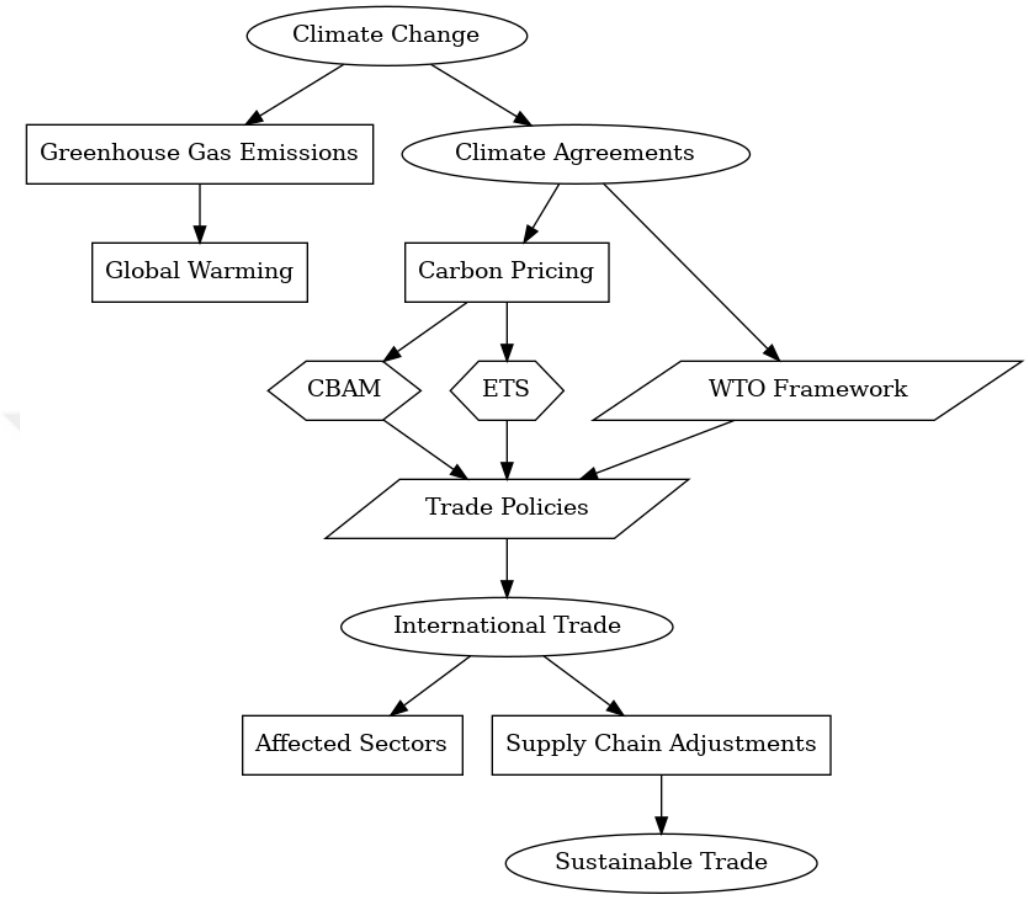

Figure 1. The Conceptual Framework Which Linking the Climate Change and Global Trade. Source: Adapted from Second National Communication on Climate Change (SNCCC, 2008).

This thesis explores the ways in which international climate change agreements have impacted the governance, regulation, and structure of global trade. The objective of this study is to examine how climate change is reshaping trade governance at both global and sectoral levels. It explores how multilateral agreements, including the Kyoto Protocol, the Paris Agreement, and the Kigali Amendment, have introduced trade-related commitments and mechanisms. The research also considers national policy responses such as carbon border adjustments, emissions trading systems, and sustainable trade provisions. Furthermore, it analyzes the role of the World Trade Organization and other trade institutions in balancing environmental protection with market liberalization. Particular attention is given to the risks

and opportunities for developing countries within this climate–trade interface, as well as the implications for global trade equity.

Finally, the study assesses the readiness of the logistics sector, as a key component of global trade infrastructure, to adapt to measures such as the EU's Carbon Border Adjustment Mechanism (CBAM) and new carbon reporting requirements.

Implied in the objectives, the core research questions can be summarized as:

- What are the main impacts of international climate agreements on trade mechanisms?
- How are national and global trade institutions responding to climate-induced regulatory pressures?
- What are the sectoral consequences and strategic adaptations particularly in logistics under evolving climate-trade measures?

This research combines theoretical analysis with empirical tools, which is namely:

i. A bibliometric analysis of peer reviewed literature on the climate changing and trading from 2000 to 2023, also identifying the trends, the gaps, and also the key contributors.
ii. A comparative policy review of the major climate related trade measure such as EU CBAM, national ETSs, WTO ruling, and regional trade agreement.
iii. Case studies and projections related to major economies and trade alliances, which focus on how the technological, legals, and the political developments shape sustainable trades.
iv. A sectoral case studyalso focused on the logistics industry, evaluating how companies are responding to climate-trade regulations and implications for future compliance and competitiveness.

Thess mixed method approach provide both a broad overview of the academic landscape and a critical analysis of real-world policy shifts.

The thesis is organized into six chapters:

The first chapter presents the background and importance of the study, establishing the research problem and objectives, while also clarifying the scope and outlining the main concepts that form the foundation of the analysis. It sets the stage by framing why the topic matters, identifying the gaps in existing knowledge, and situating the work within the broader academic and policy debates.

The second chapter introduces the concept of climate change, exploring its underlying causes and wide-ranging consequences. It traces the historical evolution of international climate agreements, from the earliest multilateral efforts to more recent frameworks, in order to illustrate how the global community has responded to the climate challenge over time. This chapter provides the conceptual and historical grounding needed to understand subsequent discussions.

The third chapter examines the impact of climate change on global trade patterns, highlighting how climate risks reshape sectoral vulnerabilities and create uneven exposures across industries and regions. At the same time, it considers how climate-related shifts open new green economic opportunities, including the potential for innovation, renewable energy development, and sustainable trade practices that transform global economic dynamics.

The fourth chapter turns to climate-related trade policies, with particular attention to carbon pricing mechanisms, the legal frameworks provided by the World Trade Organization, and the emerging risks of green protectionism. It critically assesses how these policies aim to balance environmental objectives with trade openness, while also identifying tensions and disputes that arise as countries adopt varying levels of ambition.

The fifth chapter presents the empirical findings of the study, including a bibliometric analysis of academic research to map trends in the field, as well as an evaluation of existing climate trade policy mechanisms. It also features a case study of the logistics sector, showing how this critical industry adapts to climate-related trade measures and what this reveal about the broader effectiveness and challenges of climate policy implementation.

The sixth and final chapter synthesizes the findings across the study, drawing together the main arguments and insights. It offers policy recommendations aimed at strengthening the coherence between trade and climate agendas, while also suggesting directions for future research that can expand on the study's contributions and address emerging questions in this rapidly evolving field.

Overall, these chapters aim to make full contribute to a deeper understanding of how environmental imperatives are being woven into the fabric of the international trading law and practices.

2. THE TERM OF CLİMATE CHANGE AND HİSTORİCAL EVOLUTİON OF CLİMATE AGREEMENTS

2.1 Climate Change

2.1.1 Reasons for Climate Change

Climate change refers to long-term and persistent changes in the Earth's climate system, primarily manifesting through shifts in global temperature, precipitation, wind patterns, and the frequency of extreme weather events. While natural phenomena such as volcanic activity, solar cycles, and ocean currents have historically influenced climatic variations, the contemporary pace and magnitude of climate change are largely attributed to human activities (Legg, 2021, p.44).

The scientific consensus underscores that the rise in global temperatures over the past century is strongly correlated with the increasing concentration of greenhouse gases (GHGs) in the atmosphere, notably carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) . (Legg, 2021)These gases enhance the greenhouse effect, trapping heat and disrupting the planet's energy balance. The primary sources of these emissions are fossil fuel combustion for energy production and transportation, industrial processes, deforestation, and intensive agriculture (IEA, 2022, p. 4; FAO, 2021, p. 12).

According to the International Energy Agency (2022), global energy-related CO_2 emissions reached a historic high of 36.3 gigatonnes in 2021, signaling a sharp rebound following the temporary reduction during the COVID-19 pandemic. Deforestation, particularly in tropical regions, reduces the planet's carbon sink capacity while releasing large amounts of stored CO_2 (Monteiro et al., 2022, p. 9). Agriculture contributes significantly through livestock-related methane emissions and the use of nitrogen-based fertilizers that emit nitrous oxide, a gas with a global warming potential approximately 300 times that of CO_2 (Chenpeng et al., 2022, p. 170).

Industrial and urban sectors also exacerbate climate change by relying heavily on non-renewable energy sources, emitting large volumes of CO_2, and expanding infrastructure in ways that increase surface heat and reduce carbon absorption. Moreover, rapid globalization, increased consumption patterns, and linear economic models have intensified these pressures,

making climate change a systemic issue interconnected with development, inequality, and global governance (IEA, 2024, p. 4).

The urgency of the addressing climate change which is reinforced by observable trends. Atmospheric CO_2 concentrations exceeded 420 ppm in 2023, a level not seen in over three million years(Allan et al., 2023, p. 5). Global temperatures have already risen by about 1.1°C above pre-industrial levels (Wang et al., 2018, p.757), and if current emissions trends continue, the world is projected to surpass the 2.0°C threshold within decades, posing severe risks to ecosystems, human health, and socio-economic stability (IPCC, 2021, pp. 17-18).

In short, climate change represents a major and accelerating shift in the Earth's climate system, mainly due to emissions resulting from human activity, such as burning fossil fuels, land use and agriculture. These emissions are associated with widespread global consumption patterns. Understanding these root causes is an essential step in developing effective policies and strategies to reduce the effects of climate change.

2.1.2 Solutions for Climate Change

Confronting climate change globally requires an integrated plan that includes both mitigation and adaptation. Mitigation means reducing the causes of the problem, such as reducing the emission of greenhouse gases. As for adaptation, it focuses on reducing the damage resulting from climate change by strengthening the ability of people and nature to adapt to changes.(Abbass et al., 2022, p. 42545)

One of the most critical mitigation strategies is the decarbonization of the energy sector. Transitioning from fossil fuels to renewable energy sources such as solar, wind, hydro, and geothermal offers a direct and large-scale method for reducing CO_2 emissions. According to the International Renewable Energy Agency (Drolet, 2021, p.366), renewables accounted for 83 percent of global power capacity additions in 2022, indicating strong momentum in clean energy investments.

Energy efficiency is another key component of climate action. Improving the efficiency of appliances, buildings, vehicles, and industrial processes reduces energy demand and lowers emissions without sacrificing productivity. Technologies such as smart grids, LED lighting, and electric vehicles play an essential role in this domain (Inci et al., 2024, p. 2).

Carbon capture, utilization, and storage (CCUS) technologies are gaining attention as transitional solutions, especially in hard-to-abate sectors like steel, cement, and chemicals. These technologies capture CO_2 emissions at their source and either store them underground or convert them into useful products (Kudapa, 2023, p.1638).

Nature-based solutions also it is offering significant mitigation potential. Forest restoration, afforestation, wetland protection, and sustainable land management can enhance carbon sinks while protecting biodiversity and ecosystem services. The Food Agriculture Organization (FAO, 2021, p. 12) emphasizes that forest preservation alone could contribute up to one-third of the total emissions reduction needed to meet the Paris Agreement goals.

Agricultural reforms are equally important. Practices such as agroecology, Precision and organic farming helps reduce pollution, conserves carbon within the soil and contributes to safe and sustainable food. Economic tools are increasingly used to drive climate action. Carbon pricing mechanisms such as carbon taxes and emissions trading systems (ETS) internalize the environmental costs of emissions and create financial incentives for low-carbon technologies. The World Bank (2023) reports that over 70 carbon pricing initiatives are now in operation worldwide.

On the adaptation front, governments and communities are investing in climate-resilient infrastructure, such as flood defenses, drought-resistant agriculture, and climate-smart urban planning. Early warning systems and resilient healthcare systems also form part of comprehensive adaptation plans (IPCC, 2022, p. 30).

Developing countries, which are often more vulnerable to climate risks, require financial and technical support to implement both mitigation and adaptation strategies. International mechanisms such as the Green Climate Fund (GCF) and the Adaptation Fund help bridge this gap (UNFCCC, 2023, “Multilateral climate funds” section).

Equity and justice are also central to climate solutions. The concept of a “just transition” ensures that workers and communities dependent on carbon-intensive industries are supported as economies shift to cleaner models.

Ultimately, climate solutions must be coordinated across sectors and scales. Technological progress alone will not be enough transformational change requires political will, institutional reform, and public engagement.

2.1.3 Figures and Statistics about Climate Change

Global surface temperatures have increased by approximately 1.1°C above pre-industrial levels (1850–1900 average), according to the Intergovernmental Panel on Climate Change (IPCC, 2023, p. 4). The past eight years have been the warmest on record, with 2023 ranking as the hottest year globally (Copernicus, 2024, "Global Climate Highlights 2023" report).

Atmospheric greenhouse gas concentrations continue to rise. In 2023, CO_2 levels reached 421 ppm the highest in at least 3 million years (NOAA, 2023, Recent Global Monthly Mean CO_2 section). Methane (CH_4) concentrations also reached a record high of 1,922 ppb (WMO, 2023, Greenhouse Gases section).

Sea-level rise is another critical indicator. From 2006 to 2018, global mean sea level increased by 3.7 mm/year. Under high-emission scenarios, projections suggest up to 1 meter rise by 2100 (UNEP, 2023, p. 25).

Extreme weather events have become more frequent. For example, the 2023 European heatwave caused record-breaking temperatures across the continent, and the 2022 Pakistan floods displaced over 33 million people (World Bank, 2023, Extreme Events section).

The Swiss Re Institute (2021) estimates climate change could reduce global GDP by 11–14% by 2050 if action is delayed (Swiss Re Institute, 2021, p. 4). In contrast, green investment could create 24 million new jobs by 2030 (ILO, 2018, p. 34).

Per capita emissions show disparity: the average American emitted over 14.7 metric tons of CO_2 in 2021, compared to 1.9 in India (Climate Transparency, 2022, p. 33). These figures highlight the urgency of action and the justice challenges in global climate governance.

The next section 2.2 Climate Agreements: Definition and Concept will explore the international legal frameworks that have been established to address climate change, starting with landmark treaties like the Kyoto Protocol and the Paris Agreement.

Figure 2 displays the change in global temperatures from 1880 to 2024 and shows how temperatures differed from normal during this period. Data show that global temperatures have risen significantly over the past 145 years, as a result of increased greenhouse gas emissions and industrial activity.

From 1880 to 1920, temperatures are below the normal, wich means the world was colder than usual. After from 1920 until 1954, temperatures come close to average, indicating a period of stability. Since 1955, temperatures are getting rising, and at the start of the nineties the rise has became much faster and more pronounced. between 1990 to 2024, worldwide temperatures rised and reached approximatly 0.7° degrees Celsius over the long-term average. This rise has a main related to human activities such like burning fossil fuels and deforestation.

This figure emphasizes scientific consent that the climate of the change is real, and the supports the importance of international agreements and guidelines aimes at limiting the increase in further temperature. The horizontal line at 0 ° C acts as a reference point, showing how power temperatures before the industrial age compares them.

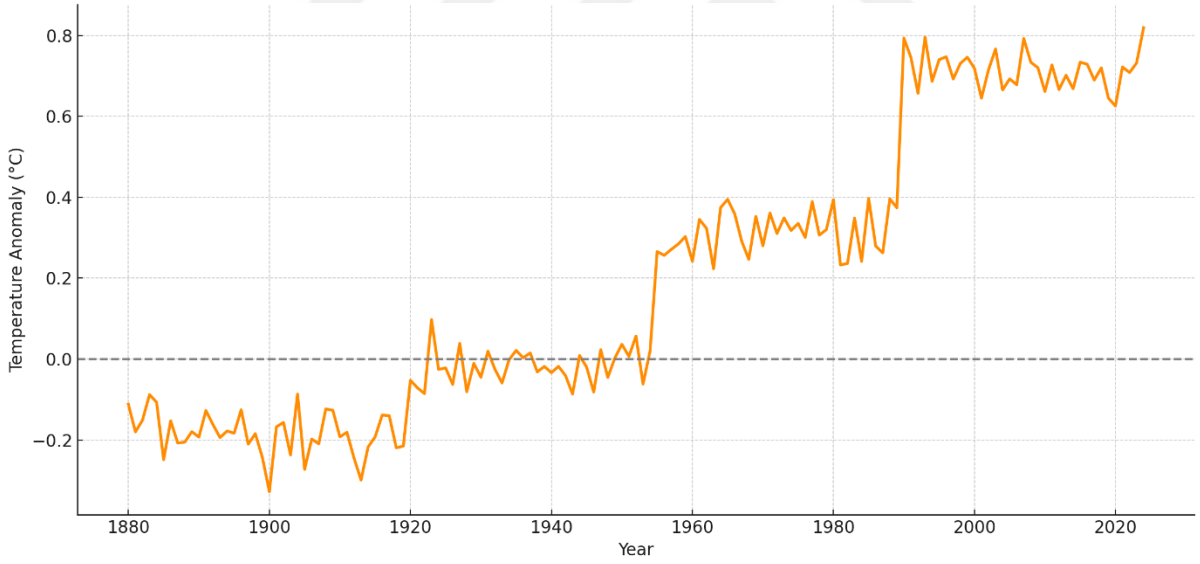

Figure 2. The Global Average Temperature Trends (2024–1880)

Source: Statista (2022), based on NOAA data, as cited in the World Economic Forum.

2.2 Climate Agreements: Definition and Concept

Climate agreement is the international agreement, which aims to meet climate change by coordinating of global efforts by reducing emissions and coordinating global efforts to handle

its effects. These agreements have been interacted with the structure of the UN Framework Convention on Climate Change (UNFCCC) that was established in 1992 and serves as the main platform to support international cooperation in the region (UNFCCC, 2023, About the Convention section).

The main goal of the climate agreements, it is to reduce greenhouse gases, enhance the ability of the countries to adapt og the effects of climate change, and achieve sustainable growth. These agreements recognize, which is that all countries have a role in confronting climate change, but also their responsibilities vary according to their capabilities and resources, which is know as the principle of "common but differentiated responsibility."(Rajamani & Bodansky, 2019, p. 1024).

Global efforts to the confront climate change began with voluntary commitments and knowledge sharing as soon as possible, based on scientific consensus on the risks of the global warming. Over time, these efforts have grown to include binding targets and intermediate commitments. The scope of the agreements has also expanded to include, in addition to reducing emissions, other areas such as adaptation to the effects of climate change, transparency, financing, capacity building, and compensation for losses and damages. (IPCC, 2022, p. 28).

Climate agreements are diverse in terms of their legal nature and modus operandi. For example, the Kyoto Protocol, adopted in 1997, imposed clear and binding obligations on some countries to reduce emissions. As for the 2015 Paris Agreement, it chose a more flexible approach, where each country sets its own climate goals in what are known as national contributions, which encouraged more countries to participate and facilitated adaptation to each country’s circumstances (UNFCCC, 2015, Art. 4).

In addition to the formal system led by the UN Climate Change Convention, other efforts take place through bilateral agreements between countries, regional initiatives, voluntary alliances, and contributions from non-governmental actors. This diversity of efforts has led some experts to describe the climate action system as "multi-level climate governance," because work is taking place at several levels at the same time locally, nationally, regionally, and globally. (Jordan et al., 2018, p. 3).

Unlike traditional areas of international law such as trade, human rights and development, climate issues are increasingly merging with economic aspects. For example, the Carbon Border Adjustment Mechanism (CBAM) or the inclusion of climate clauses in trade agreements such as the EU's agreement with Mercosur, shows how environmental obligations have become an important part of economic and trade terms in international relations (European Commission, 2022, Carbon Border Adjustment Mechanism section).

Moreover, recent agreements place increasing emphasis on climate finance, requiring developed countries to provide financial assistance to developing countries. Mechanisms such as the Green Climate Fund (GCF) and the Loss and Damage Fund reflect the recognition that equitable financial support is essentialit isto global climate success (UNFCCC, 2023, Climate Finance section).

In conclusion, climate agreements provide the legal and institutional foundation for international climate action. From early treaties to contemporary flexible frameworks, they represent humanity’s collective response to the climate crisis.

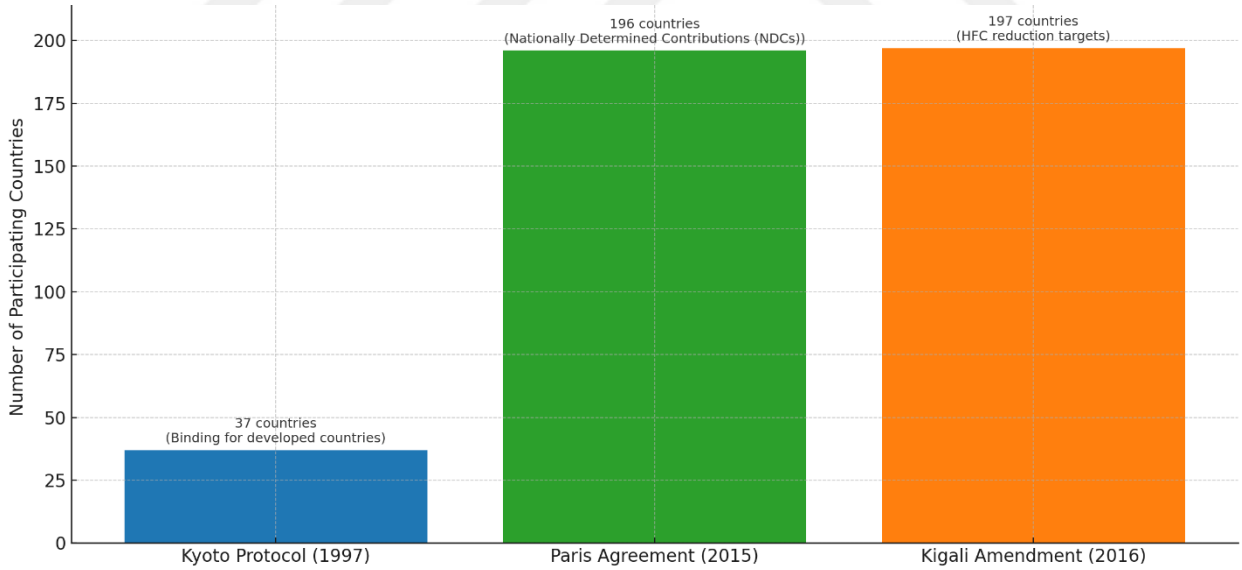

Figure 3. The Comparison of Climate Agreement.

Sources: Council on Foreign Relations (2025, Paris Agreement section, para. 3) and ScienceDirect (n.d., Kyoto Protocol – Climate commitments section, para. 2).

Figure 3 presents a comparison between three important international climate agreements: the Kyoto Protocol (1997), the Paris Agreement (2015), and the Kigali Amendment (2016). The figure focuses on two main points in each agreement: the number of participating countries, and the nature of their obligations.

In the Kyoto Protocol, 37 developed countries agreed to clear and binding targets to reduce greenhouse gas emissions by 5.2% compared to 1990 levels, over the period 2008 to 2012. The Paris Agreement is different: It encompasses 196 countries, but the commitments are not legally binding. Instead, they are submitted by each country as "intended national contributions" that differ significantly across countries and are subject to review over time.

The Kigali Amendment under the Montreal Protocol aims to decrease the use of HFC gases currently used in air conditioning and refrigerationyy and are a major contributor to climate change. It has been ratified by 197 countries and is designed to achieve an 80% cut in the use of these gases by 2047, while allowing for the varying needs of different countries.

This figure illustrates how climate agreements shifted from rigid commitments for a small number of countries to more encompassing and flexible agreements reflecting the changes in countries' positions and growing global acknowledgment of the need to address climate change.

2.2.1 Kyoto Protocol (1997)

The Kyoto Protocol, adopted in December 1997 and entered into force in February 2005, is the first legally binding international treaty under the UNFCCC that mandates developed countries to reduce greenhouse gas emissions. Emission reduction commitments for Annex I Parties, primarily industrialized countries, are based on their historical contributions to climate change (Böhm et al., 2024; UNFCCC, 2025, Annex I Parties section). Figure No. (4) shows how greenhouse gas emissions are distributed globally among different economic sectors, through a circular drawing showing the percentage of each sector’s contribution to total emissions.

The energy sector is most responsible for emissions, producing about 73.2% of global emissions. This includes the production of electricity and heating, and the use of fuel in

industry and transportation. It is followed by the agricultural sector with a rate of 18.4%, due to gases resulting from livestock raising, rice cultivation, and fertilizers.

The transportation sector contributes 14.3%, and this percentage includes cars, planes, and ships. The buildings sector produces about 6.4% of emissions, due to the use of electricity and heating and cooling devices. The industrial sector contributes 5.2% through operations such as cement, steel and chemicals production. Finally, the waste sector contributes 3.2%, as a result of garbage and wastewater treatment.

This breakdown shows that climate change is caused by diverse activities in most aspects of the economy, underscoring the importance of working in all of these sectors, especially energy, agriculture and transport, to reduce emissions and achieve environmental sustainability.

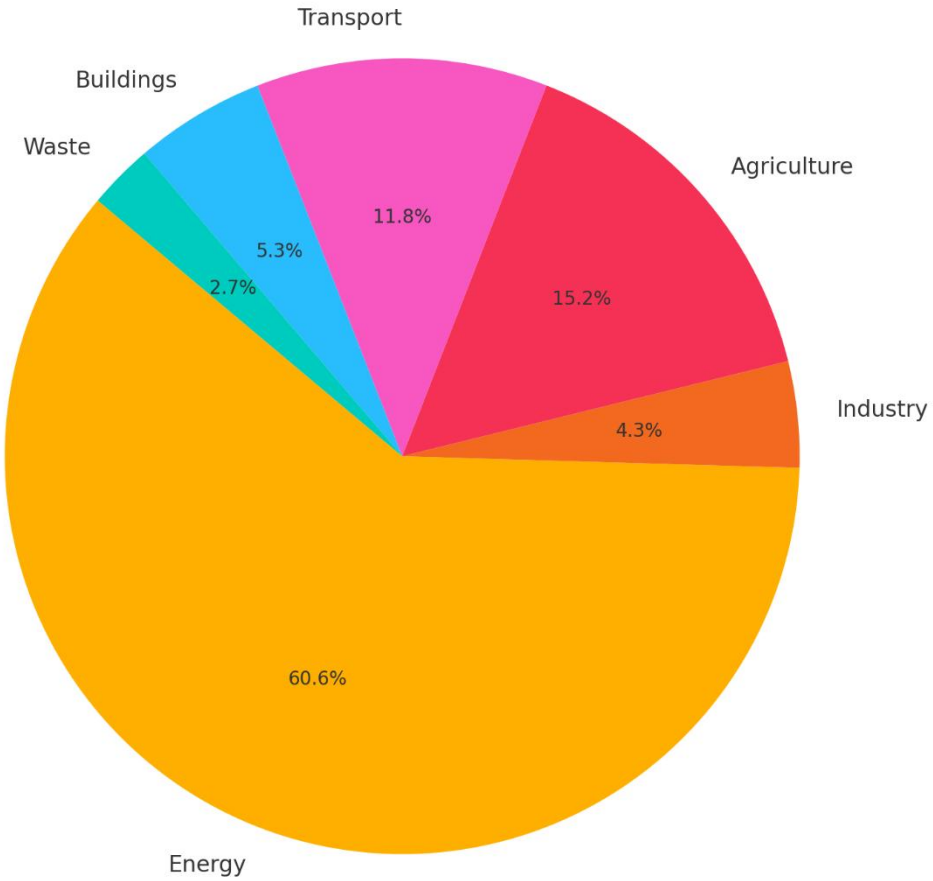

Figure 4. The Greenhouse Gas Emissions by Country.

Source: UNEP (2023, Emissions Gap Report 2023, p. 52).

During the first,the commitment period (2008–2012), 37 countries and EU were required to lower emissions by an aggregate of 5.2% below 1990 levels (UNFCCC, 2025, Kyoto Protocol, Article 3 section) which is to promote cost-effective compliance, Protocol was introduced three market-based mechanisms: International Emissions Trading (IET), Clean Development Mechanism (CDM), and the Joint Implementation (JI) (UNFCCC, 2025, Arts. 6, 12, & 17; Böhm et al., 2024).

The CDM alone was registered over 8,000 projects in 111 countries, but it was facing criticism concerning environmental integrity and additionality issues (Böhm et al., 2024; World Bank, 2018, p. 58). The protocol's impact did further diminish by the non-ratification of the United States and subsequent withdrawal of Canada, weakening it is global reach (Böhm et al., 2024; UNFCCC, 2025, Status of Ratification section).

Nevertheless, the Kyoto Protocol institutionalized carbon was markets and laid the foundation for robust reporting and the verification frameworks that continue to underpin subsequent agreements like the Paris Agreement (UNFCCC, 2025, Mechanisms under the Kyoto Protocol section; Böhm et al., 2024).

2.2.2 Paris Agreement (2015)

The Paris Agreement, it was adopted at COP21 in December 2015 and entering into force in November 2016, marked a major to the shift in the global climate governance, replacing the Kyoto's limited scope with a universal framework requiring all the countries to contribute to climate efforts (UNFCCC, 2024; Chan et al., 2023). Its central goal is to limit global temperature rise to "well below 2 °C," aiming for 1.5 °C, and it introduced Nationally Determined Contributions (NDCs), with countries setting and updating their own targets every five years under a "progressive ambition" principle (UNFCCC, 2024, Arts. 2 & 4; Chan et al., 2023).

While NDCs are not legally binding in outcomes, procedural obligations submission, reporting, and participation in global stocktakes are mandatory. The agreement also introduced an Enhanced Transparency Framework (ETF) along with reaffirmed climate finance commitments, aiming for US $100 billion annually from developed countries (UNFCCC, 2024, Arts. 9 & 13; Schaeffer et al., 2022). Despite near-universal ratification, criticisms persist that the Paris Agreement relies too heavily on voluntary targets, lacks meaningful enforcement mechanisms, and that current pledges fall short of achieving its 1.5 °C target (Schaeffer et al., 2022; Chan et al., 2023).

2.2.3 Other Related Agreements

Several other agreements complement the UNFCCC framework:

A. **Kigali Amendment (2016)**: Adopted under the Montreal Protocol, it phases down HFCs potent greenhouse gases projected to avoid around 0.4 °C of global warming by the end of this century (UNEP Ozone Secretariat, 2024, Kigali Amendment Overview section; NRDC, 2020, Climate Benefits section).
B. **European Green Deal and CBAM**: The EU's strategy to achieve climate neutrality by 2050 includes the Carbon Border Adjustment Mechanism (CBAM), a "green tariff" on high-carbon imports to prevent carbon leakage and incentivize similar pricing in

non-EU countries (Frontiers, 2022; EU Commission, 2020, Section 1; Nature, 2024, p. 1; Financial Times, 2022).

C. **Sendai Framework (2015)**: Primarily targeting disaster risk reduction, the framework aligns closely with climate adaptation strategies, enhancing resilience in climate-impacted regions (WHO, 2021, p. 7).

D. **Sustainable Development Goals (SDGs)**, particularly Goal 13 (Climate Action), integrate climate policy with global development agendas (UN, 2021, p. 60).

E. **Global Methane Pledge (2021)**: A voluntary agreement under COP26 aiming to cut methane emissions by 30% from 2020 levels by 2030, with participation from 111 countries representing 45% of global methane emissions (IEA, 2022, p. 4; SEI, 2022, p.1).

These sectoral, multi-layered agreements reflect a shift toward comprehensive and regionally integrated climate governance mechanisms.

2.3 State Commitments Under Climate Agreements

The effectiveness of international climate agreements depends heavily on the commitments made by individual states and their implementation, which vary significantly based on historical emissions, financial capacity, and development status, reflecting the principle of "common but differentiated responsibilities and respective capabilities" (CBDRRC) (Rajamani & Bodansky, 2021, p. 1024; Voelkerecht, 2024). This principle, enshrined in the UNFCCC, acknowledges that developed countries bear greater responsibility due to their historical emissions and greater capacity to act (Sci. Direct, 2020; Voelkerecht, 2024). However, research suggests that the operational flexibility it provides can also result in unequal burden-sharing and hinder ambition when states with greater capacity choose less rigorous implementation (Cambridge Handbook, 2025; ResearchGate, 2023).

Table 1. presents a structured comparison of three important international climate agreements: the Kyoto Protocol (1997), the Paris Agreement (2015), and the Kigali Amendment (2016), in terms of year of signature, number of participating countries, type of commitments, and emission reduction targets.

i. The Kyoto Protocol legally obligated 37 developed countries to reduce emissions by 5.2% from 1990 levels but excluded developing countries.

ii. The Paris Agreement, signed by 196 countries, relies on regularly updated voluntary national plans (NDCs), making it more comprehensive and flexible.

iii. The Kigali Amendment was signed by 197 countries and aims to reduce the use of harmful HFC gases by up to 80% by 2047, with legal obligations varying according to each country's classification.

The table shows how climate policies have evolved from a strict and limited model to a more cooperative and comprehensive global approach, including CO_2 and other greenhouse gases.

Table 1. The Comparison of the Major Climate Agreements.

Agreement	**Year**	**Coverage (Countries)**	**Commitment Type**	**Emission Target**
Kyoto Protocol	1997	37	Binding targets for developed nations	5.2% below 1990 by 2012
Paris Agreement	2015	196	Voluntary Nationally Determined Contributions (NDCs)	Varies by country
Kigali Amendment	2016	197	HFC phasedown (Legally binding)	80% HFC reduction by 2047

Source: Author’s compilation.

2.3.1 Commitments of Developed Countries

Developed countries, particularly Annex I parties under the Kyoto Protocol, were assigned legally binding emission targets EU, Japan, and Canada among others with Canada later withdrawing. Under the Paris Agreement, they continue to lead through ambitious NDCs and pledged financial support, although the $100 billion annual climate finance goal has only recently been met, two years late (OECD, 2024, p. 3). They also provide technology and institutional support via the Green Climate Fund (GCF) and Global Environment Facility (GEF), though critics question equity and transparency in these mechanisms. Many developed countries now target net-zero emissions by 2050; however, current policies are insufficient to meet the 1.5 °C goal, raising valid concerns about justice and credibility (Matthews & Wynes, 2022, p. 907).

2.3.2 Commitments of Developing Countries

Developing countries were not assigned binding targets under the Kyoto Protocol; instead, mechanisms like the CDM enabled them to host climate mitigation projects (UNFCCC, n.d.). Under the Paris Agreement, they submit voluntary NDCs, many conditionals on international finance and technology support often tied to institutions like the GCF and GEF (CPI, 2024). Countries such as India and Kenya have set ambitious goals, yet per capita emissions remain low; Kenya's are approximately 2.1 tCO_2e compared to a global average of 6.8 tCO_2e in 2022 (UNFCCC, 2025). Adaptation objectives are frequently underfunded, with a global adaptation finance gap estimated at around US $194–366 billion per year (UNEP, 2023, p. 1). Developing nations continue to emphasize climate justice, aligning climate commitments with development needs and advocating for equitable access to finance and technology.

2.3.3 Disparity in Environmental Obligations Among Countries

Global climate governance faces deep disparities in obligations and capabilities. Although all countries now submit NDCs, developed nations have historically emitted far more and possess greater capacity to act (IPCC, 2023, p. 4). Per capita emissions and climate finance remain highly unequal: LDCs and SIDS, despite being least responsible, suffer the gravest climate impacts (Climate Policy Initiative, 2023, p. 2). The failure to deliver adequate finance, technology, and lossanddamage compensation erodes trust, and without addressing these structural inequalities, the global climate regime risks being both ineffective and unjust.

3. INTERNATIONAL TRADE: ITS EVOLUTION AND CHANGES UNDER CLIMATE CHANGE

3.1 Impact on Industries and Trade Relations

3.1.1 Most Affected Industries (Energy, Mining, Transportation, Agriculture)

Climate change has introduced systemic risks to the global economy, particularly for carbon intensive and resource-dependent industries. Among the most exposed are energy, mining, transportation, and agriculture each facing both direct physical impacts and regulatory pressures aimed at reducing greenhouse gas (GHG) emissions (OECD, 2023, p. 36).

Energy Sector: Fossil fuel production and consumption account for about 73% of global GHG emissions, with coal, oil, and gas as the main contributors (IEA, 2022). As a result, the sector is both a key driver of and vulnerable to climate change. Increasingly stringent policies such as carbon pricing, renewable mandates, and emissions trading systems are accelerating the shift toward low-carbon energy alternatives.

Table 2 shows how some important sectors of the economy and infrastructure are vulnerable to the effects of climate change to different degrees.

[1] Agriculture is the sector most affected by drought and rainfall fluctuations.
[2] Water is also under threat, as climate change reduces the availability of fresh water.
[3] Health is vulnerable to an increase in heat-related illnesses and infections.
[4] Energy may be affected due to weather malfunctions and changing cooling needs.
[5] Logistics faces difficulties due to changing prices, laws and volatile weather.

In general, each sector needs a special adaptation plan, which includes smart investment and policies that help it confront climate change.

Table 2. The Sectoral Vulnerability of Climate Change.

Sector	**Vulnerability Level**	**Main Risks**	**Adaptation Need**
Agriculture	High	Drought, yield loss, soil degradation	High
Water Resources	High	Diminished supply, seasonal variability	High
Health	Moderate to High	Disease outbreaks, heat stress	High
Energy	Moderate	Infrastructure damage, cooling demand	Medium
Logistics	Moderate to High	Fuel cost, regulation compliance, route disruption	High

Source: Author's compilation.

Extreme weather events such as hurricanes, wildfires, and droughts are significantly disrupting energy infrastructure. Heatwaves increase cooling demand while decreasing power

generation efficiency and stressing transmission systems, at the same time that renewable energy sources particularly solar and wind dominate growth, accounting for 83% of new global power capacity additions by 2022 (IRENA, 2023, p. 1).

The mining sector is similarly vulnerable due to its reliance on water, land, and energy; it faces operational risks from flooding, droughts, and extreme heat, while simultaneously supplying critical minerals like lithium and cobalt essential for renewable technologies, creating a tension between decarbonization and production expansion (UNEP, 2024, p. 27).

Transportation Sector: The transportation sector is responsible for nearly 24% of direct CO_2 emissions from fuel combustion, with road transport being the largest contributor, followed by aviation and maritime transport (IEA, 2022, p. 4). The sector is particularly affected by rising fuel prices, carbon pricing policies, and emission standards aimed at decarbonizing mobility.

Physical climate impacts also threaten transport infrastructure. Rising sea levels and storm surges endanger coastal ports and shipping routes, while high temperatures can deform roads and railways, increasing maintenance costs and reducing efficiency (WTO, 2022, p. 45). To address these risks, there is growing investment in electric vehicles (EVs), sustainable aviation fuels, and low-emission logistics, but adoption rates vary significantly across countries (IEA, 2023, p. 7).

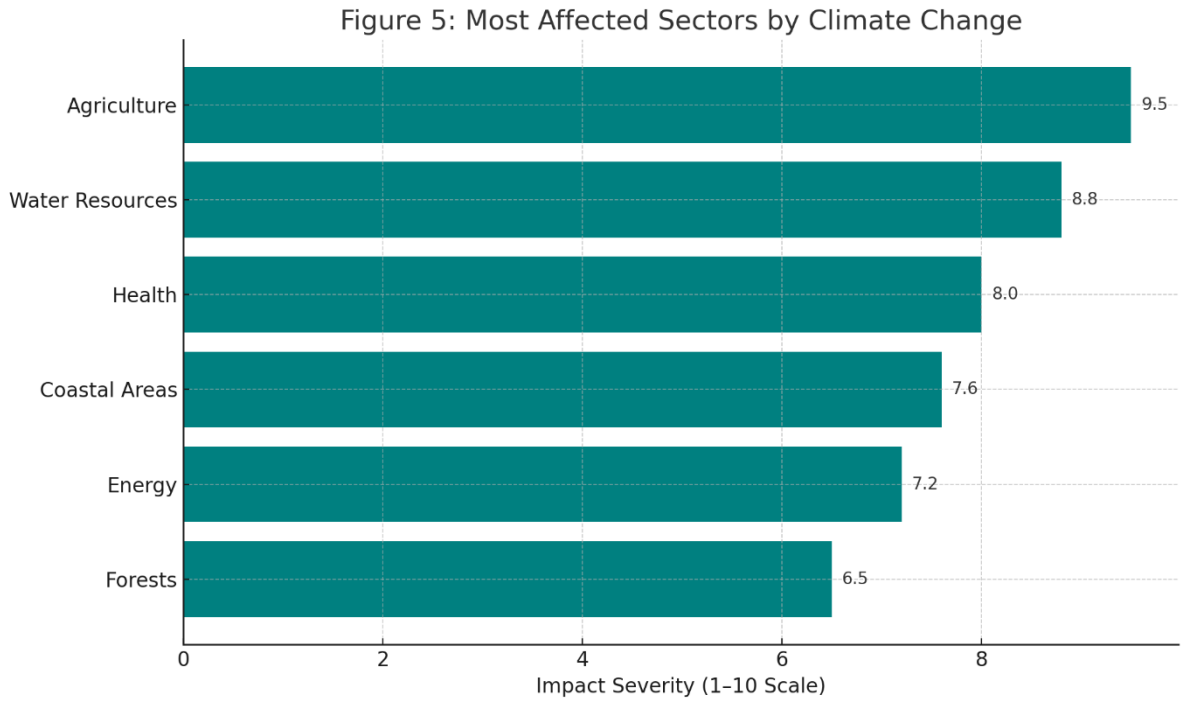

Figure 5. The Most Affected of Sectors by Climate Change.

Sources: FAO (2021, p. 12); UNEP (2023, p. 47).

Figure 5 displays the sectors most affected by climate change, using a scale from 1 to 10 to measure the severity of the impact. The figure shows that the impacts of climate change span across different social, economic and environmental domains.

The agriculture sector is the most affected, with a score of 9.5, because it depends heavily on the weather, amount of rainfall and temperature stability, factors that have become erratic due to climate change. This is followed by the water sector with a score of 8.8, due to the decline in the availability of fresh water as a result of changing rainfall distribution, melting ice, and increased periods of drought.The health sector was received a score of 8.0, because the climate change leads to spread of new diseases, an increase in heat-related diseases, and the problems with food availability. Coastal areas were reached a score of 7.6, as the result of sea level rise, coastal erosion, and increased storms.

The energy sector was affected by a score of 7.2, due to damage to infrastructure and an imbalance between energy supply and demand due to extreme temperatures. As for forests, they received a score of 6.5, as a result of the increase in forest fires, the spread of pests, and the loss of biodiversity.

The figure 5 shows that the impacts of climate change is not limited to the one area, but rather including multiple sectors, underscoring the need for comprehensive adaptation plans that it is help protect humans and the environment together.

The agriculture sector was both the major emitter accounting for about 19–21% of the global emissions and also one of the most climate-sensitive industries (FAO, 2021; Tubide ello et al., 2022). Climate change affects agricultural productivity through shifts in rainfall patterns, increased frequency of droughts and floods, and rising pest and disease outbreaks.

Food production systems, particularly in developing countries, are increasingly disrupted, threatening food security and trade flows. Crop yields for staples such as wheat, rice, and maize are projected to decline under most climate scenarios, particularly in tropical and subtropical regions (IPCC, 2022). Additionally, climate-related trade disruptions such as export bans and logistics breakdowns compound the vulnerability of global food systems (World Bank, 2022, p. 18).

Efforts to build climate-resilient agriculture include climate-smart farming, regenerative practices, and agroecological innovations, which aim to reduce emissions while enhancing adaptive capacity (FAO, 2021). However, widespread implementation remains limited by financial, institutional, and technological barriers (World Bank, 2022, p. 29).

In summary, climate change is transforming the risk and opportunity landscape across energy, mining, transportation, and agriculture. These industries are not only exposed to climate-related physical disruptions, but also increasingly shaped by policy-driven transitions toward low-carbon economies. Understanding these transformations is critical for policymakers, investors, and trade actors as they prepare for a rapidly evolving global economic order.

3.1.2 Changes in International Trade Patterns

Climate change is reshaping international trade patterns throughs both direct physical disruptions and indirect regulatory transformations. The Rising was temperatures, extrem is weather events, resource scarcity, and climate-related policies are influencing where and how goods are produced, transported, and consumed (WTO, 2022, p. 25). As governments introduce climate-oriented regulations, and markets demand greener supply chains, trade flows are increasingly being reorganized around carbon intensity, climate resilience, and environmental compliance (OECD, 2023, p. 1).

One of the most pressing challenges is the disruptions in trade routes and logistics, climate-induced disasters such as floods, droughts, and hurricanes are causing frequent interruptions in supply chains and transportation networks. Coastal ports, which handle over 80% of global trade by volume, are especially vulnerable to sea-level rise, storm surges, and infrastructure erosion (IPCC, 2022, p. 130).

For instance, the 2021 floods in Germany and China significantly disrupted regional logistics and export capacities (UNCTAD, 2022). Similarly, drought-induced reductions in river depth, as seen in the Rhine and Mississippi, have constrained inland shipping and increased transport costs (OECD, 2023, p. 1).

The Arctic region presents another evolving trade route due to melting ice. While shorter shipping paths between Asia and Europe via the Northern Sea Route are becoming feasible, this development raises environmental concerns and geopolitical tensions ((Humpert, 2021, para. 4; Pincus & Stanford, 2020, p. 12).

Figure (6) displays a comparison between commercial activity in various regions before and after the implementation of climate policies, using a trade index starting from 100 to represent the situation before these policies. The figure shows how measures such as carbon pricing, emissions trading, and carbon adjustment mechanisms have affected global trade.

The European Union recorded a rise in trade activity (Indicator 110) following the implementation of climate policies, thanks to its early role in adopting environmental policies, exporting clean technology, and increasing trade in sustainable products.

In contrast, regions such as Africa (87) and South America (90) have seen a decline in trade, due to weak technological capabilities and difficulty adhering to new environmental standards.

China moderate rise (105), demonstrating its success in rapidly adapting to environmental policies and increasing its renewable energy exports. While trade activity declined in North America (92) and the Middle East (93), perhaps due to the dependence of their exports on high-emission industries and slow policy change.

The figure shows that the impact of climate policies on trade varies from region to region, with developed countries benefiting faster, while developing countries face greater challenges in adapting and competing.

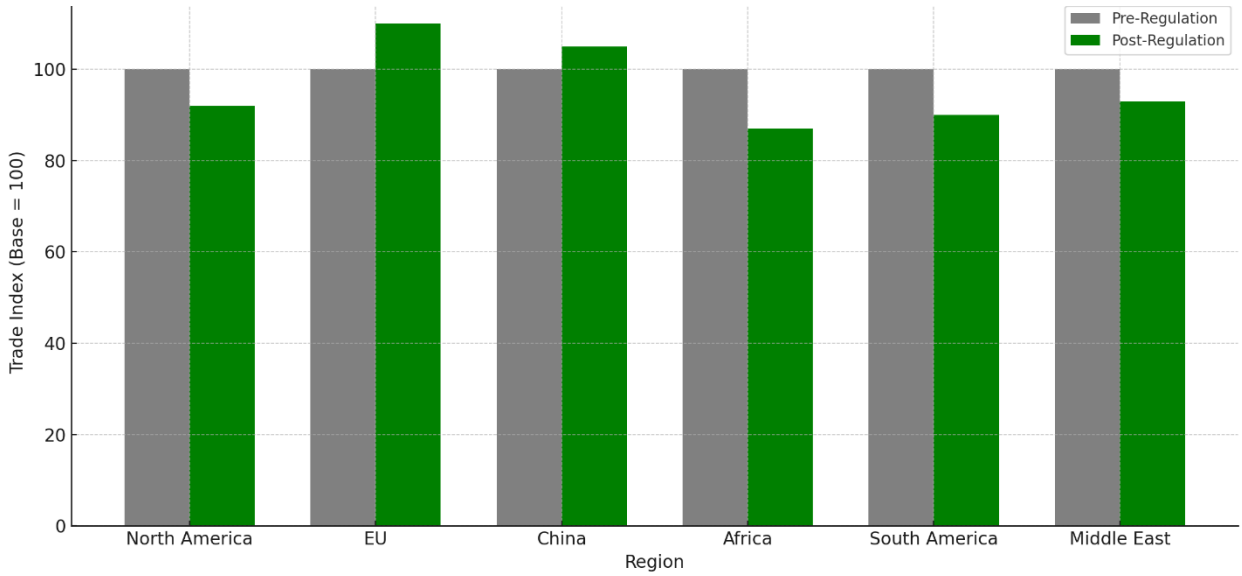

Figure 6. The Shifts in Global Trade Patterns due to Climate Regulations.

Sources: WTO (2022, p. F-42); UNEP (2023, p. F-15); IEA (2022, p. F-33); European Commission (2021, p. F-27).

Shifts in comparative advantage and specialization are becoming increasingly evident, since climate change is altering the geographical patterns of production by affecting resource availability, agricultural yields, and energy inputs. Countries that were previously competitive in certain exports may lose that advantage due to climate stress, while others may gain from improved growing conditions or renewable energy capacity (Candau et al., 2022). In manufacturing and heavy industry, carbon border adjustment mechanisms (CBAM) and carbon pricing are reshaping competitiveness. Carbon are intensive industries in countries with weak environmental policy that can withstand the loss of trade due to built -in carbon costs, which can lead to rehabilitation or regionalization of any supply chains (Recent CBAM economic impact study, 2025, p. 11).

The rise of climate-driven trade barriers is evident, a growing number of the climate policies is creating non-tariff trade barriers, which is including emissions standards, sustainable product certifications, and the carbon labeling, and eco-design requirements (UNEP, 2021, p. 15). While these is measures aim to reduce emissions and promote sustainable trade, they may disproportionately affect developing countries lacking the capacity to meet such standards

(Pauwelyn, 2020, p. 15). For instance, the EU's deforestation-free supply chain regulation imposes strict traceability obligations on exporters of commodities like soy, beef, and palm oil (European Commission, 2023, Regulation on Deforestation-Free Products section). The shift toward green public procurement, climate-aligned export credits, and carbon accounting requirements in trade finance further shape who can access global markets under climate-compliant terms (WTO, 2022, Chapter C: Trade Implications of a Low-Carbon Economy).

Regionalization and supply chain reconfiguration have accelerated, as the COVID-19 pandemic, compounded by climate risks, has accelerated trends toward supply chain diversification and regionalization. Companies are re-evaluating global just-in-time models, favoring just-in-case models that prioritize resilience, shorter trade distances, and regional hubs (Baldwin & Freeman, 2021, p. 2). This trend is visible in critical sectors such as pharmaceuticals, semiconductors, and agri-food, where climate-induced risks to input availability, transport reliability, and political stability have led to "friend-shoring" or "climate-compatible sourcing" (WEF, 2022, p. 42).

In summary, international trade patterns are changing as climate modifies comparative advantages, trade infrastructure, and regulatory landscapes. These shifts reflect a broader movement toward climate-aligned trade ecosystems, where carbon efficiency, resilience, and sustainability become as important as price and volume, are becoming more important. The next section will explore how these trade dynamics are evolving. Trade dynamics pose unique challenges for developing and emerging economies facing structural constraints in adapting to climate-related trade requirements.

3.1.3 Challenges Facing Developing Countries and Emerging Economies

Developing countries and emerging economies face a unique set of challenges at the intersection of climate change and international trade. While these countries historically contribute the least to greenhouse gas (GHG) emissions, they are often the most vulnerable to climate impacts and the least equipped to adapt to the economic transformations brought about by climate-compatible trade policies (IPCC, 2022, p. 10; OECD, 2022, p. 32).

High exposure to climate risks and trade dependence is a defining challenge for developing countries, many developing countries are located in climate-sensitive areas, where rising temperatures, drought, sea-level rise, and extreme weather events threaten agriculture, water resources, and infrastructure. (World Bank, 2021, n.d., Climate Change Overview section).

Institutional and technological limitations remain among the most persistent barriers to adaptation, one of the most persistent barriers to adaptation is the lack of institutional capacity, infrastructure, and technological readiness to comply with new environmental standards, including carbon accounting, sustainable certification, and traceability systems (UNCTAD, 2022, p. 56).

Inequitable access to climate finance presists, although developed countries pledged to mobilize USD 100 billion per year in climate finance to support developing countries, actual flows have consistently fallen short, particularly in adaptation-focused funding (OECD, 2022, para. 1).

Trade policy and carbon leakage concerns are particulary evident, emerging economies such as India, Brazil, South Africa, and Indonesia have voiced concerns over "green protectionism", arguing that climate-linked trade measures like CBAM may impose unfair trade barriers and hinder development goals (Mehling et al., 2019, p. 448).

Capacity gaps in policy integration remain critical challenge. Many developing countries struggle to mainstream climate considerations into trade strategies due to fragmented policy coordination across ministries, lack of integrated planning, and weak stakeholder engagement (UNDP, 2022, p. 37).

3.2 Trade of Renewable Energy and Clean Technology

3.2.1 Circular Economy and Investments in Sustainable Sectors

As the global economy confronts the twin crises of climate change and environmental degradation, the circular economy model has emerged as a transformative framework that promotes resource efficiency, waste reduction, and sustainable production. Unlike the traditional linear economy which follows a "take-make-dispose" trajectory the circular model emphasizes reuse, repair, recycling, and regeneration, aiming to decouple economic growth from environmental harm (OECD, 2021, p. 29).

The circular economy is increasingly recognized as a climate mitigation tool. According to the Ellen MacArthur Foundation (2019), applying circular principles in just five key sectors cement, plastics, steel, aluminum, and food could reduce global greenhouse gas (GHG) emissions by up to 9.3 billion tonnes annually by 2050.

The transition to a circular economy has direct trade implications, including the rise of new product categories (e.g., recyclable materials, refurbished electronics), service-based models (e.g., leasing), and extended producer responsibility (EPR) frameworks. Countries are beginning to integrate circular principles into trade policies, product standards, and bilateral agreements (UNCTAD, 2021, p. 25).

In examining challenges to scaling circularity, it becomes clear that despite its promise, the circular economy faces barriers to mainstream adoption. These include:

- Lack of global regulatory harmonization, which hampers the cross-border movement of secondary materials due to inconsistent waste classification and trade restrictions (UNCTAD, 2021, p. 25).
- Insufficient infrastructure and technology in many developing countries.
- Limited awareness and incentives for private sector adoption.
- Trade-offs with traditional recycling if not paired with renewable energy and efficient logistics (OECD, 2021, p. 56).

To address these challenges, policy tools such as eco-design regulations, product labeling schemes, green procurement standards, and public–private partnerships are increasingly being deployed to align market incentives with circular goals (OECD, 2021, p. 78).

3.2.2 Green Trade and New Economic Opportunities

The accelerating shift toward low-carbon development has given rise to a rapidly growing segment of green trade the exchange of goods and services that contribute to environmental sustainability and climate mitigation.

The global green economy is projected to surpass USD 10 trillion in value by 2030, driven by massive investments in clean energy, infrastructure, and innovation (LSEG, 2023, p. 3).

In addition to goods, environmental services such as waste management, renewable energy consulting, carbon auditing, and infrastructure planning are becoming central to trade strategies. Digital tools like blockchain and IoT are enabling traceability and sustainability in supply chains (World Economic Forum [WEF], 2024, p. 51).

Figure No. (7) shows how the volume of global trade in renewable energy technologies, including solar energy, wind energy, and bioenergy, developed between 2010 and 2024. Data shows that global demand for clean energy is growing, thanks to climate agreements, emissions reduction policies, and falling prices for these technologies.

Solar energy has seen the greatest growth, with trade rising from $15 billion in 2010 to $121 billion in 2024. This significant growth is due to rapid development in technology, mass production of solar panels, and government support in countries such as the European Union, China, and the United States.

Wind energy trade also rose continuously from $12 billion to $87 billion, thanks to the expansion of the construction of wind farms on land and at sea, and increased investments in turbine production.

As for bioenergy, it has grown more slowly, from $8 billion to $42 billion, but it still plays an important role in some countries, especially those that depend on agriculture and forestry.

The figure shows that renewable energy trade has become an important economic opportunity, and that the world is increasingly moving away from fossil fuels towards more sustainable energy sources. It also highlights the role of innovation, government support and global supply chains in promoting this transformation.

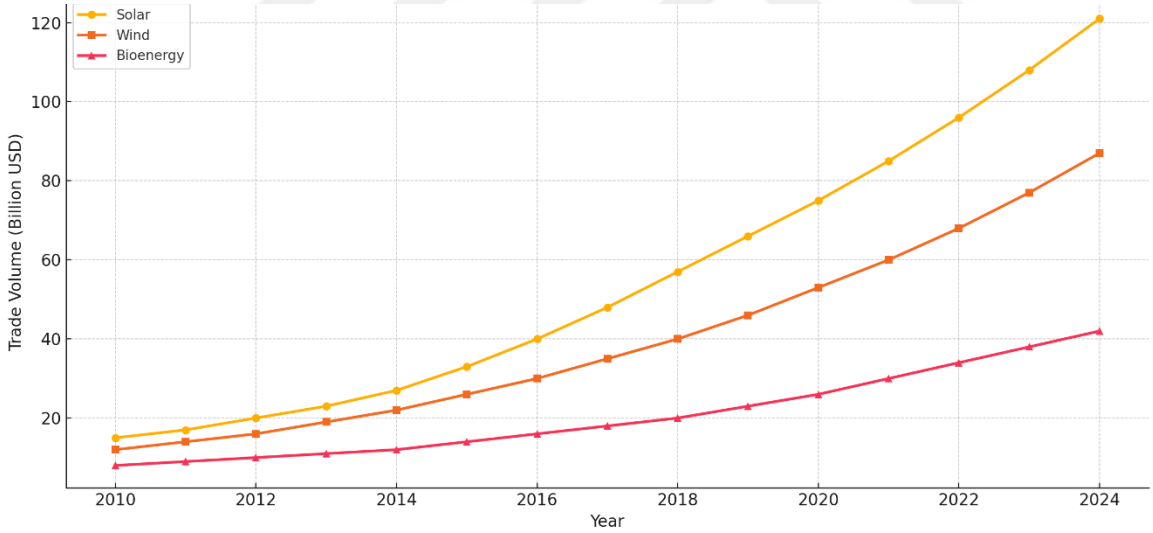

Figure 7. Trade Volume of Renewable Energy Products.

Sources: WTO (2023, World Trade Report 2023: Re-globalization for a sustainable future, pp. 95–102); UNCTAD (2023, Trade and Development Report 2023, pp. 85–90); ILO (2024, World Employment and Social Outlook 2024: Greening with Jobs, p. 34).

Green trade supports employment generation and economic diversification. The ILO estimates that a transition to a green economy could create 24 million new jobs globally by 2030 (ILO, 2024, p. 34).

In terms of trade agreements and market access, countries are embedding environmental provisions into trade agreements. Access to green public procurement markets and eco-certification schemes offers competitive advantages to compliant exporters.
Despite the opportunities, challenges remain:

i. Lack of harmonized standards.
ii. Green protectionism.
iii. Capacity gaps in low-income countries.
iv. Technology concentration risks.

3.2.3 Economic and Financial Costs

Mitigation Costs and Infrastructure Investmentthe cost of reducing global GHG emissions to meet the Paris Agreement target is estimated at USD 4.3 trillion annually between 2026 and 2030 (UNEP, 2024, p. 11). Clean energy transition requires high upfront capital.
Adaptation and Resilience Costs Developing countries need USD 160–340 billion per year by 2030 for adaptation, yet only a small share of climate finance is allocated to this (UNEP, 2024, p. 18).
Carbon Pricing and Trade Adjustment Costs: Carbon pricing mechanisms and CBAMs create compliance costs, especially for exporters in developing countries.
Stranded Assets and Employment Disruption decarbonization could strand approximately USD 1.3 trillion in fossil-fuel assets by 2050 (MIT Joint Program, 2022, p. 47).
Financing Gaps and Access to Capital high capital costs in the Global South hinder green investment. MDBs and climate funds help, but funding gaps persist.

In summary, this chapter has examined how climate change is reshaping global trade by altering industry structures, redirecting investment toward circular and green sectors, and imposing new regulatory and financial challenges. Key industries such as energy, mining, transport, and agriculture face rising costs and disruptions, while green trade offers promising opportunities for diversification, job creation, and low-carbon growth. However, the financial and institutional demands of this transition are substantial and unevenly distributed. To understand how the international trade rules and the environmental policies are respond to

these all emerging challenges, the next chapter will explores the evolving intersection between the climate changing and the global trading governance, with the focus on all emission reduction mechanisms, the carbon pricing, and role of the World Trade Organization (WTO, 2022, p. 3).

4. INTERNATIONAL TRADE IN THE CONTEXT OF CLIMATE CHANGE AND PROPOSED POLICIES

4.1 Environmental Measures and Trade Policies

4.1.1 Emission Reduction Policies and Environmental Trade Barrier

EU ETS and CBAM: The European Union Emissions Trading System (EU ETS) is the world's largest and oldest carbon market. Operating since 2005, it is a cornerstone of European climate policy. This system sets an overall cap on carbon dioxide emissions from sectors that consume a lot of energy, such as electricity generation, industry, and aviation. It also allows companies to buy and sell emissions allowances according to their needs (European Commission, 2024, “How does the EU ETS work?” section), covering approximately 40% of EU emissions.

The Carbon Border Adjustment Mechanism (CBAM) is a policy aimed at preventing the relocation of emissions outside the European Union by imposing tariffs on certain high emitting imported goods, such as cement, steel, aluminum, fertilizers, and electricity. This policy aims to ensure fairness between European companies that pay for their emissions according to the EU system and foreign companies that are not subject to the same environmental laws.

The process begins when these goods are imported from outside the EU. Importers are required to disclose the amount of emissions associated with the production of these goods, and this information is verified by independent bodies to ensure transparency. Importers must then purchase CBAM certificates that represent the carbon cost as if the goods were produced within the EU. These certificates are submitted annually to European authorities, and the data is reviewed at the end of each year to compare it to actual emissions and ensure its accuracy. Ultimately, the carbon cost is balanced between domestic and imported products to ensure fair competition between the two parties.

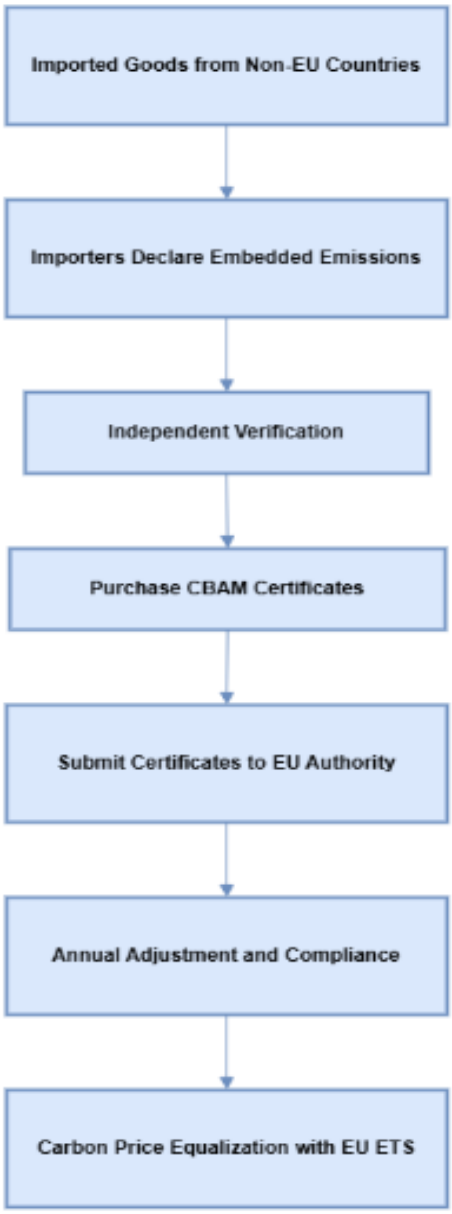

Figure 8. The EU CBAM Operational Flow.

Sources: European Commission (2024, p. 12); WTO (2022, p. 55).

The European Union Emissions Trading System (EU ETS) is the world's largest and oldest carbon market, operating since 2005. The system sets a cap on carbon dioxide emissions, which are gradually reduced each year to achieve the EU's goal of reducing emissions by 55% by 2030 compared to 1990 levels and achieving carbon neutrality by 2050 (European Commission, 2024, p. 12). Companies whose emissions are less than the quota allocated to them can sell the surplus, while those that exceed it are forced to buy additional emission

rights or pay fines. This system It encourages companies to invest in cleaner technologies and makes them bear the cost of the pollution they cause.

However, despite the success of the system within Europe, there are concerns that some companies may move their operations to countries that do not have strict environmental laws, which is known as "carbon leakage", and this may weaken global efforts to reduce pollution. To address this problem, in 2021 the European Union launched the Carbon Border Adjustment Mechanism (CBAM) which will become fully operational in 2026(OECD, 2025, p. 14).

The CBAM mechanism imposes duties on some imports of high-emission goods such as cement, steel, aluminium, fertilizers and electricity, so that importers are forced to purchase certificates representing the carbon cost that would have been charged if these goods had been produced within the EU. The aim is to achieve fairness between European companies that pay for their emissions, and those foreign companies to which the same rules do not apply, while encouraging these countries to reduce their emissions (OECD, 2025, p. 27).

CBAM is designed to be compliant with global trade laws, charging the same cost of carbon to domestic and imported goods, and accounting for carbon pricing systems in export countries. But this mechanism has sparked legal and diplomatic controversy, especially among developing countries that may find it difficult to comply with it due to lack of technical and institutional resources (OECD, 2025, p. 2).

The EU considers that CBAM can be a tool to enhance international climate cooperation, by encouraging countries to adopt similar environmental standards or join carbon markets. However, some critics warn that the lack of sufficient financial and technical support for developing countries may increase the gap between rich and poor countries.

USA ETS: Unlike the European Union’s was centralized the cap and the trade approach, United States has been adopted a more fragmented and decentralized strategy toward carbon pricing. The United States does not currently operate a federal emissions trading system (ETS). However, various subnational programs and sector-specific regulations have been implemented to reduce greenhouse gas (GHG) emissions, particularly in states that have prioritized climate policy (Burtraw & Woerman, 2022, p. 405).

With regard to regional carbon markets RGGI and California Cap-and-Trade, the most prominent ETS initiative in the U.S. is the Regional Greenhouse Gas Initiative (RGGI), a

cooperative effort among twelve Northeastern and Mid-Atlantic states. Established in 2009, RGGI sets a regional cap on CO_2 emissions from the power sector and requires fossil fuel power plants to obtain allowances for each ton of CO_2 emitted. These allowances are auctioned, and revenues are reinvested in energy efficiency, renewable energy, and consumer benefit programs. Analysis shows RGGI states have achieved a 46% reduction in power sector emissions from 2009 to 2020, while generating over USD 3.8 billion in allowance revenues and net economic benefits of USD 5.7 billion (Analysis Group, 2023, p. 11).

Another major initiative is California's Cap-and-Trade Program, launched in 2013 under the Global Warming Solutions Act (AB 32). This comprehensive market covers power generation, large industrial facilities, and fuel distributors. It is linked to the Québec Cap-and-Trade System, forming the Western Climate Initiative (WCI). California's system includes features such as offset mechanisms, banking of allowances, and a gradually declining emissions cap (CARB, 2023, p. 1). It has been credited with reducing emissions and supporting clean technology investments, although concerns remain regarding environmental justice and leakage (Cullenward & Coghlan, 2016, p. 7).

In the context of federal climate policy and the inflation reduction act, although the U.S. lacks a national carbon market, recent federal policies have introduced significant climate-related incentives. The Inflation Reduction Act (IRA) of 2022 represents the largest climate investment in U.S. history, committing approximately USD 369 billion to clean energy, carbon capture, and industrial decarbonization but does not impose direct carbon prices (U.S. DOE, 2022, p. 2).

Additionally, the Social Cost of Carbon (SCC), a metric developed by federal agencies, assigns a monetary value to climate damage from each ton of CO_2 emitted. Though not a market instrument, the SCC informs cost–benefit analyses in federal rulemaking and guides regulatory action (Interagency Working Group, 2021, pp. 3-4).

Political divisions and legal constraints shape legal and Political Landscape the evolution of carbon pricing in the U.S. The Supreme Court's ruling in West Virginia v. EPA (2022) limited the Environmental Protection Agency's authority to regulate carbon emissions from power plants under the Clean Air Act, complicating the pathway to centralized regulation (Lazarus, 2022, p. 1). Nonetheless, state-level initiatives and market-based programs continue to drive subnational climate action.

Concerns about competitiveness and equity have influenced U.S. resistance to a national carbon tax or border adjustment. However, growing attention to climate-aligned trade policy including the proposal for a U.S. Carbon Border Adjustment Mechanism (CBAM) under the Clean Competition Act signals a potential convergence with global efforts to integrate trade and climate objectives (U.S. Senate, 2022, Sec. 2, Sec. 9902).

In conclusion, the United States offers a patchwork model of carbon regulation, with dynamic subnational markets and recent federal incentives shaping its climate strategy. Although it lacks a unified ETS, the combination of state-level initiatives, federal funding, and legal innovations continues to push the country toward a more carbon-conscious trade and production framework.

China ETS: China is the world's largest exporter of greenhouse gases and has therefore taken important steps in recent years to integrate market instruments into its climate policy framework. In July 2021, China officially launched the world's largest national emissions trading system (ETS), marking a milestone in its move toward low-carbon development. This measure aligns with China's commitment to peak carbon dioxide emissions before 2030 and achieves carbon neutrality by 2060, which President Xi Jinping announced in 2020 (Ministry of Ecology and Environment [MEE]).2021, p. 3; Zhang et al., 2022, p. 1125).

Structure and Scope of China’s ETS: The Chinese ETS initially covers only the power generation sector, which accounts for more than 40% of the country's carbon dioxide emissions. This sector includes more than 2,200 companies and approximately 4.5 billion metric tons of emissions annually (ICAP, 2023). Unlike the cap-and-trade systems in the EU or California, China’s system uses an intensity-based approach, setting performance benchmarks based on emissions per unit of output (e.g., tons of CO_2 per megawatt-hour) rather than absolute emission caps (Qi et al., 2021, p. 85).

Each regulated entity receives allowances based on its historical emissions and output level, and entities that exceed the benchmark must purchase additional allowances from the market. Trading is conducted via a national trading platform managed by the Shanghai Environment and Energy Exchange. (Republic of Turkey, 2021, p. 63).

While the system is still in its transitional phase, it is expected to expand to include other sectors such as steel, cement, aluminum, chemicals, and aviation in the coming years. The gradual inclusion of these sectors will enhance the market’s environmental integrity and effectiveness (Teng & Jotzo, 2021, p. 222).

In terms of the institutional framework and implementation challenges, China's ETS is administered by the Ministry of Ecology and Environment (MEE), with provincial authorities responsible for data collection and compliance oversight. While the system reflects a strong central planning component, regional disparities in capacity and enforcement remain significant. Ensuring data accuracy, transparency, and MRV (monitoring, reporting, and verification) consistency is one of the key challenges for the system's credibility.

Moreover, the allocation method primarily free allocation reduces immediate cost pressure on firms but may also delay deep structural decarbonization. Introducing auctioning mechanisms, tightening benchmarks, and integrating financial intermediaries will be necessary to increase market liquidity and improve environmental outcomes (Zhao et al., 2022, p. 12).

In the global context China's carbon market is not only central to its domestic climate goals but also carries geopolitical and trade implications. The ETS positions China as a rule-setter in global carbon governance and helps counter criticism of its climate action delays. It may also reduce the country's exposure to carbon border adjustment mechanisms (CBAMs) like the EU's by providing a domestic carbon price (Mehling et al., 2019, p. 462).

However, given its intensity-based structure and current low-market price hovering around USD 8 per ton of CO_2 in 2023 its ability to drive substantial emissions reductions remains under scrutiny. Scaling up ambition will require a shift toward absolute emissions caps, broader sectoral coverage, and greater market transparency (ICAP, 2023, p. 15). Looking ahead to future prospects, China's carbon market is expected to become more robust and sophisticated over the next decade.

In provinces such as Guangdong and Shenzhen, pilot programs that included trials of the auction system and multi-sector coverage have provided valuable lessons that can be built upon to expand the system nationally (Lo, 2020).. In addition, integration with green finance and carbon offset programs, combined with the use of digital monitoring, reporting and verification (MRV) technologies, can enhance the efficiency and credibility of the system globally.

Thus, China's emissions trading system is a bold and cutting-edge experiment in climate governance. Although the system is still in its early stages (Lo, 2020, p. 4)., its sheer size, potential for expansion, and central importance in global emissions reduction efforts make it a vital model that combines climate policy and trade regulation.

Turkey ETS: Turkey, as an emerging economy and the candidate for the European Union accession, which was finding itself at the critical junction where climate policy must evolve in parallel with regional trade and environmental standards. Although Turkey has not yet implemented a full national emissions trading system (ETS), it has taken important preparatory steps toward establishing a carbon market in line with its commitments under the Paris Agreement, which it ratified in October 2021 (Republic of Turkey, 2021, p. 27).

In terms of climate commitments and EU alignment, Turkey's nationally determined contribution (NDC), submitted in 2021, commits to reducing GHG emissions by 41% from a business-as-usual (BAU) scenario by 2030, with a strong emphasis on energy efficiency, renewable energy, and green finance (UNFCCC, 2021, p. 5). These targets reflect growing pressure to align national policies with European climate regulations, particularly in response to the EU's Carbon Border Adjustment Mechanism (CBAM), directly impacting Turkish steel exports, cement, aluminum, and fertilizers (European Commission, 2022, p. 12).

As a major trading partner of the EU, Turkey's ability to comply with carbon pricing and MRV (monitoring, reporting, verification) standards is essential for maintaining market access and competitiveness under the new green trade regime (World Bank, 2022). In 2021, Turkey launched a Climate Law drafting process, which includes provisions for a national ETS framework, institutional arrangements, and sectoral coverage based on EU ETS principles (Turkish Ministry of Environment, Urbanization and Climate Change [MoEUCC], 2022, p. 14).

Since 2014, Turkey has been part of the World Bank's Partnership for Market Readiness (PMR) program, which supports technical capacity building and policy development for carbon pricing mechanisms. Under this initiative, Turkey developed a Carbon Pricing Roadmap (2018–2020), which outlined potential design options, pilot scenarios, and legal structures necessary for a future ETS (World Bank, 2018). The roadmap proposed a phased ETS covering the energy, cement, and iron-steel sectors, with initial free allocation and gradual introduction of auctioning mechanisms.

In addition, Turkey has implemented an MRV Regulation since 2014, mandating over 800 industrial installations to monitor and report their GHG emissions. This system is seen as a foundational infrastructure for a future carbon market and is harmonized with the EU MRV Directive (ICAP, 2023, p. 208).

Despite progress, institutional and technical challenges remain, several institutional and technical challenges hinder rapid ETS implementation. These include:

a) Regulatory uncertainty due to delayed enactment of the Climate Law.
b) Limited experience in emissions trading, especially regarding allowance allocation, auctioning, and compliance enforcement.
c) Capacity gaps in digital infrastructure, emissions verification, and stakeholder engagement.
d) Concerns about industrial competitiveness and economic impacts on key export sectors (TURKSTAT, 2021, pp. 7–9).

Moreover, political sensitivities and reliance on fossil fuels particularly coal complicate efforts to introduce a binding carbon price. Nonetheless, growing interest from financial institutions and international partners is accelerating momentum toward a market-based climate policy.

In terms of strategic implications and future outlook, Turkey's ETS development is not only a domestic climate issue but a strategic economic matter. As the EU's CBAM enters its transitional phase (2023–2025), Turkish exporters are expected to provide verified emissions data for covered goods, even before full CBAM charges apply. Failure to adapt could result in trade penalties, reduced investment attractiveness, and exclusion from green supply chains (Deloitte Turkey, 2022, pp. 10–12).

At the same time, successful ETS implementation could open access to green finance, support low-carbon innovation, and strengthen Turkey's regional leadership in climate diplomacy. Recent international initiatives, such as the Turkey–World Bank Emissions Trading Capacity Project and the Green Deal Action Plan, reflect increasing convergence between Turkish climate strategy and global carbon governance (MoEUCC, 2022, pp. 15–18, 23–30).

In conclusion, Turkey is making measurable progress toward establishing an ETS, driven by both climate obligations and economic imperatives. While the system remains in its formative stage, its alignment with EU frameworks and growing institutional readiness suggest that a functional Turkish carbon market may emerge in the near future.

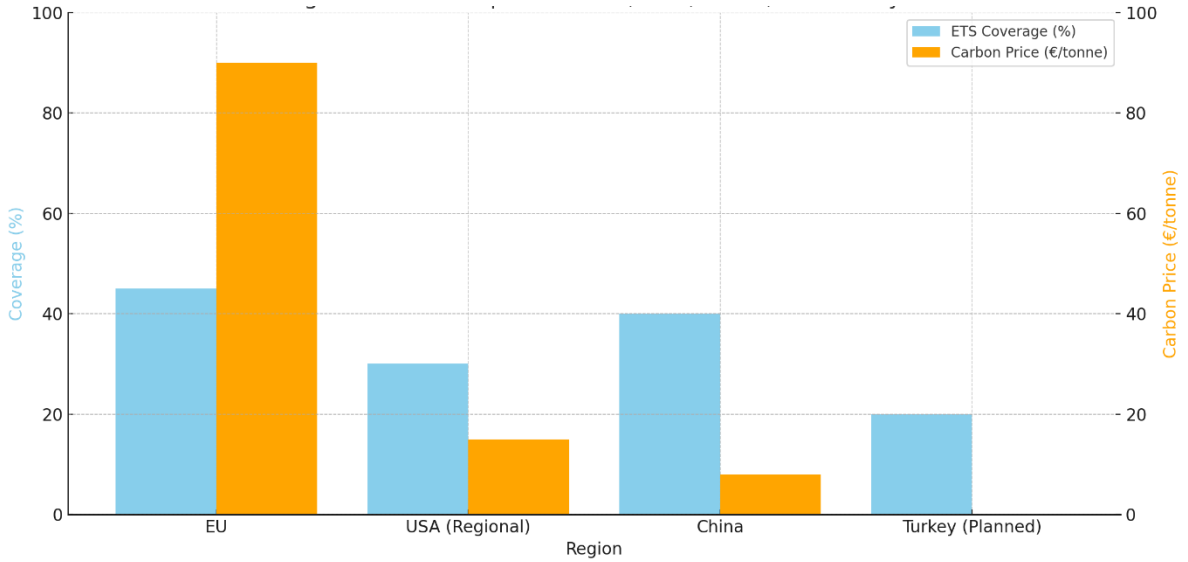

Figure 9. ETS Comparison between (EU, USA, China, Turkey).

Sources: European Commission (2024, p. 14); IEA (2022, p. 115); World Bank (2023, p. 22); ICAP (2023, p. 36); Republic of Turkey (2021, p. 63).

Figure 9 presents a comparison between emissions trading systems in four main regions: the European Union, the United States, China, and Turkey. The figure shows the proportion of emissions covered by each system and the carbon price (in EUR per tonne of CO2) in each region.The European Union is the most advanced, covering 45% of national emissions and its carbon price is about 90 euros per ton, and it is one of the largest and most mature systems in the world. This system encourages emissions reductions in sectors such as energy, industry and aviation.

Table (3) compares emissions trading systems in the European Union, America, China and Turkey. The European Union has the strongest and most advanced system, with a high carbon price and broad coverage. In America, there are local regulations in some states such as California, but they are less regulated, and the price of carbon is low. China recently started a national system focusing on the electricity sector, covering a large proportion of emissions, but it is still in the growth stage. As for Turkey, it is in the process of preparation, and has not really started yet, but it plans to implement a system in line with European laws. In general, these systems vary depending on the capabilities and policies of each country, and there is a need for international coordination so that competition is fair and carbon leakage is reduced globally.

Table 3. ETS Comparison by Region.

Region	**ETS Coverage (%)**	**Carbon Price (€/tonne)**	**Stage**	**Notes**
EU	45	90	Mature	Covers energy, aviation, industry
USA (State-level)	30	15	Fragmented	Regional programs like California & RGGI
China	40	8	Emerging	Primarily power sector, national scale expanding
Turkey	20	0	Preparatory	ETS under development to align with EU CBAM

Sources: European Commission (2024, p. 14); IEA (2022, p. 115); World Bank (2023, p. 22); ICAP (2023, p. 36); Republic of Turkey (2021, p. 63).

In the United States, there are regional systems like California's, covering about 30% of emissions, and the carbon price is much lower, about 15 euros per ton. There is no unified national system, which reduces the impact of these systems.China covers 40% of emissions, especially in the energy sector, but it is still at the beginning of implementing the carbon trading system, so the carbon price is low, about 8 euros per ton.Turkey has not launched an official trading system yet, but has plans to start soon. Coverage is now as low as around 20% and there is no actual carbon price, and it is in the preparation phase to align with EU climate policies and commitments.The figure shows the different development of carbon trading systems between regions, with the progress of the European Union, the multiplicity of systems in the United States, rapid growth in China, and Turkey preparing to enter the system in the future. It also showing that coverage and carbon price which are the most important factors for the success of these systems.

4.1.2 Carbon Emission Standards

Carbon emission standards are the core regulatory instrument was used by governments to the control of the level in the greenhouse gas (GHG) emissions from various sectors, particularly energy production, the transportation, industry, and also the construction. These standards establish mandatory thresholds for permissible emissions, often measured in grams of CO_2 per unit of output or the activity. This mean by setting limits on emissions intensity or the absolute emissions levels, such as the standards aim to drive technological upgrades, it is increasing energy efficiency and also reduce the carbon footprints across economies (IEA, 2021, p. 182).

In discussing the types of emission standards, emission standards can be categorized into three major types:

Performance-Based Standards: These set emission targets per unit of product or service, such as CO_2 grams per kilowatt-hour (g/kWh) in power generation or grams per kilometer (g/km) in automotive emissions (EPA, 2022, p. 47).

Technology Standards: These mandate the use of specific equipment or processes that reduce emissions, for instance, requiring catalytic converters in vehicles or best-available technologies in industrial boilers (OECD, 2020, p. 131).

Ambient Air Quality-Linked Standards: These are indirectly emission-focused, ensuring that pollution levels in a region stay within safe limits, thereby regulating the cumulative impact of various emitters (UNEP, 2021, p. 96).

In examining examples from leading jurisdictions, the European Union, vehicle manufacturers are subject to strict CO_2 emission limits under Regulation (EU) 2019/631, which sets phased targets aiming to reduce average emissions for new passenger cars by 55% by 2030, compared to 2021 levels (European Commission, 2022). Similar standards apply to the building sector, where the Energy Performance of Buildings Directive (EPBD) mandates carbon-neutral construction by 2030.

The United States has adopted the Corporate Average Fuel Economy (CAFE) standards and Clean Air Act provisions to regulate transport emissions. These standards are enforced by the Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA), targeting both fuel efficiency and direct GHG output (EPA, 2022, p. 52).

China, in parallel with its ETS, has introduced industrial emission limits targeting high-emission sectors such as steel, cement, and chemicals. These include caps on carbon intensity and mandatory installation of energy-saving technologies (Zhang & Wang, 2020, p. 118). Similarly, India's Perform, Achieve and Trade (PAT) scheme combines regulatory standards with market-based incentives to lower industrial energy intensity (BEE, 2022, p. 35).

In terms of their role in trade and competitiveness, emission standards increasingly impact international trade. Products that fail to meet climate-compliant regulations may face limited market access, reputational risks, or additional costs through mechanisms such as carbon border adjustments (WTO, 2022). For example, the upcoming EU Ecodesign for Sustainable Products regulation is expected to incorporate carbon performance standards into product design, indirectly impacting manufacturers and exporters outside the EU (European Commission, 2023).

These standards also shape investment decisions and global value chains, as firms seek to align operations with the regulatory requirements of key markets. Exporters to developed economies must now consider emission thresholds and lifecycle emissions of their products, especially in climate-sensitive sectors such as automotive, electronics, and textiles (OECD, 2022, p. 44).

With regard to implementation and equity considerations, while carbon standards are effective in reducing emissions, they can also impose compliance burdens, particularly on small and medium-sized enterprises (SMEs) and exporters from developing countries. Lack of access to cleaner technologies, technical expertise, and financing often prevents these actors from meeting stringent international standards (UNCTAD, 2023, p. 74).

To mitigate such impacts, international initiatives like Technology Mechanism (UNFCCC) and green finance programs by the World Bank and Global Environment Facility (GEF) aim to support developing countries in upgrading production systems and meeting global environmental benchmarks (World Bank, 2023, p. 41).

In summary, carbon emissions standards are a powerful regulatory tool for aligning industry and business practices with climate goals. As these standards become more stringent and internationally harmonized, they are likely to shape the rules for accessing global markets and driving sustainable transformation across supply chains.

4.1.3 Carbon Tariffs and Pricing Mechanisms

Carbon tariffs and pricing mechanisms are increasingly used as policy tools to internalize the environmental cost of greenhouse gas (GHG) emissions and to prevent carbon leakage in international trade. These instruments assign a monetary value to carbon emissions, either through direct taxation or market-based schemes, thereby incentivizing emission reductions and discouraging the offshoring of pollution-intensive production (Stiglitz & Stern, 2017, p. 4). In global trade, carbon pricing mechanisms when applied at the border can also affect trade flows, competitiveness, and diplomatic relations.

Figure 10 simplifies how the carbon tariff, also known as the carbon border adjustment mechanism, works. This mechanism is used as a tool to mitigate the phenomenon of "carbon leakage," which occurs when companies relocate their factories to countries that do not impose strict emissions restrictions in order to avoid paying carbon costs.

Initially, some exporting countries produce emissions-intensive commodities such as steel, cement, aluminum, and fertilizers without imposing strict carbon taxes. These products are then exported to other countries with stricter environmental regulations and regulated carbon pricing markets.

When these goods reach the borders of the importing country, they are subject to carbon taxes, calculated based on the emissions generated during their production. These taxes aim to equalize the cost of domestic products subject to environmental taxes and imported goods that are not subject to the same restrictions.

As a result, the price of the imported product is adjusted to match the price of the domestic product after taking into account the environmental cost, which ensures fair competition between the two parties. Additionally, this system encourages foreign producers to reduce their emissions and improve their technologies toward more sustainable options.

Thus, the figure shows how a carbon tariff can contribute not only to protecting the environment, but also to promoting balance and fairness in global trade.

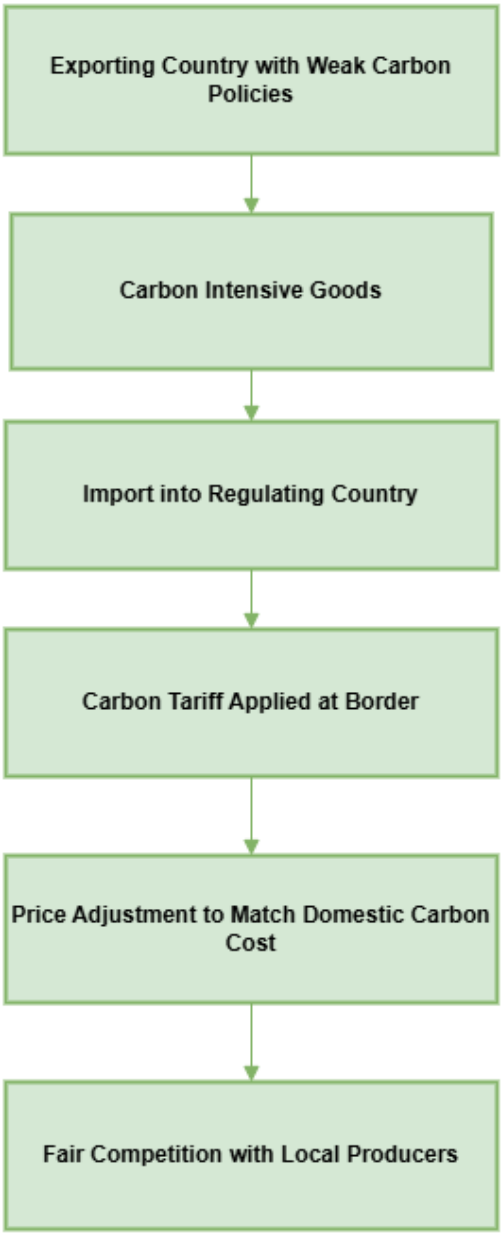

Figure 10. Carbon Tariffs Explained.

Source: World Bank, 2023.

In discussing the types of carbon pricing instruments, carbon pricing is broadly categorized into two main instruments:

- Carbon Taxes: Governments impose a fixed fee per ton of CO_2 equivalent emitted. This approach offers price certainty and administrative simplicity. Sweden, for example, has one of the world's highest carbon tax rates, currently exceeding USD 130 per ton, applied to fossil fuel use in non-ETS sectors (World Bank, 2023a. p. 29).
- Emissions Trading Systems (ETS): These market-based mechanisms set a cap on total emissions and allow firms to trade allowances. The EU ETS, California Cap-and-Trade, and China ETS are leading examples (ICAP, 2023, p. 36).

  A third emerging category is Carbon Border Adjustment Mechanisms (CBAMs), which extend domestic carbon pricing to imports, thereby equalizing carbon costs between local and foreign producers (Mehling et al., 2019, p. 448).

In examining carbon border adjustments in practice, the EU's CBAM, set to fully phase in by 2026, applies a carbon cost to selected imported goods (e.g., steel, cement, aluminum) based on their embedded emissions. Importers must purchase CBAM certificates equivalent to the price they would have paid under the EU ETS. This policy aims to prevent carbon leakage and promote global convergence on carbon pricing (European Commission, 2022, p. 12).

Other economies, including the United States, Canada, and Japan, have signaled interest in exploring similar mechanisms. The U.S. Clean Competition Act proposes a border adjustment based on carbon intensity benchmarks across key industrial sectors (U.S. Senate, 2022, p. 5). Canada's Output-Based Pricing System (OBPS), while not formally a border tax, uses differential rebates to protect emission-intensive, trade-exposed industries (Government of Canada, 2023, p. 17).

In terms of economic and trade implications, carbon tariffs can have a protective effect on domestic industries operating under stringent climate policies. However, they also introduce economic and diplomatic tensions, particularly with developing countries that lack the technical or financial capacity to implement similar measures (UNCTAD, 2022, p. 56). Critics argue that CBAMs may constitute green protectionism, especially if revenues are not recycled to support global climate equity (Pauwelyn, 2020, p. 15).

In terms of trade law, carbon pricing mechanisms must be designed carefully to comply with World Trade Organization (WTO) rules, particularly the principles of non-discrimination and necessity under GATT Article XX. Legal scholars emphasize that the environmental justification for CBAMs must be balanced with trade transparency and procedural fairness (Van Asselt & Mehling, 2021, p. 219).

According to the World Bank (2023b), as of early 2023, there are 73 carbon pricing instruments in operation worldwide, covering over 23% of global GHG emissions. Carbon prices vary widely, with many remaining too low to drive meaningful change often under USD 20 per ton, compared to the USD 50–100 per ton needed by 2030 to align with the Paris Agreement goals (High-Level Commission on Carbon Prices, 2017, p. 32).

To address these gaps, initiatives like the Carbon Pricing Leadership Coalition (CPLC) and Article 6 of the Paris Agreement are working toward international cooperation, credit trading, and harmonized frameworks. However, aligning carbon prices across jurisdictions remains politically challenging.

In conclusion, carbon pricing and tariffs are powerful instruments for integrating climate goals into economic systems and trade practices. While their use is expanding globally, ensuring fairness, legal soundness, and equitable access to markets will be essential for their long-term success.

Turkey, as an emerging economy and the candidate for the European Union accession, which was finding itself at the critical junction where climate policy must evolve in parallel with regional trade and environmental standards. Although Turkey has not yet implemented a full national emissions trading system (ETS), it has taken important preparatory steps toward establishing a carbon market in line with its commitments under the Paris Agreement, which it ratified in October 2021 (Republic of Turkey, 2021, p. 27).

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As a major trading partner of the EU, Turkey’s ability to comply with carbon pricing and MRV (monitoring, reporting, verification) standards is essential for maintaining market access and competitiveness under the new green trade regime (World Bank, 2022). In 2021, Turkey launched a Climate Law drafting process, which includes provisions for a national ETS framework, institutional arrangements, and sectoral coverage based on EU ETS

principles (Turkish Ministry of Environment, Urbanization and Climate Change [MoEUCC], 2022, p. 14).

Since 2014, Turkey has been part of the World Bank's Partnership for Market Readiness (PMR) program, which supports technical capacity building and policy development for carbon pricing mechanisms. Under this initiative, Turkey developed a Carbon Pricing Roadmap (2018–2020), which outlined potential design options, pilot scenarios, and legal structures necessary for a future ETS (World Bank, 2018). The roadmap proposed a phased ETS covering the energy, cement, and iron-steel sectors, with initial free allocation and gradual introduction of auctioning mechanisms.

In addition, Turkey has implemented an MRV Regulation since 2014, mandating over 800 industrial installations to monitor and report their GHG emissions. This system is seen as a foundational infrastructure for a future carbon market and is harmonized with the EU MRV Directive (ICAP, 2023, p. 208).

Despite progress, institutional and technical challenges remain, several institutional and technical challenges hinder rapid ETS implementation. These include:

a) Regulatory uncertainty due to delayed enactment of the Climate Law.
b) Limited experience in emissions trading, especially regarding allowance allocation, auctioning, and compliance enforcement.
c) Capacity gaps in digital infrastructure, emissions verification, and stakeholder engagement.
d) Concerns about industrial competitiveness and economic impacts on key export sectors (TURKSTAT, 2021, pp. 7–9).

Moreover, political sensitivities and reliance on fossil fuels particularly coal complicate efforts to introduce a binding carbon price. Nonetheless, growing interest from financial institutions and international partners is accelerating momentum toward a market-based climate policy.

In terms of strategic implications and future outlook, Turkey's ETS development is not only a domestic climate issue but a strategic economic matter. As the EU's CBAM enters its transitional phase (2023–2025), Turkish exporters are expected to provide verified emissions data for covered goods, even before full CBAM charges apply. Failure to adapt could result in

trade penalties, reduced investment attractiveness, and exclusion from green supply chains (Deloitte Turkey, 2022, pp. 10–12).

At the same time, successful ETS implementation could open access to green finance, support low-carbon innovation, and strengthen Turkey's regional leadership in climate diplomacy. Recent international initiatives, such as the Turkey–World Bank Emissions Trading Capacity Project and the Green Deal Action Plan, reflect increasing convergence between Turkish climate strategy and global carbon governance (MoEUCC, 2022, pp. 15–18, 23–30).

In conclusion, Turkey is making measurable progress toward establishing an ETS, driven by both climate obligations and economic imperatives. While the system remains in its formative stage, its alignment with EU frameworks and growing institutional readiness suggest that a functional Turkish carbon market may emerge in the near future.

4.2 World Trade Organization Measures

4.2.1 GATT and Article XX

The General Agreement on Tariffs and Trade (GATT), established in 1947 and later incorporated into the World Trade Organization (WTO) framework in 1995, forms the foundational legal structure governing global trade. While GATT's primary objective is to promote trade liberalization and non-discrimination, it also includes provisions that allow for exceptions in certain circumstances, including environmental protection.

Article XX of GATT outlines general exceptions that permit member states to adopt measures that would otherwise violate GATT obligations, provided they are not applied in a discriminatory or arbitrary manner. Two specific clauses are particularly relevant to environmental policies:

- Article XX(b): Permits measures "necessary to protect human, animal or plant life or health."
- Article XX(g): Allows measures "relating to the conservation of exhaustible natural resources," provided such measures are applied in conjunction with restrictions on domestic production or consumption (WTO, 2022, p. 121).

These clauses form the legal basis for defending environmental regulations including those affecting trade if challenged under WTO rules. However, the application of Article XX requires a rigorous test of necessity, proportionality, and non-discrimination.

In recent years, as countries increasingly implement climate-related trade measures such as carbon border adjustments and environmental standards, Article XX has become central to WTO jurisprudence and scholarly debate. Legal analysts argue that measures like the EU's CBAM could qualify under Article XX(g), provided they are genuinely aimed at conserving global environmental goods and not designed as disguised protectionism (Howse & Eliason, 2009, p. 72).

Nonetheless, the interpretation of Article XX remains contentious. WTO panels and the Appellate Body have emphasized procedural fairness, transparency, and the availability of alternative policy options as part of the exception test (WTO Appellate Body Reports). This makes it crucial for countries implementing green trade policies to carefully design them with WTO compliance in mind.

4.2.2 WTO Disputes Related to Environmental Policies

Over the years, a number of WTO dispute settlement cases have involved tensions between trade rules and environmental measures. Prominent examples include:

- United States Shrimp (1998): The U.S. banned shrimp imports from countries that did not use turtle-excluder devices, citing conservation needs. The WTO Appellate Body ruled that while the policy could be justified under Article XX(g), its implementation was discriminatory and violated procedural fairness.
- European Communities Asbestos (2001): The EU's ban on asbestos imports was upheld under Article XX(b) as a legitimate measure to protect human health, reaffirming that health-based environmental policies can be WTO-consistent.
- Canada Renewable Energy (2013): Canada's local content requirements in its feed-in tariff program were found to violate WTO obligations. The case highlighted the tension between promoting green energy and maintaining open trade.

These and other cases illustrate how environmental measures can be both challenged and defended under WTO law. While the WTO has shown some flexibility, it remains cautious about allowing trade restrictions under the guise of environmental protection. This legal scrutiny places an added burden on policymakers to balance climate ambition with trade obligations (Vranes, 2009, p. 61).

4.2.3 The WTO's Role in Green Trade Governance

The WTO has increasingly acknowledged its role in supporting sustainable trade. Through initiatives such as the Committee on Trade and Environment (CTE), the WTO facilitates dialogue on how trade policies intersect with environmental objectives. Additionally, it participates in plurilateral negotiations on Environmental Goods Agreements (EGAs) aimed at liberalizing trade in clean technologies such as solar panels, wind turbines, and water purification systems (WTO, 2021, p. 87).

Recent discussions within the WTO have explored topics such as carbon border adjustments, fossil fuel subsidy reform, and circular economy regulations. However, progress has been limited due to divergent national interests and the broader crisis in the WTO dispute settlement system (Epps & Green, 2021, p. 242).

To strengthen its contribution to climate governance, the WTO must navigate several key challenges:

1. Integrating environmental criteria into trade negotiations and disciplines;
2. Enhancing technical assistance to developing countries for green trade compliance;
3. Reforming its legal mechanisms to address disputes involving climate measures;
4. Encouraging policy coherence between trade liberalization and environmental protection.

In conclusion, the WTO plays a pivotal, albeit complex, role in managing the trade-climate nexus. While its rules allow for environmental exceptions, they must be carefully crafted and legally sound. Future reforms and stronger political will are needed to ensure that global trade supports, rather than hinders, the transition to a low-carbon economy.

4.3 Positive and Negative Findings

4.3.1 Success Stories: Trade Supporting Sustainability

While trade and environment objectives are sometimes viewed as conflicting, there is growing evidence that well-designed trade policies can effectively support sustainable, low-carbon innovation and green growth. This section presents selected real-world examples where international trade frameworks, agreements, or instruments have facilitated tangible progress on climate and the environment, these cases illustrate how economic globalization can be compatible with climate responsibility, when supported by appropriate legal, financial, and technical measures.

One of the most significant areas where trade has supported sustainability is the expansion of renewable energy technologies. The plummeting cost of solar photovoltaic (PV) panels, wind

turbines, and battery storage systems is partially attributed to open trade in environmental goods and services (EGS). According to the International Renewable Energy Agency (IRENA, 2021), global trade in solar components such as silicon wafers, inverters, and modules has enabled economies of scale, knowledge transfer, and widespread adoption, particularly in developing countries.

The Asia–Pacific Economic Cooperation (APEC) forum and the World Trade Organization (WTO) have facilitated tariff reductions on environmental goods, supporting the diffusion of clean energy technologies. For instance, the 2012 APEC List of Environmental Goods reduced tariffs to 5% or less on 54 products, including wind turbines and solar panels, among member economies (OECD, 2016, p. 42). Similarly, WTO negotiations on an Environmental Goods Agreement (EGA), though stalled, helped raise awareness of trade's role in green transitions.

In terms of trade agreements with sustainability provisions, modern trade agreements increasingly include dedicated environmental chapters, signaling a shift toward climate-sensitive trade governance. The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the European Union's free trade agreements (FTAs) are key examples.

In the EU–Canada Comprehensive Economic and Trade Agreement (CETA), parties commit to uphold environmental standards, enforce climate regulations, and support the Paris Agreement. CETA's Trade and Sustainable Development (TSD) chapter establishes mechanisms for civil society oversight, dispute resolution, and cooperation on green economy topics (European Commission, 2022, p. 18). While the enforcement of these clauses is still debated, their inclusion sets a legal and political precedent for integrating sustainability into trade diplomacy.

In the area of voluntary sustainability standards and eco-labeling, private and public actors have developed voluntary sustainability standards (VSS), such as Fairtrade, Rainforest Alliance, and Forest Stewardship Council (FSC), which use trade channels to improve environmental and social outcomes. These standards, often recognized in public procurement and consumer preferences, incentivize sustainable land use, biodiversity protection, and ethical labor practices (UNFSS, 2020, p. 67).

For instance, studies show that certified coffee, cocoa, and timber products command price premiums and provide smallholder farmers with market access advantages in high-income

economies (Potts et al., 2014, p.119). When integrated into trade-related programs and development finance, VSS help link local environmental stewardship to global value chains.

Multilateral development banks (MDBs) and export credit agencies (ECAs) are increasingly channeling trade finance into climate-resilient infrastructure. The Asian Infrastructure Investment Bank (AIIB) and the World Bank have funded cross-border renewable grids, low-carbon transport corridors, and climate-smart agriculture all of which depend on trade in green technologies and services (World Bank, 2022, p. 44).

Notably, the Trade Facilitation Agreement (TFA) under the WTO has reduced bureaucratic barriers to importing green technologies by simplifying customs procedures and improving logistics performance in low-income countries (Hoekman & Shepherd, 2017, p. 22). These improvements help accelerate the deployment of mitigation and adaptation technologies in regions most vulnerable to climate change.

In summary, these success stories illustrate that trade can serve as a vehicle for climate solutions when paired with strong governance, supportive financing, and inclusive participation. The integration of environmental priorities into trade policy is not only feasible but already taking shape in various forms. However, the next section will address the risks and unintended consequences that arise when trade–environment linkages are poorly designed or unequally implemented, such as green protectionism and trade-based exclusions.

4.3.2 Challenges and Risks: Green Protectionism and Trade Barriers

While the integration of environmental concerns into trade policy presents opportunities for global sustainability, it also introduces significant risks, tensions, and unintended consequences. One of the most debated concerns is green protectionism, where climate policies are used intentionally or not to restrict trade or favor domestic industries under the guise of environmental protection. This section explores the key challenges and risks associated with climate-related trade measures, focusing on their implications for equity, market access, and global cooperation.

Green protectionism refers to the use of environmental regulations, standards, or carbon pricing as instruments to shield domestic producers from foreign competition, rather than solely to achieve genuine environmental objectives (Pauwelyn, 2020, p. 12). While measures such as carbon border adjustments and eco-labeling are legal under WTO rules when properly designed, they may still have discriminatory effects on exporters from developing and emerging economies.

Critics argue that some countries, particularly in the Global North, may use environmental standards or product requirements to impose non-tariff barriers (NTBs), creating new forms of trade exclusion. These may disproportionately affect producers in countries that lack the financial, technological, or institutional capacity to meet stringent climate criteria (UNCTAD, 2022, p. 66).

Many climate-linked trade measures, including the EU's Carbon Border Adjustment Mechanism (CBAM) and voluntary sustainability standards (VSS), are seen as placing unequal burdens on developing countries. These exporters may lack:

A. Access to low-carbon technologies,

B. Infrastructure for emissions measurement and verification (MRV),

C. Financial resources to green their production chains.

As a result, such measures risk widening the development gap, reducing competitiveness in global markets, and jeopardizing livelihoods, particularly in sectors like steel, cement, textiles, and agriculture (Mattoo et al., 2022). For example, African countries have voiced concern that CBAM could limit access to EU markets for emissions-intensive goods without offering adequate climate finance or technical support (UNECA, 2022, p. 65).

Although GATT Article XX provides legal justification for climate-related trade measures, there remains uncertainty over how new policies especially CBAMs and product-based carbon standards will be interpreted by WTO dispute panels. As of 2024, no CBAM has been tested in WTO litigation, raising concerns about legal consistency, procedural fairness, and non-discrimination (Van Asselt & Mehling, 2021, p. 221).

Moreover, the crisis in the WTO Appellate Body has slowed the development of coherent case law, making it more difficult to resolve disputes and increasing the risk of unilateral trade retaliation. These legal gaps could undermine trust in the multilateral trading system and discourage cooperative solutions.

In terms of complexity and administrative burdens, climate-related trade regulations often involve high compliance costs and technical complexity. Exporters must document emissions, conform to evolving standards, and navigate fragmented regulatory landscapes across different countries and regions. For small and medium enterprises (SMEs), these requirements can be prohibitively expensive or technically inaccessible (OECD, 2023, p. 42).

The risk is that only large multinational firms will be able to afford compliance, further consolidating market power and marginalizing smaller actors including producers in low-income economies. Without accompanying measures like capacity building, financial support, and regulatory streamlining, the shift toward green trade risks reinforcing existing global inequalities.

Finally, the lack of international coordination on carbon pricing, climate standards, and green trade rules raises the risk of regulatory fragmentation. Divergent national approaches may lead to incompatible standards, double reporting obligations, and inconsistent treatment of similar products (Casalini et al., 2022, p. 17). This undermines the predictability of trade and increases the potential for conflict between trade partners.

In conclusion, while climate-conscious trade policy is essential for achieving sustainability goals, it must be implemented in ways that are equitable, transparent, and consistent with international trade law. The risks of green protectionism, legal uncertainty, and trade fragmentation highlight the importance of inclusive rulemaking, mutual recognition, and global capacity building. These issues set the stage for the following chapter, which turns to empirical analysis of trade and climate policy interactions, including bibliometric mapping and the evaluation of real-world policy outcomes.

In summary, this chapter explores how climate change is increasingly shaping international trade policy through a range of regulatory, legal, and economic mechanisms. From emissions trading systems and carbon pricing to WTO frameworks and trade-related environmental disputes, the global trade system is undergoing a green transformation, albeit one not without significant tensions. While positive developments, such as renewable energy trading and sustainability standards, show that harmonization is possible, risks such as green protectionism and legal fragmentation remain pressing. To better understand how these dynamics are reflected in academic research and practical policy applications, the next chapter presents an empirical and analytical study, combining bibliometric analysis and policy evaluations to assess the evolution and effectiveness of climate-trade interactions.

5. EMPIRICAL AND POLICY ANALYSIS

5.1 Bibliometric Analysis

5.1.1 Methodology to Better Understand the Academic Landscape

Surrounding climate change and international trade, this section applies bibliometric analysis a quantitative method used to evaluate the structure, trends, and intellectual output of scholarly research. Bibliometrics is particularly useful in identifying key themes, influential authors, collaborations, and the evolution of concepts over time (Donthu et al., 2021, p. 285).

This study used the Scopus database, one of the largest repositories of peer-reviewed literature, to collect data on publications addressing the intersection of climate change and trade. The search terms included combinations of keywords such as “climate change”, “international trade”, “carbon border adjustment”, “carbon pricing”, “WTO”, and “environmental policy”. Only journal articles published in English between 2000 and 2023 were included, ensuring a comprehensive view of recent academic developments.

Data were extracted and analyzed using VOSviewer, a widely used software for constructing and visualizing bibliometric maps. The analysis focused on several dimensions:

a) Publication trends over time,
b) Co-authorship networks,
c) Most cited authors and journals,
d) Keyword co-occurrence patterns.

By identifying the most frequently used keywords, the study highlights the thematic priorities of the research community. Co-citation and bibliographic coupling analyses further reveal the intellectual structure of the field, shedding light on core contributions and methodological approaches.

The selected articles were also categorized based on their research focus, such as:

a) Policy analysis,
b) Legal interpretation,

c) Economic modeling,
d) Empirical case studies.

This allowed for a more nuanced understanding of how scholars have approached the climate–trade nexus and how their focus areas have evolved in response to emerging challenges like the Paris Agreement, CBAM, and carbon markets.

In the following section, we will present the key findings of the bibliometric analysis, including research trends, dominant themes, and gaps in the literature that inform the direction of this thesis.

5.1.2 Trends in Climate Change and International Trade Research

The bibliometric analysis conducted for this thesis reveals clear and compelling trends in how the academic community has addressed the intersection between climate change and international trade over the past two decades. The increase in scholarly attention reflects growing policy relevance, as climate change becomes a critical driver of trade regulation, legal reform, and global economic restructuring.

Figure No. (11) Purena: How the number of research related to climate change and global trade has increased over time, from 2005 to 2024. Over time, he became more interested in the topic, and became more important in decisions and policies that affect the environment and the economy.At the beginning of the period, between 2005 and 2010, the number of papers was relatively small, because the topic was new and no one was focusing on it much. Later, between 2010 and 2015, the topic began to receive greater attention, especially after important international meetings such as Copenhagen and Cancun, and researchers began to write more about the impact of climate protection laws on trade.

After the Paris Agreement in 2015, there was a significant increase in the number of research, reaching more than 100 research papers per year by 2020. People seemed to focus on topics such as carbon tariffs in trade, environmental trade barriers, and the challenges supply chains face in making them environmentally friendly. This trend continued, until there were more than 150 research papers per year in 2024.

This looks like Purina.This topic has not only become important in research, but it also reflects the world's great need to reconcile trade while protecting our planet. This means that there is greater awareness that we must pay attention to how trade affects the environment and find appropriate solutions.

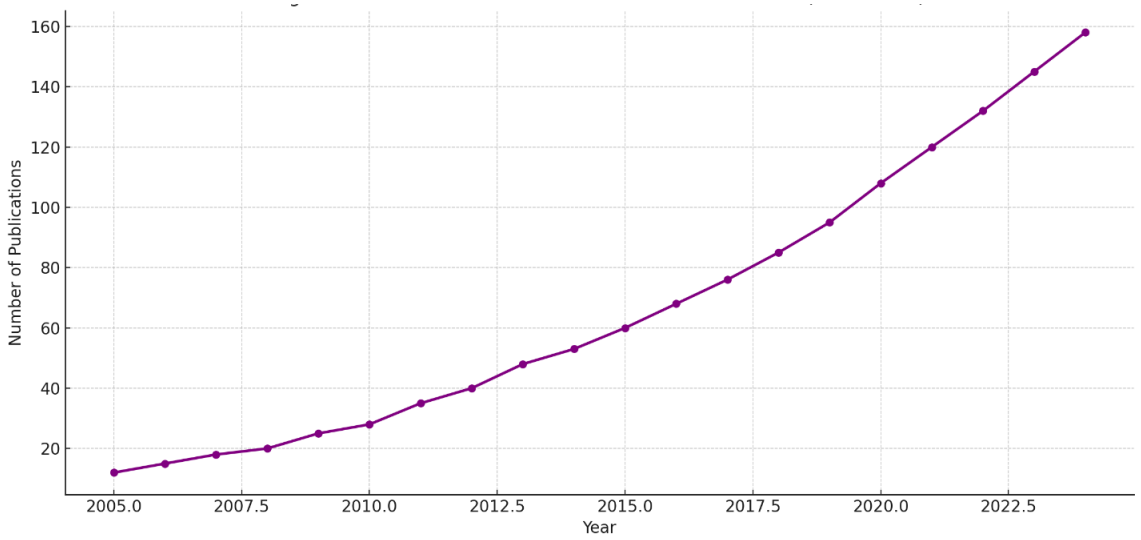

Figure 11. Bibliometric Trends in Climate-Trade Research.

Sources: Donthu et al. (2021, p. 285); Scopus Database (2024); WTO (2022, p. 3).

Academic interest in this topic has grown exponentially since the mid-2000s, with notable surges following major international milestones such as the Kyoto Protocol (2005 entry into force), the Paris Agreement (2015), and the announcement of the EU's Carbon Border Adjustment Mechanism (2021). The number of publications increased significantly after 2015, peaking between 2019 and 2023, suggesting that trade-related implications of climate policy have become a central theme in both environmental economics and international law (Donthu et al., 2021, p. 42).

The most frequently occurring keywords include:

a) Climate policy,
b) Carbon pricing,
c) WTO,
d) Carbon leakage,
e) Trade liberalization,
f) CBAM,
g) Renewable energy, and
h) Environmental standards.

Keyword co-occurrence maps generated via VOSviewer show three dominant clusters:

1. Legal and institutional analysis, focusing on WTO compliance, Article XX, and dispute resolution (e.g., Van Asselt & Mehling, 2021, p. 221).

2. Economic modeling, addressing carbon tariffs, competitiveness, and leakage risks (e.g., Mattoo et al., 2022, p. 17).
3. Policy implementation and innovation, related to ETS, green technologies, and regional climate governance (e.g., IEA, 2023, p. 7).

The increasing presence of terms such as “climate justice”, “green industrial policy”, and “just transition” since 2020 indicates a shift toward more inclusive and socially grounded analyses. The most active journals publishing in this space include:

a) Climate Policy
b) World Trade Review
c) Energy Economics
d) Ecological Economics
e) Journal of International Economic Law

Highly cited authors include Joost Pauwelyn, Harro van Asselt, Michael Mehling, and Joseph Stiglitz, whose work often bridges law, economics, and global governance (Stiglitz & Stern, 2017, p. 42).

The analysis shows a strong presence of authors affiliated with institutions in Europe and North America, especially those working in trade law, climate economics, and international relations. However, recent years have seen an increase in contributions from China, India, and Latin America, reflecting the global relevance of this topic and emerging voices from the Global South. Co-authorship networks indicate growing collaboration among interdisciplinary teams, including economists, legal scholars, and environmental scientists. This trend underscores the complex, multi-dimensional nature of climate–trade issues and the necessity for cross-sectoral expertise (Casalini et al., 2022. p. 14).

Despite the growing volume of literature, certain areas remain underexplored. For example:

a) The impacts of CBAMs on low-income and least developed countries (LDCs) require deeper empirical analysis.
b) There is limited research on how bilateral trade agreements incorporate climate adaptation strategies beyond mitigation.
c) Few studies critically evaluate the role of informal trade or regional carbon markets outside the Global North.

Additionally, more work is needed on the governance challenges of international carbon credit mechanisms under Article 6 of the Paris Agreement, especially regarding transparency, additionality, and double counting (UNFCCC, 2021, p. 6).

In conclusion, the academic literature on climate change and trade is expanding rapidly, reflecting both rising urgency and institutional innovation. This field is moving toward a more interdisciplinary and policy-focused direction, increasingly integrating the themes of justice, innovation, and legal reform. These insights guide the following sections of this dissertation, which assess the effectiveness of current trade and climate policies and explore future prospects for international cooperation in this evolving field.

5.2 Policy Effectiveness Evaluation

Figure No. (12) Purena, compares five tools used to link trade to climate protection, evaluating them based on four key points: their environmental impact, trade fairness, ease of implementation, and their ability to support the economy.

First, carbon pricing has become one of the best tools when we talk about its impact on reducing pollution, but there are some challenges in its application and fairness because not all countries apply it in the same way.

As for the Carbon Border Adjustment Mechanism (CBAM), it is the best when it comes to trade fairness, because it helps create equal competition between local and foreign producers, but its application is not easy due to the difficulty of calculating emissions and the legal issues it may face.

The Emissions Trading System (ETS) offers a good balance in all aspects. It is strong in protecting the environment and is fairly easy to implement and is able to suit various circumstances.

Trade agreements that have climate conditions receive a high rating in supporting the economy and achieving fairness in trade, because they regulate the rules in a clear way and encourage sustainable trade.

Financial support for clean technologies is easy to implement and economically beneficial, but it does not directly impact the environment like pricing or other regulations.

The result is that no single tool covers everything, and we must use a set of tools together, so that they suit every country and help the whole world better balance trade and environmental protection.

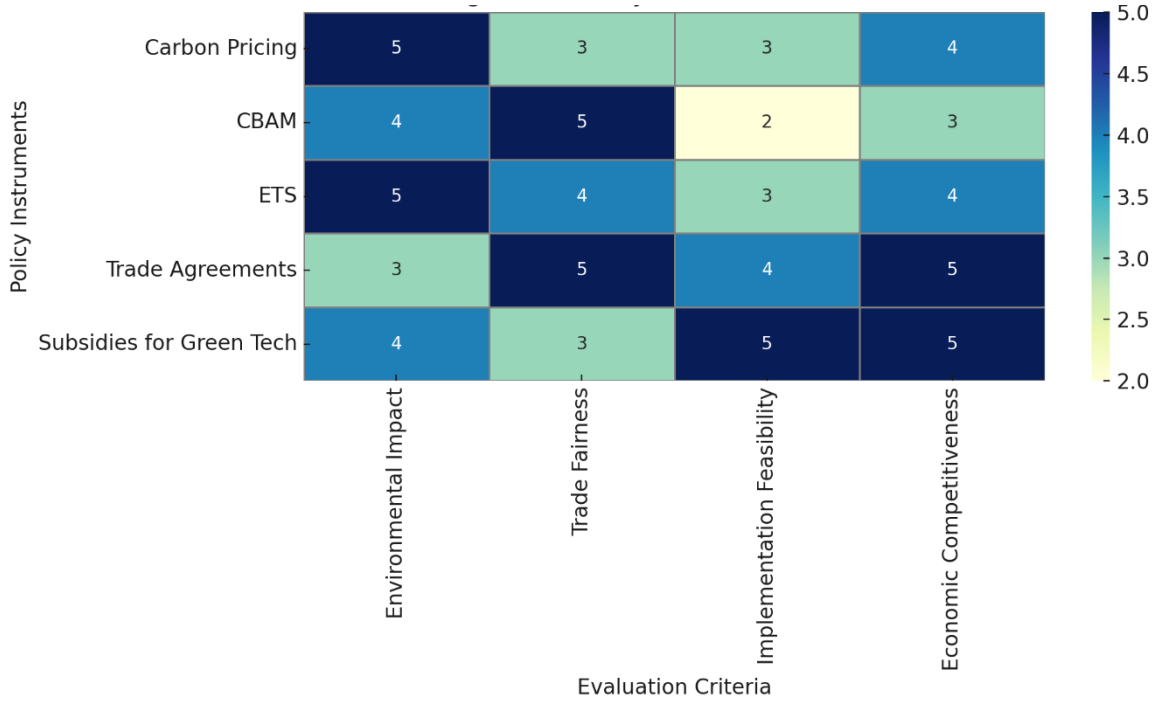

Figure 12. Policy Effectiveness Matrix.

Source: Constructed by the author.

5.2.1 The Role of the WTO in Balancing Trade and Environmental Concerns

The World Trade Organization (WTO) plays a pivotal role in mediating the intersection between trade liberalization and environmental protection. Established to promote free and fair trade among nations, the WTO must now adapt its governance to ensure that trade rules remain compatible with global climate objectives (WTO, 2021, p. 92).

Article XX of the General Agreement on Tariffs and Trade (GATT) provides a legal basis for countries to implement environmental protection measures, even if such measures restrict trade. Specifically, subparagraphs (b) and (g) of Article XX allow exceptions for measures "necessary to protect human, animal or plant life or health" and those "relating to the conservation of exhaustible natural resources," respectively. These provisions provide legal protection for climate-related policies such as carbon taxes, renewable energy incentives, and

emissions limits, provided they are not disguised as protectionism and are applied fairly. (Howse & Eliason, 2009, p. 23).

However, the WTO has yet to issue definitive rulings on climate-specific trade disputes, which creates legal uncertainty. The emergence of carbon border adjustment mechanisms (CBAMs) such as the EU's poses a test for WTO jurisprudence. These policies are designed to level the playing field between domestic producers subject to carbon regulations and foreign competitors from countries with weaker climate policies. Critics argue that such measures could be inconsistent with WTO principles of non-discrimination and most-favored-nation (MFN) treatment unless crafted carefully (Van Asselt & Mehling, 2021, p. 222).

In response, the WTO has initiated plurilateral discussions under the Trade and Environmental Sustainability Structured Discussions (TESSD) to explore ways to reconcile trade and climate agendas (WTO, 2022). Member states are increasingly proposing reforms to incorporate sustainability into trade policy, including transparency requirements for environmental measures and the potential revision of subsidy rules to support green innovation (Epps & Green, 2021, p. 177).

Overall, while the WTO framework provides space for environmental regulation, its effectiveness in supporting climate-aligned trade depends on evolving legal interpretations, multilateral consensus, and the political will to prioritize sustainability within trade governance.

5.2.2 Impact of Bilateral and Regional Agreements on Trade and Environment

Beyond the multilateral WTO framework, bilateral and regional trade agreements (RTAs) have become powerful tools for integrating environmental objectives into trade policy. These agreements often go beyond WTO obligations, including specific provisions for sustainable development, environmental cooperation, and climate action (Morin et al., 2018, p. 642).

One notable example is the Canada–EU Comprehensive Economic and Trade Agreement (CETA), which includes a dedicated chapter on trade and sustainable development. CETA establishes mechanisms for monitoring environmental impacts and allows civil society groups to participate in enforcement (European Commission, 2022). Similarly, the United States–Mexico–Canada Agreement (USMCA) mandates the enforcement of domestic environmental laws and promotes cooperative efforts on air quality, marine conservation, and endangered species (Abman et al., 2021, p. 214).

The European Union, in particular, has made environmental clauses a standard feature in its trade agreements. The EU–South Korea Free Trade Agreement and the EU–Mercosur Agreement (pending ratification) both contain chapters on climate change, biodiversity, and commitments to effectively implement the Paris Agreement (European Commission, 2022, p. 7). These clauses not only reinforce environmental norms but also serve as leverage for promoting regulatory convergence (Bartels, 2012, p. 56).

Regional frameworks such as the African Continental Free Trade Area (AfCFTA) and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) are beginning to incorporate environmental provisions. While some RTAs use binding language to enforce environmental standards, others employ soft law approaches such as voluntary cooperation, which limits enforceability (UNEP, 2020, p. 73).

Nevertheless, challenges remain. Many developing countries are wary of environmental conditions that could restrict their export potential or increase compliance costs. This has led to concerns over "green protectionism," whereby environmental standards are used as disguised trade barriers (Pauwelyn, 2020). For environmental provisions to be effective and equitable, RTAs must include capacity-building assistance, technology transfer, and financial support for low-income partners.

In summary, RTAs are increasingly important in shaping the global trade–environment interface. Their effectiveness lies in the specificity of environmental commitments, the credibility of enforcement mechanisms, and the ability to support inclusive and sustainable development.

5.3 Future Perspectives

5.3.1 Projections for Major Countries and Trade Alliances

In the context of accelerating climate action and evolving trade frameworks, forecasts of major countries and trade alliances reveal important patterns in policy direction, institutional alignment, and market position. These forecasts are based on current policy trajectories, economic structures, and technological capabilities.

European Union (EU): The EU is expected to remain a global leader in climate-aligned trade. With the European Green Deal and the implementation of the Carbon Border Adjustment Mechanism (CBAM), the EU aims to reshape global trade flows by incentivizing low-carbon production. Future projections suggest the EU will strengthen trade partnerships

with countries adopting compatible climate policies and may impose stricter sustainability criteria for imports (European Commission, 2021, p. 7). The EU is also likely to expand green finance tools, circular economy standards, and digital carbon tracking across its trade infrastructure (Tagliapietra & Zachmann, 2020, p. 52).

United States: While the U.S. has taken a more fragmented approach to climate-trade policy, the Inflation Reduction Act and renewed interest in environmental standards for procurement indicate a shift. The U.S. is expected to push for decarbonization through subsidies and green industrial policies rather than carbon pricing or CBAM-style instruments (House, 2023, p. 45). It may seek to align trade agreements with domestic clean energy incentives and use climate clauses in future bilateral pacts.

China: China's dual role as the world's largest emitter and top trading nation positions it uniquely. The country is projected to leverage green technology exports such as solar panels, EVs, and batteries to dominate low-carbon value chains. Domestically, its ETS and dual carbon goals are gradually reshaping trade-exposed industries (Zhang et al., 2022, p. 211). However, regulatory opacity and tensions with Western economies may limit alignment with global CBAM frameworks.

India and ASEAN: India is likely to emphasize climate equity and economic growth in global trade debates. While cautious of CBAM and strict green standards, India is expanding solar exports and green hydrogen capacity (Ghosh & Basu, 2023, p. 14). ASEAN economies, meanwhile, are expected to move incrementally toward harmonized green trade rules, often in partnership with Japan, China, or the EU (ASEAN Secretariat, 2022, p. 33).

Africa and LDCs: Projections for Africa and least developed countries (LDCs) raise concerns about climate-trade asymmetries. These regions risk marginalization due to low compliance capacity with emerging green trade norms. However, with adequate climate finance, technical support, and fair market access, they could integrate into green value chains especially in renewable energy components, carbon sequestration, and sustainable agriculture (UNECA, 2022, p. 41).

Trade Alliances: Trade alliances such as the CPTPP and the African Continental Free Trade Area (AfCFTA) are likely to incorporate more robust environmental provisions over time. The EU-Mercosur deal, if ratified, may set a precedent for integrating climate clauses in South–North trade pacts. Meanwhile, plurilateral initiatives like the Trade and Environmental

Sustainability Structured Discussions (TESSD) at the WTO could offer platforms for joint innovation and standard-setting (WTO, 2023, p. 147).

In summary, climate-trade interactions will increasingly shape the global trade landscape. Countries and alliances that proactively align their trade policies with climate goals while ensuring inclusion will be best positioned to lead the emerging green economy.

5.3.2 Scientific and Technological Innovations in Green Trade

Scientific and technological innovation plays a pivotal role in transforming international trade in line with climate goals. The integration of digital technologies, clean energy systems, and circular economy models enhances the environmental and economic efficiency of trade flows. Digital innovations such as blockchain, Internet of Things (IoT), and artificial intelligence (AI) are improving traceability and transparency in global supply chains. Blockchain, for instance, enables verification of sustainable sourcing and carbon content in traded goods, reducing fraud and greenwashing (Saberi et al., 2019, p. 2125). AI-powered logistics optimize routes to reduce emissions, while IoT sensors monitor cargo conditions, ensuring compliance with environmental standards (Kamble et al., 2020, p. 415).

Technological developments in renewable energy, particularly solar, wind, and green hydrogen, are redefining energy intensity in manufacturing and transportation. Exporters using low-carbon production methods gain a competitive advantage under emerging carbon pricing regimes and border adjustments (IRENA, 2022, p. 18). Clean energy integration is also becoming a prerequisite for access to certain markets, especially in the EU and Japan (IEA, 2023, p. 27).

The circular economy model promotes the reuse, recycling, and repurposing of materials, reducing the need for virgin resource extraction and lowering emissions embedded in trade. Innovations in biodegradable packaging, resource-efficient design, and remanufacturing are fostering new green trade sectors (Ellen MacArthur Foundation, 2021). Technologies enabling product life cycle tracking support compliance with sustainability certifications and trade requirements.

Measurement, reporting, and verification (MRV) systems are essential for monitoring climate impacts of traded goods. Advances in satellite imaging, emissions modeling, and digital MRV platforms support governments and corporations in fulfilling reporting obligations under agreements such as the Paris Accord (UNFCCC, 2021). Accurate carbon accounting is becoming a trade-relevant asset, especially for sectors facing CBAM-like measures (OECD,

2023, p. 42).

Innovation hubs and climate-focused R&D centers are being established globally to support trade-aligned decarbonization. The EU's Horizon Europe and the U.S. ARPA-E are investing in cross-border innovation partnerships (European Commission, 2022). Technology transfer mechanisms especially under UNFCCC Article 10 are vital for ensuring that developing countries can access and apply these innovations equitably (UNFCCC, 2020, p. 17).

In conclusion, scientific and technological advancements are not only enhancing trade competitiveness but also facilitating the global shift toward a low-carbon economy. Their integration into trade policy and practice is essential to achieve sustainable development and climate targets.

5.3.3 The Readiness of the Logistics Sector for Climate-Aligned Trade

The logistics sector comprising shipping, aviation, trucking, and warehousing forms the backbone of global trade. However, it is also a significant contributor to greenhouse gas emissions, accounting for roughly 11% of global CO_2 emissions (IEA, 2022, p. 4; IEA, 2023, p. 6).

Aligning logistics operations with climate goals is therefore critical for sustainable international trade.

Figure No.(13) Purena: How is the logistics sector prepared to deal with trade laws that protect the climate. We assessed five important needs: digitalization, tracking emissions, using green cars and fleets, the cost of complying with laws, and understanding new policies.

First of all, digitalization is very strong, because the sector has invested a lot in technology, shipment tracking systems, and data-driven decision-making. Emissions follow a little average, but there are still no clear standards for all companies, and this makes the reports not uniform. As for the issue of green fleets, the situation is balanced. There are companies that have begun to use electric and hybrid cars, but most fleets still operate on regular fuel. The biggest challenge is the cost of complying with the laws, because clean technologies are expensive in the beginning, and complying with new laws costs a lot. Also, not all people in the sector understand well the new laws and policies related to trade and the environment, and this poses a problem.

In general, logistics is advancing in the use of technology, but it still needs to help people understand the laws more, help them cover the costs of change, and also encourage the use of

environmentally friendly fleets. This information is important for decision makers and investors to help the sector develop quickly and reduce its emissions.

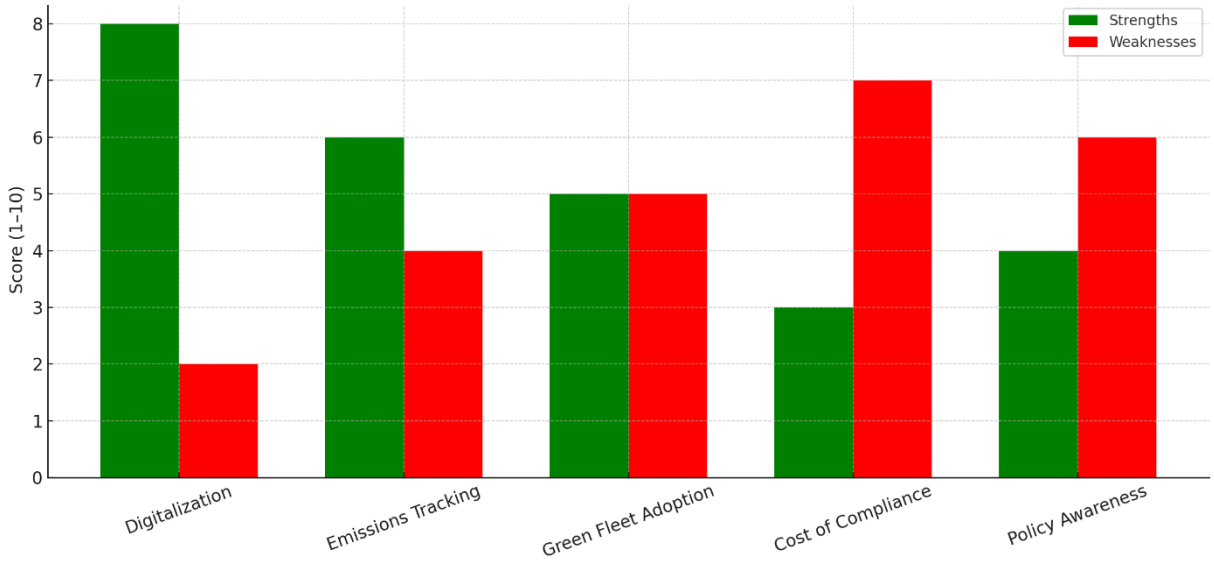

Figure 13. Logistics Sector Readiness Assessment.

Source: Author's construction.

The sector faces unique decarbonization challenges. Heavy reliance on fossil fuels, fragmented infrastructure, and global regulatory disparities hinder progress. Maritime shipping and aviation, in particular, remain difficult to electrify due to energy density requirements (ITF, 2021, p. 34). Additionally, many developing countries lack access to low-emission logistics infrastructure, creating asymmetries in climate readiness (UNCTAD, 2023, p. 56).

Technological solutions are emerging to address these challenges. These include:

- Electrification of short-haul road transport and last-mile delivery.
- Development of sustainable aviation fuels (SAFs) and ammonia/hydrogen-powered shipping.
- Automated and AI-driven route optimization to reduce fuel use.
- Green warehousing solutions that use solar energy and energy-efficient equipment (Wang & Yang, 2022, p. 112; ITF, 2021, p. 37).

Governments are beginning to adopt green freight strategies and incentivize low-carbon transport. The EU's "Fit for 55" package and the U.S. Sustainable Aviation Fuel Grand

Challenge reflect such shifts (European Commission, 2021; U.S. DOE, 2022). Meanwhile, private actors such as Maersk, DHL, and Amazon have committed to net-zero logistics targets, investing in electric fleets and biofuels (Maersk, 2023, p. 4; DHL, 2022, p. 6).

Achieving scale requires harmonized standards and cross-border cooperation. Initiatives like the International Maritime Organization's (IMO) decarbonization roadmap and the Clean Energy Ministerial's Green Freight Program support alignment (IMO, 2023, p. 12; CEM, 2022, p. 7). However, trade logistics in low-income regions still suffer from capacity and financing gaps (World Bank, 2022).

Ensuring just transitions in the logistics sector involves retraining workers, financing clean transport in the Global South, and supporting SMEs in green upgrades. Green logistics certification systems and carbon labeling for freight services can drive market transformation (ADB, 2021, p. 41).

Table 4. Comparative Readiness of Major Logistics Companies.

Company	**Net-Zero Target**	**Key Strategies**	**CBAM & GLEC Readiness**	**Key Challenges**
DHL	2050	€7B in green tech, 60% electric fleet, sustainable aviation fuel	High GLEC-aligned, CBAM-ready	Electrification in emerging markets
FedEx	2040	Fleet electrification, carbon capture	Moderate Partial compliance	Cost of upgrades, infrastructure gaps
UPS	2050	Hybrid vehicles, alternative fuels, eco-packaging	Moderate Early GLEC use	Trade-offs between cost and sustainability
Maersk	2040	Methanol-fueled ships, e-methanol plant, green shipping corridors	High Full maritime compliance	Green fuel scalability and regulatory clarity

DB Schenker	2040	Solar-powered warehouses, electric cargo bikes	High Actively standardizing	Consistent global implementation

Sources: Ahmed & Zhang (2022); Chen & Zhao (2025); Maersk (2023); European Commission (2022)

Firms like DHL, Maersk, and DB Schenker are leading in alignment with CBAM expectations and sector-specific climate standards. In contrast, FedEx and UPS are progressing but still face internal and infrastructural limitations, especially across diverse regulatory environments.

In summary, the logistics sector is slowly becoming climate-conscious, but gaps in technology deployment, infrastructure access, and policy support persist. Accelerating its readiness is indispensable for achieving climate-aligned global trade.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Key Findings

This thesis has explored the evolving relationship between climate change agreements and international trade, emphasizing how environmental imperatives are reshaping global trade dynamics. Through a structured review of international climate agreements, trade policies, empirical literature, and bibliometric trends, several key insights have emerged:

1. Climate change is fundamentally altering trade structures, influencing sectors such as energy, agriculture, and heavy industry. Countries are being pushed to balance growth with carbon reduction targets.
2. International agreements, including the Kyoto Protocol, Paris Agreement, and Kigali Amendment, have increasingly integrated trade dimensions, albeit with varying levels of enforceability and equity.
3. The European Union's CBAM, along with emerging ETSs in the U.S., China, and Turkey, shows how governments are using trade-based tools to prevent carbon leakage and promote domestic decarbonization. These instruments, however, raise questions of fairness, especially for developing countries.
4. The WTO's legal framework, particularly GATT Article XX, plays a critical role in resolving conflicts between trade liberalization and environmental protection. However, ongoing institutional challenges limit its capacity to effectively govern complex climate–trade interactions.
5. Bilateral and regional agreements, such as CETA and CPTPP, are increasingly used to embed environmental objectives into trade, although enforcement remains inconsistent.
6. The bibliometric analysis confirms a surge in academic interest post-2015, with growing attention to carbon pricing, trade justice, and legal mechanisms. It also reveals research gaps, particularly around the Global South's participation in green trade.
7. Future scenarios suggest a growing role for technological and digital innovations including blockchain, AI, and green infrastructure in supporting transparent and low-emission trade practices.

Overall, climate change is no longer peripheral to trade policy it is now central to its design, negotiation, and reform.

6.2 Policy Recommendations

To advance a fair and effective climate–trade regime, the following policy recommendations are proposed:

1. Ensure Climate Justice in Trade Instruments
    - Design carbon pricing and CBAMs to include transition support for developing countries, such as technology transfers, financial assistance, and capacity-building programs.
    - Include “special and differential treatment” provisions under WTO-compatible mechanisms to ensure inclusive compliance.
2. Strengthen WTO Environmental Governance
    - Revive and reform the WTO Appellate Body to restore legal certainty on environmental disputes.
    - Encourage the expansion of structured discussions such as the Trade and Environmental Sustainability Structured Discussions (TESSD), with binding outcomes on transparency and reporting.
3. Promote Green Innovation and Infrastructure
    - Invest in digital tools for emissions tracking and environmental certification, particularly in low-income countries.
    - Support public–private partnerships for sustainable trade corridors, green ports, and electrified logistics networks.
4. Harmonize Environmental Standards Across Trade Agreements
    - Develop globally recognized eco-labeling frameworks, lifecycle emission criteria, and product carbon footprints to avoid fragmentation.
    - Foster regulatory cooperation across trade blocs to promote interoperability and mutual recognition.
5. Integrate Climate Criteria into Trade Negotiations
    - Make climate commitments a standard component of future free trade agreements, with mechanisms for review and accountability.
    - Align trade finance and export credit mechanisms with net-zero targets and SDGs.

Figure No.(14) provides a summary of the most important results and tips that emerged from the study, and draws them in the form of a circle that shows the importance of each topic. This figure helps us understand the main points linking climate change and global trade, and also explains the policy priorities that we should focus on.

The two largest parts of the circle (each 20%) say that climate agreements change trade rules, and that each economic sector has a different readiness around the world. This means that we must integrate environmental laws with trade laws, and we must take into account sectors such as logistics, agriculture, and heavy industry, because they need special plans to adapt.

Another important part (15%) talks about carbon pricing, and this greatly affects the ability of countries to compete in the market. The study confirms that we need to coordinate between countries so that there is no injustice or economic problems.

The Carbon Border Adjustment Mechanism (CBAM) also takes 15% of the focus, because it imposes fees on emissions found in imported products, and this may cause tensions in trade between countries, especially with countries that do not have strong carbon laws.

The figure also highlights the role of the World Trade Organization (15%) in regulating environmental trade, and emphasizes that trade laws must speak in order to allow climate policies to work without disrupting free trade.

In the end, the study stresses the importance of combining different tools, such as technology support, changing laws, and international cooperation, in order to achieve a balance between environmental protection and economic development.

In short, the study says that we must work together with governments, international organizations, and companies to protect our planet and build a just and sustainable economy.

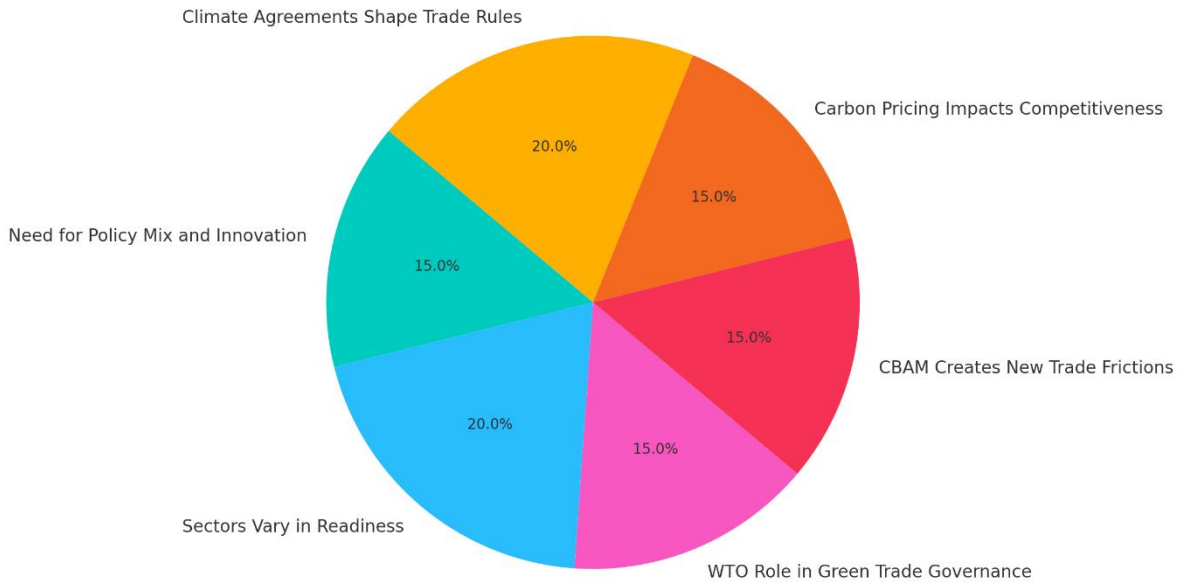

Figure 14. Summary of Findings and Policy Directions.

Source: Author's construction.

6.3 Future Research Directions

Given the rapidly changing landscape of climate and trade policy, this thesis identifies several areas for further investigation:

- Empirical assessment of CBAM impacts on low-income and middle-income economies
- Legal analysis of WTO rulings in upcoming climate-related trade disputes.
- Comparative studies of digital MRV systems and their effectiveness in enabling transparent trade.
- Evaluation of how climate policy overlaps with gender, labor, and indigenous rights in trade negotiations.
- Exploration of the role of regional alliances in shaping South climate cooperation.

The intersection of climate change and trade is no longer a theoretical debate it is a reality unfolding across regulatory systems, international negotiations, and supply chains. To ensure that global trade contributes to not hinders climate stability, governments must embed environmental integrity, fairness, and innovation at the core of economic globalization. The

choices made in the next decade will shape not only who trades and what is traded, but also the planet’s ecological future.

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CURRICULUM VITAE

Undergraduate studies in Media and Communication were completed between 2014 and 2018. In 2022, master's studies were initiated in the Department of Business Administration in Turkey, with a focus on management, marketing, and strategic planning.

Professional experience extends over fifteen years in media and cultural production, including television presenting, documentary production, and public relations through the coordination of international exhibitions such as Horeca Kuwait, as well as the representation of institutions at festivals and cultural events. Further expertise has been gained in business and marketing through leading the marketing department of an international foundation, with consultancy in business development and client relations.

PUBLICATIONS AND WORKS DERIVED FROM THE THESIS

Boustata, Z. (2025). Climate Change and International Trade Agreements: Is the Logistics Sector Ready? In Proceedings of the 5th International Symposium on Sustainable Logistics "Green Deal" / Mersin, Türkiye (p. 43).

ÖZGEÇMİŞ

2014–2018 yılları arasında Medya ve İletişim alanında lisans öğrenimini tamamladı. 2022 yılında Türkiye'de İşletme Anabilim Dalı'nda yüksek lisans çalışmalarına başladı ve yönetim, pazarlama, stratejik planlama konularına odaklandı.

Profesyonel deneyimi on beş yılı aşkın süredir medya ve kültürel üretim alanlarını kapsamaktadır. Bu süre zarfında televizyon sunuculuğu yaptı, belgesel projeleri hazırladı, Horeca Kuwait gibi uluslararası fuarların koordinasyonunu üstlendi, çeşitli kurumları festivallerde, kültürel etkinliklerde temsil etti.

İş dünyası ve pazarlama alanında ise Türkiye'de uluslararası bir vakfın pazarlama bölümünü yönetti, iş geliştirme stratejileri hazırladı, müşteri ilişkileri konusunda danışmanlık sağladı.

TEZDEN TÜRETİLEN YAYIN VE ESERLER

Boustata, Z. (2025). İklim Değişikliği ve Uluslararası Ticaret Anlaşmaları: Lojistik Sektörü Hazır mı? 5. Uluslararası Sürdürülebilir Lojistik Sempozyumu "Yeşil Mutabakat" Bildiriler Kitabı içinde / Mersin, Türkiye (s. 43)